Appendix A
Selection of Contaminants

ATSDR scientists used several criteria for selecting the chemical and radioactive contaminants for the exposure pathways identified at the Fernald site. These criteria include (1) environmental levels exceeding the media-specific comparison value, (2) noted community health concerns, and (3) the quality and extent of sampling data with which to evaluate potential exposure and human health hazard. For inorganic compounds (metals) and radionuclides, background values may also be considered, because some of these substances occur naturally.

The highest environmental concentration detected in off-site samples is compared with the media-specific comparison values in the Environmental Contamination, Exposure Pathways and Potentially Exposed Populations section of this report to determine if it is elevated enough to warrant further evaluation (ATSDR 1993). Media-specific comparison values are contaminant concentrations in specific environmental media (e.g., soil, water, air) that are considered to be "safe" under default assumptions about exposure. Comparison values are *not* thresholds of toxicity. While concentrations at or below comparison values may be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would produce adverse health effects. Generally, if a concentration exceeds one or more media-specific comparison values, an estimated exposure dose from the contaminant is evaluated further in the Environmental Contamination, Exposure Pathways and Potentially Exposed Populations and Public Health Implications sections of this report.

For chemicals, the media-specific comparison values used in this public health assessment include ATSDR's environmental media evaluation guides (EMEGs), cancer risk evaluation guides (CREGs), and reference dose media evaluation guides (RMEGs) (ATSDR 1993). Similar values developed by the U.S. Environmental Protection Agency (EPA) and used in this health assessment are maximum contaminant levels (MCLs) and EPA's Region III Risk-Based Concentrations (EPA 1989).

EMEGs are media-specific chemical comparison values that are developed for soil, water, and air. EMEGs are derived from ATSDR's minimal risk levels (MRLs), which are presented in ATSDR's Toxicological Profiles. An MRL is a health-based comparison value representing an estimate of daily human exposure to a chemical that is not likely to pose adverse non-cancer effects over a specified duration of exposure. MRLs are developed for acute (less than 14 days), intermediate (15 to 364 days), and chronic (365 days or more) exposure durations.

RMEGs are media-specific chemical comparison values derived from EPA's reference doses (RfDs). RfDs are health-based guidelines for non-cancer effects. An RMEG is used when an EMEG is not available for a chemical. An RfD is an estimate of daily exposure to a contaminant below which adverse non-cancer effects are not likely to occur over a lifetime (EPA 1989).

CREGs are estimated chemical contaminant concentrations in a specific medium that are anticipated to result in one excess cancer in one million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs), also known as cancer potency factors (CPFs). CPFs are developed for chemicals shown to be carcinogenic in either animals or humans (EPA 1989).

MCLs are contaminant concentrations in water derived by EPA to be protective of public health (considering the availability and economics of water treatment technology) over a lifetime at an ingestion rate of 2 liters of water per day. MCLs are enforceable regulatory values. MCLs are used to screen for both chemical and radioactive contaminants.

For radionuclides, the soil comparison values used in this public health assessment are the soil-screening values established by the National Council on Radiation Protection and Measurements (NCRP 1999). These screening values are land-use, scenario-dependent. Because the land use around the Fernald site could fit into any one of four scenarios (agricultural, heavily vegetated pasture, heavily vegetated rural, or suburban), the lowest screening value from any of these scenarios for a particular radionuclide was used. For instance, the lowest soil screening value for radium 226 is 0.11 pCi/g (4.1 Bq/kg) for the heavily vegetated rural scenario, but the lowest screening value for radium 228 is 0.07 pCi/g (2.7 Bq/kg) for the agricultural scenario. These four scenarios are defined below:

Agricultural (AG): Primarily food production for human consumption, no dwellings

Heavily vegetated pasture (PV): Primarily milk or meat production, no dwellings

Heavily vegetated rural (RV): Fields and forest with some ingestion of food from gardens, wild game, fruits, or mushrooms, with some dwellings

Suburban (SU): Residential properties with limited food production, such as in personal vegetable gardens

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 1993. Public health assessment guidance manual. Atlanta: US Department of Health and Human Services.

[EPA] US Environmental Protection Agency. 1989. Risk assessment guidance for Superfund, Vol. 1, human health evaluation manual (part A). EPA/540/1-89/002. Washington, DC: US Environmental Protection Agency.

[NCRP] National Council on Radiation Protection and Measurements. 1999. Recommended screening limits for contaminated surface soil and review of factors relevant to site specific studies. Report No. 129. Bethesda, MD: 1999 Jan.

Appendix B
Exposure Doses and Health-Based Guidelines

Chemicals

The following *general equation* is used to estimate human exposure dose for *chemical* contaminants:

$$\textit{Estimated Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

Estimated Exposure Dose	=	Exposure dose calculated as milligrams of contaminant per kilogram of body weight per day (mg/kg/day)
C	=	Contaminant concentration, in milligrams per kilogram (mg/kg), milligrams per liter (mg/L), or milligram per cubic meter (mg/m^3)
IR	=	Intake rate for ingestion or inhalation, in milligrams or kilograms per day (mg/day or kg/day), liters per day (L/day), or cubic meters per day (m^3/day)
EF	=	Exposure frequency, or number of exposure events per unit of time (e.g., year) of exposure
ED	=	Exposure duration, or the duration over which exposure occurs (e.g., years)
BW	=	Body weight, in kilograms (kg)
AT	=	Averaging time, or the time period over which cumulative exposures are averaged (e.g., total years of exposure x 365 days per year)

The assumptions ATSDR used to calculate exposure doses for *chemical*s in completed or potential exposure pathways are provided in the discussion section for each pathway (i.e., groundwater, soil, air, surface water, biota). ATSDR used the estimated exposure doses as *screening-level* analyses of public health hazard by comparing the estimated exposure doses with *health-based guidelines* for the chemical, route of exposure, and exposure duration (i.e., acute, intermediate, or chronic). When an estimated exposure dose for a chemical exceeded its corresponding health-based guideline, ATSDR then evaluated the chemical further in the Public Health Implications section of the report, using a more in-depth, weight-of-evidence approach (ATSDR 1993).

Health-based guidelines include ATSDR's minimal risk levels (MRLs) and EPA's reference doses (RfDs) for non-cancer effects, and cancer risk ranges (1 in 10,000 to 1 in 1,000,000 excess cancer risk) for cancer effects. MRLs and RfDs are conservative values because they are based on levels of exposure reported in the scientific literature, which represent no-observed-adverse-effect-levels (NOAELs) and lowest-observed-adverse-effect-levels (LOAELs) for the most sensitive outcome for a given route of exposure (e.g., ingestion or inhalation). In addition, uncertainty factors are applied to

NOAELs and LOAELs to account for variation in the human population and uncertainty in extrapolating from animals to humans, and for added protection of the most sensitive individuals. Therefore, MRLs and RfDs may have uncertainties spanning an order of magnitude or more. Additional information on ATSDR's MRLs is presented in each ATSDR toxicological profile.

When evaluating the potential for cancer to occur, ATSDR scientists often use cancer risk ranges based on EPA's cancer potency factors (CPFs). CPFs define the relationship between exposure doses and the likelihood of developing cancer over a lifetime (EPA 1989). CPFs are developed using data from animal or human health studies and often require extrapolation from high exposure doses administered in animal studies to the lower exposure levels typical of exposure to environmental contaminants. CPFs represent the upper-bound estimates of the probability of developing cancer at a defined level of exposure; therefore, they tend to be conservative and may even overestimate the actual risk, in order to account for uncertainties in the data used in the extrapolation.

ATSDR scientists may also use cancer effect levels (CELs) reported in the scientific literature to determine possible cancer effects from exposure at the exposure doses estimated for the contaminant of concern and pathway. The CELs are similar to LOAELs for non-cancer effects, but they represent minimal levels of effect for cancer effects. The CELs are derived from animal and human health studies and represent the lowest dose of a chemical in a study, or group of studies, that produces a significant increase in the occurrence of tumors in the exposed population as compared to an unexposed group. Additional information on CELs is presented in each ATSDR toxicological profile.

Radiation

The following general equation is used to estimate human exposure dose (committed effective or equivalent doses) for *radioactive* contaminants:

Committed Effective or Equivalent Dose *(lifetime dose in sieverts from specified intake)*	=	C x IR x EF x ED x IDC

Where:

Committed Equivalent Dose	=	Equivalent dose received in a particular tissue or organ over a person's lifetime following the intake of radioactive materials into the body
Committed Effective Dose	=	Sum of the committed tissue or organ equivalent doses and the appropriate organ or tissue weighting factor integrated over the person's lifetime
C	=	Contaminant concentration, in becquerels per gram (Bq/g), becquerels per liter (Bq/L), or becquerels per cubic meter (Bq/m^3)*
IR	=	Intake rate for ingestion or inhalation
EF	=	Exposure frequency, or number of exposures per unit of time of exposure
ED	=	Exposure duration, or the duration over which exposure occurs
IDC	=	Age-dependent ingestion or inhalation dose coefficients, in sieverts per becquerels (Sv/Bq)*

* 1 becquerel = 27 picocuries; 1 sievert = 100 rem

ATSDR uses age-dependent ingestion and inhalation dose coefficients developed by the International Commission on Radiological Protection.

The *committed effective dose* (CED) is a calculated whole body dose arising from the one-time intake of a radionuclide, with the assumption that the total intake is at one time and the entire dose (a 70-year dose for a child and a 50-year dose for an adult) is received in the first year following the intake. The *committed equivalent dose* is the entire absorbed dose from the intake of a radionuclide averaged over a tissue or organ and weighted by the type and energy of the radiation (ICRP 1991). When evaluating the carcinogenic effects of radiation, ATSDR scientists use a total CED (from all pathways) of 5,000 millirem (50 millisieverts) over a lifetime as a comparison value. ATSDR believes the total CED of 5,000 millirem (50 millisieverts) over a lifetime70 years is protective of human health (ATSDR 2004). ATSDR typically uses the current MRL for external, chronic exposure to ionizing radiation (100

mrem/year) as the comparison value when evaluating non-carcinogenic effects of radiation. This level is based on exposure to average U.S. background radiation levels with added uncertainty factors for human variability (i.e., the average annual effective dose to the U.S. population is 360 mrem/year). This annual dose has not been associated with adverse health effects in humans or other animals (ATSDR 1999).

The committed effective and committed equivalent doses for radioactive contaminants in completed or potential exposure pathways are presented in the discussion section for each pathway (i.e., groundwater, soil, air, surface water, biota). At the *screening-level* analysis phase in the exposure pathways analyses, ATSDR used the maximum concentrations to estimate these doses. In assessing *public health implications*, ATSDR determined the likelihood of developing a fatal cancer (or other adverse health effect) over a person's lifetime based on the total committed effective and committed equivalent doses from *all* pathways for a hypothetical maximally exposed person.

Reference

[ATSDR] Agency for Toxic Substances and Disease Registry. 1993. Public health assessment guidance manual. Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1999. Toxicological profile for uranium. Atlanta: US Department of Health and Human Services; 1999 Sep.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2004. Public health assessment: Y-12 Uranium Releases, Oak Ridge Reservation (USDOE). Atlanta: US Deartment of Health and Human Services; 2004 Jan.

[EPA] US Environmental Protection Agency. 1989. Risk assessment guidance for Superfund, Vol. 1, human health evaluation manual (part A). Washington, DC: EPA/540/1-89/002.

[ICRP] International Commission on Radiation Protection. 1991. 1990 recommendations of the International Commission on Radiation Protection. Publication 60. Oxford: Pergamon Press.

Appendix C
Community Concerns

As stated previously in this report, ATSDR has been compiling community concerns expressed by Fernald residents since 1993. These concerns are grouped on the next pages under the following headings:

HEALTH CONCERNS
- Cancer
- Non-Cancer Effects

ENVIRONMENTAL EXPOSURES
- Air
- Soil
- Surface Water
- Groundwater
- Biota

SPECIFIC POPULATIONS' CONCERNS

PROCEDURAL CONCERNS
- Remediation
- Lack of Trust
- Emergency Response
- Monitoring or Sampling
- General
- Recommendations by the Public

Note: Some concerns that ATSDR presents as statements under one heading may appear again under another heading. Although ATSDR has not intentionally reported individual concerns under more than one heading, some of the comments contained more than one concern and may appear more than once. ATSDR adopted this structure to show how the concerns were expressed and to emphasize recurring topics that were heard. The comments were paraphrased, and most of them are presented in the first person to emphasize the personal nature of the conversations that took place during the private meetings.

At the end of this section, ATSDR has summarized concerns gathered by the Fernald Health Effects Subcommittee and by the community group, Fernald Residents for Environmental Safety and Health, Inc. (FRESH).

Health Concerns

Cancer

Cancer is classified as a group of diseases that arise from normal cells that become abnormal and begin to grow uncontrollably. These abnormal cells may invade surrounding normal tissue and spread to distant parts of the body (metastasize). Most scientists agree that the process that causes cancer is complex and involves the interaction of environment, genes, and lifestyle factors. Socioeconomic status and access to health care may also play a role. The overall risk for cancer increases with age, as does the risk of cancer mortality (Laszlo 1988). Substances that cause cancer are known as carcinogens. Carcinogens can be chemical, physical (e.g., radiation), or biological (e.g., viral).

Although several risk factors are associated with different types of cancers, many people who get the disease do not have a readily identifiable risk factor (ACS 1999). Research studies have examined how environmental exposure may increase a person's risk of developing cancer, but more studies are needed on the interaction of environment, genetics, and lifestyle. Also, many studies have examined populations, not individual risk. If you are concerned about your own or a family member's risk of developing cancer, you should consult your personal physician. The American Cancer Society local chapters also have information on risk factors and prevention.

Skin Cancer

I am concerned about skin and lung cancer.

I am concerned about skin lesions and lip cancer.

My husband had facial cancer. He did not work at Fernald.

A child's father had skin cancer and fungus on his foot.

Around December 18–25, 1984, Fernald had its last big air release. At the time, I had an outdoor wedding. After that my husband developed skin cancer and my son developed a bad skin rash and a spot on his lungs. My husband used to eat vegetables grown in our garden and fish from the Great Miami River; my son is a non-smoker.

There have been at least six cancers in my old neighborhood (Thrush Road), including lung cancer in a non-smoker. My grandmother had skin cancer. What health effects could uranium in the groundwater have caused?

Skin cancer is one of the most common types of cancers in the United States. There are two main types of skin cancers, non-melanoma (the most common) and melanoma. Most non-melanoma cancers are either basal cell or squamous cell carcinomas. Basal cell carcinoma—the most prevalent type—is usually found on the head and neck. Squamous cell carcinoma, the second most common type, usually occurs on the face, neck, ear, lips, and back of the hand. Some of the known risk factors for non-

melanoma skin cancer are exposure to ultraviolet (UV) radiation or sunlight, fair skin, chronic exposure to certain chemicals (such as arsenic and industrial tar), and exposure to radiation (ACS 1999).

Melanoma is a more serious form of skin cancer that occurs in the melanocytes, which are cells that produce melanin, the substance that gives skin its color. Although melanoma tends to appear on the trunk of fair-skinned men and the lower legs of fair-skinned women, other skin types and body parts can be affected. Melanoma accounts for approximately 4% of all skin cancer diagnoses, but 79% of all skin cancer deaths. During the past 20 years the incidence of melanoma has doubled in the United States. The risk factors for melanoma include an atypical mole, fair skin, family history of the disease, and treatment with immune suppression agents (ACS 1999).

Some studies suggest that dermal exposure to polycyclic aromatic hydrocarbons (PAHs) in the workplace may increase a person's risk for skin cancer (Soll-Johanning et al.1998; Boffetta et al. 1997; Moran 1992; Nelson 1987). However, similar studies involving environmental exposures do not provide evidence for an association with skin cancer occurrence (Purde and Rahu 1979; Hussain et al.1998). This may be due to PAH concentrations in the environment generally being lower than concentrations under occupational conditions. For example, the concentrations of PAHs in off-site surface soils near the Fernald facility are many times lower than the levels shown to cause adverse health effects in occupational studies.

One study showed an increased risk for non-melanoma skin cancer in a population potentially exposed to radium 226 (Black et al.1994). However, this finding was of borderline statistical significance, and the overall study was hampered by many confounding factors, making interpretation of the finding difficult.

Preliminary analyses of data from the Fernald Medical Monitoring Program (FMMP) suggest that the number of new cases of melanoma may be greater than expected among Fernald residents, as compared to the Surveillance Epidemiology and End Result (SEER) data for Ohio (Pinney 1999). However, the findings of these initial analyses are being evaluated further to determine whether the observed increases warrant further investigation.

ATSDR reviewed monthly uranium air monitoring data at the site boundaries for 1971 through December 1984. The uranium concentrations measured at these air stations for December 1984 were less than the maximum results for all month between 1971 and November 1984 and were similar to the average values (Shleien 1995). These concentrations were also significantly less than the concentrations used by ATSDR to determine if adverse health effects could result from past accidental releases. ATSDR also reviewed information on historical accidental releases at the site, and none were reported for December 1984; however, these releases involved uranium and uranium compounds and did not include releases of non-uranium chemicals.

For information on the adverse health effects that may be caused by uranium in groundwater, refer to the Health Implications section of this report.

On the basis of available information, ATSDR has no evidence that past or current exposure to contaminants from the Fernald site has contributed to an increased risk for skin cancer in the surrounding population.

Respiratory (Lung and Bronchus) Cancer

I am concerned about skin and lung cancer.

I've had breast cancer and lung cancer and currently have brain cancer.

Three of my brothers died of cancer; one died of lung cancer.

My husband worked at the plant and died of lung cancer in 1982.

My church congregation (in Crosby) has a large number of cancer illnesses; many women have had lung and breast cancer.

There have been at least six cancers in my old neighborhood (Thrush Road), including lung cancer in a non-smoker. My grandmother had skin cancer. What health effects could uranium in the groundwater have caused?

Lung cancer can begin in any part of the lung and can spread (metastasize) to other parts of the body. There are also some types of cancer that can begin elsewhere and spread to the lungs, such as metastatic breast cancer or melanoma. The two major types of lung cancer are Small Cell Lung Cancer (SCLC), which makes up about 20% of lung cancers, and Non-Small Cell Lung Cancer (NSCLC), which makes up approximately 80% of lung cancers. Approximately 95% of the SCLC starts in the central portion of the chest and spreads to the lungs or starts in the hormonal cells in the lung. NSCLC includes primarily adenocarcinoma (~40%), squamous cell carcinoma (~30%), and large cell undifferentiated carcinoma (10–15%). Adenocarcinomas usually develop in the outer region of the lung. Squamous cell carcinomas tend to begin in the center of the lung. Large cell undifferentiated carcinomas tend to be large tumors that begin in the outer region of the lung. All NSCLC spread easily to nearby lymph nodes and distant sites. Some lung cancers can have the characteristics of both SCLC and NSCLC (ACS 1999).

Lung cancer is the leading cause of cancer deaths in males and females in the United States. The average age at diagnosis is 60 years old. Risk factors for lung cancer includes smoking tobacco, chronic exposure to environmental tobacco smoke (second hand smoke), recurring lung infection with tuberculosis (TB) and some types of pneumonia, and a family history of lung cancer. Some studies show that exposure to air pollution in some urban areas can cause a slight increase in the risk for lung cancer in those populations. There is also some suggestive evidence that smoking marijuana can increase the risk for lung cancer (ACS 1999).

Exposure to radon and radon daughters is also a risk factor for lung cancer (Lubin et al.1997; Samet et al.1990). Although it is mostly a concern for people who live in certain areas of the country where radon gas tends to accumulate in their homes, it has also been recognized as a public health concern for the general population. Testing of indoor air and proper ventilation in homes can reduce the risk for lung cancer due to indoor exposure to radon.

The CDC's Fernald Risk Assessment Project predicted the number of lung cancer deaths that are likely to occur among residents (residing within 10 kilometers of the facility) through 2088 as a result of radiation exposure from the Fernald facility during its period of operation (Killough et al.1998). The project predicted a 1% to 12% greater-than-expected number of lung cancer deaths in the Fernald community, compared to a community without exposure to radiation from the Fernald site. The increase in lung cancer mortality was presumed to result primarily from exposure to radon and radon daughters from the K-65 silos on the Fernald site. Almost all increased lung cancer deaths occurred among persons first exposed to radon emissions from the Fernald site before 1980, when emissions were highest. The results of the Fernald Risk Assessment Project are considered predictive, because they have not been confirmed in an analytical epidemiologic study. Additional information about the CDC's Risk Assessment Project is provided in Appendix D of this report.

Epidemiologic studies of workers occupationally exposed to uranium in mines, mills, and processing facilities provide evidence, although not conclusive, for an association between exposure to uranium in air and lung cancer (ATSDR 1999; Hornung et al.1998). Because workers were exposed to toxic and cancer-causing substances in addition to uranium, such as silica dust, radon and radon daughters, tobacco smoke, phosgene gas, heavy metals and solvents, the studies are considered inconclusive. These other exposures are likely to have contributed to the lung cancers observed. For example, miners who smoked cigarettes were at a much greater risk of developing lung cancer than those who did not smoke cigarettes. People who work with asbestos are also at an increased risk for lung cancer (Ahrens et al.1998).

Heavy metals (i.e., arsenic) found in off-site surface soils near the Fernald site have been shown to cause lung cancer incidence and death in workers exposed daily to these metals in air. Because there are no measurements of arsenic in on-site or off-site air at the Fernald facility, ATSDR used very conservative assumptions in the air pathway analysis to *estimate* the concentration of arsenic that would result if surface soils became re-suspended in air and were a source of human exposure to Fernald residents. ATSDR's estimated airborne concentrations were considerably lower than the levels shown to produce lung cancer in occupationally exposed workers (ATSDR 1998).

There is also some evidence for a genetic predisposition in some people that makes them more susceptible to respiratory cancer after exposure to a carcinogen (Ghardirian et al.1997; El-Zien et al.1997).

Occupational exposure concerns were referred to NIOSH.

Gastrointestinal Cancer

My wife died of cancer of the stomach, intestines, and pancreas 9 years ago.

My father died of stomach cancer.

One uncle had colon cancer.

I've had cancer three times (breast and colon).

I worked at the plant from 1952 through 1984 and was involved in all the plant operations. I was diagnosed with colon cancer in 1989, and I had surgery.

I was diagnosed with esophageal cancer in 1992; I quit smoking 25 years ago.

Cancer of the esophagus, stomach, and colon can all be categorized as *gastrointestinal cancer*. Cancer of the *esophagus* is three times more likely to occur in men than women and affects African-Americans about three times as often as whites. There are two main types of esophageal cancer, squamous cell carcinoma and adenocarcinoma. Squamous cell carcinoma accounts for about 50% of the disease and is more likely to affect African-Americans than other racial and ethnic groups. Adenocarcinoma occurs more often in whites than other racial and ethnic groups. Both types of esophageal cancer are more often diagnosed in people 45 years of age or older (ACS 1999). Risk factors include sex, race, alcohol abuse, tobacco use (e.g., cigar, cigarettes, chewing tobacco), chronic heartburn or acid reflux, a diet low in fruits and vegetables, Burkett's esophagus, and other rare diseases of the esophagus.

Stomach cancer, also known as gastric cancer, can develop in any of the five sections of the stomach. If left untreated, it can spread to other areas of the body. Most Americans diagnosed with stomach cancer are 50 years of age or older. Stomach cancer is relatively rare in the United States compared to other areas of the world, possibly because dietary habits are important risk factors for this disease. A diet high in salted or smoked foods, as well as one that is high in starch and low in fiber, may contribute to the occurrence of stomach cancer. Other risk factors include tobacco and alcohol abuse, stomach polyps, vitamin B12 deficiency, *Helicobacter pylori* infection, previous stomach surgery, and rare genetic conditions. There is also evidence that people with blood type A may be at slightly higher risk for the disease (ACS 1999).

Colon cancer, also known as colorectal cancer, can begin in any of the four areas of the colon or rectum and spread to other areas of the body if left untreated. As with stomach cancer, colorectal cancer is mostly diagnosed in people 50 years of age or older. Risk factors for this disease include colon polyps, chronic inflammatory bowel disease, a diet high in animal fat, a low level of physical activity, a family history of colon cancer, and certain genetic conditions (ACS 1999).

There is limited evidence from animal and human (occupational) studies for an association between exposure to the polyaromatic hydrocarbon benzo(a)pyrene and cancer of the gastrointestinal tract (Xu et al.1996; Thyssen et al.1981). One occupational study reported that sufficient exposure to benzo(a)pyrene in air resulted in an increased occurrence of stomach cancer (Xu et al.1996).

Benzo(a)pyrene was found in *one* off-site surface soil sample above ATSDR's health-based comparison value. ATSDR did not consider it a contaminant of health concern, because any exposure to this concentration would have been limited in frequency and duration resulting in a potential dose from accidental ingestion of this soil that would be many times lower than levels shown to cause stomach cancer. Other studies examining the association between exposure to environmental contaminants and colorectal cancer have been suggestive, but the studies could not take into account individual risk factors for the disease (Gulis et al.1998; Riberio et al.1996).

ATSDR has no evidence that past or current off-site exposure to contaminants from the Fernald site has contributed to an increased risk for esophageal, stomach, or colorectal cancer in the surrounding community. Occupational exposure concerns were referred to NIOSH.

Breast Cancer

I've had breast cancer and lung cancer and currently have brain cancer.

I've had cancer three times (breast and colon).

I live half a mile from the site. I had a brain tumor, breast cancer, kidney stones, gallbladder problems, stomach problems, and a herniated bowel. My doctor says the brain tumor is probably due to an increase in radiation dose from living near Fernald. I had a hysterectomy, and the doctors said I had many, many fibroid tumors rather than a single large tumor, which is more typical.

My church congregation (in Crosby) has a large number of cancer illnesses; many women have had lung and breast cancer.

My sister was diagnosed with breast cancer.

Although most breast cancers are diagnosed in women, breast cancer does occur very rarely in men. However, the following discussion pertains only to female breast cancer, because there is limited information on risk factors for male breast cancer.

Breast cancer is the second most common cancer in women, the second leading cause of cancer death in women, and the leading cause of death in women between 40 and 55 years of age. The number of newly diagnosed breast cancer cases rose by 4% per year during the 1980s, but has since leveled off. Although a variety of factors have been associated with an increased risk for breast cancer, it is important to note that some people who get breast cancer do not have any of these risk factors (ACS 1999).

Gender can be considered a risk factor, because women are 100 times more likely to develop breast cancer than men. The risk of developing breast cancer increases with age. Whites tend to develop breast cancer at a higher rate than African-Americans, but African-American women are more likely to die from the disease. Asian and Hispanic women have lower rates of this disease than do African-American women. Other risk factors are a family history of breast cancer, therapeutic irradiation of the chest area,

and alcohol abuse. Factors associated with a slightly increased risk are early age of first menstruation or late age of menopause, use of oral contraceptives, late age (more than 30 years of age) of first childbirth or not having children, and estrogen replacement therapy. Genetics is thought to play a role in an estimated 5% to 10% of breast cancer cases (ACS 1999). Numerous inconclusive studies have evaluated the association between breast cancer and various other risk factors, such as having a child but not breast-feeding, consuming a diet high in animal fat, obesity, and a low level of physical activity.

There is much controversy in the scientific community as to whether there is an association between exposure to certain environmental contaminants, called "endocrine disruptors," and breast cancer. These chemicals are so named because of their ability to behave like hormones and other substances that occur naturally in the body and in some foods. Once they are taken into the body, these chemicals alter the function of the endocrine system (e.g., by increasing or decreasing the response) and may cause adverse effects on an organism or its offspring (NIOSH 1998).

Within the category of endocrine disruptors, much attention has been given to two widely spread contaminants, polychlorinated biphenyls (PCBs) and the banned insecticide DDT with its metabolite, DDE. Some scientists believe that these chemicals contribute to the development of breast cancer in humans, because they have been found to mimic the activity of the hormone estrogen in laboratory experiments (Feigelson et al.1996; Rudel 1997). In these experiments, the contaminants bind to the "estrogen receptors" of breast cells grown *in vitro* (in a test tube), causing the cells to divide and grow continuously, a common feature of cancerous cells. Other scientists point to evidence of endocrine disruption in certain wildlife populations exposed to these chemicals in the environment (Soto 1998), and others, not convinced that these chemicals contribute significantly to breast cancer development in humans, point out that human health studies have failed to show a definite association between occupational or environmental exposure to endocrine disruptors and an increase in the risk of developing breast cancer (Davidson 1998; Datson et al.1997; Safe 1997). However, almost all scientists agree that more studies are needed on how diet (Schildkraut et al.1999; Verma et al.1998), genetics (Moysich et al.1998), and environmental exposures may together affect an individual's risk for this disease.

EPA's Office of Prevention, Pesticides and Toxic Substances chairs an Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC) that focuses on chemicals in drinking water and food that may be endocrine disruptors. Additional information about these chemicals and methods for screening and testing for them in water and food can be obtained by accessing EPA's home page (http://www.epa.gov).

ATSDR has no evidence that past or current exposure to endocrine-disruptor type contaminants from the Fernald site has contributed to an increased risk for breast cancer in the Fernald community. Additional information about endocrine disruptors and the possible effects on breast cancer development can be obtained by contacting NIOSH or EPA.

Central Nervous System (CNS) Cancer

Eleven years ago my child (then aged 7) was diagnosed with a brain tumor. Hospital staff asked if the child was exposed to radiation.

I've had breast cancer and lung cancer and currently have brain cancer.

My wife has a brain tumor (frontal lobe meningioma), my next door neighbor had two brain tumors within the same year, and a neighbor down the street died of a brain tumor.

Three of my brothers died of cancer. One died of brain cancer.

There is a high incidence of brain tumors in the area. Is it safe to eat produce grown in the area?

I live half a mile from the site. I had a brain tumor, breast cancer, kidney stones, gallbladder problems, stomach problems, and a herniated bowel. My doctor says the brain tumor is probably due to an increase in radiation dose from living near Fernald. I had a hysterectomy, and the doctors said I had many, many fibroid tumors rather than a single large tumor, which is more typical.

My son was diagnosed with neuroblastoma. There are 12 houses on our street and 6 cancers there. Is neuroblastoma related to site activities?

The central nervous system (CNS) is composed of the brain and spinal cord. There are many different cell types in the CNS, and cancer can occur in any of them. Metastatic brain cancer, which originates in other organs and then spreads to the brain, is the most common type of brain cancer in adults. Primary brain cancer originates in the brain itself and is relatively rare in adults. Brain cancer is the second most common type of cancer in children. Neuroblastoma, the third most common type of brain cancer diagnosed in children, is very rare in adults (ACS 1999).

The risk factors for CNS cancers differ for adults and children. In adults, therapeutic radiation to the head area (as treatment for other cancers) is a risk factor for brain cancer. Some studies suggest an association between ingesting the sugar substitute aspartame and an increased risk for brain cancer in adults. Other studies of the relationship between exposure to low-level electromagnetic fields (EMF) and the risk for brain cancer are inconclusive and controversial. For children, exposure to ionizing radiation (as a treatment for other cancers) is a known risk factor for brain cancer. There is some evidence of genetic susceptibility to brain cancer in families with very specific genetic disorders (ACS 1999, Preston-Martin 1996).

Many studies have examined the association between occupational or environmental exposure to ionizing radiation and the risk for brain cancer. Most of the occupational studies have been done in groups of workers employed in the nuclear energy or nuclear weapons industry. The majority of these studies have investigated cancer mortality rates among workers who died from a variety of causes, including brain cancer, rather than cancer incidence among exposed workers (Alexander 1991). This is because it is often easier to obtain information on causes of death than on disease status during the work history of an employee, especially if a worker died before the beginning of the study. In addition, many

of these studies do not include a measure of individual exposure to radiation, because the studies were conducted years after the exposure occurred. Overall, there is some disagreement about the role of occupational exposure to ionizing radiation and cancer mortality in the studies' cohorts.

Studies of the association between environmental exposure to ionizing radiation and occurrence of brain cancer in communities surrounding nuclear energy or nuclear weapons facilities suffer from methodological issues related to exposure and case ascertainment (Forman 1987; Wakeford and Berry 1996). For example, there is rarely information about individuals' exposure levels. In most of these studies, exposure is estimated using information such as distance from residence to the nuclear facility. Also, individuals in the study population who have been diagnosed with brain cancer may move or die before the study begins and may not be included in the study. This creates a selection bias if more highly exposed individuals tend to move away from a community more often than less exposed individuals. Overall, the results from these studies do not provide conclusive evidence for an increased risk for brain cancer from living near a nuclear facility.

ATSDR has no evidence that past or current off-site exposure to contaminants from the Fernald site has contributed to an increased risk for CNS cancers in the community. No chemicals or radioactive materials are known to have been released from the site at levels that have been shown to cause CNS cancers in humans or laboratory animals.

Hematopoietic Cancer

(Cancer affecting the formation of blood cells, i.e. leukemia)

There are three cases of leukemia and one case of cervical cancer on my street.

My father-in-law died of leukemia.

Leukemia is a form of cancer that begins in the blood-forming cells of the body but can spread to other areas. There are four main types of leukemia: (1) *acute myelogenous leukemia* (AML), (2) *acute lymphocytic leukemia* (ALL), (3) *chronic myelogenous leukemia* (CML), and (4) *chronic lymphocytic leukemia* (CLL) (ACS 1999). *Acute* leukemia occurs when the affected cells do not mature properly so they reproduce and accumulate very rapidly. Acute leukemia can overrun the body within a few weeks or months. In *chronic* leukemia, the cells eventually mature but are abnormal. They remain in the bloodstream much longer than normal white blood cells and are unable to combat infection well. Chronic leukemia is slow-growing and progressively worsens over years. The terms *myelogenous* and *lymphocytic* refer to the types of cells that are involved. If the abnormal white blood cells are primarily granulocytes or monocytes, the leukemia is categorized as *myelogenous*, or myeloid. If the abnormal blood cells arise from bone marrow lymphocytes, the leukemia is categorized as *lymphocytic*.

AML is the most common form of adult leukemia. The average age of most patients at diagnosis is 65 years, and more men are affected than women (Onc 2004). *ALL* occurs predominantly in children,

peaking at 4 years of age; however, adults can also have ALL. It is seen more frequently in industrialized nations and is slightly more common among white children and boys. *CML* is easily diagnosed, because it has a genetic peculiarity, or marker. About 95% of CML patients have a genetic translocation between chromosomes 9 and 22 in their leukemic cells. CML affects mainly middle-age and older adults and is rare (2% to 3%) in children. *CLL* is the most common leukemia in North America and Europe and occurs in older adults. (It is very rare in people less than 50 and has not been associated with radiation exposure.) Men with CLL outnumber women by 2-to-1 (Onc 2004).

Diet, smoking, alcohol abuse, exposure to benzene, and certain infections are risk factors for leukemia in adults. Both adults and children who have been exposed to high doses of ionizing radiation (e.g., atomic-bomb survivors) are at increased risk of developing leukemia. There is an increased risk for leukemia in children with Down's syndrome or certain rare genetic conditions. Other potential risk factors for childhood leukemia are maternal alcohol abuse and cigarette smoking, paternal occupational exposure to certain chemicals and solvents, and exposure to contaminated groundwater (ACS 1999).

Studies have been conducted to evaluate the association between leukemia and exposure to low-frequency electromagnetic radiation (EMF); the results of these studies are inconclusive and somewhat controversial. Several studies have been conducted to examine the significance of geographical clustering of leukemia cases around some urban areas or contaminated sites (Alexander 1998; Pretridou et al. 1997). The findings of these studies are suggestive at best, because they generally lack specific information about individual exposures and potential risk factors.

ATSDR has no evidence that past or current off-site exposures to contaminants from the Fernald site have contributed to an increased risk for leukemia in the community.

Lymphopoietic Cancer

An 18-year-old boy next door died of lymphoma in 1986.

Both Hodgkin's lymphoma (HL) and Non-Hodgkin's lymphoma (NHL) are cancers that develop in the lymphatic system, which is part of the body's immune system that fights diseases and infection. Because lymphatic tissue is present in many areas of the body, these types of cancers can develop virtually anywhere and spread throughout the body (ACS 1999). Hodgkin's and Non-Hodgkin's lymphomas are distinguished and differentiated by the appearance, cell type, and genetic make-up of the affected lymphocytes, a type of white cell.

Hodgkin's lymphomas, or Hodgkin's disease, account for less than 1% of all cases of cancer in the United States. Hodgkin's disease occurs more often in persons with a family history of the disease, men between the ages of 15 and 34, and people over 55. The Epstein-Barr virus may also be associated with an increased chance of getting this disease.

Non-Hodgkin's lymphomas account for about 5% of all cancers in the United States. Potential risk factors include age/sex (increase risk with increase in age and more cases with men), weakened immune system, having Acquired Immune Deficiency Syndrome (AIDS), being an organ transplant recipient, and extensive exposure to certain chemicals such as pesticides, solvents, or fertilizers. Exposure to high levels of ionizing radiation, such as experienced by atomic-bomb survivors or Chernobyl survivors, has been shown to produce slight increases in the risk of developing NHL. Radiation therapy to treat other cancers has also been shown to produce slight increases in the risk for NHL. In children, the risk factors also include a congenital immune deficiency that makes them more susceptible to infectious disease (ACS 1999).

ATSDR has no evidence that past or current off-site exposure to contaminants from the Fernald site has contributed to an increased risk for either Hodgkin's or non-Hodgkin's lymphoma in the surrounding community. The radiation doses associated with atomic-bomb and Chernobyl survivors and radiation therapy are much greater than the maximum doses estimated for persons near the Fernald site.

Prostate Cancer

My father had prostate cancer. He was an organ donor, but upon his death, the hospital would not accept his organs due to their contamination.

My father had prostate cancer.

Prostate cancer develops from the prostate gland and can spread to different parts of the body. It is the second most common cancer in men after skin cancer, and the second leading cause of death in men after lung cancer. The primary risk factor for prostate cancer is age; it is most often diagnosed in men over 50 years of age. African-American men are twice as likely as white men to develop prostate cancer. Other potential risk factors are a diet high in animal fat, being overweight, and a low level of physical activity. There is some evidence that prostate cancer may run in families (ACS 1999).

There is no evidence that prostate cancer is linked to exposure to environmental contaminants. Preliminary findings of the Fernald Medical Monitoring Program (FMMP) suggest that the number of new cases of prostate cancer among FMMP participants is greater than expected compared to persons in the Surveillance Epidemiology End Result (SEER) program for Ohio. However, the observed increase may not be an actual increase in the number of new cases, but may have resulted from the use of a new diagnostic test that improved the identification of existing cases (Pinney 1999).

Reproductive System Cancers

I am concerned about breast and testicular cancer.

There are three cases of leukemia and one case of cervical cancer on my street.

Are cervical cancer and thyroid disorders related to site activities?

My wife and I drank well water for 3 ½ years and cistern water for 7 years. She died of vaginal cancer.

I have an enlarged thyroid and have had cervical cancer. Are cervical cancer and thyroid disorders related to the site?

I've lived near the plant since I was 9. My 19-year-old daughter was diagnosed 1 year ago with an ovarian tumor; one ovary was removed. I have had uterine cancer and tumors on my back.

Cancers of the reproductive system are associated with a variety of risk factors. Some occupational exposures have been associated with an increased risk for testicular cancer. Other risk factors are undescended testicles and injury to the testicles. Infection with Human Papilloma Virus (HPV) is a risk factor for both cervical and vaginal cancer. Human immunodeficiency virus (HIV), infection, smoking, low socioeconomic status, and a diet low in fruits and vegetables are all risk factors for cervical cancer. Some women with vaginal cancer developed the disease because their mothers took the drug diethylstilbestrol (DES) during pregnancy. Women over 50 years of age are at greater risk for ovarian and vaginal cancer. Family history of ovarian cancer or breast cancer, early age at first menstruation or late age of menopause, late age (over 30 years) of first childbirth, or not having children are also associated with an increased risk for ovarian cancer. Both infertility and the use of a specific type of fertility drug have also been associated with a slight increased risk for ovarian cancer (ACS 1999).

ATSDR has no evidence from human health studies, medical case reports, and animal laboratory studies that exposure to the types and levels of contaminants in off-site environmental media near the Fernald site are risk factors for reproductive system cancers.

Other (and Unspecified) Cancers

A 15-year-old neighbor died of cancer 8 or 9 years ago.

A neighbor woman died of cancer 6 or 7 years ago.

I feel that there is an excess of cancer in the community.

There are two other cases of cancer in people who grew up playing in the creek.

My wife died of cancer. Two of my neighbors died of cancer.

My husband died of cancer. Also, two neighbors had cancer.

One citizen offered a list of people on Buell Road with cancer and thyroid problems, past and present.

In my neighborhood, eight people have had cancer.

My mother and I have had cancer.

A boy with a large tumor in his leg had the leg amputated.

Both my parents died of cancer in the 1970s.

My husband worked at Cintas Corporation in a heating job that used formaldehyde. He had Guillain-Barré syndrome, Graves' disease, and a collapsed lung. He had his gallbladder and bladder removed and died of cancer.

My husband ate meat and produce from our farm and drank well water; he died of cancer. Is eating meat and produce raised in the area and drinking well water hazardous to the community's health?

My mother-in-law and father-in-law both died of cancer.

There are many cancers on Buell Road; there are also many animal sicknesses and deaths there.

My church congregation (in Crosby) has a large number of cancer illnesses; many women have had lung and breast cancer.

I live 2 or 3 miles from the site. I am concerned that many others in the nearby area have cancer.

My son was diagnosed with neuroblastoma. There are 12 houses on our street and 6 cancers there. Is neuroblastoma related to site activities?

I have tumors all over my body for no reason, including benign tumors on my neck and breast. I've had female disorders and a partial hysterectomy; soon after that tumors appeared again. My father-in-law died of leukemia; a great aunt died of cancer. I have a great deal of stress from living in this area. Are my tumors due to the site's activities?

There have been at least six cancers in my old neighborhood (Thrush Road), including lung cancer in a non-smoker. My grandmother had skin cancer. What health effects could uranium in the groundwater have caused?

I have a list of deaths from cancers and other causes in the community.

My daughter died of small-cell cancer at age 35; her physician said he had never seen this type of cancer in anyone under age 65. She was a smoker but the tumor was in the middle of her chest, and there was no lung involvement. Her son had hair loss his junior year in high school. Her daughter was born with deformities of the left fingers and toes. Could these health problems be related to the site?

As stated above, many different risk factors are associated with different types of cancers, but many people who get the disease do not have a readily identifiable risk factor. Although many studies examined how environmental exposures may increase a person's risk of developing cancer, more studies need to be conducted on the interaction between a person's lifestyle, genetics, and environmental exposures. The studies that have been done examined populations, as opposed to individual risk. If you are concerned about your own risk or that of someone in your family, you should consult your personal physician. The local chapter of the American Cancer Society also has information on risk factors and prevention.

Non-Cancer Effects

Dermatological Effects

Around December 18–25, 1984, Fernald had its last big air release. At the time, I had an outdoor wedding. After that my husband developed skin cancer, and my son developed a bad skin rash and a spot on his lungs. My husband used to eat vegetables grown in our garden and fish from

the Great Miami River; my son is a non-smoker.

I am concerned about my children. They have warts, cysts, and moles. One has chicken pox scars and the 10-year-old has sores in his mouth.

Back in the 1950s an occurrence of a mist covered [my husband and me] one evening. After that, I developed skin problems—little spots on my face.

Occupational exposure to high levels of some organic chemicals (e.g., PCBs and dioxins) has been associated with various dermatologic effects, such as chloracne (Klaassen et al. 1996); however, high levels of these chemicals have not been found in media near the Fernald site.

ATSDR reviewed monthly uranium air monitoring data at the site boundaries for 1971 through December 1984. The uranium concentrations measured at these air stations for December 1984 were less than the maximum results for all month between 1971 and November 1984 and were similar to the average values (Shleien 1995). These concentrations were also significantly less than the concentrations used by ATSDR to determine if adverse health effects could result from past accidental releases. ATSDR also reviewed information on historical accidental releases at the site, and none were reported for December 1984; however, these releases involved uranium compounds and other radioactive contaminants and did not include releases of non-radioactive chemicals.

ATSDR reviewed information on historical accidental releases at the site in the 1950s. There was an accidental release of uranium hexafluoride from a cylinder at the Pilot Plant on November 7, 1953 that lasted 15 minutes. This release was 17 times smaller than the accidental release of uranium hexafluoride discussed in the air pathway section of the report. (Both releases were from the Pilot Plant.) Modeling of the 1966 accident estimated that adverse health effects would not be expected; however, an individual with sensitive skin may experience temporary skin irritation that would not cause lasting adverse health effects even from the 1953 release.

If you are concerned about your exposure and risk for dermatological problems, contact your health care provider. At present, ATSDR has no other evidence that exposure to chemicals and radioactive materials from the Fernald site would result in any dermatologic effects in persons in the surrounding community.

Endocrine

I have a cousin with thyroid problems and memory loss. I have something in my lung and difficulty breathing; also, I have a deteriorating disk in my back.

One citizen offered a list of people on Buell Road with cancer or thyroid problems, past and present.

I have diabetes, and there is no history of diabetes in my family.

Are cervical cancer and thyroid disorders related to site activities?

I have thyroid and gallbladder problems. Are these related to the site? My son lived all his life near the site, and now I have grandkids living there. The kids have kidney problems and sugar in their blood.

I have an enlarged thyroid and have had cervical cancer. I know that studies have shown that female thyroid disorders can be related to the site's activities. Are cervical cancer and thyroid disorders related to the site?

I have Graves' disease (thyroid disorders) and the highest metabolism ever recorded. I've had three radioiodine treatments, and I've built up immunity to the treatments. I have two knots on my leg, which my physician cannot explain. My daughter is very sick. The site causes us lots of anxiety. What are the illnesses in the community, and how severe are they?

Of the many risk factors for thyroid disorders and diabetes, most are associated with genetics and lifestyle (e.g., smoking, diet, exercise). There is some evidence from human health studies that thyroid disorders and diabetes may result from exposure to certain types of environmental contaminants. For example, some studies indicate that thyroid disorders can occur in populations exposed to high levels of radioactive iodine (Edwards 1995). Radioactive iodine has not been found in environmental samples collected at the site or near the site. Diabetes has been shown to result from exposure to high levels of inorganic arsenic in drinking water (Shih-Meng et al. 1999). Arsenic was found in off-site groundwater; however, ATSDR's estimated doses to residents near the site from exposure (ingestion) of arsenic-contaminated water are considerably lower than the exposure doses shown to be related to the development of diabetes in this study.

At present, ATSDR has no other evidence that exposure to chemicals and radioactive materials from the Fernald site would result in any adverse endocrine effects in persons in the surrounding community.

Developmental and Reproductive Effects

There are a large number of birth defects among my daughter's classmates.

I had a grandson born deformed 3 years ago, who died at 4 months.

My nephew has a birth defect of double toes. My son was born with a cleft palate and missing femurs.

My older sister's grandson has a gene defect—Hurler's syndrome.

[My daughter] has a deformity and can't see from her right eye. Is there a problem with birth defects or some other type of genetic problem?

[My son] has another child with multiple bones in his toe. My daughter, born in 1957, has a child with Pierre Robin syndrome. Will these birth defects carry to future generations?

My wife was diagnosed with Guillain-Barré syndrome in 1973.

My husband worked at Cintas Corporation in a heating job that used formaldehyde. He had Guillain-Barré syndrome, Graves' disease, and a collapsed lung. He had his gallbladder and bladder removed and died of cancer.

Are there any genetic mutations in children from things at FEMP?

My daughter was born with trisomy 18. She was diagnosed at birth and died 5 weeks later. A home nurse who cared for her before she died reported that eight babies with genetic defects lived within a 10-mile radius of the site. Could my daughter's defect be related to environmental exposure from the site? Anecdotal information indicated that an 18-month-old has Hoopers syndrome, and friends have had multiple miscarriages and infertility.

I am infertile. I have had various tests and have low or no sperm.

One of my sons was born in 1953. He has low sperm counts and has adopted all his children.

My daughter had two miscarriages within 3 years.

There is evidence from human health and laboratory animal studies that maternal exposure to certain environmental chemicals, such as solvents, PCBs, dioxins, and heavy metals is related to an increased occurrence of developmental and reproductive effects in offspring (ATSDR 1997; Fredriksson et al. 1993; MDPH 1997; Weir and Fisher 1972). Some of the effects observed in these studies are abnormalities or delays in cognitive and physiological development, neurobehavioral effects, and childhood leukemia. Boron is the only one of these chemicals found off-site at the Fernald facility. However, the maximum concentrations of boron found in these surface soils and predicted in air are considerably lower than levels shown to cause adverse effects in the laboratory animals studied (Weir and Fisher 1972).

Many of the conditions listed above are not believed to be linked to exposure to environmental contaminants. Pierre Robin syndrome has no known risk factors and is most likely solely genetic in nature (Widesmiles 1999). Guillain-Barré syndrome is a neurological condition that may be an autoimmune disease. (An autoimmune disease is a condition in which the body forms an immune response against its own tissues.) There are no known causes for this syndrome (GBS 1999). Cleft palate—the fourth most common birth defect among children born in the United States—is believed to be caused by a combination of genetic, nutritional, and environmental factors. Potential risk factors include maternal use of tobacco, alcohol, and certain medications (IIBD 1999). Hurler's syndrome is a metabolic disease that is genetic in nature (NORD 1999).

Although exposure to chemical and radioactive contaminants can theoretically cause cellular mutations, ATSDR has no evidence that exposure to any of the contaminants from the Fernald site would result in an increase in birth defects in the surrounding community. Residents who are concerned about their own or their children's risk of passing on genetic disorders to offspring should consult their physician or a geneticist who can assess an individual's risk for these disorders.

Musculoskeletal Effects

I have severe arthritis that severely limits my mobility.

I have a deteriorating disk in my back.

Could my rheumatoid arthritis and muscular problems be related to the fact that my mother worked at Fernald as a clerk during her pregnancy?

Arthritis is a general term for many different diseases affecting the joints and connective tissues in the body. There are more than 100 different types of arthritis. Both disk deterioration and rheumatoid arthritis are autoimmune diseases. One out of every three Americans is affected by one or more of these diseases. Currently, none of these conditions are believed to be caused by exposure to environmental contaminants (AF 1999).

Respiratory Effects

I have kidney stones, gallbladder problems, and upper respiratory problems.

Several of the contaminants (e.g., uranium, arsenic, and boron) present in off-site surface soils near the Fernald facility are capable of causing respiratory toxicity when exposure occurs at high enough levels. But with the exception of uranium (and radon), there are no on-site or off-site air measurements of these chemicals; therefore, ATSDR used conservative methods in estimating the *maximum* concentrations that may be present in ambient air near the Fernald facility. ATSDR also made the conservative assumption that children and farmers were exposed to these predicted maximum concentrations during most of each day, for several consecutive years. The predicted maximum airborne concentrations, and human exposure doses for all of these contaminants (including uranium), are not likely to cause respiratory effects in Fernald residents.

Non-Specific Effects

Our son, born in 1955, has a child with a low white blood count and another child with multiple bones in his toe.

My family suffers from boils two to three at a time over the last 2–3 years. One son has blood in his urine. I have elevated liver enzymes and blood in my stool.

I have ringing in my ears, balance and dizziness problems, concentration difficulties, a terrible memory, and prostate problems.

My 10-year-old limps for no apparent reason and is a slow learner.

My entire family has chronic fatigue. My sister had seizures between ages 8 and 10; she has a weak immune system and suffers hair loss.

I am concerned about what may be in the soil and the frequency of different types of illnesses.

I raised six children on a farm near the Fernald plant, and I am worried about adverse health outcomes that might result from living close to Fernald. One son committed suicide, and I think his depression was caused by some chemical exposure. This son also had asthma. One daughter has asthma and sinus problems. Another daughter has food allergies and boils. This daughter

and her husband have been experiencing memory losses.

I have a lung nodule and suspect asbestos exposure. I also have an ulcer, colon problems, and dizzy spells. I realize that these may not be related to Fernald, but I would very much like to be put on Butler County water.

I live half a mile from the site. I had a brain tumor, breast cancer, kidney stones, gallbladder problems, stomach problems, and a herniated bowel. My doctor says the brain tumor is probably due to an increase in radiation dose from living near Fernald. I had a hysterectomy, and the doctors said I had many, many fibroid tumors rather than a single large tumor, which is more typical.

This list includes many different health concerns, each of which is associated with a variety of known and unknown risk factors. On the basis of the information reviewed for this public health assessment, ATSDR has no evidence that exposure to chemical and radioactive contaminants from the Fernald site is associated with an increased risk for any of these health conditions, except kidney effects, in the population surrounding the site. (A detailed discussion of the evidence for kidney effects from exposure to uranium from the Fernald site is provided in the Public Health Implications section of this report.) However, a physician or health care provider can better assess an individual's risk for these conditions.

Environmental Exposures

ATSDR grouped the concerns about environmental exposures by medium, i.e., air, soil, surface water, groundwater, and biota. ATSDR did not provide specific responses to these concerns, because most of them are addressed in the Environmental Contamination, Exposure Pathways and Potentially Exposed Population section of this report.

Air

When Fernald was operating there were odors from the site.

I have tested my house for radon, but I think the radon testing kits are unreliable. Could it still be contaminated because of previous absorption?

A tornado came through here in the late 1960s and went toward Indiana. Could it have carried contaminated soil, air, or water?

Soil

A tornado came through here in the late 1960s and went toward Indiana. Could it have carried contaminated soil, air or water?

I am concerned about what may be in the soil and the frequency of different types of illnesses.

Surface Water

A tornado came through here in the late 1960s and went toward Indiana. Could it have carried contaminated soil, air, or water?

People used to swim in the gravel pits and in Paddy's Run Creek. Are the gravel/sand pits contaminated?

Are the food and water in the area contaminated?

The Miami River was very clear in 1967; now it appears very cloudy and dirty.

Local gravel pits fill with rain water, and there are no outlets for the runoff.

Groundwater

Fernald representatives sample my well annually; tests indicate some contamination.

The groundwater is not monitored on the west side of Paddy's Run Creek.

My husband and I used to drink well water. We still use cistern water for non-potable uses. Is the cistern water safe?

I drank well water at home and at the plant. What about exposures to employees drinking well water on the job (at Fernald)?

[My spouse and I] have used well water and grown our own food and eaten wild game from this area.

I drank water from a well from 1979 through 1991. What are the effects of using contaminated groundwater for potable and non-potable purposes?

My husband ate meat and produce from our farm and drank well water; he died of cancer. Is eating meat and produce raised in the area and drinking well water hazardous to the community's health?

I drank well water for 9 years and then found out it is contaminated. Is it safe to wash with the well water?

Biota

When Fernald was operating, there were odors from the site and a silver sheen on plants around the area.

I've heard that birds in the area were tested at Fernald and that they were extremely contaminated. If the birds were dying, we must have been exposed to something very dangerous.

[My spouse and I] have used well water and grown our own food and eaten wild game from this area.

Are the food and water in the area contaminated?

Have fish in the river been checked for uranium?

Why is produce from this area still being sold? Is the milk safe?

[My nephew] ate vegetables grown in the yard and drank water from a cistern. He is now in his late 40s and has no known health problems other than a growth on his gum.

I have heard rumors of blind fish in the river. Could this be a result of contaminants in the river?

Is there a health problem associated with consumption of wild game? I have killed deer and small game with tumors on them and that appeared to be no good to eat.

My husband ate meat and produce from our farm and drank well water; he died of cancer. Is eating meat and produce raised in the area and drinking well water hazardous to the community's health?

There is a high incidence of brain tumors in the area. Is it safe to eat produce grown in the area?

ATSDR determined that no exposure pathways pose a known human health hazard under *current* conditions at the site. ATSDR determined that *past* exposures to non-uranium chemicals in air and groundwater pose an indeterminate health hazard. ATSDR used the term *indeterminate*, because ATSDR did not have enough information to make a definitive assessment of the level of public health hazard. For additional information about past releases, refer to the Environmental Contamination, Exposure Pathways and Potentially Exposed Populations section of this report.

ATSDR has conducted three health consultations that specifically address *current* public health hazards from environmental exposure: (1) consumption of milk from farms near the Fernald site, (2) consumption of produce (fruits and vegetables) grown near the Fernald site, and (3) use of groundwater for non-potable uses (ATSDR 1995a, 1996a, 1996b). ATSDR determined that none of these pathways of exposure pose a human health hazard and that wild game caught in the area should also be safe for consumption.

Specific Populations' Concerns

Children

Is it safe for me and my children to stay here (continue living in this area)?

I am concerned about exposures to children.

A Girl Scout camp north of the Fernald Environmental Management Project (FEMP) has been closed. Is there any danger in trying to use it now?

I am concerned about radiation leakage from the site and its effect on the health of my wife and children.

Elderly

Both sets of my grandparents lived within one-half mile of the site.

ATSDR has no information indicating that children and elderly persons are currently at increased risk of adverse health effects from exposure to chemicals and radioactive materials from the Fernald site. Therefore, it is not necessary for anyone to move away from the area. In addition, ATSDR completed a health consultation addressing the public health hazard from *current* exposure to radon emissions from the K-65 silos at the Fernald site (ATSDR 1995b). The health consultation concluded that exposure from the K-65 silos does not pose a *current* public health hazard. If you are concerned about the safety of using the former Girl Scout camp site, you should speak with the Ohio Environmental Protection Agency contact person listed in the For Additional Information section of this report.

Workers

I am concerned about take-home exposure; I used the same locker for street clothes and work clothes. I worked in all areas of the plant.

Did the plant physician die of causes related to radiation exposure?

The focus of this public health assessment is chemicals and radioactive materials from the Fernald site that have migrated off the site and are a source of exposure to persons in the surrounding community. Additional information about Fernald workers may be obtained by contacting the representatives from the Department of Energy or the CDC's National Institute of Occupational Safety and Health (NIOSH) listed in the For Additional Information section of this report.

Procedural Concerns

The focus of this public health assessment is chemicals and radioactive materials from the Fernald site that have migrated off the site and are a source of exposure to persons in the surrounding community. Therefore, ATSDR did not specifically address many of the following procedural concerns, and some concerns are addressed in the main body of this report. Additional information about other issues may be obtained by contacting the representatives from the Department of Energy, CDC's National Center for Environmental Health, US Environmental Protection Agency—Region VII, Ohio Environmental Protection Agency, Ohio Department of Health, and the Fernald Medical Monitoring Program listed in the For Additional Information section of this report.

Remediation

I am concerned about releases to the environment from the remediation process.

What are the health effects of exposure from the 1950s?

Will FEMP be receiving wastes from other plants?

Lack of Trust

In the late 1960s and early 1970s in the mornings a white film covered "everything." This was during the time when Fernald representatives told residents they would stop burning materials on site; instead they began burning things late at night and early on Sunday mornings.

I am upset because I was told it was too late to get into the Fernald Medical Monitoring Program even though I sent in my paperwork at the start of the program.

The Fernald Medical Monitoring Program is not as good as it is made out to be. We need better, continued health monitoring.

Communications from the Fernald fund management (trustees) are not good. Forms were not sent out to all residents; forms were left at stores, banks, and other places to be picked up.

I heard that money distributed from the fund was based on how well a person filled out the forms and not on actual conditions. This should be checked.

I have not received answers from the Fernald Medical Monitoring Program to any of my questions.

I believe that dose reconstruction will not account for the buildup of white substance that occurred in the night.

I feel the public was lied to through the years and kept in the dark. The Purina sign is an example of this.

When the site was first built the "older ones" said it would cause a lot of illnesses; see what has happened.

A major concern or desire I have is to finally get accurate and true information.

The University of Cincinnati collected blood samples from people who live close to the site to compare the results with others further away from the site, but no one has received the results of the blood analyses or the study results.

Citizen is concerned about the adequacy with which medical monitoring results are disseminated.

Emergency Response

Might natural disasters such as tornadoes move drums off site and cause public exposure?

Monitoring or Sampling

Where can we have our water tested for mercury, lead and uranium: Should it be tested for contaminants other than these?

FEMP sampled the riverbanks near my house, and I haven't seen any results.

Someone sampled my well but I have not been informed of the results.

How do I get on the mailing lists and get my water tested?

Citizen would like to obtain results of water samples collected from the trailer park system.

General

Citizen provided names of doctors in the area who may have information useful to ATSDR and CDC.

Citizen is willing to release her medical records to ATSDR.

Citizens are "meeting-ed to death."

Well water will not sour in a cistern, but city water will.

The government took the best location over the aquifer for itself, though it could have taken an out-of-the-way place.

Property values are going down.

Were former residents included in the CDC Dosimetry Reconstruction study?

Do occupational medical records reveal whether radiation testing was done?

Can citizens get the radiation records of deceased family members?

Recommendations by the Public

Document the groundwater flow and direction.

Educate the community about health issues.

ATSDR should attend FRESH meetings

Advertise in the *Cincinnati Enquirer*, the *Venice Cornerstone*, and the *Harrison Press.*

ATSDR should conduct public forum-type meetings and be available for question and answer sessions.

Try to locate our soil samples and use them in the public health assessment if they are useful.

A couple wishes to be on the ATSDR mailing list.

Investigate the large number of cancers in the members of our church.

I would like ATSDR to track birth defects and provide information on these to the community.

ATSDR should enlist volunteers from the community to go door to door to collect information. I will volunteer to do so.

Address the incidence of cancer.

Discuss concentration in soils.

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Concerns Compiled by the Fernald Health Effects Subcommittee

The following are concerns that were compiled by the Fernald Health Effects Subcommittee (FHES). FHES has already addressed many of these individual concerns.

- I worked at Fernald for 32 years. It's imperative that the working conditions which existed when operating be exposed. The exposure to radon and thorium gases were unnoticed until 1986 when Westinghouse came on board. The health conditions in plants 2 and 3 should be exposed.
- I have no confidence in CDC or any of the associations it may have with Fernald or its contractors since CDC's involvement with political issues outside of its jurisdiction, specifically gun control. I've watched the waste at Fernald of which CDC is merely a part. Don't waste my time or tax money!
- Please keep on it to better our area. I am sorry I haven't been able to attend any meetings due to health problems, but I do try every chance I get to talk to Lisa Crawford—not often though.
- What good is all of this? It's like a pacifier put in your mouth. Originally not knowing what this Fernald crap was about, I settled for an amazingly low amount and now the health problems are escalating. So what good are they?
- I believe supervision and management are poor although maybe made more difficult because of union rules. Money is wasted (new materials thrown away, sloppy cleanup—spills, etc.). I question the safety of the whole cleanup. I question water being pumped into the big Miami. I really resent the fact that we are 1/4 mile from Fernald and cannot get on the public water line—why can't we pay a prorated share and have the line extended? A private water line for Delta Steel and another firm was laid from Crosby/Willey Road past our property and over to Delta Steel. All that cost and work for nothing because the public water line is over there now. This money could have been spent on other things—I know it was a deal with the government—lawsuit with Delta—that is just another stupid, wasteful use of tax money.
- My husband died of cancer last November. Cancer destroyed a wonderful person, and he suffered the torture of the damned his last few months on this earth. Also, I had to be operated on for skin cancer on my face and upper arm. What is the point of coming to any more meetings? The government will never admit that they are to blame, and there isn't enough compensation in the entire world to make up for the loss of my dear husband.
- It would be really useful to have a single list (and thumbnail description) of the numerous health studies of the Fernald workers and residents.
- It seems very clear that the whole Fernald Plant's activities should be closed down as soon as possible after removal of all contaminated materials off-site!!! The concrete findings of your current research should be published in the Cincinnati newspapers when completed!! We also feel any and all irresponsible actions of those in charge of removing and cleaning up waste and contaminants need to be prosecuted and punished to fullest extent of the law to offset the ridiculously high costs of having this work done at the Fernald plant!!! Thank you!

- Given the difficulty in conducting a valuable, meaningful, epidemiological study with the small number of people in the affected area, wouldn't it be better to spend the time and resources on establishing a medical monitoring program for area residents?
- My real concern is that everyone is aware that a problem or problems exist at Fernald. For a decade now there had been a lot of posturing over this, by the private sector and the US Government, for all of which I volunteered 4 years of my life to protect. Now the same people are risking my health and my family's life because no one is willing to step up and take responsibility. If there is a problem and we have been and are still at risk, then do something about it. If it becomes evident that I develop problems due to neglect at Fernald you can be certain I will take whatever action to protect myself and my family. If we are at future risk, I think we should be informed, and told to what extent the dangers are present. I am meeting with a realtor Sunday to discuss leaving this area after 12 years, and this is one of my concerns. I have had open heart surgery and have developed tendinitis in both shoulders and arthritic conditions in my neck and hands since living here. My age is 50 and it is not abnormal for someone to have these problems, but I am concerned as to whether living in the vicinity of Fernald may have caused or added to my discomfort. Bottom line, if it is broke, fix it! At least come clean and tell if and what other risks we may face. Ten years is a long time to hold your breath. I do not see any reason to continue the masquerade.
- Just how safe is the well water outside of the southern 3-mile area around Fernald? My wife and I live about 5 miles south of "F," just short of the water line built by the DOE.
- Is the subcommittee considering the files of information and health concerns ATSDR gathered 2 or 3 years ago from "people who live near the Fernald site" in Oxford, Ohio—the Alba Craft site—which was a satellite machine shop for Fernald and less than 15 miles away as the crow flies? You should. And you should show more interest in such populations.
- He had deterioration of the brain. He began having this in 1987 or before. He was 56 years old when he started noticing this.
- I appreciate the concern for our health and also the environment. Keep up the good work.
- How much longer will this cleaning up take to complete??? Why aren't more reports of hard information put in the Cincinnati newspaper regarding the health effects of the plant's operation??? How effectively are the huge costs of doing this site cleanup being checked???
- Can the administrative costs of this entire operation be trimmed down at all??? After all we're talking about taxpayers' money!!! We need to hear more hard responses from our state senators about this whole situation. Thank you for working on these concerns!!!
- Please re-check our water supply! It has been a year or two.
- I have no interest in this project. Where was the federal government oversight when all this contamination was going on for 30 years??? I think it's just a big boondoggle now to waste taxpayers' money and send all this literature out to citizens who aren't involved and don't want it cluttering up their mail; it is another example of government waste.
- Please continue to keep us informed.
- Thank you for sending the FHES Meeting Announcement for the November 5–6, 1997 meeting, including the copy of the "Executive Summary" report covering the sixth meeting of

the Health Effects Subcommittee. Though not specifically stated in the agenda of the upcoming meeting, I hope that you will include the effects of thorium 232 in the study, since this element carries a rather high energy decay level.

- Why is no one addressing the fact that several have already said that they saw or were part of the burning of dangerous chemicals at night? This looks more like a cover-up than a real effort to find out just what the persons from this area were really exposed to. I would like to see this looked into, not just brushed aside. If you all really are what you say you are, you will find out about this because I know it to be true, after hearing it from many, many workers and neighbors.
- I am also concerned about the "potential health impacts" on my vegetable garden. Please supply information.
- My parents bought 60 acres in 1941. We had milk cows, pigs, and chickens and raised most of our vegetables and some fruit. In 1949 my husband and I built a house on the farm. Most of the farm is now Interstate 74. My dad died in 1971 of leukemia. In 1953 I had a baby boy born with a hole in his heart. At that time there was nothing they could do for him so in 1954 he died. We all lived there from '41 to '66. I'm 76 years old, and in October 1996 I had to have colon cancer operations. I never thought about reporting any of this to Fernald Health Effects Subcommittee until I got sick. Now things haven't been going too well for me and I was wondering if I could get any financial help.
- Please send me all the information you have available concerning Fernald.
- I'm sorry I didn't get to the meeting of May 7, 1998. I would like to have heard about bone cancers and kidneys. If you have any thoughts on those subjects, would you please send them to me? I have been laid up since June 18, 1996, when my leg went out just walking across the floor. They put a total knee in August 28, 1996. I had so much pain they took part of it out and put a new one in on April 8, 1997. I have so much pain they had a brace made special for my leg. They want me to wear it to see if it will help; if it doesn't I will go through my third operation. If you have any information on thyroid I would like that also, as my husband and I both have thyroid conditions. We have lived out here since 1952.
- The "Health Care Providers Working Group" has a major task to develop educational material for local health care providers. I would like to follow their progress. Maybe attend meetings, see agendas, and get any mailings they produce. I work around the Mound Nuclear Weapons facility and we have *no* Health Effects Subcommittee. Local health care providers are greatly in need of education about contamination coming from these sites. Please respond with ways I could interact with this working group.
- Start conducting these meetings when "working" people may attend (weekends) and legal action will not be taken.
- We live 6 miles from the plant. My husband was diagnosed with colon cancer in September 1995 at age 51, then liver and brain cancer in December 1997. He died in February 1998. Please add his name and cancer type to your records for our area. Is colon cancer more prevalent in our geographic area? If so, what preventable measures do you suggest for the rest of us?

- My husband died in November 1994 of colon cancer. He had cancer in both lungs and a malignant rectal tumor for which he had undergone surgery to have a colostomy in the summer of 1996. He had 30 radiation treatments for the rectal cancer and more than 50 chemotherapy treatments for the lung cancer. All to no avail. He also underwent surgery on his right arm and shoulder due to a malignant tumor that weakened the bone and caused it to break—he had an entire right shoulder prosthesis and in the upper arm. He had more radiation treatments, since the tumor was too extensive and was into the muscle also and could not be removed entirely during surgery. He had some physical therapy, but never regained the use of his arm. Before he died, he had several more breaks in other parts of his right arm due to more malignant tumors and underwent more radiation treatments. My husband was practically helpless the last 2 months of his life. I had to bathe him, dress him, and undress him. I had a hospital bed for him and oxygen. Finally, I called hospice for help in the middle of October. They helped me a few times per week. My husband was in so much pain. In November the hospice had him taken to the hospital, where his pain could be controlled better. I spent most days and nights with him at the hospital until he died 6 days later.
- I want to know what is being done as far as exposure and birth defects when Fernald was releasing gases. There has got to be a way of getting data on children born in the 1970s and '80s and where their mothers lived or worked. I work for the NW district and there are too many children in the DH, MH, and SBH classes that were born in '85–'87 and whose mothers lived or worked in the area of Fernald. The article in the *Enquirer* was right. You are going to wait so long that the affected children will be dead and you'll be off the hook and we'll never know for sure whether the fact that 3 children were born on the same street, downwind, and in the 6.2-mile radius of Fernald and had birth defects is a coincidence, or there is a link. Contact the surrounding school districts and I think you would be amazed at the number of kids in special classes that may have a link to Fernald. I hope to hear from you, but I will not let this drop. I am going to follow this letter up with a phone call to Senator Dewine and Congressman Chabot. I feel very strongly that this should be looked into.
- I am a resident at the Branch Hill trailer court and I am worried about my health and my family's health. The *Cincinnati Enquirer* stated that they estimate deaths until the year 2088 from Fernald. I moved 3 years ago and I became pregnant, and my daughter who is almost 2 years old was born with a cleft lip, and she was diagnosed with having gross motor delay. Children's Hospital neurology department did an MRI on her to rule out cerebral palsy. I have two other older daughters with no birth defects. I would like a physical every few years to help detect any problems associated with Fernald.
- Thank you for the complete physicals you are now offering every 2 years. I have a nephew who lives in California and was never contacted by anyone from Fernald (never received any compensation—nothing) even though he was there almost every day—in and out of different areas delivering things for Federal Express. I feel the very least they could do is offer him something. He has just been overlooked by everyone since he transferred to California about the time this all came about.
- I want to know why I am not qualified for the medical monitoring program. My whole family is in it. I have lived in Ross for 55 years since 1943. I was told everyone was to be in it, but when

I called to get papers to sign up I never received them. This has been going on for one year or more if you start when they first started, but I just tried again to get into it a year ago. There is never any explanation why I never receive anything. Also, I am the only one in the family that receives this information about meetings.

- My family has been living in the area since 1985. We missed the chance for the medical monitoring program. I recently learned that until 1987 radon releases from the K-65 silos were very high. Has the committee ever considered recommending medical monitoring for residents such as my family? I would really like it, especially for my children who have lived here most of their lives.
- I am interested in knowing if my husband's work at the Herring-Hall-Marvin Company had any connection with the Fernald company. He machined uranium slugs from rolled rods in the 1940s to the early 1950s. He mentioned to me at different times that whenever the metal chips fell to the floor they would smoke or catch on fire, so he knew it was something that was secret for the government.

Community Study of Health Outcomes in the Fernald Area

(Conducted by Fernald Residents for Environmental Safety and Health, Inc.)

Sometimes, a group of residents in a community affected by a hazardous waste site takes the initiative to conduct a health study on its own, in order to assess the amount of and different types of illnesses in their community. These are typically not analytical epidemiologic studies and, therefore, cannot link specific types of environmental exposure to adverse health outcomes. Because the information about cases is volunteered by residents, it is not possible to determine if all cases have been identified, nor is it possible to verify the exact diagnosis. Nonetheless, when this information is viewed together with other scientific studies of residents in the area, it helps illuminate the overall health status of the community and focus community-based health activities.

A community health study is currently being carried out by members of Fernald Residents for Environmental Safety and Health, Inc. (FRESH). FRESH is gathering information directly from the residents of the Fernald area about health outcomes that have occurred in the vicinity of the Fernald site. The information in the study is not obtained from a cancer registry, hospital database, or other official source. The purpose of this study is to map disease occurrence in order to discern disease patterns in the area. Members of FRESH provided the information to ATSDR. The residents' comments up to January 1999 are listed below. The total number of cases identified is 426. Some people reported having more than one illness.

The adults between the ages of 30 through 40 have low sperm counts, multiple miscarriage, brain tumors, pituitary tumors, thyroid diseases, and liver cancer.

There is a large cluster located in Ross, Ohio, northeast/southeast of the Fernald site. This is the direction of the prevailing winds. As one looks toward Morgan Township (southwest) this area is rural, but one road has been greatly affected. The wind blows in a southwesterly direction. The families were possibly affected by radon emission from the K-65 silos along with thoron gas from thorium storage.

As you move south, the next cluster is Branch Hill (Trailer Court). If you continue to move south you notice a tiny cluster. This is the location of some of the contaminated wells. Fernald's effluent line is north of the private wells. Many young adults played in Paddy's Run Creek, which empties into the Great Miami River.

FRESH community study of health outcomes

Health Outcomes	# of Cases	Health Outcomes	# of Cases
Unspecified cancer	253	Female cancers	7
Childhood leukemia	7	Bladder cancer	2
Adult leukemia	1 (worker at site)	Bone cancer	9
Malignant tumors	6	Pancreatic cancer	5
Breast cancer	16	Multiple miscarriages	5
Brain tumors	4	Birth defects	5
Testicular cancer	4	Learning disability	7
Colon cancer	18	Guillain-Barré Syndrome	1
Liver cancer	9	Pituitary tumors	4
Stomach cancer	3	Kidneys	10
Lymphoblastic lymphoma in infants	2	Turned green—worker	1
Thorium/U-235/U-238	2	Adrenal cancer	1
Lung cancer	18	Babies born with 18 chromosomes	1
Respiratory disease	3	Throat tumors	3
Adenoid cystic carcinoma	1	Rare heart defects/stillborn	2
Melanoma	5	Soft tissue disease	3
Hodgkin’s disease	1	Reproductive problems (male)	3
Prostate cancer	1	Idiopathic bilateral fibrosis	1
Thyroid diseases	13	Spina bifida	1
Hepatitis	2	Chronic fatigue syndrome	1
Blood disorders	3	Chronic depression	3
Blood clotting disorders	1	Diabetes	1

Appendix D
Summary of the Fernald Dosimetry Reconstruction Project and the Fernald Risk Assessment Project

The Fernald Dosimetry Reconstruction Project

In response to community concerns, CDC's National Center for Environmental Health (NCEH) contracted the Radiological Assessments Corporation (RAC) to perform an extensive assessment of the amount of radioactive materials released from Fernald during its years of operation (1951 to 1988) and to estimate radiation doses received by people living near the site during this time period. The project, called the Fernald Dosimetry Reconstruction Project (FDRP), was conducted as a series of tasks; the final report, Task 6, was released in September 1998 (Killough et al.1998).

The RAC contractors used historical records from the facility and conducted interviews with former and current Fernald employees and area residents to reconstruct routine plant operations, document accidents, and evaluate unmonitored emission sources (Shleien et al.1995). They estimated the quantities of radioactive materials released to air, surface water, and groundwater, then used computer models to predict the transport and fate of releases in the environment (Voilleque et al.1995). They evaluated available environmental monitoring data and compared them with model predictions to verify that the estimates of releases and transport were reasonable (Killough et al.1995). Finally, they estimated radiation exposure doses that resulted from the estimated releases and the potential risks associated with those doses (Killough et al.1998).

To estimate doses, RAC developed nine exposure scenarios representing hypothetical residents of the area (Killough et al.1998). Each of the scenarios used different assumptions about lifestyle, diet, and locations of home, school, and work, all of which are variables that affected the amount of radiation exposure. For example, all scenarios included inhalation exposure; however, the amount of inhalation exposure varied according to many factors such as proximity of the residence to Fernald, activity level, and the amount of time spent outdoors. The nine scenarios were developed to represent a range of typical area residents. The contractors felt that people living near the Fernald site would find that one of the scenarios paralleled their own experiences. The key assumptions used for each of the nine scenarios are shown in Table D-1. All the scenarios considered only radiation exposure that occurred between 1951 and 1988 within 10 kilometers (6.2 miles) of the site, the area designated by the study as the "assessment domain."

Using mathematical models, the RAC contractors estimated the radiation dose that each of these hypothetical residents would have received. The models incorporated a variety of uncertainties associated with the estimates of levels of radiation in the environment. Therefore, the estimated doses are presented as median values with a range between the 5^{th} and 95^{th} percentile of the median values. The range indicates the range of uncertainty surrounding the median estimate.

Table D-1. The Nine Exposure Scenarios in the CDC's Fernald Dose Reconstruction Project (Killough et al.1998)

Scenario Number	Gender	Date of Birth	Years of Exposure	Key Feature	Home	School	Work	Percentage of Diet From Local Sources
1	F	1-1-46	38	Received inhalation exposure close to site	Family farm within 1 mile of site center (Northeast sector)	Elda Elementary, Ross Middle and High Schools	Family farm	Vegetables, fish, beef and poultry: 50% Eggs and milk: 100%
2	M	1-1-51	38	Lived close to K-65 silos	Family farm within 1.2 mile of site center (West sector)	Elda Elementary, Ross Middle and High Schools	Hamilton	Vegetables and poultry: 50% Eggs and milk: 100%
3	M	1-1-51	38	Drank well water	Family farm within 1.2 miles of site center (South sector)	Elda Elementary, Ross Middle and High Schools	Family dairy farm	Vegetables and poultry: 50% Eggs and milk: 100%
4	F	7-15-60	18	Received typical inhalation exposure from 1960 to 1978	2.4 miles from site center in Ross (East-northeast sector)	Elda Elementary, Ross Middle and High Schools	Moved away	Vegetables, eggs, and milk: 10%
5	M	1-1-51	38	Worked outside the area	Near Layhigh, 5 miles north of site center (North sector)	Morgan Elementary, Ross Middle and High Schools	Hamilton	Consumed no food produced or grown locally
6	F	1-1-46	38	Irrigated using water near the site	Family farm 1.9 miles from site center (East-southeast sector)	Elda Elementary, Ross Middle and High Schools	Family farm	Vegetables, fish, beef, and poultry: 50% Eggs and milk: 100%
7	M	1-1-51	38	Irrigated using water farther from the site	6.2 miles from site center in Miamitown (South sector)	Elda Elementary, Ross Middle and High Schools	Miamitown	Vegetables, fish, and poultry: 50% Eggs and milk: 10%
8	M	1-1-70	13	Received exposure as a child in Ross	2.5 miles from site center in Ross (East-northeast sector)	Elda Elementary, Ross Middle and High Schools	Family farm	Vegetables, eggs, milk: 10%
9	M	1-1-51	18	Attended school in Ross and then left area	Near Route 128 6.2 miles from site center (Northeast sector)	Elda Elementary, Ross Middle and High Schools	Moved away	Consumed no food produced or grown locally

The results of the FDRP indicate that the majority of the estimated radiation doses for each scenario resulted from breathing radon and radon decay products. For each scenario, the lung was the organ that received the highest radiation dose, and radon and its decay products accounted for 85% to 95% of the dose to the lung, depending on the scenario. The most important factors affecting the radiation doses were the duration of residence in the assessment domain and the location of the residence relative to the site. Because the predominant winds in the area are from the southwest, exposures were predicted to be highest to the northeast of the site.

The RAC contractors used studies of underground miners, who were occupationally exposed to radon, to estimate the risk of lung cancer mortality that would result from the estimated exposures to radon and its decay products. The median excess lifetime risk of lung cancer mortality associated with exposure to Fernald-related radiation ranged from 0.1% (1 chance in 1000) for scenario #8 to 1.3% (about 1 chance in 100) for scenario #1. Scenario #1 was designed to represent the realistic maximum inhalation exposure to Fernald-related radiation, because the hypothetically exposed person was assumed to reside less than 1 mile northeast of Fernald. For scenario #1, the 5^{th} percentile value was 0.24%, and the 95^{th} percentile value was 9.6%. This means that the hypothetical person in scenario #1 may have a risk of lung cancer mortality as low as 0.24%, or as high as 9.6%. The median risk of lung cancer for this scenario, 1.3%, is considered the best estimate of the lung cancer risk for this person.

The Fernald Risk Assessment Project

The CDC's NCEH conducted the Fernald Risk Assessment Project (FRAP) to provide a comprehensive summary of the potential health effects of the Fernald site on the surrounding community (CDC 1998, 2000). The risk assessments used information in the FDRP (Voilleque et al.1995; Shleien et al.1995; Killough et al.1995,1998) and demographic information about the population around the Fernald site to produce community-level estimates of cancer risk. (However, risk assessments are theoretical estimates normally using conservative assumptions. Actual risk may be lower or even zero.) The cancer risk was estimated for people exposed to radioactive materials released from the Fernald site during its years of operation—specifically, for persons who resided within 6.2 miles (10 kilometers) of the site boundary for any length of time between 1951 and 1988. There have been two phases of the FRAP.

Phase I

Because the results of the FDRP indicated that lung cancer was the most likely adverse health outcome associated with exposure to radionuclides released while Fernald was operating, Phase I focused on potential lung cancer risk in the community (CDC 1998). Phase I's goal was to produce a more realistic estimate of the number of lung cancer deaths associated with Fernald-related radiation exposure in the assessment population.

To estimate risk for the entire community living within 6.2 miles (10 kilometers) of the site, NCEH researchers divided this area into 160 cells and obtained information about the number, age, and sex of people living in those cells during the years of plant operations. The researchers used software

produced during the FDRP to generate estimates of radiation exposure and accompanying risk of lung cancer for different subgroups within this population. Life-table methodology, which models mortality in a population over time, was used in conjunction with lung cancer risk factors to estimate possible lung cancer deaths over time. Estimates were projected through 2088, the year in which someone first exposed in 1988 (the last year of plant operations) would turn 100. The number of "background" lung cancer deaths that would normally be expected to occur in this population was also estimated.

The Phase I report estimated that between 40,000 and 53,000 people lived in this area for some period of time between 1951 and 1988. Lung cancer deaths in this population were predicted to be between 1% and 12% greater than the number expected if that population had not been exposed to radiation from Fernald. (This range was the 90% credibility interval; the median estimate was 3%.) This translates to a range of 25 to 309 lung cancer deaths, with a median of 85 deaths. The majority of these deaths were estimated to occur among smokers (65 deaths) rather than among people who have never smoked (20 deaths). Fernald-related lung cancer mortality was highest closest to the site boundaries and east of the site, with declining rates farther from the boundaries and west of the site. Because the installation of containment measures in the K-65 silos in 1979 greatly reduced radon emissions, mortality in people first exposed between 1951 and 1979 was compared to mortality in people first exposed in 1980 and later. It was found that almost all of the estimated increase in lung cancer deaths occurred among those first exposed before 1980.

Phase II

Phase I of the FRAP focused on lung cancer mortality, primarily resulting from exposure to radon and radon decay products, which were estimated by the FDRP to produce the majority of the radiation exposure dose. Radon and its decay products primarily affect the lung (CDC 1998). However, the FDRP also found that uranium and other radionuclides accounted for part of the radiation exposure dose. These radionuclides primarily affect body organs other than the lung. Therefore, Phase II focused on potential health effects resulting from exposure to radionuclides other than radon. The health outcomes addressed were kidney cancer, female breast cancer, bone cancer, and leukemia (CDC 2000). These cancers were selected on the basis of scientific information and community concerns.

Unlike the Phase I evaluation, which was intended to provide a more *realistic* estimate of increased lung-cancer mortality, the Phase II evaluation was intended to provide a *screening-level* estimate of the increased incidence of selected cancers. The Phase II report used estimates of the *maximum* Fernald-related radiation dose that members of the community within 6.2 miles (10 kilometers) of the site may have received to provide an "upper-bound," or worst-case, estimate of the number of resulting cancers. It was assumed that all members of this population were breathing contaminated air, receiving external radiation exposure, and using contaminated irrigation water. In addition, it was assumed that all of the milk, eggs, fish, meat, and vegetables eaten by this population were contaminated by radiation. As in the Phase I report, the researchers used the software produced during the FDRP to generate estimates of radiation exposure based on these assumptions.

The Phase II report analyzed the same people living near the site as the Phase I report. The assessment area was divided into 12 geographical areas, for which risk estimates were produced. In addition, a risk assessment was produced for a hypothetical individual who received the maximum exposure previously described *and* drank contaminated well water. The FDRP report indicated that at least three off-site wells south of Fernald were likely contaminated with radionuclides by the mid-1960s. Of these, Well 15 was found to have the highest concentrations of radionuclides. Thus, the contamination levels estimated over time for this well by the FDRP were used to derive estimates of *maximum* dose for an individual using contaminated well water for drinking and irrigation. The number of persons who were exposed to contaminated well water is likely very small.

To translate the estimated doses into cancer risks, the report used risk factors recommended by the International Council on Radiation Protection (ICRP), the National Council on Radiation Protection (NCRP), and the U.S. Environmental Protection Agency (EPA). These values are based on the cancer experience of human populations exposed to ionizing radiation, primarily atomic-bomb survivors and people exposed to radiation for medical reasons. On the basis of these risk values, researchers produced upper-bound estimates of the number of cases of certain types of cancer that might occur in the assessment population as a result of exposure to radiation released from Fernald during its years of operation. This estimate was produced first for the hypothetical population that did not use contaminated well water. A new estimate was then produced using the assumption that all persons residing in the two areas 1 to 4 kilometers southeast and southwest of the site used contaminated well water. (This is a conservative assumption that likely greatly overestimates the number of people who used contaminated well water). Estimates for Fernald-related incidences of kidney cancer, breast cancer, and bone cancer in the assessment population as a whole did not change when it was assumed that contaminated well water was used. However, the leukemia incidence estimate increased from a range of 1 to 18 additional cases to a range of 3 to 23.

Including the assumption that a segment of the population used contaminated well water, the report estimated that *maximum* exposure to Fernald-related radiation in this assessment population may result in 23 or fewer additional cases of leukemia, 4 or fewer additional cases of kidney cancer, 4 or fewer additional cases of bone cancer, and 3 or fewer additional cases of female breast cancer over what would be expected in the assessment population in the absence of exposure to site-related radiation.

Individual risks to the small segment of the population that used contaminated well water were also estimated by use of a hypothetical individual exposure scenario. The median estimates of the percentage increase in the lifetime risk of cancer for this hypothetical individual were as follows: 0.7% for kidney cancer, 0.03% for breast cancer, 6% for bone cancer, and 6% for leukemia. Judging from the results of the Phase II report, CDC did not recommend a more detailed analysis of the potential risk for kidney, female breast, or bone cancer resulting from radiation released from the site.

Further Work

As a follow-up to the Phase I and Phase II studies, NCEH conducted a Feasibility Assessment for a Community-Based Epidemiologic Study of Lung Cancer and Radiation Exposures near the Former

Feed Materials Production Center (Garbe 1999). NCEH's assessment concluded that an in-depth epidemiological study of Fernald-related radiation exposures and lung cancer is not feasible at this time. Such a study would not address community concerns about cancer related to the site, primarily because the availability and quality of local records does not appear to be adequate for systematic, unbiased, and complete identification of past residents (Garbe 1999).

References

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Killough GG et al. 1995. Fernald Dosimetry Reconstruction Project Task 4—environmental pathways—models and validation. Neeses, SC: Radiological Assessments Corp (RAC); 1995.

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Appendix E
Comparison of ATSDR/NAREL and DOE Radon Monitoring Program Data

DOE's Fernald Environmental Management Project (FEMP) operates an ambient radon monitoring program. In the past, the program had two separate monitoring systems: (1) a real-time monitoring system using Pylon detectors that operate continuously and provide radon concentration data for set time intervals, such as hours, and (2) a long-term monitoring system using alpha-track etch detectors (radon cups) that measure total radon concentration over longer intervals. In more recent years, FEMP used a 6-month monitoring period for the alpha-track detectors, which provided an estimate of long-term radon concentrations but was not extremely sensitive to fluctuations in radon concentration (i.e., they were not very sensitive to individual radon releases). The Pylon detectors are more effective at detecting short-term fluctuations in radon concentrations, such as those expected from a release.

In 1992, ATSDR entered into an interagency agreement with the US Environmental Protection Agency's National Air and Radiation Environmental Laboratory (NAREL) to monitor environmental radon in the vicinity of the Fernald site. Data collected by NAREL in 1993 and 1994 were presented in ATSDR's Health Consultation for the K-65 silos, issued in May 1995. The radon releases during 1993 and 1994 did not appear to be a public health concern. ATSDR has continued to monitor for radon near the site through September 2003. The information provided in this appendix compares the NAREL/ATSDR data for 1995 and 1996 with the radon monitoring results reported by FEMP for these years.

The alpha-track detectors used by FEMP are very similar to the detectors used by NAREL/ATSDR. NAREL/ATSDR uses three alpha track detectors at each location. In 1995 and 1996, FEMP used two or three alpha track detectors at each location (DOE 1972–1999). The biggest difference between the two programs is that the majority of the FEMP's monitors were located on site or at the fenceline, while NAREL/ATSDR's monitors were located at selected residences surrounding the site. However, a comparison between the radon monitoring programs can be conducted for similar time frames to determine if the programs are finding similar results.

FEMP radon monitoring data from 1995 were obtained from Table 25 of the 1995 Site Environmental Report (DOE 1972–1999). Results for FEMP's 1996 radon monitoring programs were obtained from the 1997 Integrated Site Environmental Report (DOE 1972–1999). The 1997 data were also available in this report, but were altered, reportedly to correct the results for bias of the detectors. Because this was not done in previous monitoring periods, the FEMP data for 1997 were not considered comparable to previous years. Therefore, the comparison period consists of 2 years, 1995 and 1996.

For purposes of comparing the results of the two monitoring programs, the data for each were plotted for similar time periods. A plot of the average results for 1995 and 1996 is shown in Figure E-1. Figure E-1 shows that over the 2-year period, the differences between the two data sets are not statistically significant.

Table E-1 summarizes the results for each monitoring system for 1995 and 1996, and shows a bias toward higher readings for NAREL in 1995 and FEMP in 1996. The table also shows an agreement in the results when averaged over the 2-year period. These biases could be caused by using different manufacturers' devices or by the different time periods monitored. The exposure time for FEMP monitors was 6 months, whereas the exposure period for NAREL monitors was approximately 4 months. Data from 27 locations were averaged from the FEMP program, and data from 10 locations were averaged for the NAREL program.

Table E-1. Comparison between FEMP and NAREL radon monitoring (values in pCi/L)

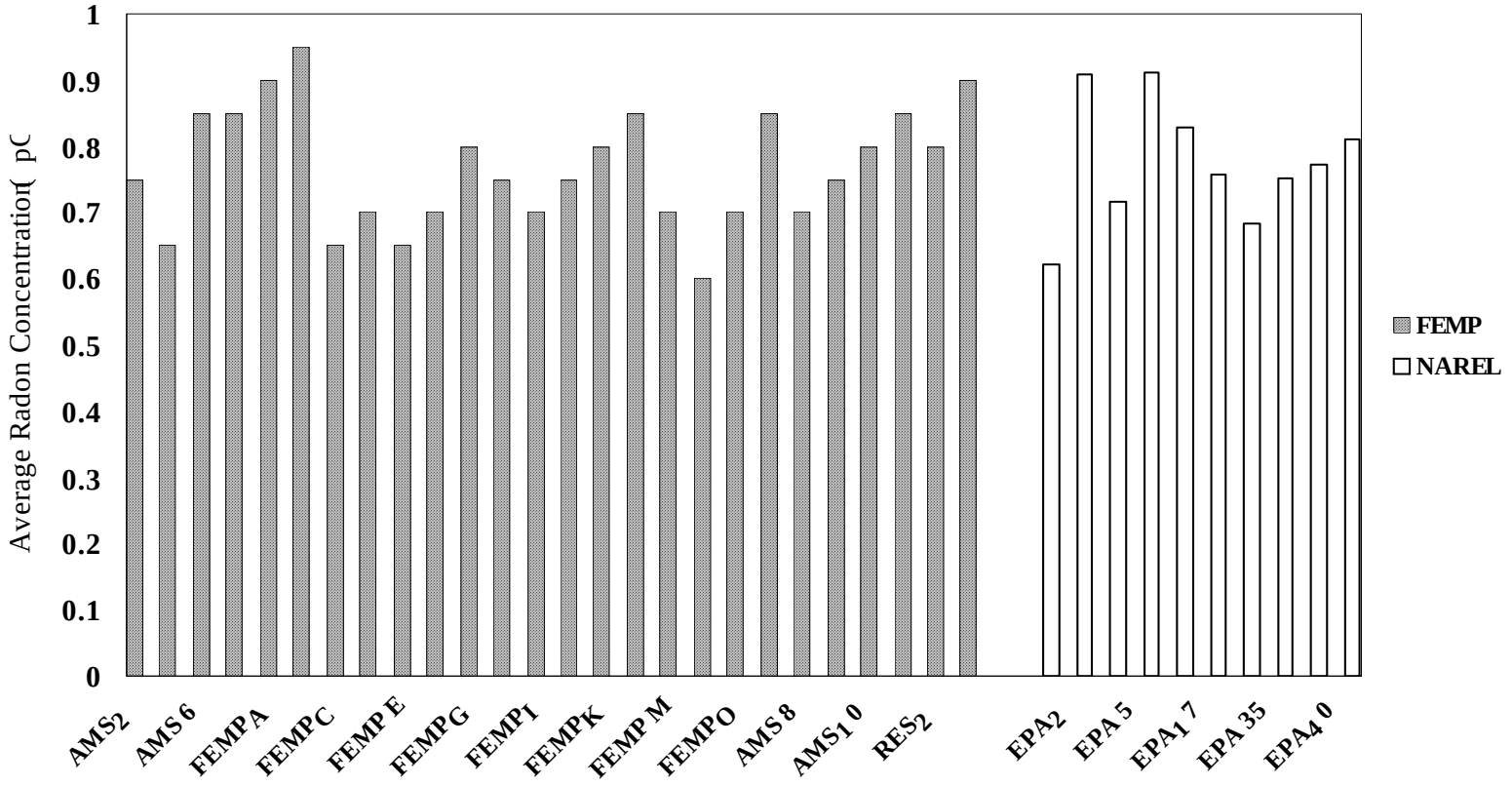
Program	Statistic	1995 Results	1996 Results	1995–1996 Results
FEMP	Range	0.5–1.1	0.6–1.0	0.5–1.1
	Average ± Standard Deviation	0.75 ± 0.14	0.78 ± 0.10	0.77 ± 0.12
NAREL	Range	0.8–1.2	0.4–0.7	0.4–1.2
	Average ± Standard Deviation	1.01 ± 0.13	0.54 ± 0.10	0.78 ± 0.27
Key pCi/L = picocuries per liter				

According to the 2 years of radon monitoring around the FEMP site, there does not appear to be a difference in long-term concentrations measured by the FEMP program and the NAREL program. Therefore, FEMP data were used for 1989 through 1998 to determine current potential exposure off-site to radon and radon decay products.

Reference

[DOE] US Department of Energy.1972–1999. Environmental monitoring annual reports for 1972–1995, and the integrated environmental monitoring program for 1997–1999. US Department of Energy, Fernald Environmental Management Project (and Feed Materials Production Center).

Figure E-1. Comparison of FEMP and NAREL Radon Measurements near the Fernald Site
Average Radon Concentrations for 1995 through 1996



Appendix F
ATSDR's Glossary of Terms

Absorption The process of taking in, as when a sponge takes up water. Chemicals can be *absorbed* through the skin into the bloodstream and then transported to other organs. Chemicals can also be *absorbed* into the bloodstream after breathing or swallowing.

Activity (Radioactivity) The number of nuclear transformations occurring in a given quantity of material per unit of time.

Acute Occurring over a short time, usually a few minutes or hours. An *acute* exposure can result in short-term or long-term health effects. An *acute* effect happens up to one year after exposure.

Ambient Surrounding. A*mbient* air is usually outdoor air (as opposed to indoor air).

Analyte A chemical component of a sample to be determined or measured. For example, if the *analyte* is mercury, the laboratory test will determine the amount of mercury in the sample.

Background Level A typical or average level of a chemical in the environment. *Background* often refers to naturally occurring or uncontaminated levels.

Background Radiation Radiation resulting from cosmic rays and naturally occurring radioactive material. *Background radiation* is always present. Its level can vary with altitude and the amount of radioactive material present in soil and building materials.

Becquerel (Bq) A unit of measure for a quantity of radioactive material; one *becquerel* is that quantity of radioactive material in which one atom decays in one second (1 Bq = 1 dps = 27 pCi).

Biological Indicator of Exposure Biomedical testing or the measurement of a chemical (analyte), its metabolite, or another marker of exposure in human body fluids or tissues in order to validate human exposure to a hazardous substance.

Biological Monitoring Measuring chemicals in biological materials (blood, urine, breath, etc.) to determine whether chemical exposure in humans, animals, or plants has occurred.

Biological Uptake The transfer of hazardous substances from the environment to plants, animals, and humans. This may be evaluated through environmental measurements, such as measurement of the amount of the substance in an organ known to be susceptible to that substance. More commonly, biological dose measurements are used to determine whether exposure has occurred. The presence of a contaminant or its metabolite in human biologic specimens, such as blood, hair, or urine, is used to confirm exposure and can be an independent variable in evaluating the relationship between the exposure and any observed adverse health effects.

Body Burden The total amount of a chemical in the body. Some chemicals build up in the body because they are stored in fat or bone or are eliminated very slowly.

Carcinogen Any substance that may produce cancer.

Carcinoma Any malignant neoplasm composed of epithelial cells, regardless of their derivation.

Case Study The medical or epidemiologic evaluation of a single person or a small number of individuals to determine descriptive information about their health status or potential for exposure through interview or biomedical testing.

CERCLA The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund. This is the legislation that created ATSDR.

Chronic Occurring over a long period of time (more than one year).

Committed Effective Dose The International Commission for Radiological Protection (ICRP) term for the sum of the products of the weighting factors applicable to each body organ or tissue that is irradiated and the committed equivalent dose to the organs or tissues. The *committed effective dose* is used in radiation safety because it implicitly includes the relative carcinogenic sensitivity of the various tissues.

Committed Equivalent Dose The equivalent dose to organs and tissues of reference that will be received from an intake of radioactive material by an individual over the 50-year period following the intake.

Comparison Values Estimated contaminant concentrations in specific media that are not likely to cause adverse health effects, given a standard daily ingestion rate and standard body weight. The *comparison values* are calculated from the available scientific literature on exposure and health effects.

Concentration The amount of one substance dissolved or contained in a given amount of another. For example, sea water contains a higher *concentration* of salt than fresh water.

Contaminant Any substance or material that enters a system (the environment, human body, food, etc.) where it is not normally found.

Curie (Ci) The quantity of radioactive material in which 37 billion transformations occur per second, which is approximately the activity of one gram of radium.

Decay Product (Daughter Product, Progeny) Radioisotopes that are formed by the radioactive transformation of some other radioisotope.

Decay, Radioactive Transformation of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.

Depleted Uranium Uranium in which the percentage of uranium 235 to total uranium of all isotopes is decreased from 0.72% to a lower value.

Dermal Referring to the skin. *Dermal* absorption means absorption through the skin.

Dose The amount of a substance to which a person is exposed. For chemicals, *dose* often takes body weight into account. For radioactive materials or radiation, *dose* denotes the quantity of radiation or energy absorbed and is a generic term for absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose.

Enriched Uranium Uranium in which the percentage of uranium 235 to total uranium of all isotopes is increased from 0.72% to a higher value.

Environmental Contamination The presence of hazardous substances in the environment. From the public health perspective, *environmental contamination* is addressed when it potentially affects the health and quality of life of people living and working near the contamination.

Epidemiology The study of the occurrence and causes of health effects in human populations. An *epidemiological* study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor is associated with the health effect.

Exposure Contact with a chemical by swallowing, by breathing, or by direct contact (such as through the skin or eyes). *Exposure* can be short-term (acute) or long-term (chronic).

Exposure Registry A system for collecting and maintaining in a structured record, information on persons with documented environmental exposure(s). The *exposure registry* evolved from the need for fundamental information concerning the potential impact on human health of long-term exposure to low and moderate levels of hazardous substances.

Geographic Information System (GIS) A computer hardware and software system designed to collect, manipulate, analyze, and display spatially referenced data for solving complex resource, environmental, and social problems.

Gray (Gy) The international (SI) unit of absorbed radiation dose. One *gray* equals the absorption of one joule of energy per kilogram of absorber. One *Gy* equals 100 rad.

Hazard A source of risk only if an exposure pathway exists, and if exposures create the possibility of adverse consequences.

Health Consultation An ATSDR response to a specific question or request for information pertaining to a hazardous substance or facility (which includes waste sites). It often contains a time-critical element that necessitates a rapid response; therefore, it is a more limited response than an assessment.

Health Education A program of activities to promote health and provide information and training about hazardous substances in the environment that will result in the reduction of exposure, illness, or disease. This program—both national and site-specific in focus—includes diagnosis and treatment information for health care providers and activities in communities to enable them to prevent or mitigate the health effects from exposure to hazardous substances at hazardous waste sites.

Health Outcome Data A major source of data for public health assessments. The identification, review, and evaluation of health outcome parameters are interactive processes involving the health assessors, data source generators, and the local community. *Health outcome data* are community specific and may be derived from databases at the local, state, and national levels, as well as from data collected by private health care organizations and professional institutions and associations. Databases to be considered include morbidity and mortality data, birth statistics, medical records, tumor and disease registries, surveillance data, and previously conducted health studies.

Indeterminate Public Health Hazard A category assigned to sites or pathways for which no conclusions about public health hazard can be made because data are lacking.

Ingestion Swallowing (such as eating or drinking). Chemicals can get into or on food, drink, utensils, cigarettes, or hands where they can be *ingested.* After *ingestion,* chemicals can be absorbed into the blood and distributed throughout the body.

Inhalation Breathing. Exposure can occur from *inhaling* contaminants, because they can be deposited in the lungs, taken into the blood, or both.

Isotopes Any nuclides of the same element having the same number of protons in their nuclei (same atomic number), but differing in the number of neutrons (different mass number or atomic weight).

Media Soil, water, air, plants, animals, or any other parts of the environment that can contain contaminants.

Metabolism All the chemical reactions that enable the body to work. For example, food is *metabolized* (chemically changed) to supply the body with energy. Chemicals can be *metabolized* and made either more or less harmful by the body.

Metabolite Any product of metabolism.

Microcurie One-millionth of a curie, symbolized as μCi.

Millicurie One-thousandth of a curie, symbolized as mCi.

Minimal Risk Level (MRL) An estimate of human exposure to radiation or a chemical that is likely to be without appreciable risk of adverse noncancerous effects over a specified duration of exposure.

Morbidity Illness or disease. *Morbidity* rate is the number of cases of a disease in a population.

National Priorities List (NPL) The Environmental Protection Agency's (EPA) list of sites that have undergone preliminary assessment and site inspection to determine which locations pose immediate threat to persons living or working near the site and are most in need of cleanup.

No Apparent Public Health Hazard A category assigned to sites or pathways where human exposure to contaminated media is occurring or has occurred but below a level of health hazard.

No Public Health Hazard A category assigned to sites for which data indicate no current or past exposure and no potential for exposure in the future and, therefore, no health hazard.

Picocurie One-trillionth of a curie, symbolized as pCi (1 pCi = 0.037 Bq = 0.037 dps).

Plume An area of chemicals or radioactive materials in a particular medium, such as air or groundwater, moving away from its source in a long band or column. A *plume* can be a column of smoke from a chimney or contaminants moving with groundwater.

Public Health Hazard A category assigned to sites or pathways that pose a *public health hazard* as a result of long-term exposures to hazardous substances.

Public Availability Session An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public Comment An opportunity for the general public to comment on Agency findings or proposed activities. The public health assessment process, for example, includes the opportunity for public comment as the last step in the draft phase. The purposes of this activity are to (1) provide the public, particularly the community associated with a site, the opportunity to comment on the public health findings contained in the public health assessment, (2) evaluate whether the community health concerns have been adequately addressed, and (3) provide ATSDR with additional information.

Radiation The emission of energy through space or through media in the form of waves. The term, when unqualified, usually refers to electromagnetic radiation, i.e., infrared, visible light, ultraviolet, x-ray, or gamma ray. It can also refer to corpuscular emissions, i.e., alpha and beta radiation.

Radioactivity The property of certain nuclides to spontaneously transform into another element by emitting alpha or beta particles.

Rem A unit of radiation dose equivalent. The dose equivalent in *rem* is numerically equal to the absorbed dose in rad multiplied by a quality factor.

Risk In risk assessment, the probability that something will cause injury, combined with the potential severity of that injury.

Route of Exposure The way in which a person may contact a chemical substance. For example, drinking (ingestion) and bathing (skin contact) are two different *routes of exposure* to contaminants that may be found in water.

Sievert An international standard unit of radiation dose equivalent. One *sievert* equals 100 rem.

Specific Activity The total radioactivity of a given nuclide per gram of an element—a measure of the concentration of radioactivity, which may be expressed as μCi/gram, Bq/L, etc.

Superfund Another name for the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), which created ATSDR.

Toxicological Profiles Documents in which ATSDR scientists interpret all known information on a specific substance and specify the levels at which people may be harmed if exposed. It also identifies significant data gaps in knowledge on substances and serves to initiate further research, when needed.

Urgent Public Health Hazard A category assigned to sites or pathways that pose a serious risk to public health as the result of short-term exposures to hazardous substances.

Volatile Organic Compounds (VOCs) Substances containing carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen; these substances easily become vapors or gases. A significant number of the *VOCs* are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry cleaning fluids).

Appendix G
Public Comments and ATSDR's Responses

ATSDR received comments on the Feed Material Production Center (a.k.a. Fernald Environmental Management Project) Public Health Assessment, Public Comment version (May 12, 2000) from individuals and agencies. ATSDR thanks all of those who took the time to comment. This appendix includes these public comments and ATSDR's responses.

1. **"'Past air exposure was a public health hazard.' I've felt that since 1991 when my son was diagnosed with leukemia."**

   Response: ATSDR acknowledges this comment. Please refer to the discussion on hematopoietic cancer (which includes leukemia) in Appendix C of this report.

2. **"ATSDR recommends two additional follow-up actions. A third is needed - incidence of actual cancer rate by type of cancer including a 10 mile area northeast to southeast of Fernald (the hilltop area which catches the prevailing summer and winter winds). And, compare the results with the places that are known to be free of contamination."**

   Response: The Fernald Medical Monitoring Program, described in this report, provides a complete medical evaluation of the current health status of eligible persons in the community, evaluates risk factors for illnesses or diseases of participants, provides education to participants on how to modify risk factors for illness or disease, and establishes a baseline database which may be useful for further epidemiological research. ATSDR published a report—Prevalence of adverse health outcomes in residents of the area surrounding the former Feed Materials Processing Center at Fernald, Ohio, participating in the Fernald Medical Monitoring Program—in August 2001, which summarizes the results. (Pinney et al.2001)

   After completion of the Fernald Dosimetry Reconstruction Project in 1998, the CDC's NCEH performed a two-phase study on the health impact of the site on the surrounding community:

   – "Estimation of the Impact of the Former Feed Materials Production Center (FMPC) on Lung Cancer Mortality in the Surrounding Community." (CDC 1998)

   – "Screening Level Estimates of the Lifetime Risk of Developing: Kidney Cancer, Female Breast Cancer, Bone Cancer, Leukemia - Resulting from the Maximum Estimated Exposure to Radioactive Materials Released from the Former Feed Material Production Center (FMPC)" (CDC 2000)

   Both phases of the study focused on 10 kilometers in all directions surrounding the site. As the distance from the site increases, the potential impact from the site decreases, and the likelihood of

other interfering factors increases substantially, such as other hazardous waste sites and other industry in the area.

3. **"'922 persons reside....within one mile of the Fernald site...white (917), [other] 11' Comment: 917 plus 11 is 928, not 922."**

   Response: The 1990 US Census determined that 922 persons reside within 1 mile of the site. Based on racial subgroups, 917 are white, 1 is American Indian/Native Alaskan, and 4 are Asian or Pacific Islander for a total of 922. "Hispanic origin" is an ethnic subgroup (not a racial subgroup), and members of an ethnic subgroup are members of the racial subgroups stated in the public health assessment. ATSDR has added some statements to the Demographic section.

4. **"'There is a slightly higher rate of non-white persons....residing within 10 kilometers (95.1%) as compared to 5 kilometers (99.2%) or 1 mile (99.5%) of the site.' Comment: I'm sure you meant to quote the complement of these percentages....While these two arithmetic oversights may seem insignificant, they cause me to question the validity of the technical data that is presented in the rest of the report which repeatedly uses the words: estimated, assumption, hypothetical, sampling, and other such non-specific terms."**

   Response: Percentages in this sentence of the demographic section have been corrected.

5. **" 'at the Fairfield Mercy Hospital, Cincinnati, Ohio'... Fairfield Mercy is in Butler County; Cincinnati is in Hamilton County. Another example of an erroneous fact!"**

   Response: Mercy Health Partners (one of the sponsors for the health care providers educational workshops) covers the Greater Cincinnati Area which includes more than Hamilton County. ATSDR will clarify the location in the public health assessment.

6. **" 'Highest annual average uranium concentration measured....at BS-3, on the eastern...boundary' Comment: I lived in that direction for 25 years."**

   Response: Location BS-3 is an air monitoring station on the eastern boundary of the site property. The highest annual average uranium concentrations were recorded at this station, but the concentration would dilute quickly as it moves away from the site. Also, no adverse health effects would be expected from exposure to this concentration.

7. **" 'Exposure to air contaminants may occur via inhalation of contaminants released directly to air from the Fernald site.' Comment: This scares the devil out of me."**

   Response: ATSDR acknowledges this comment; however, this sentence was used in the description of the environmental pathways in general and does NOT indicate that exposure occurred or that exposures occurred at a level to cause adverse health effects.

8. **" 'Our maximum (worst-case) estimated 1-hour airborne concentrations...located 2,500 feet north-northeast of the facility'.... Comment: In 1 hour the winds had taken the contaminated air across Northern Hills, far beyond your 2,500 feet. How bad was our air 10 miles away?"**

   Response: This paragraph includes the following information: "...ATSDR estimated that the maximum 1-hour SO_2 concentration at the nearest residence, located 2,500 feet from the stack was 227 micrograms per cubic meter ($\mu g/m^3$). The estimated maximum 1-hour NO_x at this reidence was 89 $\mu g/m^3$." However, concentrations decrease at increasing distance from this residence. The SO_2 and NO_x concentrations attributed to this site would be indistinguishable from background concentrations 10 miles away in any direction.

9. **" '...the prevailing wind direction is to the northeast or southeast from the silos'. Comment: I lived 10 miles - due southeast.**

   Response: ATSDR acknowledges this comment. Airborne concentrations decrease significantly as one moves further away from the site. Please refer to the Air Pathway section of this report for more information on potential contaminants and concentrations.

10. **" 'Increased urinary excretion of proteins (proteinuria), amino acids (amino aciduria), or glucose (glucosuria) may indicate kidney damage...' Comment: My 5/11/00 test at Mayo Clinic showed 1508 mg of protein in my urine. The acceptable range is 0 - 150. I am 10 times the high end of the range."**

    Response: ATSDR acknowledges this comment and hopes that you are seeking advice from your personal physician.

11. **" 'CDC determined that inhalation and direct radiation effects of radon and radon decay products in air posed a human health hazard under past conditions at the site.' Comment: This also scares the devil out of me."**

    Response: ATSDR acknowledges this comment. Please refer to CDC's Estimation of the Impact of the Former Feed Materials Production Center (FMPC) on Lung Cancer Mortality in the Surrounding Community (CDC 1998) for further details.

12. **" 'Gamma rays and x-rays...can travel long distances'. Comment: Your study covered only 10 km, I lived 17 km away."**

    Response: The statement quoted in this comment is part of the description of what ATSDR considers when evaluating potential exposures from radioactive materials at any site. As discussed in the next paragraph in this report, the maximum external radiation exposure doses at the property boundary for this site (and thus off-site) are not at a level that would cause adverse health effects.

13. **" '...increase in lifetime risk...6% for leukemia.' '...the [FRAP] report estimated that exposure to Fernald-related radiation in the entire assessment population resulted in 23 or fewer additional cases of leukemia....' Comment: That is a damning indictment and it just covered a 10 km area. Those quotes have turned me into an anti-nuclear proponent even though it won't bring back my son."**

" 'Both adults and children who have been exposed to high doses of ionizing radiation (atomic bomb survivors, Chernobyl survivors) are at increased risk of developing leukemia.' 'ATSDR has no evidence that past or current exposure to contaminants from the Fernald site has contributed to an increased risk for leukemia in the Fernald community.' Comment: Your conclusion contradicts the quotes on pages 98 and 99 and insults those people who are the '23 additional cases of leukemia'.

Response: ATSDR acknowledges these comments; however, this theoretical risk assessment (CDC 2000) was extremely conservative, and the actual risk of developing these diseases from exposure to site-related radioactive materials or radiation should be lower and may be zero. To understand fully the context of the quoted statements, please read the description of "Phase II Fernald Risk Assessment Project" in Appendix D of this public health assessment or the CDC report, "Screening Level Estimates of the Lifetime Risk of Developing: Kidney Cancer, Female Breast Cancer, Bone Cancer, Leukemia - Resulting from the Maximum Estimated Exposure to Radioactive Materials Released from the Former Feed Material Production Center (FMPC)". CDC acknowledges that their estimates of lifetime excess risk for developing these cancers are based on hypothetical individuals who received the *maximum estimated* dose from exposure to radioactive material potentially released from the site from 1951 through 1988, including exposure to contaminated well water (which few people, if any, drank). The greatest increase in risk of developing leukemia came from the assumption that the person was drinking contaminated well water for this entire time. CDC also acknowledges that the over-estimation of the number of cases results from developing these estimates using unrealistic assumptions including that all persons who ever lived within one of the 12 areas under consideration received the maximum estimated radiation dose for that area under the above conditions. These estimates are extremely conservative.

14. **"The DOE does not agree that additional evaluation of the current exposure path from groundwater via privately owned wells in the South Plume is needed. To eliminate this exposure path a rigorous evaluation was performed to determine the location and owners of all privately owned wells down gradient of the Fernald Environmental Management Project (FEMP) that could be impacted at present or in the future by FEMP related contamination. A public water distribution line was partially funded by the DOE to provide public water for these and many other residents in the area. DOE paid for the hook-up and continues to pay the water bills for residents whose wells were impacted by FEMP related contamination. Residents were required to either have their wells properly abandoned or install backflow preventors to eliminate the possibility of contamination of the waterline. Records are available through Hamilton County that document the residents**

who opted for backflow preventors rather than abandonment. Residents that opted for backflow preventors did so in order to continue to utilize the wells to water gardens and other non-potable uses. DOE believes it has conducted all reasonable activities to eliminate consumption from these wells as an exposure pathway."

Response: ATSDR agrees that no further testing of privately owned wells in the South Plume area is *currently* warranted. Additional chemical analyses on water from the many on-site and off-site monitoring wells in this area and the fact that people in this are no longer consuming well water demonstrates that *currently* there is no need for further private well sampling in the South Plume area. ATSDR was also concerned about private wells to the east of the plant since the groundwater across the top of the site moves from the west to the east, and there is a uranium plume on site in this area. (Some chemicals and compounds may be transported in the aquifer at different rates than uranium and their pattern of migration may be different than the uranium plume.) However, *currently* water samples from monitoring wells along the eastern boundary of the site do not have chemical contaminants in concentrations that would be of health concern; therefore, ATSDR does not suggest additional monitoring of private wells to the east of the site but recommends that groundwater from these monitoring wells continue to be monitored for site-related chemicals. Therefore, ATSDR's recommendations and conclusions will be changed to reflect the above discussion.

15. **In response to ATSDR's recommendation that DOE should continue to monitor groundwater in the South Plume including analysis for contaminants that may be drawn into the South Plume by remediation activities, DOE states that they perform extensive monitoring not only of the South Plume but also the entire portion of the aquifer that has been impacted at levels exceeding the FEMP's final cleanup levels....**

Response: ATSDR will incorporate this information into the Public Health Action Plan section of the report; however, this recommendation will remain.

16. **DOE does not believe that an in-depth assessment of past exposure to residents using private wells will deliver any new significant information....**

Response: ATSDR's recommendation has been modified. The recommendation is for an in-depth assessment of past exposure to chemical contaminants; however, this assessment may not be possible because of limited information on the quantities and use of non-uranium chemicals in the *past* (particularly, during the 1950s and 1960s) at this site. (Exposure to radioactive contaminants was estimated in CDC's Fernald Dosimetry Reconstruction Project.)

17. **DOE concurs with ATSDR's recommendation to continue radon monitoring. The IEMP presents DOE's radon monitoring program, which will continue until the site is fully remediated....DOE disagrees with ATSDR's recommendation to use alpha track-etch detectors. During the biennial review of the IEMP conducted in 1998, DOE proposed**

expanding the use of continuous radon monitors, while simultaneously eliminating the use of alpha track-etch detectors for measuring environmental radon concentrations at the FEMP. After gaining regulatory agency concurrence, DOE discontinued the use of alpha track-etch detectors for environmental radon monitoring at the end of 1998....

Response: ATSDR acknowledges the first part of this comment and has incorporated this information in the Public Health Action Plan of this document. After further review, ATSDR also agrees with the second part of this comment and has deleted this portion of the recommendation.

18. **"Although Agency for Toxic Substances and Disease Registry (ATSDR) did not conclude that the air pathway presented a health hazard either under past or present scenario, the assumptions used in the evaluation were by ATSDR's admission very conservative. Specifically, ATSDR assumed all air particulate to be two microns in diameter. The DOE recently concluded a study that included size fractionation of current air particulate emissions. The study concluded that more than 70% of the FEMP particulate emissions are greater than 15 micron in diameter and that the DOE may over estimate its current dose estimates by as much as a factor of seven. DOE has forwarded a copy of the study to the ATSDR under separate cover."**

Response: ATSDR acknowledges the above comment. (This study was published in the Health Physics Journal in December 2002; Vol. 83, No. 6, pp 892-900 and will be cited in the total suspended particulate discussion for the air pathway in the public health assessment.) ATSDR uses very conservative assumptions during the contaminant screening process. Given that these airborne particles were not a public health hazard during the screening process, no further evaluation was necessary.

19. **"ATSDR mentioned that the continuous radon monitors used by the DOE are temperature sensitive and do not perform well outside of the optimal temperature range. The DOE has eliminated this problem by providing a heat source within the monitor housings. Additionally, ATSDR recommends a backup for the monitors. The Environmental Management (EM) program currently has back-up battery power for each of the continuous radon monitors and each of the fenceline monitors is checked on a daily basis to ensure continual operation."**

Response: ATSDR acknowledges the above comment. These modifications were made by DOE during and after ATSDR's health consultation for the K-65 silos in 1995 as responses to ATSDR's concerns.

20. **"...in Table 19.... It does not seem reasonable that the maximum uranium concentrations in vegetables under the current condition could exceed the uranium concentrations in vegetables under the past condition by an order of magnitude...."**

Response: ATSDR agrees with this statement. The maximum uranium concentration in any vegetable under *current* conditions was the value listed in Table 19 of the public comment draft, but, as noted at the bottom of the table, it should have been the average of the maximums for various types of vegetables. This has been corrected in this document. (This table is now Table 27.)

21. **"In the text of the report, ATSDR concluded that the chemical exposure for ingestion of biota for a child under the current scenario slightly exceeds the health-based guidelines; although, this concern is not mentioned in the conclusion of the report. It is difficult to understand how this pathway could exceed guidelines under the current scenario and not the past scenario, since site emissions have continued to decrease over time."**

Response: When ATSDR changed to the average of the maximums for the *current* concentrations of chemical uranium in vegetables, the *current* exposure doses were recalculated. Currently none of the estimated chemical exposure doses exceed ATSDR's health-based guideline for ingested chemical uranium.

References

[CDC] Centers for Disease Control and Prevention. 1998. Estimation of the impact of the former Feed Materials Production Center (FMPC) on lung cancer mortality in the surrounding community. Atlanta: US Department of Health and Human Services; 1998 Dec.

[CDC] Centers for Disease Control and Prevention. 2000. Fernald Risk Assessment Project Phase II—screening level estimates of the lifetime risk of developing kidney cancer, female breast cancer, bone cancer, leukemia resulting from the maximum estimated exposure to radioactive materials released from the former Feed Materials Production Center (FMPC). Atlanta: US Department of Health and Human Services; 2000 Mar.

Pinney S, et al. 2001. Prevalence of adverse health outcomes in residents of the area surrounding the former Feed Materials Processing Center at Fernald, Ohio, participating in the Fernald Medical Monitoring Program. Atlanta: US Department of Health and Human Services; 2001 Aug.