PUBLIC HEALTH ASSESSMENT

WELDON SPRING SITE REMEDIAL ACTION PROJECT
(CHEMICAL PLANT, RAFFINATE PITS, QUARRY)
ST. CHARLES, ST. CHARLES COUNTY, MISSOURI
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ABBREVIATIONS AND ACRONYMS

ALI	Annual Limit of Intake
ATSDR	Agency for Toxic Substances and Disease Registry
Bq	Becquerel
CERCLA	Comprehensive Environmental Response Compensation and Liability Act, or Superfund
CREG	Cancer Risk Evaluation Guides
DNB	1,3-Dinitrobenzene
DNT	2,4-Dinitrotoluene
DNT	2,6-Dinitrotoluene
DOE	U. S. Department of Energy
EMEG	Environmental Media Evaluation Guides
EPA	U.S. Environmental Protection Agency
ICRP	International Commission on Radiological Protection
kg	kilogram
m^3	cubic meter
mg	milligram
mrad	millirad
mrem	millirem
mSv	millisievert
MRL	Minimal Risk Level
MCLGs	Maximum Contaminant Level Goals
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
PALI	Public Annual Limit of Intake
PCBs	Polychlorinated Biphenyls
pCi/g	picocurie per gram
pCi/L	picocurie per liter
RfD	Reference Dose
RMEG	Reference Media Evaluation Guide
TNB	1,3,5-Trinitrobenezene
TNT	2,4,6-Trinitrotoluene

PUBLIC HEALTH ASSESSMENT

WELDON SPRING SITE REMEDIAL ACTION PROJECT (CHEMICAL PLANT, RAFFINATE PITS, QUARRY) ST. CHARLES, ST. CHARLES COUNTY, MISSOURI

SUMMARY

The U.S. Department of Energy Weldon Spring Site Remedial Action Project (chemical plant site), is a former uranium processing facility located in eastern Missouri on the property of the former U.S. Army Weldon Spring Ordnance Works. The chemical plant site consists of two noncontiguous areas: 1) the 205-acre chemical plant area which includes several raffinate pits, and 2) the quarry. Surface water, soil, sludge, sediment, and groundwater within the chemical plant site contain chemical and radioactive contaminants.

The Agency for Toxic Substances and Disease Registry (ATSDR) reviewed on-site chemical exposure information and site conditions. Currently, public access to the chemical plant site is restricted by fences and 24-hour guards at entry gates. Therefore, *current public exposure pathways to on-site chemical contaminants are incomplete, and no exposure exists to pose a public health hazard*. However, in the past, trespassers may have gained access to the site and swam in the quarry and raffinate pits. ATSDR evaluated their potential exposure and found that *trespassers' infrequent short-term exposure to chemical contaminants was highly unlikely to result in health effects*.

The chemical plant site is surrounded by the U.S. Army Weldon Spring Ordnance Works Site which includes the August A. Busch Memorial Conservation Area, Weldon Spring Conservation Management Area, the Weldon Spring Training Area, and other small properties. These areas are considered the off-site areas. ATSDR completed a Public Health Assessment on the Weldon Spring Ordnance Works Site in March 1995. ATSDR scientist re-evaluated potential exposures in those areas and concluded that *exposure to chemical contaminants in surface water, groundwater, water from the St. Charles County well field and off-site private wells, and effluent releases from the chemical plant site to the Missouri River does not pose a public health hazard*. In addition, *recreational consumption of fish and game within the training area and the conservation areas poses no apparent public health hazard*. ATSDR also prepared several Health Consultations on chemical and radioactive contaminants in areas on and off the DOE chemical plant site. The findings of these prior ATSDR evaluations are included where appropriate in this Public Health Assessment on the chemical plant site.

ATSDR also reviewed on-site and off-site radiological exposure information and conditions. The exposure scenarios ATSDR evaluated include: trespassers swimming in quarry or raffinate pits; reservists performing field activities in the training area; anglers fishing, hunters hunting, and hikers hiking in the conservation areas; residents drinking from off-site private wells; staff and students attending the Francis Howell High School; and consumers of crops (e.g., corn) grown in conservation areas. In all of the scenarios evaluated, past and current exposures to radionuclides pose(d) *no public health hazard* or *no apparent public health hazard*.

Through a series of meetings, telephone calls and correspondence, ATSDR has obtained information on the community's concerns about contaminant exposures and specific health effects related to the chemical plant site. Local residents have expressed concern about: (1) exposures to airborne radioactive contamination at the

Francis Howell High School, (2) consumption of contaminated fish from lakes in the conservation areas, (3) contaminant migration to the St. Charles County well field and potential contamination of the County water supply, and (4) a potential increased incidence of childhood leukemia in St. Charles County. ATSDR has evaluated these community concerns as part of this health assessment. In summary,

1. Air monitoring conducted at the site boundary and the high school has shown that airborne radioactive contaminants are not moving beyond the site boundary, and radiation levels at the high school are within normal background ranges.

2. Contaminant concentrations in fish are very low, and recreational consumption of fish from the conservation areas does not pose a public health hazard.

3. Groundwater contaminants from the Weldon Spring quarry have not migrated to the St. Charles County well field, and ongoing remediation at the quarry will further reduce the potential for contaminant migration. Current groundwater monitoring procedures are adequate to determine the distribution of contaminants.

4. Cancer incidence data from the Missouri Cancer Registry indicate that there may have been higher than expected rates of childhood leukemia for several years during the period 1983-1992. However, the geographical distribution of these cases suggests that these cases are not related to contaminant exposures at the chemical plant site. In addition, exposure to the types and levels of contaminants present at the site has not been shown to cause childhood leukemia. ATSDR will work cooperatively with the Missouri Department of Health to further investigate possible environmental factors for the childhood leukemia cases in St. Charles County.

ATSDR evaluated available environmental monitoring data obtained from the U.S. Department of Energy, the Missouri Department of Natural Resources, St. Charles County, and the U.S. Department of the Army. ATSDR evaluated human exposure pathways to chemical and radioactive contaminants at the site. ATSDR also evaluated health information from the Missouri Department of Health to address community health concerns.

Based on these evaluations of environmental data, human exposure pathways, human health outcomes, and community concerns, ATSDR has determined that *the chemical plant site poses no apparent public health hazard* to the general public. Access restrictions prevent public exposure to chemical and radioactive contaminants on-site. In general, the public is not exposed to chemical and radioactive chemicals off-site. However, any *exposures to off-site contaminants are expected to be infrequent and short-term and do not pose a public health hazard*.

INTRODUCTION

The Weldon Spring Site Remedial Action Project (chemical plant site) is in southern St. Charles County, Missouri, about 30 miles west of St. Louis (see Figure 1). The chemical plant site, currently administered by the U.S. Department of Energy (DOE) for environmental restoration and site cleanup, is a former uranium refining facility. DOE is responsible for chemical and radioactive contaminants within the chemical plant site and all off-site radioactive contaminants from the site. The chemical plant site is on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL), and restoration is overseen through the EPA Superfund process.

The DOE's chemical plant site consists of two noncontiguous areas: (1) the chemical plant area and (2) the quarry (see Figure 2). The 205-acre chemical plant area includes buildings, support structures, Ash Pond, Frog Pond, and raffinate pits (see Figure 3). The chemical plant area was first used to produce 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), and 2,6-dinitrotoluene (DNT) and later to process uranium and thorium. The Ash Pond is a surface impoundment, and the Frog Pond is a waste settling basin within the chemical plant area. Four raffinate pits are waste settling basins used in the processing of uranium and thorium. The nine-acre quarry was used for waste disposal.

This public health assessment on the Weldon Spring Site Remedial Action Project (chemical plant site) addresses public exposures to chemical and radioactive contaminants within the DOE chemical plant site (chemical plant area, raffinate pits, and quarry) and to radioactive contaminants released from the chemical plant site into the off-site environment. The assessment also addresses the health concerns voiced by members of the surrounding community. These community concerns include exposure concerns (ways that people may have eaten, drunk, or inhaled contaminants) and health concerns (specific illnesses those community members feel that exposure to site contaminants may have caused).

The DOE chemical plant site is surrounded by the U.S. Army Weldon Spring Ordnance Works site, which is also listed on the EPA NPL because of contamination from the production of TNT and DNT (explosives) during World War II. The Weldon Spring Ordnance Works NPL Site includes the Weldon Spring Training Area, August A. Busch Memorial Conservation Area, Weldon Spring Conservation Management Area, and many other small properties within the original 17,232 acres of U.S. Army property (see Figure 2) [1]. The Army is responsible for all chemical contamination within the Weldon Spring Ordnance Works NPL Site [1]. The Agency for Toxic Substances and Disease Registry (ATSDR) completed a Public Health Assessment on the Weldon Spring Ordnance Work Site in March 1995. The 1995 public health assessment addressed issues related to chemical exposures at the Weldon Spring Ordnance Works Site. ATSDR also prepared several health consultations on chemical and radioactive contaminants in the chemical plant site and in the Weldon Spring Ordnance Works Site. The findings of these prior ATSDR evaluations are included, where appropriate, into this Public Health Assessment on the chemical plant site to address community exposure concerns.

This public health assessment does not address exposure to past chemical plant workers or to workers involved in remediation-related activities. EPA and the Department of Labor, Occupational Safety and Health Administration (OSHA) require that workers involved in site restoration be trained in the use and safe handling of hazardous materials and follow strict site-safety plans and operational procedures

BACKGROUND

Site History

In 1941, the U.S. Department of the Army procured approximately 17,000 acres of land in St. Charles County to build the Weldon Spring Ordnance Works facility. From 1941 to 1946, the facility produced 2,4,6-trinitrotoluene (TNT) and 2,6-dinitrotoluene (DNT) on 20 chemical process lines. The facility was declared surplus property in 1946, and between 1947 and 1949, approximately 15,000 acres were transferred to the State of Missouri, the University of Missouri, and the St. Charles County Public School District.

Of the remaining 2,000 acres under control of the U.S. Department of Army in 1955, 205 acres were transferred to the Atomic Energy Commission for the construction of a uranium refining facility. This 205-acre parcel consisted of the chemical plant site. The Mallinckrodt Chemical Works processed uranium and thorium ores into metal compounds from 1957 until the plant closed in 1966. The chemical plant site was returned to the U.S. Department of Army control in 1967 for construction of a herbicide production facility. Decontamination of the uranium refining facilities was attempted from 1968 to 1970, but abandoned because of cost. In 1972, St. Charles County acquired the plant well field and water treatment plant.

The U. S. Department of Energy (DOE) regained control of the chemical plant site in 1984 and began site characterization and remediation in 1986. The quarry was placed on the National Priorities List (NPL) in 1987, the listing was expanded to include the chemical plant area and raffinate pits in 1989. The U.S. Army-controlled Weldon Spring Ordnance Works site was listed separately in 1990.

Environmental Setting

The chemical plant site is in eastern Missouri, within the confluence of the Mississippi and Missouri rivers. The Weldon Spring Ordnance Work Site which surrounds the chemical plant site (chemical plant area and quarry) covers two land types. The northern portion, including the chemical plant area, is characterized by moderately hilly, northward dipping topography comprising thin glacial deposits overlying limestone bedrock [2]. The southern portion of the site, including the quarry, is characterized by rugged topography with narrow irregular drainage systems with short and steep gradient streams. The transition between these land types occurs just south of the chemical plant area and corresponds with a primary drainage basin and a groundwater divide that diverts water north to the Mississippi River and south to the Missouri River [2].

Annual precipitation for this area averages approximately 37 inches per year, with more than half occurring as rainfall between March and July. Annual evaporation, based on average free water surface evaporation (1956-1980 data) is approximately the same as precipitation (~37 inches per year). Prevailing winds are from the south during summer and fall and from the northwest and west-northwest during winter and spring. Average wind speeds are about 8.7 miles per hour (mph) for May through November and 10 mph for December through April [3].

Regional Hydrology

Three aquifers are present within the region of the chemical plant site: an alluvial aquifer in the saturated sand and gravel next to the Mississippi River and the Missouri River, a shallow bedrock aquifer that occurs throughout most of the area, and a deep bedrock aquifer.

The alluvial aquifer is unconfined, and the water table surface is at or within a few feet of the land surface. Thickness of the alluvial aquifer decreases rapidly away from the rivers, but in the St. Charles County municipal well field, the alluvial aquifer has a thickness of 100 to 110 feet. Water in the alluvial aquifer generally moves to and discharges into the adjacent rivers [2]. Hydraulic conductivities are very high in this aquifer, calculated to be between 535 and 600 feet per day [4].

The upper portion of the shallow bedrock aquifer exhibits some karstified features with fractures and joints enlarged by dissolution; however, it is not strictly classified as karst [5]. The uppermost limestone has weathered to clay, but fracture permeability is high so overall permeability/hydraulic conductivity decreases downward into the unweathered, competent limestone. In areas where the overlying glacial till or weathered limestone is absent or eroded, the shallow bedrock aquifer may discharge either to springs or to surface streams that may recharge the aquifer at swallow holes [2]. A groundwater divide follows surface topography and streams, with groundwater flowing northward from most of the site and southward from the southern portions of the site [2].

Groundwater Use

The St. Charles County Water Department currently owns and operates the municipal well field along the Missouri River. The well field is approximately one-half mile south of the quarry. Eight municipal wells pump an average of 12 million gallons of water per day from the alluvial aquifer. These wells can pump a maximum of 22 million gallons per day. Well depths vary from 100 to 130 feet in depth. Water from this Weldon Spring municipal well field is sold to the Missouri American Water Company, formerly the Missouri Cities Water Company, which serves about 60,000 people throughout St. Charles County. Also, approximately 60 private water wells are near the chemical plant site [2]. We do not know the details of well construction and usage. However, the State of Missouri has conducted a well survey (although it was not a complete census of the entire area) and monitors many of these wells for site-related contaminants (unpublished well survey and analytical results, summary data in [2]).

Land Use and Demographics

The DOE chemical plant site (chemical plant area and quarry) is surrounded by the U.S. Army Weldon Spring Ordnance Works Site (Weldon Spring Training Area, August A. Busch Memorial Conservation Area, and Weldon Spring Conservation Management Area) (see Figure 2).

The U.S. Army Weldon Spring Training Area comprises about 1,700 acres, with approximately 200 acres used for training troops and the remaining portion dedicated to site cleanup and decontamination activities. Remaining areas surrounding the chemical plant site are within the August A. Busch Memorial Conservation Area and the Weldon Spring Conservation Management Area (conservation areas).

The August A. Busch Memorial Conservation Area consists of about 8,000 acres on the north boundary of the chemical plant site, and the Weldon Spring Conservation Management Area is about 7,000 acres to the south. The Missouri Department of Conservation maintains and administers both conservation areas. The department has a multiple-use philosophy of land management. The conservation areas serve as forest and refuge for a variety of wildlife and birds; 32 stocked lakes provide fishing opportunities; and approximately 1,000 acres south of the quarry and along the Missouri River floodplain are used for land lease farming of grains and forage crops. No livestock are raised on the leased land. Several employees of the Missouri Department of Conservation live with their families in the August A. Busch Memorial Conservation Area.

Seasonal hunting for squirrel, groundhog, dove, rabbit, white-tailed deer and wild turkey occurs by special permit. Edible aquatic species in the lakes in the August A. Busch Memorial Conservation Area include black bass, white bass, channel, flathead and blue catfish, crappie, bluegill, carp, sunfish, and crayfish. Hunting dog field trials take place on portions of the Weldon Spring Conservation Management Area, and the August A. Busch Memorial Conservation Area has a practice shooting range. Other recreational use of the land includes hiking trails, bird-watching, and a variety of educational conservation activities. The Katy Trail, a Missouri Department of Natural Resources park, is a major east-west hiking and bicycling trail along the former Missouri-Kansas-Texas railroad right-of-way; the trail passes within several hundred yards of the quarry.

A Missouri Department of Transportation road maintenance facility is east of the chemical plant site (see Figure 4). Approximately 35 employees work at this facility, which houses road construction equipment and equipment repair activities. The Francis Howell High School is approximately one-half mile east of the chemical plant site (see Figure 4). The high school has occupied the site for 33 years. The student/staff population has varied greatly during this period and currently includes approximately 2,000 individuals.

Two residential areas located approximately 2 to 3 miles east of the chemical plant site, the town of Weldon Spring and the Weldon Spring Heights community, have a combined population of about 1,250. The area north of the August A. Busch Memorial Conservation Area supports low to moderate density residential use, some commercial activity, and a trailer park along Highway 40/61. Land west of the Weldon Spring Conservation Management Area is predominantly farmland. Also, a limited amount of cattle grazing may occur in this area.

Figure 5 shows population densities (based on 1990 census block estimates). The only residents in the original boundaries of the 17,000 acre Weldon Spring Ordnance Works are less than ten Missouri Department of Conservation personnel and families at the August A. Busch Memorial Conservation Area (see Figure 4). Population densities for census blocks north and northeast of the chemical plant site are generally less than 100 residents per block but have been increasing, with some blocks having densities of 500 or more residents.

Health Outcome Data

Available health outcome data include information about the relative frequency of specific illnesses, cancers, causes of death, and the general health status of a community. This public health assessment features two uses of health outcome data: (1) to evaluate the frequency of known health effects from contaminants at the site to determine whether St. Charles County residents have higher than expected rates relative to state or national rates; (2) to address community concerns about the occurrence (frequency) of specific diseases by evaluating and determining whether St. Charles County residents had contracted those diseases at rates different from state and national rates.

The Missouri Department of Health furnished the following list of available health outcome data. ATSDR epidemiologists evaluated these data only in the context of this public health assessment and reported all results to the Missouri Department of Health:

- Cancer registry data for all of St. Charles County, by zip code for 1980-91;
- Vital statistics (birth and death records) for all of St. Charles County, by address location, for 1972-92; and
- Birth defects records for all of St. Charles County, by zip code, for years 1980-87.

ATSDR staff members did not receive personal identifiers (e.g., names, addresses) for persons included in these data sets. The Missouri Center for Health Statistics published the specific data items in each set [6].

ATSDR Site Activities

Preliminary Public Health Assessment

ATSDR completed a Preliminary Public Health Assessment for the Weldon Spring Site, concentrating on the 9-acre abandoned limestone quarry, in 1988 (see Appendix E). The assessment concluded that the quarry is a public health concern because likely human exposure to on-site gamma radiation poses a significant health risk to persons having access to the quarry [7].

ATSDR completed an Addendum to the Preliminary Public Health Assessment for the Weldon Spring Site, in 1990 (see Appendix E). The addendum responds to a U.S. Environmental Protection Agency (EPA) request for ATSDR to evaluate the health threat posed to U.S. Army reservists training in designated areas of the Weldon Spring Training Area [7]. This training area contained lead, TNT, and other TNT-related compounds. ATSDR concluded that the lead, TNT, and TNT-related compounds in the designated training areas pose a minimal health risk to reservists and recommended a radiological survey of the designated training areas [7].

Health Consultations

In 1989, in response to an EPA request, the ATSDR Emergency Response Branch conducted a health consultation on consumption of fish collected from lakes within the August A. Busch Memorial Conservation Area (see Appendix E). The consultation evaluated concentrations of heavy metals (arsenic, lead, and mercury) in composite samples of whole fish, cleaned fish (scaled, beheaded, and eviscerated), and fillets of fish [8]. ATSDR concluded that the occurrence of metals in composite fish samples from these lakes does not present a public health threat to area residents who have occasional meals of locally caught fish [8]. ATSDR recommended limiting fish consumption to once per month, collecting additional fish samples, and identifying and educating anglers who fish in these lakes [8].

In response to another EPA request, ATSDR conducted another health consultation in 1993 on additional whole fish and fish fillet data collected from Lake 36 within the August A. Busch Memorial Conservation Area (see Appendix E). ATSDR concluded that the levels of arsenic, lead, and mercury in these fish samples did not represent a health threat for either infrequent or subsistence consumption [9]. Additionally, based on the decrease in lead levels from 1988 analyses to the 1992 analyses, Missouri Department of Health staff members do not consider an advisory for these lakes necessary [1].

In 1993, ATSDR evaluated the public health implications of contaminant clean-up levels that DOE staff members proposed for remedial action at the site. ATSDR determined that there are no completed chronic exposure pathways for public exposure to contaminated soils at the chemical plant site or in adjacent off-site areas (see Appendix E) [10]. Also, the proposed clean-up levels are protective of public health for accidental or intermittent exposures but would not be protective under any future residential occupancy conditions at the site [10]. Additionally, off-site areas have not been evaluated for non-radioactive soil contamination [10]. ATSDR recommended that DOE maintain site access restrictions and institutional control, evaluate off-site areas for non-radiologic contamination, and modify dose assessment procedures if the site is released for public access [10].

In 1994, at the request of DOE, ATSDR conducted a health consultation on the human health hazard posed by the interim remedial action plan for removing bulk wastes from the quarry (Appendix E). As the Record of Decision describes it, the remedial action plan called for removal of bulk waste from the quarry and transporting the waste to a temporary storage area in the chemical plant area [11]. ATSDR concluded that the remedial action plan for excavating, transporting, and temporarily storing the quarry bulk waste does not present a potential for public exposures to hazardous wastes [11]. The consultation did not identify any specific health concerns related to excavating or transporting the bulk wastes but did recommend the use of dust control techniques to minimize worker exposures [11].

In 1994, in response to a request from local citizens, ATSDR completed a health consultation on potential exposure of Francis Howell High School students and staff to airborne radionuclides from the chemical plant site (see Appendix E). Results from DOE air monitoring did not indicate any airborne radioactive materials above background concentrations at the school [12]. Also, measurements from monitoring stations at the site boundary and at the high school during site building demolition (1993 calendar year) did not show any air concentrations of site-related contaminants, including alpha emitting materials (uranium, thorium, etc.), above background [12]. ATSDR concluded that off-site migration of contaminants to the Francis Howell High School was not occurring and that contamination from the chemical plant site does not pose a public health concern for students and faculty at the school [12].

Site Visits and Community Involvement

ATSDR staff members have made several visits to the Weldon Spring area to meet with site personnel; local, state, and federal officials; and concerned citizens. The first visit was a tour of the Weldon Spring Training Area and former Weldon Spring Ordnance Works facility on February 6-8, 1991. ATSDR staff members met with representatives of the U.S. Army, the Missouri Department of Health, and the Missouri Department of Conservation. The second visit to the DOE chemical plant site on June 8-12, 1992, included a tour of the DOE facility and meetings with representatives of federal and state regulatory agencies, the St. Charles County school administration, and The St. Charles Countians Against Hazardous Waste.

ATSDR staff members attended a December 16, 1992, public hearing sponsored by the DOE and the EPA, which attracted approximately 150 concerned residents. Twenty-five people presented specific comments regarding the "Proposed Plan for Remedial Action at the Chemical Plant Area." Other individuals or group representatives said they would provide written comments to the DOE and EPA. The Community Health Concerns section of this public health assessment contains a list of community health concerns collected at this meeting and other meetings.

ATSDR staff members joined representatives of Boston University in a series of meetings with local health officials, St. Charles County government officials, area residents, and members of The St. Charles Countians Against Hazardous Waste and the Coalition for the Environment (St. Louis area). These meetings took place May 24-26, 1993, and focused on identifying community health concerns and verifying a list of previously identified concerns. Community concern over possible exposure to airborne radioactive materials at the Francis Howell High School prompted ATSDR to conduct the 1994 health consultation on that issue.

ATSDR staff members attended an EPA-sponsored demonstration of bioremediation of the U.S. Weldon Spring Ordnance Works' soil contaminants during a trip to the site April 5 - 8, 1994. ATSDR staff members also met with representatives of EPA, the Army, and the Missouri Departments of Health and Conservation. During that visit, ATSDR representatives met with members of the public and the medical community to discuss specific health concerns. Public availability sessions July 11-12, 1994, at two public schools near the Weldon Spring NPL sites were an outgrowth of that visit. Approximately 24 members of the community gave ATSDR specific health concerns.

The community concerns obtained at these site visits and through related telephone conversations and correspondence fall into two general categories: (1) concerns about exposure to contaminants and (2) concerns about specific health effects or disease. The following Community Health Concerns section contains descriptions of these concerns.

COMMUNITY HEALTH CONCERNS

We obtained community health concerns from local residents, health care providers, and government representatives in a series of meetings, telephone calls and correspondence. Several meetings with representatives of The St. Charles Countians Against Hazardous Waste have allowed us to verify the resulting list of community health concerns. The community concerns are categorized as concerns about contaminant exposures (Table 1) and concerns about specific health effects (Table 2).

The list of community exposure concerns in Table 1 identifies the areas, times (e.g., past, present, future), and populations of concern. Most exposure concerns involved residents living adjacent or close to the site or exposures occurring in the adjacent conservation areas. Exposure occurring as a result of releases of treated water from site water-treatment plants to the Missouri River and to food crops grown in nearby areas are the only community health concerns that involve residents outside the Weldon Spring area.

The Environmental Contamination and Public Health Implications section of this public health assessment addresses the community exposure concerns with evaluations of human exposure pathways. An exposure pathway includes both environmental and human components that lead to human exposure. After evaluating the status of each exposure pathway, Agency for Toxic Substances and Disease Registry (ATSDR) health assessors evaluate the public health significance of completed exposure pathways by determining the likelihood that site contaminants will produce adverse health effects.

Most of the community health concerns listed in Table 2 are for different types of cancer. The most common concern was about higher-than-expected leukemia rates for children of St. Charles County. Residents expressing these concerns did not have any information about the possible routes or times of exposure to contaminants for most of the health concerns. No specific health outcome concerns appeared for populations outside St. Charles County, although several people expressed concern about contamination of potential drinking water from the Missouri River. The Evaluation of Community Health Concerns section of this public health assessment addresses these concerns about specific diseases through evaluations of the likelihood that site contaminants will produce a particular disease and whether that disease is occurring at normal or expected rates for the area.

Many Weldon Spring residents also had concerns about the reliability of the environmental monitoring data collected by the U. S. Department of Energy (DOE) and its contractors. ATSDR assessors did not evaluate the reliability of DOE monitoring data as part of this assessment. However, in the past, ATSDR staff members attempted to evaluate the adequacy of DOE particulate air monitoring at the Francis Howell High School. EPA's National Air and Radiation Environmental Laboratory staff said the information provided was not sufficient to allow them to determine the adequacy of the data [13]. However, based on the information and data provided, ATSDR concluded that contamination from WSS and building demolition did not pose a public health concern [hazard] for persons at the Francis Howell High School. That conclusion was based on the following information: the characterization study, which indicates that property at the high school is not contaminated; gross alpha measurements, which show that no airborne migration of alpha-emitting radionuclides is occurring from the site to the high school; and radon data, which indicate that radon emissions from WSS do not contribute to radon exposures at the high school [12].

In addition to collecting community concerns, we released the Public Comment draft of the Public Health Assessment of the Weldon Spring Quarry/Plant/Pits (USDOE) on September 30, 1996. The comment period ended November 29, 1996. During that period, we received one comment from the public. A summary of the comment and our response is provided in Appendix F.

TABLE 1. COMMUNITY EXPOSURE CONCERNS

Exposure Concerns	Area of Concern	Time of Concern	Population of Concern
1) Private, off-site wells: Contamination of private wells by toxic substances migrating from the Weldon Spring Training Area and chemical plant site.	North (down grade) of training area and chemical plant site	Past	Residents and businesses with private wells
2) Fish and game: Ingestion of contaminants that have bioaccumulated in fish and game from the conservation areas.	Conservation areas	Past, present and future	Hunters, fishers, and their families
3) Airborne radioactivity, past: Exposure to airborne releases of radioactive contamination (including radon).	Off site	Past	Francis Howell High School students/staff, Weldon Spring Heights Community and other residents
4) Off-site soil: Past and current exposure to areas of off-site soil contamination during recreational activities in the adjacent conservation areas.	Discrete areas within the training area and conservation areas	Past, present, future	Conservation areas visitors and military personnel in the training area
5) Surface water: Past exposure to on-site surface water at the quarry and raffinate pits or off-site conservation area lakes.	On-site pits/quarry; Off-site conservation area lakes	Past	Site trespassers, conservation area visitors.
6) Airborne radioactivity, present/future: Exposure to airborne releases of radioactive contamination during site cleanup for students and staff of the Francis Howell High School.	Off site	Present, future	Francis Howell High School students/staff, Weldon Spring Heights Community and other residents
7) Incinerator: Construction of an on-site incinerator to dispose of hazardous materials.	Off site	Future	Francis Howell High School students/staff,. and other nearby residents
8) Remedial workers: Site remedial worker exposure to asbestos and other hazardous materials due to insufficient worker training.	On site	Present, future	Site remedial workers
9) County Municipal Wells: Contamination of the St. Charles County municipal well	Public well field down grade from	Future	St. Charles County residents

field by toxic substances migrating from the quarry.	quarry		
10) Missouri River: Contamination of Missouri River because of release of water from water treatment plants at quarry and chemical plant .	Missouri River downstream of release outfalls	Present, future	Residents of St. Louis County
11) Waste storage cell: Potential releases of toxic substances from the Weldon Spring waste storage cell because of earthquakes or karst dissolution and collapse in limestone terrain.	North (down grade) of training area and chemical plant area	Future	Residents and businesses with private wells
12) Food crops: Crops are grown next to site and on ; there is concern that these crops may be contaminated by site-related hazardous materials and consumed by people (According to U. S. Department of Energy staff no one eats the crops grown on the conservation areas).	Conservation areas and University of Missouri Research farm	Past, present and future	General public

TABLE 2. COMMUNITY HEALTH CONCERNS

Health Outcome Concerns or Questions	Exposure Route	Area of Concern	Time of concern	Sub-Population of Concern
Childhood leukemia	Unknown	St. Charles County	Past during production releases 1957-66 and cleanup 1967-72	Students at Francis Howell High School and children living adjacent to site
Unspecified health effects from former workers exposure to radioactive materials	Multiple exposure routes	On site	Past 1957-66	Site workers
Autism	Unknown	St. Charles County	Unknown	Unknown
Renal cell cancer	Unknown	Residential areas adjacent to site	Unknown	Area residents
Infertility	Unknown	Residential areas adjacent to site	Unknown	Area residents
Alopecia	Unknown	Residential areas north of site	1980-present	Children

Hodgkin's disease	Unknown	Unknown	Unknown	Unknown
Nasal-pharyngeal cancer	Inhalation	Unknown	Past	Area residents
Prostate cancer	Unknown	Unknown	Unknown	Unknown
Aplastic anemia	Unknown	Unknown	Unknown	Unknown
Unspecified cancer	Unknown	Unknown	Unknown	Unknown
Breast cancer	Unknown	Unknown	Unknown	Unknown
Spina bifida	Unknown	Unknown	Unknown	Adjacent residents
Physical Hazards Potential site hazards due to localized concentrations of explosive materials at the Former Ordnance Works	Not Applicable	Chemical plant site and training area; old waste pipelines	Present and future	Site remedial workers
Unknown means community members did not know about exposure times or areas for specific medical concerns.				

PUBLIC HEALTH ASSESSMENT

WELDON SPRING SITE REMEDIAL ACTION PROJECT
(CHEMICAL PLANT, RAFFINATE PITS, QUARRY)
ST. CHARLES, ST. CHARLES COUNTY, MISSOURI

ENVIRONMENTAL CONTAMINATION AND PUBLIC HEALTH IMPLICATIONS

Introduction

There is documentation of the release of chemical and radioactive contaminants into the environment from the chemical plant site (chemical plant, raffinate pits, and the quarry). In this section, Agency for Toxic Substances and Disease Registry (ATSDR) scientists evaluate whether people are exposed to chemical and radioactive contaminants from the chemical plant site and, if they are exposed, what the public health implications are. This section also contains the findings of prior ATSDR evaluations to address community members' exposure concerns (Table 1).

The release of contaminants into the environment does not always result in exposure. To determine whether people are exposed to contaminants from the chemical plant site and the Weldon Spring Ordnance Work Site, ATSDR scientists evaluate the environmental and human components that can lead to human exposure. The evaluations include examinations of published reports, environmental data, transport mechanisms, land use, and resource use to identify exposure pathways by which a contaminant migrates from a source to an area where the public may come in contact with the contaminant. An exposure pathway consists of five elements: a source of contamination, transportation of environmental media, point of exposure, a route of human exposure, and an exposed population.

The pathways analysis determines the status of each pathway. Exposure pathways may be (1) complete (all five pathway elements exist, exposure is occurring); (2) potential (at least one of the five elements is missing but the missing element could exist, exposure may occur); or (3) incomplete (one of the five elements is missing and will never be present, exposure will not occur).

After identifying complete and potential exposure pathways, ATSDR health scientists determine the public health implications of each completed pathway. Different methods are used to evaluate the public health significance of exposure pathways for chemical contaminants and radioactive contaminants.

To evaluate exposure to chemical contaminants, ATSDR toxicologists initially conduct a preliminary screening of chemicals identified at points of exposure to determine whether contaminants are present in an environmental medium at concentrations that may be of health concern (see Appendix A). This preliminary screening compares the maximum concentration of each chemical found in each medium to a chemical- and media-specific ATSDR health-based comparison value. ATSDR comparison values are extremely conservative and protective of public health in that they are based on daily long-term exposure to chemical doses that are unlikely to result in adverse health effects. Chemicals with maximum concentrations that exceed ATSDR health-based comparison values are evaluated in further site-specific detail to determine the public health implications of exposure. This site-specific evaluation involves estimating chemical exposure doses from realistic site-specific exposure scenarios and comparing them with standard health-based doses that are unlikely to cause an appreciable risk to health as well as to other medical and toxicological information. If the maximum concentration of a chemical is below the ATSDR health-based comparison value, exposure to the chemical at the point of exposure is unlikely to pose a public health hazard and there is no further assessment of exposure.

To evaluate radioactive materials, ATSDR health physicists use location-specific exposure scenarios instead of single media-specific comparison values because people can be exposed to radioactive materials in one or more environmental media (see Appendix C). These are hypothetical exposure scenarios, representing site-specific activities that have occurred or are occurring at or near the site. We estimate total exposure to radiation for each scenario by considering the maximum concentration of each radionuclide in each environmental medium that contributes to exposure. From this estimate of total radiation dose, we subtract background radiation doses (i.e., the natural amount of radionuclides present in the environment that contributes to the total radiation dose) to get the net radiation dose. We compare this radiation dose with nationally accepted standards to determine public health implications of each exposure scenario. For the general public (i.e., anyone not specifically classified as a radiation worker), the maximum net annual radiation dose is limited to 100 millirem per year (mrem/yr).

Chemical Exposure Pathways

On-Site Soil, Sediment, and Sludge

On-site describes locations on the U. S. Department of Energy (DOE) chemical plant site, which includes the chemical plant area, raffinate pits, and the quarry (see Figures 2 and 3). The chemical plant area, raffinate pits, and quarry are each enclosed by fences and have 24-hour guards at the entry gates. With public access restricted, *current exposure pathways involving chemical contaminants in on-site soil, sediment, and sludge are incomplete, and no exposure exists to pose a public health hazard.* Because local residents expressed concern about trespassing in the past, ATSDR evaluated potential trespassers' exposure and found that *trespassers' infrequent short-term past exposure was highly unlikely to result in health effects.*

Sludge samples from raffinate pits and a few soil samples from within the chemical plant area contain arsenic, lead, vanadium, nitrates, 2,4,6-trinitrotoluene (TNT) and polychlorinated biphenyls (PCBs) at concentrations that exceed ATSDR screening comparison values for chronic soil ingestion. Concentrations of arsenic, lead, PCBs, TNT, and polycyclic aromatic hydrocarbons in a few soil samples from the quarry also exceeded ATSDR screening comparison values for chronic soil ingestion. Frequent and long-term ingestion of these contaminated on-site soils may result in exposure doses that can cause adverse health effects. However, trespassers' infrequent short-term exposure to chemicals in on-site soil, sediment, and sludge is highly unlikely to result in health effects. Because of access restrictions, exposure pathways to chemicals in on-site soil, sediment, and sludge are incomplete and do not pose a public health hazard.

On-Site Surface Water

Several residents expressed concern over exposures that may have occurred as a result of trespassers swimming in the raffinate pits or quarry. Past access restrictions included chain-link fencing and warning signs, and current restrictions include the addition of 24-hour guards. As a result of current access restrictions, *exposure pathways to chemical contaminants in on-site surface water are incomplete, and no exposure exists to pose a public health hazard*. In addition, *past swimmers' infrequent short-term exposure to chemicals in on-site surface water is highly unlikely to result in health effects*.

Surface water samples collected from the raffinate pits from 1983 to 1987 contained concentrations of antimony, arsenic, chromium, lead, molybdenum, nitrate, sulfate, selenium, and vanadium that exceeded the ATSDR screening comparison values for chronic ingestion of drinking water. Quarry surface water samples collected from 1979 to 1987 contained arsenic concentrations that exceeded the ATSDR screening comparison values for chronic ingestion of drinking water. Frequent and long-term ingestion of surface water from the raffinate pits and the quarry may result in chemical exposure doses that can cause adverse health effects. However, trespassers' infrequent short-term exposure to chemicals in on-site surface water is highly unlikely to result in health effects.

On-Site Groundwater

DOE maintains more than 80 groundwater monitoring wells within the chemical plant and quarry boundaries (see Figure 6). These wells do not provide water for consumption, and site safety plans stipulate precautions to prevent accidental exposure to groundwater. Because chronic exposure to groundwater from on-site wells is not possible and accidental ingestion is very unlikely, *the on-site groundwater pathway is incomplete, and no exposure exists to pose a public health hazard*.

Groundwater samples collected from on-site monitoring wells in 1979, 1980, 1981, 1985, and 1987 contained antimony, lead, manganese, nitrates, sulfates, and 1,3,5- trinitrobenzene at concentrations that exceeded the ATSDR screening comparison values for chronic ingestion of water. Infrequent short-term exposure to chemicals in on-site groundwater is unlikely to result in any adverse health outcome. Without a completed chronic exposure pathway, the on-site groundwater is not a public health hazard.

On-Site Asbestos

Many on-site buildings and pipelines contained or were covered by asbestos insulating material. Removal and demolition of those facilities could expose workers to airborne asbestos. However, safety procedures used by workers while removing asbestos-containing materials are designed to limit exposures to workers and the public. U.S. Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations require adherence to site safety plans and operational procedures. Because of these safety procedures and regulatory guidelines, *the on-site asbestos exposure pathway is incomplete, and no exposure exists to pose a public health hazard.*

Off-Site

Off-site areas are portions of the original 17,232-acre Weldon Spring Ordnance Works that include the Weldon Spring Training Area, August A. Busch Memorial Conservation Area, Weldon Spring Conservation Management Area, University of Missouri-Missouri Research Park, and other small properties (see Figure 2). In the 1995 Public Health Assessment for the Weldon Spring Ordnance Works Site and in various health consultations, ATSDR scientists evaluated chemical contaminants in these off-site areas surrounding the DOE chemical plant site and assessed the public health implications of chemical contaminants in these off-site areas [1]. ATSDR health physicists evaluated off-site radioactive contaminants in the Radioactive Materials Exposure Scenarios section of this public health assessment.

Off-Site Soil

In the 1995 Public Health Assessment on the Weldon Spring Ordnance Works Site, ATSDR environmental health scientists determined that public access is controlled but that trespassers might evade controls and gain access to the training area and contaminated conservation areas. However, this exposure would be infrequent and short-term and would represent no apparent health hazard [1]. While preparing this health assessment, ATSDR environmental health scientists reconsidered this information and concluded that the *off-site soil pathway is incomplete, and no exposure exists to pose a public health hazard*. Trespassers who ignore and evade security and warning measures may have short-term and infrequent contact with contaminated soils.

Off-Site Groundwater and Surface Water

In the 1995 Public Health Assessment on the Weldon Spring Ordnance Works Site, ATSDR environmental health scientists evaluated the potential for exposure to off-site groundwater and off-site surface water. ATSDR scientists identified chemical contaminants associated with production processes in groundwater samples from monitoring wells and in surface water samples from outfalls, springs, lakes, and streams within the boundaries of the former Weldon Spring Ordnance Works [1]. The karst nature of the subsurface geology in the vicinity of the site has created many springs where groundwater becomes surface water and swallow-holes where surface water flows underground to become groundwater. ATSDR geologists determined that the karstic terrain is such that tracing groundwater contaminant plumes with any accuracy is not possible. However, in general terms, groundwater flow correlates roughly to surface water drainage [1].

Off-Site Private Wells

In the 1995 public health assessment, ATSDR scientists concluded that, in the past people at the Twin Island Resort were exposed to low levels of explosive contaminants in drinking water from resort wells (see Figure 4) [1]; however the extent of their exposure was unknown, and their exposure was classified as *an indeterminate public health hazard* [1]. Current exposure to chemical contaminants in groundwater from off-site private wells was reduced or eliminated in 1989 when citizens were provided bottled water [1]. After reconsidering this exposure pathway, ATSDR environmental health scientists concluded that *the off-site private well water pathway is currently incomplete and poses no public health hazard*.

Training Area and Conservation Areas

In the 1995 Public Health Assessment of the Weldon Spring Ordnance Works Site, ATSDR scientists concluded that *the contaminated groundwater exposure pathway at the training area is incomplete, and at the conservation areas, groundwater exposure is possible, although not frequent. In both areas, groundwater exposure is not considered a threat* [poses no health hazard] *to human health* [1]. No drinking water wells are within the conservation areas, and institutional controls enacted by the U.S. Army prohibit the use of groundwater on the training area [1]. Since the start-up of the Weldon Spring Ordnance Works and continuing today, the St. Charles County well field has supplied drinking water for these areas [1].

After reconsidering this exposure pathway, ATSDR environmental health scientists believe that in both the training area and the conservation areas the *groundwater exposure pathway is incomplete, and no exposure exists to pose a public health hazard*.

Surface Water

Groundwater flow at the site can generally be roughly correlated to surface water drainages (i.e., springs and streams), and public exposure is possible through contact with a few springs and streams [1]. The 1995 health assessment stated that because of the low probability that someone would drink water from the springs and the lower probability that anyone would frequently drink this water, *the springs should not be considered a threat* [poses no health hazard] *to human health* [1].

ATSDR scientists have determined that incidental ingestion of water (short-term exposure) containing these contaminant concentrations will not result in any health effects. Therefore, *off-site surface water in the Weldon Spring Training Area, the August A. Busch Memorial Conservation Area, and the Weldon Spring Conservation Management Area poses no public health hazard*.

St. Charles County Well Field

People drinking water from the St. Charles County Water Department are not exposed to chemical plant site contaminants. *The municipal drinking water pathway is incomplete, and no exposure exists to pose a public health hazard*.

The St. Charles County Water Supply District #2 provides drinking water to the chemical plant site and to residents northeast of the chemical plant site [1]. The county water department obtains water from a municipal well field next to the Missouri River in the southern portion of the original Weldon Spring Ordnance Works property (see figures 2 and 6) [1]. This well field draws water from the Missouri River alluvial aquifer and the bedrock aquifer [1]. However, the proximity of the well field to the Missouri River and infiltration through the alluvial aquifer indicate that the major source of water is from the river [1]. The water from the well field passes through the St. Charles County water treatment facility before being distributed to local users [1]. The St. Charles County Water Department routinely monitors the municipal wells and adjacent monitoring wells for site-related contaminants [1]. Detectable levels of contaminants were reported on only one sampling event and are attributed to laboratory measurement error [1].

Extensive groundwater monitoring suggests that contaminants have seeped from the quarry [1]. Contaminants from the quarry have been detected in shallow alluvial aquifer monitor wells immediately downgrade of the quarry, but exposure to the groundwater from these monitor wells is not occurring (see Figure 6) [1]. These contaminants in the groundwater have not migrated beyond the northern margin of the alluvial aquifer and have not been detected in municipal supply wells [2, 14, and 15]. This drinking water exposure pathway is incomplete. In addition, ongoing remediation at the quarry will further reduce the potential for contaminant migration to the public water supply wells.

Missouri River

Effluent released from the chemical plant site water treatment plants into the Missouri River do not pose a public health hazard because the effluent is treated and monitored before released into the Missouri River. The site's water treatment plant releases effluent into the Missouri River through an underground pipeline that runs parallel and south of the southeast drainage. A second underground pipeline runs parallel to Katy Trail and discharges effluent from the quarry water treatment plant into the Missouri River. Discharge permits require that the effluent be evaluated before its release to the Missouri River. Contaminant concentrations in the effluent are at or below background levels for area surface waters. Effluent is monitored for site contaminants including total uranium, gross alpha, gross beta, and thorium and radium isotopes. Sample analyses by DOE, EPA, the Missouri Department of Natural Resources, St. Charles County, and St. Louis County all show that the treated water is meeting all discharge requirements and that contaminant concentrations are below levels that may cause adverse health effects.

Fish

In a 1988 health consultation, ATSDR toxicologists concluded that no one should get sick from eating fish from the lakes but recommended eating no more than one fish meal per month from those lakes [8]. Based on more recent sampling data, ATSDR toxicologists concluded in a 1993 health consultation that contaminant concentrations are lower than those in the 1989 report and that no health effects are likely, even for persons consuming fish at subsistence consumption rates [9]. In the 1995 ATSDR Public Health Assessment on the Weldon Spring Ordnance Works, ATSDR scientists determined it is unlikely that fish in the conservation areas would be contaminated at levels of concern, based on recreational fishing [1]. The health assessment also concluded that *recreationally eating fish from the conservation areas poses no apparent public health hazard* [1].

After reviewing the 1995 health assessment, ATSDR scientists agree that *recreationally eating fish from the conservation areas poses no apparent public health hazard*.

Game Animals

In the 1995 ATSDR Public Health Assessment on the Weldon Spring Ordnance Works, ATSDR scientists concluded that *consumption of game animals from conservation areas is not an apparent public health hazard* [1].

After reviewing the 1995 health assessment, ATSDR scientists agree that *consumption of game animals from conservation areas is not an apparent public health hazard*.

Waste Storage Cell

A few citizens mentioned concerns regarding potential release of toxic substances from failure of a waste storage cell because of karst collapse or earthquake. The Weldon Spring area is susceptible to earthquakes and is underlain by karstified limestone [1]. At the chemical plant site, limestone is overlain by relatively impermeable layers of clay and weathered limestone. Because of the low permeability of the clays capping the limestone and of the high water table, large sinkholes have not formed in these limestones [16]. Placement of a low permeability surface barrier [16] will provide greater protection against acidic water reaching and dissolving the underlying limestone. *As a result of the natural and engineered features of the chemical plant site storage cell, karst collapse is unlikely. Therefore, potential for contaminant release and human exposure is minimized*. The use of appropriate design features and impermeable materials can also reduce the risk of cell failure because of earthquakes. The storage cell will include both clay and synthetic top and bottom liners to prevent leaching of groundwater. Even in the very unlikely event of a storage cell collapse, leaching of contaminants to the water table aquifer (and potential exposures to site contaminants) will be reduced if waste materials currently stored in the open are stored in the proposed waste cell.

Incinerator

A few citizens mentioned concerns regarding potential exposure to emissions from a proposed incinerator. Information about a proposed plan for a hazardous material incinerator at the Weldon Spring Training Area is included in the 1995 Weldon Spring Ordnance Works public health assessment [1]. ATSDR's evaluation concluded that *there will be no significant emissions of contaminants if the incinerator is appropriately designed and operated* [1].

Radioactive Material Exposure Scenarios

Radionuclides have been detected in various media in areas where the public may have been exposed or may be exposed currently. These points of exposure are in the chemical plant site, Weldon Spring Training Area, August A. Busch Memorial Conservation Area, Weldon Spring Conservation Management Area, and off-site private wells. Maximum radionuclide concentrations measured in the training area and conservation areas soil are presented in Table 3. The maximum radionuclide concentrations measured in surface water, fish, wild game, and groundwater are presented in Table 4.

TABLE 3. MAXIMUM RADIONUCLIDES CONCENTRATIONS IN SOIL

Radionuclide	Maximum Soil Concentration (pCi/g)	
	Training Area	Conservation Areas
U-238	29,530	3,020
Th-230	n.a.	10,100
Ra-226	40.1	430
Th-232	450	240
U-235	1,388	49.7
n.a.- training area soil measurements are not available.		

TABLE 4. MAXIMUM RADIONUCLIDES CONCENTRATIONS IN OTHER MEDIA

Radionuclide	Quarry or Raffinate Pits	Conservation Areas			Off-site Private Wells	Crops

	Surface Water (pCi/L)	Surface Water (pCi/L)	Fish (pCi/g)	Wild Game (pCi/g)	Ground Water (pCi/L)	Corn (pCi/g)
U-238	2580	500.00	0.936	0.00	n.a.	n.a.
U-234	2430	378.00	0.892	0.146	n.a.	n.a.
Th-230	756	8.80	0.03	n.a.	45.1	1.49
Ra-226	164	6.42	0.15	n.a.	10.3	0.24
Pb-210	4.1	83.20	n.a.	n.a.	n.a.	n.a.
Po-210	1.3	2.30	n.a.	n.a.	n.a.	n.a.
Th-232	36.3	2.20	0.00	n.a.	8.5	0.193
Ra-228	32	15.00	n.a.	n.a.	4.0	0.836
Th-228	3.7	2.20	n.a.	n.a.	n.a.	0.221
U-235	322	38.00	0.035	0.005	n.a.	n.a.
Ac-227	5	12.7	n.a.	n.a.	n.a.	n.a.
n.a.- measurements not available for that medium at that location.						

ATSDR health physicists evaluated hypothetical exposure scenarios that represent activities that have occurred or are occurring at points of exposure in the chemical plant site, training area, conservation areas, and private off-site wells containing radionuclides. We then calculated effective radiation doses and determined the public health implications for each exposure scenario. In addition, health physicists evaluated community exposure concerns, such as exposure to trespassers swimming in Quarry and Raffinate Pits, airborne exposure at the Francis Howell High School, and consumption of corn grown in nearby areas. For each scenario, ATSDR health physicists calculated the effective radiation dose using conservative exposure assumptions and the maximum radionuclide concentrations in each medium (see Appendix C). The use of conservative exposure assumptions and maximum concentrations of each radionuclide in each medium overestimates potential radiation exposures and effective radiation doses; therefore, ATSDR's approach is very conservative because realistic radiation exposures and doses are much less than ATSDR's estimates. We compared the estimated effective radiation dose to nationally and internationally accepted standards, such as the annual radiation dose limit of 100 mrem/yr for the general public, to determine public health implications of each exposure scenario (see Appendix C).

Quarry and Raffinate Pits

Swimmers Scenario

Residues from the processing of uranium and thorium were placed in the quarry and raffinate pits, and water samples from these areas confirm the presence of radionuclides. Because of community members' concerns, ATSDR evaluated the risk of adverse health effects to persons who may have swum in these areas. ATSDR health physicists calculated an effective radiation dose of 0.4 mrem/yr to swimmers (see Appendix C). Based on this estimated annual effective radiation dose, *swimming in the quarry or raffinate pits did not pose a radiation health hazard*.

Weldon Spring Training Area

U.S. Military Reservist Scenario

Radioactive contaminants have been detected in isolated soil samples from the Weldon Spring Training Area. In the past, U.S. military reservists performing field training exercises in the Weldon Spring Training Area may have been exposed to radionuclides in soil, surface water, and air and to external radiation. ATSDR health physicists calculated an effective radiation dose of 68.8 mrem/yr to reservists (see Appendix C). Based on this estimated annual effective radiation dose, *the training area poses no apparent radiation health hazard to reservists.*

Conservation Areas

Anglers, Hunters, Hikers Scenarios

Soil, surface water, fish, and wild game samples from the August A. Busch Memorial Conservation Area and the Weldon Spring Management Conservation Area contain radionuclides. Fishing, hunting, and hiking are common activities in the conservation areas. Anglers, hunters, and hikers may be exposed to radionuclides in conservation area surface water, soil, and air and to external radiation. In addition, anglers and hunters may be exposed to radionuclides by eating their catch. ATSDR health physicists calculated effective radiation doses of 4.7 mrem/yr, 9.1 mrem/yr, and 6.1 mrem/yr for the angler, hunter, and hiker scenarios, respectively (see Appendix C). Based on these estimated annual effective radiation doses, *fishing, hunting, hiking in the conservation areas do not pose an apparent radiation health hazard.*

Off-Site Private Wells

Off-Site Private Well Owner Scenario

Groundwater samples from off-site private wells contained radionuclide contaminants. In the past, people who used and drank groundwater from these private wells may have been exposed to radionuclides by drinking the water and by breathing ambient air. ATSDR health physicists evaluated a private well exposure scenario involving consumption of groundwater and inhalation of airborne radionuclides from groundwater. ATSDR health physicists calculated the effective radiation dose of 29.4 mrem/yr for people who, in the past, used groundwater from off-site private wells (see Appendix E). Based on this estimated annual effective radiation dose, *the use of off-site private well groundwater posed no apparent radiation health hazard in the past, does not pose a radiation health hazard now, and will not pose a radiation health hazard in the future*.

Francis Howell High School

Staff and Students Scenarios

At the request of local citizens, ATSDR completed a health consultation in 1994 on the potential exposure of Francis Howell High School students and staff to airborne radionuclides from the chemical plant site. Results from DOE air monitoring samples did not indicate any airborne radioactive materials above background concentrations at the school. Also, measurements from monitoring stations at the site boundary and at the high school during site building demolition (1993 calendar year) did not show any increased concentrations or exposures to site related contaminants above background. Additionally, gross alpha particulate concentrations at the facility boundary and the high school did not show any off-site migration of airborne alpha-emitting materials (uranium, thorium, etc.). ATSDR health physicists calculated an annual effective radiation dose of 0.3 mrem/yr to the staff and students (see Appendix C). Based on this estimated annual effective radiation dose, *the site posed no apparent radiation health hazard to staff and students at the school, and it does not pose a radiation health hazard now nor will it in the future*.

Crops

Crops Consumer Scenario

During interviews with the public, citizens expressed concern about the ingestion of crops grown near the conservation areas. Portions of the conservation areas and farmlands outside the conservation areas are used to grow corn, soybeans, milo, wheat, and sunflowers. In general people are likely to eat locally grown corn whereas the other crops usually require some type of processing before people eat them. Therefore, it is unlikely that soybean, milo, wheat and sunflowers are grown directly for local human consumption.

According to Weldon Spring Site staff members, people do not eat the corn grown in the conservation areas. However, ATSDR health physicists evaluated human ingestion of the corn to address the public's concern. The estimated annual effective radiation dose to consumers of corn is 37.3 mrem/yr (see Appendix C). Based on this estimated annual effective radiation dose, *eating corn grown in or near the conservation areas poses no apparent radiation health hazard*.

The probability and severity of health effects increase as exposure to radiation increases, although exposure to background levels of radiation (i.e., those levels naturally occurring in the environment) are thought not to produce noticeable health effects in humans [17]. For radiation protection purposes, the effective radiation dose from radiation exposures above background is calculated as an indicator of potential health effects. Cancer is believed to be the predominant health effect associated with chronic radiation exposures [17, 18, 19, 20, and 21]. The radiation exposures in areas adjacent to the chemical plant site are low-level, chronic exposures. Table 5 contains the internal and external doses calculated for potentially exposed persons near the chemical plant site.

TABLE 5. EFFECTIVE RADIATION DOSES FOR EXPOSURE SCENARIOS (Including Background)

Exposure point	Exposed Population	Internal Effective Dose mrem/yr	External Effective Dose mrem/yr
Quarry or Raffinate Pits	Swimmers	0.4	<0.01
Training Area	U.S. Army Reservists	68.8	0.01
Conservation Areas	Anglers Hunters Hikers	4.7 9.1 6.1	<0.01 <0.01 <0.01
Off-Site Private Wells	Residents with contaminated wells	29.4	n.a.
Francis Howell High School	Staff and students	0.3	n.a.
Crops (corn)	Consumers of corn grown in conservation areas	37.3	n.a.
n.a. denotes no external dose calculated, but ATSDR believes it is much less than 0.01 mrem/yr			

The total effective radiation doses for specific activities or populations near the chemical plant site including background are less than the International Commission on Radiological Protection (ICRP) recommended 100 mrem/yr (excluding background) for the general public. These calculated annual effective doses are unlikely to result in health effects. Therefore, based on the exposure scenarios evaluated in this public health assessment, the chemical plant site does not pose a public health hazard.

Data Quality

The contaminant values recorded in this public health assessment are based on data developed for the U. S. Department of Energy, the Department of the Army, and the State of Missouri. These data were transferred electronically to ATSDR and translated into ATSDR's Federal Facilities Information Management System (FFIMS). The FFIMS contains a Geographic Information System, which relates environmental sampling data to the location the data represent. Many of the environmental data ATSDR received could not be matched with geographic locations, and many of the geographic locations did not have corresponding data values. When data values appeared erroneous, ATSDR staff members confirmed them with site managers. Published reports and documents were used when possible to supplement analysis of the electronically-transmitted data.

The information ATSDR received included specific quality control parameters, such as field blanks, laboratory blanks, duplicate samples, and detection limits. Detection limits for all data used in this report were lower than appropriate health comparison values, enabling ATSDR to have confidence in its ability to evaluate exposures to contaminants for possible adverse human health effects.

EVALUATION OF COMMUNITY HEALTH CONCERNS

The Missouri Department of Health maintains health information within the Office of Surveillance, Research, and Evaluation of the Division of Chronic Disease Prevention and Health Promotion. The data comprise several components, including a cancer registry. This section assesses information from this registry that is relevant to community health concerns or to exposures occurring at the chemical plant site.

Community members expressed concern about several types of cancers: childhood leukemia, renal cell, nasal-pharyngeal, prostate, breast, and Hodgkin's disease. There was also concern about the total numbers of cancer cases in the area. The Missouri Department of Health investigated the incidence of these types of cancer in St Charles county, as well as the incidence of all cancers in zip codes near the site (63303, 63304, 63341, and 63366) [22, 23]. The results of this investigation did not indicate that cancer incidence in these areas was elevated. However, one possible exception is for childhood leukemia in St Charles County. If funding becomes available, the Missouri Department of Health plans to conduct a more detailed investigation (i.e., a case control study versus a descriptive study) of childhood leukemia to determine possible reasons for the increase in the number of new cases of leukemia.

Community members also expressed concern about effects such as autism, infertility, alopecia, aplastic anemia, and spina bifida. However, Agency for Toxic Substances and Disease Registry (ATSDR) staff have not been able to obtain information on the number of people in the area with these conditions and, therefore, has no way of determining whether St. Charles County has higher than expected incidence rates for these diseases. In the absence of definitive information about the incidence rates for these diseases, the following sections will assess whether site contaminants have been related to those specific health outcomes identified by community members (Tables 1 and 2).

Childhood Leukemia

Incidence data on childhood leukemia in St. Charles County for 1970-1993 indicate two time periods with statistically greater numbers of cases than expected [22, 23]. A 1986 report of a hospital record search identified 13 cases (7 expected) in children under 15 for 1975-1979 [24]. However, the 22 cases identified for the whole study period (1970-1983) were not statistically greater than the 20 cases expected. Also, the geographic distribution of those cases did not appear to have any relation to the chemical plant site [22].

A more recent data analysis has found 12 leukemia cases (6 expected) in St. Charles County females under 15 years of age for the period 1985-1991, but the overall occurrence of childhood leukemia was not elevated [23]. The Missouri Department of Health plans to follow up on these results, if funding becomes available, by conducting a case-control study of childhood leukemia in St. Charles County, including a detailed evaluation of the geographic distribution of the documented leukemia cases.

Most of the concerns about leukemia incidence have questioned the role of on-site radioactive contaminants as a cause of leukemia. The primary radioactive materials at the site are uranium, thorium, and their respective decay products. Neither uranium nor thorium has been linked to childhood leukemia [25, 26]. The incidence of leukemia has been linked to benzene, unidentified viral agents, and very high doses of radiation [27, 28]. ATSDR has not identified exposure to these contaminants.

Autism

ATSDR does not have information about the incidence rate of autism in St. Charles County. However, none of the contaminants present at the chemical plant site have been causally related to autism, and ATSDR scientists have not identified any completed pathways of public health significance.

Renal Cell Cancer

Uranium and several other heavy metals (i.e., mercury and lead) that are present at the chemical plant site have been linked to renal diseases following oral and inhalation exposures [25, 29, 30]. However, these metals have not been linked to renal cell or other kidney cancers. The information in the Missouri cancer registry for St. Charles County does not indicate a higher than expected rate of kidney cancers for this area. Based on the information available, exposure to site contaminants are not expected to result in renal cell cancer in residents of St. Charles County.

Alopecia

The State of Missouri's birth and death registries do not include the incidence rate of alopecia, so ATSDR staff has no information about expected or observed rates. Many contaminants have been linked to alopecia, including several that are present at the chemical plant site [25, 29, 30, and Appendix D]. In areas of potential public exposure, these contaminants are present at background concentrations. Consequently, exposure at the conservation area is essentially the same as exposures in residential areas of nearby St. Charles County.

Although exposure to these contaminants cannot be ruled out as a cause of alopecia, doses for these contaminants via soil ingestion are much lower than those expected to create health problems. Additionally, there has been no identification of pathways of significant exposure to site contaminants.

Infertility

The State of Missouri's birth and death registries do not include incidence rates for infertility, so ATSDR staff have no information about expected or observed rates. Reproductive problems have not been identified with exposure to uranium [29] or thorium [23], although infertility has been associated with very high radiation exposures [19]. The radiation doses that have been linked with temporary or permanent infertility [19] are single doses that are 10,000 to 350,000 times greater than the largest annual exposure identified at Weldon Spring (i.e., military personnel at training area). ATSDR has not identified any pathways of radiation exposure that are capable of producing adverse health effects.

Hodgkin's Disease, Nasal-Pharyngeal Cancer, Prostate Cancer, Unspecified Cancer (total cancers), Breast Cancer, and Aplastic Anemia

Data from the Missouri Cancer registry do not indicate higher than expected incidence rates for any of these cancers or for aplastic anemia in St. Charles County. ATSDR scientist have not identified any pathways of significant exposure to any contaminants at the chemical plant site. The available data do not indicate that exposure to contaminants from the chemical plant site have caused these diseases in residents living around the site.

Physical Hazard of Localized Explosive Materials

Institutional controls restrict (if not totally eliminate) public access to areas within the chemical plant site, the Weldon Spring Training Area, and conservation areas that have significant levels of explosives contamination. Localized high concentrations are not a danger in terms of accidental detonation, since even the pure product (2,4,6-trinitrotoluene [TNT] or 2,4-dinitrobenzene [DNT]) is extremely insensitive to physical shock. Also, remedial procedures appropriate to the prevention of inappropriate handling or exposure to explosive materials are in place [18].

PUBLIC HEALTH ASSESSMENT

WELDON SPRING SITE REMEDIAL ACTION PROJECT
(CHEMICAL PLANT, RAFFINATE PITS, QUARRY)
ST. CHARLES, ST. CHARLES COUNTY, MISSOURI

CONCLUSIONS

The Weldon Spring Site Remedial Action Project (chemical plant site), which includes the chemical plant, raffinate pits, and quarry, poses *no apparent public health hazard* to the general public. Access restrictions prevent public exposure to chemical and radioactive contaminants on site. In general, the public is not exposed to chemical and radioactive contaminants off site. However, in the event of potential off-site exposure, the cumulative chemical or radioactive contaminant exposure from multiple exposure pathways poses no apparent public health hazard.

We developed six conclusions while performing this public health assessment:

1. On-site soil, sediment, sludge, surface water, groundwater, and asbestos in the chemical plant, raffinate pits, and quarry areas *do not pose a public health hazard*. Currently, access restrictions prevent public exposure to on-site chemical and radioactive contaminants; therefore, no exposure pathways exists. In addition, infrequent short-term exposure to on-site chemical contaminants (e.g., exposures to past trespassers and quarry or raffinate pit swimmers) is unlikely to result in health effects. However, frequent long-term exposure to on-site chemical contaminants may result in exposure doses that are associated with adverse health effects.

2. Off-site surface water in the Weldon Spring Training Area, the August A. Busch Memorial Conservation Area, and the Weldon Spring Conservation Management Area *poses no public health hazard*. Public exposure is possible through contact with a few springs and streams. Incidental ingestion of water containing these contaminant concentrations (short-term exposure) will not result in any health effect.

3. Drinking water obtained from the St. Charles County well field for the St. Charles County Water Supply District #2 *poses no public health hazard*. Contaminants from the Weldon Spring quarry have not been detected at the St. Charles County well field. Ongoing remediation at the quarry will reduce the potential for contaminant migration.

4. The release of treated effluent from the chemical plant site *poses no public health hazard* for St. Louis communities obtaining drinking water from the Missouri River. Current procedures for treating and monitoring effluent prior to release are protective of public health.

5. Field activities performed by U.S. Army Reservists in the training area; fishing by anglers, hunting by hunters, and hiking by hikers in the conservation areas; drinking from off-site private wells; teaching at, working in, and attending the Francis Howell High School; and consuming crops (e.g., corn) grown in conservation areas pose(d) *no apparent public health hazard*. Swimming in the quarry or raffinate pits by trespassers also posed *no public health hazard*.

6. St. Charles County might have had an elevated incidence of childhood leukemia for several years

during the period 1985-1992. However, there has been no identification of pathways of contaminant exposure that could link the leukemia cases or any other community health concern to the chemical plant site.

The following conclusions are based on findings in the 1995 Public Health Assessment for the Weldon Spring Ordnance Works Site and pertain to chemical contaminants only. Some of the cited conclusions have been augmented by current review and study performed during this health assessment.

7. In the past, exposure to groundwater from off-site private wells was an *indeterminate public health hazard* [1]. This drinking water exposure pathway was eliminated in 1989, when citizens were provided bottled water [1]. Groundwater from off-site private wells poses *no public health hazard*, because no one is consuming the groundwater (i.e., the drinking water pathway is incomplete).

8. Fish and game animals from the conservation areas *pose no apparent public health hazard* [1].

9. Exposure to off-site soil and groundwater in the Weldon Spring Training Area, August A. Busch Memorial Conservation Area, and the Weldon Spring Conservation Management Area is incomplete and *does not pose a public health hazard* [1]. In addition, infrequent short-term exposure to contaminants in on-site soil and groundwater is unlikely to result in health effects [1]. However, frequent long-term exposure to on-site contaminants may result in exposure doses that can cause adverse health effects.

Health Activities Recommendations Panel (HARP) Statement

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, requires the Agency for Toxic Substances and Disease Registry (ATSDR) to perform public health actions needed at hazardous waste sites. The ATSDR Health Activities Recommendation Panel (HARP) evaluated the data and information developed in the Weldon Spring chemical plant site Public Health Assessment to determine the need for follow-up health actions. Because people have not been exposed to contaminants at levels of health concern in the past, are not currently being so exposed, and are unlikely to be so exposed for the foreseeable future, no follow-up health studies are indicated at this time. ATSDR will reevaluate the need for follow-up health actions if new information about this site becomes available.

PUBLIC HEALTH ACTIONS

The public health action plan for the U. S. Department of Energy (DOE) Weldon Spring Remedial Action Project National Priorities List (NPL) Site (chemical plant, raffinate pits, and quarry) contains a description of actions the Agency for Toxic Substances and Disease Registry (ATSDR) and/or other governmental agencies will take at and in the vicinity of the site after the completion of this public health assessment. The purpose of this plan is to ensure that this public health assessment not only identifies public health hazards but provides a plan of action to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. An Agency for Toxic Substances and Disease Registry (ATSDR) commitment to follow up on this plan is included to ensure the plan's implementation. The following public health actions are to be implemented:

ACTIONS PLANNED

1. ATSDR will coordinate with the Missouri Department of Health in the ongoing inquiry into cancer incidence in the Weldon Spring area.

2. The State of Missouri should continue to monitor private groundwater wells in the vicinity of the site. Samples should be analyzed for appropriate contaminants.

3. ATSDR will review remedial activities proposed in relation to the protection of public health. ATSDR

will provide comments, and recommendations as appropriate to the U.S. Environmental Protection Agency (EPA), the DOE, and the State of Missouri.

4. The DOE, the EPA, and the State of Missouri should continue to monitor the water treatment plant's effluent and verify that National Pollutant Discharge Elimination System permit requirements are met before the water is released to the Missouri River.

5. The DOE must maintain administrative control and access restrictions for the chemical plant site and quarry as long as waste materials remain on site or until cleanup of contaminated areas is complete.

ATSDR will reevaluate and expand the Public Health Action Plan as needed. New environmental, toxicological, or health outcome data, or the results of implementing the above proposed action may determine the need for additional actions at the site.

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FIGURES


Figure 1. Location Map - Weldon Spring Area

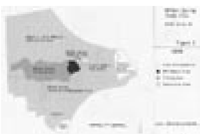
Figure 2. Weldon Spring Study Area


Figure 3. Chemical Plant Site


Figure 4. Chemical Plant Site

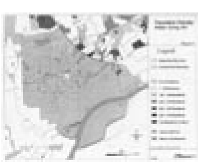
Figure 5. Population Density

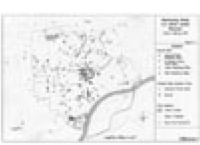
Figure 6. Monitoring Wells and Other Water Sources

Figure 7. Locations of Contaminated Lakes and Surface Soil

PUBLIC HEALTH ASSESSMENT

WELDON SPRING SITE REMEDIAL ACTION PROJECT
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APPENDIX A: CHEMICAL EVALUATION

Agency for Toxic Substances and Disease Registry (ATSDR) scientists consider several factors in evaluating environmental sampling data and determining the public health significance of exposure, including the following: (1) concentration of contaminants on and off a site; (2) sampling design, (3) comparison of site-related contaminants concentrations with background concentrations, ATSDR health-based comparison values for noncarcinogenic and carcinogenic endpoints, other standard health-based doses, and medical and toxicological information; and (4) community health concerns.

Evaluating sampling design includes reviewing approaches used to find contamination. ATSDR considers several factors when determining the contaminants to which people might be exposed: spatial distribution of sampling locations, sampling frequency, concentration changes over time, medium-to-medium differences, and correlation between the selected list of analytic parameters and suspected environmental contaminants.

For each medium of concern, health assessors compare site-related data with background data to decide whether the site is the source of contamination. They use state, regional, or national background data when local data are not available. High levels of chemicals from native mineral deposits or other natural sources may influence background levels in local soil and water significantly. Background levels could be anthropogenic substances in the environment from manufactured, non-site sources (e.g., gravel for a road or parking lot). If the maximum concentration of contaminants exceeds background levels, ATSDR scientist will evaluate these exposures further.

ATSDR scientist perform preliminary screenings of chemical contaminants at potential and completed exposure areas by comparing the maximum chemical concentrations in to chemical- and media-specific ATSDR health-based comparison value. ATSDR scientist use the results of this conservative preliminary screening to select contaminants for further evaluation. The comparison values include Environmental Media Evaluation Guides (EMEGs), Reference Dose-based Media Evaluation Guide (RMEGs), and Cancer Risk Evaluation Guides (CREGs) developed by ATSDR; and Reference Dose (RfD), Maximum Contaminant Levels (MCLs), and Maximum Contaminant Level Goals (MCLGs) developed by the U.S. Environmental Protection Agency (EPA).

EMEGs, RMEGs, and CREGs are media-specific comparison values ATSDR developed to assist scientist in selecting environmental contaminants for further evaluation for potential health impacts. EMEGs are based on ATSDR minimal risk levels (MRLs) and factor in body weight and ingestion rates. RMEGs are derived from the EPA oral Reference Dose. EMEGs and RMEGs do not consider carcinogenic effects. CREGs are estimated contaminant concentrations based on one excess cancer in a million people exposed over a lifetime. CREGs are calculated from EPA's cancer slope factor.

An EPA RfD is an estimate of the daily exposure to a contaminant that is unlikely to cause adverse health effects. EPA's MCLG is a drinking water health goal. These values include margins of safety and represent levels where no known or anticipated adverse health effects should occur. EPA's MCLs represent contaminant concentrations that EPA deems protective of public health (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an exposure rate of 2 liters of water per day. While MCLs are regulatory concentrations, MCLGs are not.

These comparison values provide estimates of levels believed to be without adverse health effects. These comparison values are extremely conservative and protective of public health, in that these values are based on daily long-term exposure to chemical doses that are unlikely to result in adverse health effects. The comparison values are usually derived from animal studies and occupational exposures. The severity of health effects is related not only to the exposure dose but to the route of exposure (entry into the body) and the amount of chemical the body absorbs. For those reasons, comparison values used in public health assessments are contaminant concentrations in specific media and for specific exposure routes. There may be several comparison values for a specific contaminant. ATSDR generally selects the comparison values that are calculated using the most conservative exposure assumptions to protect the most sensitive segment of the population.

Evaluators used the following assumptions to calculate comparison values (EMEGs, CREGs, and RMEGs) used in this public health assessment:

Child Body weight = 16 kilograms (kg)
Water ingestion rate = 1 liter(L)/day

Soil ingestion rate = 200 milligrams (mg)/day
Pica soil ingestion rate = 5000 mg/day

Adult Body weight = 70 kg
Water ingestion rate = 2 L/day
Soil ingestion rate = 100 mg/day
Occupational soil ingestion rate = 500 mg/day

Listing of a contaminant in this public health assessment does not mean exposure to the contaminant will cause adverse health effects. Rather, the listing of a contaminant indicates that the concentration of the contaminant exceeded an ATSDR screening comparison value and that the contaminant has been evaluated in further detail using realistic site-specific exposure scenarios with standard health-based doses (MRLs, RfD) that are unlikely to cause an appreciable risk to health as well as to other medical and toxicological health guidelines.

APPENDIX B: TOXICOLOGICAL IMPLICATIONS

Uranium

The following is a brief description of the health effects of ingested uranium. Approximately 0.2-5% of ingested uranium transfers to the body; the body excretes the remainder. The major sites of uranium deposition are bone and kidneys. The health effects of uranium in the bone results from its radioactive decay. Appendix C, Radiation Evaluation, describes the cumulative health effects of uranium and the other radionuclides detected in areas at the chemical plant site. The effects of uranium in the kidneys result primarily from its binding to certain kidney structures (renal tubular cells), causing the tubular cells to die. The death of renal tubular cells can lead to kidney damage. One to three micrograms uranium per gram (µg/g) of renal tissue is the threshold for nephrotoxicity. To protect the public, it is recommended not to exceed a kidney dose of 0.1 µg/g, which corresponds to a total uranium content of 31 µg for 2 kidneys in a standard man (70 kilograms, or 154 pounds).

In an actual case for an acute exposure to uranium at a kidney dose of 86.717 mg, initial effects included dizziness, nausea, anorexia, abdominal pain, diarrhea, tenesmus, and pus and blood in the stool.

Thorium

Studies on thorium workers have shown that breathing thorium dust may cause an increased chance of developing lung disease and cancer of the lung or pancreas many years after exposure. Changes in the genetic material of body cells have also occurred in workers who breathed thorium dust. Liver diseases and effects on the blood have appeared in people who have received thorium injections for special X rays. Many types of cancer have also occurred in these people many years after the thorium injections. Since thorium is radioactive and may be stored in bone for a long time, bone cancer is also a potential concern for people exposed to thorium. Animal studies have shown that breathing thorium may cause lung damage. Other animal studies suggest that drinking massive amounts of thorium can cause death from metal poisoning. The presence of large amounts of thorium in the environment could result in exposure to more hazardous radioactive decay products of thorium, such as radium and thorium. Thorium is not known to cause birth defects or infertility.

Nitroaromatics

The understanding of nitroaromatics' effects on humans is based on the evaluation of exposure by way of inhalation of pure product during manufacturing activities. The concentrations in soil are obviously many orders of magnitude smaller that those workers would have encountered in the production facilities, and the potential exposures from soil are short-term and infrequent.

The first thorough documentation of the toxic effects of 2,4,6-trinitrotoluene (TNT) occurred during large-scale production of TNT during World War I. Many workers in munitions factories died of TNT intoxication. With application of hygienic precautions (such as periodic hand-washing, routine changes of protective clothing, and respiratory protection) to prevent inhalation exposure, fatalities decreased. Liver disease and aplastic anemia were the primary resulting causes of death. Absorption of TNT through the skin or lungs can produce cyanosis (lack of oxygen-carrying capacity of the blood), severe liver damage, anemia, cataract formation, central nervous system effects, and kidney damage.

Long-term, low-dose TNT-ingestion studies have been carried out in mice, rats, and dogs. Hematological signs of anemia and liver damage appeared at higher doses in mice and rats over a 24- to 26-week period. When dogs were fed TNT over 26 weeks, liver damage appeared at all dosage levels. Increased incidence of urinary bladder papilloma and carcinoma resulted in female rats. Using this study, EPA classified TNT as a Group C chemical (possible human carcinogen). It should be emphasized, however, that these effects were the result of *long-term* exposure by ingestion, not of such infrequent, incidental exposures that site trespassers would likely encounter.

There is no information available on the health effects of 1,3,5-trinitrobenezene (TNB). Because of its structural similarity to 1,3-dinitrobenzene (DNB), assumptions are that its health effects might be similar to those caused by DNB. Data about health effects after exposure to DNB are limited. Six workers exposed to an unknown concentration of DNB dust developed cyanosis that began within 1 day of exposure and lasted 2 weeks. Health effects also included anemia accompanied by palpitations, dizziness, and fatigue. Anemia persisted an average of three days. Follow-up examinations over a 10-year period did not reveal any adverse health effects. Well-documented health effects in animals include toxic effects resulting in death and pathological effects on the liver, spleen, and testes. These effects resulted in weight loss, anemia, and decreased reproductive capacity. There was some evidence of increased toxicity in older animals. A 16-week study of rats' ingestion of DNB in drinking water detected both splenic and testicular effects. High uncertainty factors apply because of lack of long-term studies. DNB is considered a Class D chemical (not classified as to human carcinogenicity) because of lack of information about its carcinogenicity. Because of the uncertainty of using DNB studies to develop guidelines for TNB, additional safety assumptions were included in the calculations. As is the case with TNT, the effects noted are for long-term ingestion, not the infrequent, incidental exposure that trespassers would experience.

Lead

The effects of lead once it is in the body are the same, regardless of how it enters the body. Exposure to lead is especially dangerous to unborn children, infants, and young children. For infants and young children, lead ingestion has been shown to decrease intelligence scores, slow growth and cause hearing impairment. Exposure to high lead levels can cause brain and kidney damage in both children and adults. There has been no demonstration of lead's ability to cause cancer in humans. To date, workplace studies do not provide enough information to determine workers' risk of cancer from lead exposure. However, some research with rats and mice has shown tumors will develop in subjects fed large doses of lead [30]. The concentrations of lead in some soil samples at the training area are elevated to the point where exposure may reasonably be considered a hazard.

Polychlorinated Biphenyls

EPA has classified polychlorinated biphenyls (PCBs) as probable human carcinogens. Human studies show that acne-like rashes can occur as a result of occupational exposures to PCBs. Other studies of occupational exposure suggest that PCBs might cause liver cancer. Reproductive and developmental effects may result from occupational exposure. It must be emphasized that these effects are not definitively proven.

Asbestos

The U.S. Department of Health and Human Services has determined that asbestos is a known carcinogen. Information on health effects of asbestos in humans comes from studies of workers exposed to high levels of asbestos in the workplace. These worker studies revealed increased incidence of lung cancer and mesothelioma. These diseases develop over a period of years, and both are usually fatal. There is also evidence to suggest increased incidence of other cancers (e.g., cancers of the stomach, intestines, esophagus, pancreas, and kidneys). Members of the public exposed to lower levels of asbestos may be at increased risk for cancer, but the risk is usually small and difficult to verify. Exposure via inhalation also poses the risk of asbestosis, scarring of the lungs. This disease causes breathing difficulty and decreases blood flow in the lungs. Asbestosis is a serious illness, in most cases resulting from exposure to high levels of asbestos via inhalation. There is little evidence that exposure via consumption of asbestos results in adverse health effects.

APPENDIX C: RADIATION

APPENDIX C1: Radiation Overview

Because radiation has been found at the chemical plant site and adjacent areas and because many people are unfamiliar with radiologic terms, a brief overview is presented here. All matter is composed of atoms. An atom is the smallest particle of a chemical element that can be divided and still retain the characteristic properties of the element. The basic components of an atom are protons, neutrons, and electrons. The quantity of those particles combined with their energy state determine the stability or instability of an atom. If an atom is unstable, it can break down into a more stable atom. When that happens, the unstable atom ejects either a particle or a known amount of energy, and the atom develops greater stability. That process is radioactive decay. The ejected particle or energy is the radiation; the atom that decays is a radionuclide [1].

The ejected particle or energy may be one of three types of radiation: alpha particles, beta particles, or gamma photons. When radioactive decay occurs, the radiation produced can interact with nearby objects. During that interaction, energy may be transferred or absorbed from the ejected radiation to the object of interaction. Radiation dose, measured in rad or gray, is the amount of energy transferred from the radiation to the object. It is believed that the three types of radiation affect people with different degrees of severity. The alpha particle has the greatest biological effect, the beta particle has a mid-range biological effect, and the gamma has the least biological effect. Therefore, other units of measure, rem or sievert, express radiation dose to people and incorporate the biological effectiveness of each radiation type [2].

The penetrating gamma rays and other types of shorter-range radiation particles interact with material and cause ionizations. The number of ionizations that occur in a given volume of air indicate the amount of radiation present in the nearby area. By counting the number of ionizations in a gamma radiation detector, an investigator can determine whether gamma-emitting radionuclides are present [3].

When ionizing radiation travels through the body, it can change the structure of molecules in the body [2]. The changed molecular structure may have the following results:

- restorate its original structure,
- lead to impaired physiological function,
- lead to a different physiological function, or
- change the genetic code for future cells, tissues, and organs [4].

Cells that repair their molecular structure behave as normal, unaffected cells in the body [2]. Cells that do not repair their molecular structure (e.g., those with damage to the nucleus) can have an impaired or different function [4]. That is, unrepaired molecules within a cell can lead to abnormal cellular behavior within the body. If the impaired function of a cell is severe enough, it can lead to the death of that cell (i.e., cellular death) [2, 5, 6].

At moderate to high doses of radiation (acute exposure), a number of biological effects--ranging from vomiting and fatigue to changes in the blood and cellular death--are observed [2, 4]. The health effects caused by moderate doses (acute exposures) are generally observed with gamma doses of 25,000 to 50,000 millirads (mrads) [i.e., 25,000 to 50,000 millirem (mrem), which is very large when compared with the public exposure limit of 100 mrem/year] [2]. At high doses, the number of cell deaths may overwhelm the body, leading to the death of the individual [2]. Acute-exposure effects at high doses generally begin to occur at gamma doses of 200,000 mrads (i.e., 200,000 mrem) [2].

The radiation exposures at the chemical plant site and adjacent areas are low-level, chronic exposures. At low doses of radiation (chronic exposure), the body can recover from the death of cells caused by impaired physiological function, but those cells that are not repaired and survive with an impaired or different function can be a source of mutations [4]. Cancer is believed to be the predominant health effect associated with chronic radiation exposures [2, 6]. However, epidemiological methods show increased risks of cancer on the order of 1 in 10 to 1 in 10,000 (1/10 to 1/10,000) for 1,000 to 10,000 mrad (i.e., 1,000-10,000 mrem) exposures [7]. The lowest level of risk that can be attributed to a radiation exposure is 1.40 (i.e., a 40% relative excess); therefore, no direct epidemiological method exists to link cancer incidence with radiation exposures less than 10,000 mrem [7]. For the purposes of radiation protection, it is assumed that the incidence of cancer increases linearly as radiation doses increase [2, 7].

APPENDIX C2: Radiation Exposure and Dose Standards

The Agency for Toxic Substances and Disease Registry (ATSDR) has evaluated contaminants discussed in subsequent sections of this appendix to determine whether exposure to them has public health significance. To select contaminants for discussion, ATSDR considers several factors: contaminant concentrations compared with health-based values, potential pathways of exposure, and community health concerns.

ATSDR's approach to evaluating radionuclides and other radioactive materials differs from the agency's approach to evaluating nonradioactive hazardous materials. Because of the additive effects of radiation on the human body, investigators calculate the dose from radionuclide or radioactive materials for all exposure routes. Once they have determined the doses by various routes, they calculate a total dose.

This public health assessment contains discussions of health effects that may result from exposures to site contaminants. Chemicals released into the environment do not always result in human exposure. People can be exposed to a chemical contaminant only if they breathe, ingest, or touch the contaminant. If radioactive materials are present, individuals can experience exposure by just being near contaminated water, soil, or air (i.e., irradiation by external sources) [2, 8].

Several factors influence exposure: the exposure concentration (how much), the duration of exposure (how long), the route of exposure (breathing, eating, drinking, skin contact, or proximity to gamma-emitting radionuclides), and the multiplicity of exposure (combination of contaminants). Once a person is exposed, individual characteristics--age, sex, nutritional and health status, lifestyle, and family traits--influence how the contaminant is absorbed (taken up by the body); metabolized (broken down by the body); and excreted (eliminated from the body). When the contaminant is a radionuclide, the same factors and individual characteristics apply, along with exposure via external irradiation, in determining the health effects.

ATSDR researched the scientific literature to determine the possible health effects of radionuclides. For information about radiological hazards, ATSDR reviewed the International Commission on Radiological Protection (ICRP) publications. ICRP's basic responsibility is to provide guidance in matters of radiation safety by preparing recommendations on the basic principles of radiation protection. The recommendations are published in reports and various journals (e.g., publications of the ICRP).

For purposes of radiation safety standards, ICRP recognizes three categories of exposure: occupational, public, and medical. For members of the public, ICRP recommends an effective-dose limit of 1 millisievert (mSv) [100 millirem (mrem)] above background in a year [9]. (That limit is for the purposes of radiation protection only. No adverse health effects have been directly attributed to a radiation exposure at that level.) ICRP does not make recommendations for medical exposures. However, the commission does recommend that people receive only necessary exposures and that exposures be limited to the minimum dose necessary for medical benefit to the patient.

The current ICRP recommendations specify an annual limit on intake, defined as the amount of radionuclide that delivers the occupational effective-dose limit from ingestion or inhalation exposures. ICRP staff members use the average career span of an occupationally exposed person--50 years--to calculate the occupational annual limit of intake. ICRP recommends using the average lifetime of an individual (70 years), and the public's effective-dose limit, 1 mSv (100 mrem) per year, to determine the public's annual limit of intake by way of ingestion or inhalation.

The probability and severity of health effects increase as exposure to radiation increases, although exposure to background levels of radiation (i.e., those levels naturally occurring in the environment) are thought not to produce noticeable health effects in humans [7]. Thus, for radiation protection purposes, the dose resulting from radiation exposures above background is calculated as an indicator of potential health effects.

In evaluating the data on radioactive contaminants for this public health assessment, ATSDR could not calculate annual background values in each medium at each exposure point under investigation. Thus, to calculate radiation doses from exposure to a contaminated medium, ATSDR used the maximum concentration detected in that medium. The concentrations are values transmitted from the Department of Energy or the Department of the Army. In cases where needed data were not in the database, ATSDR used maximum concentrations found in published documents. One exception was the case of inhaled radionuclides. For inhaled radionuclides, ATSDR modified published dose estimates instead of using measured air concentrations to calculate inhalation doses.

APPENDIX C3: Radiation Doses at the Chemical Plant Site

Introduction

Radiation dose is usually divided into two categories, internal and external. Internal doses result from exposure to radioactive sources inside the body; external doses result from exposure to radioactive sources outside the body [2].

Whether an exposure contributes to a person's internal or external dose depends primarily on the type of radiation to which a person is exposed. Most alpha particles cannot travel far and are prevented from entering the body by the body's dead layer of skin. Because the dead layer of the skin--the epidermis--can stop the alphas particles, the particles do not contribute a biologically significant dose. Therefore, exposures to alpha particles originating outside the body would not contribute to a person's external dose; however, if an alpha particle source is deposited within the body, it could (depending on its location) contribute to a person's internal dose. Gamma photons can travel long distances and can easily penetrate and irradiate body tissues; therefore, people can be exposed to gamma photons through both external or internal sources. Beta particles also may be responsible for both internal and external doses, but they do not penetrate body tissue as easily as gamma photons, limiting the dose from external sources. The total dose is the sum of a person's external and weighted internal doses [2].

For internally deposited radionuclides, the Agency for Toxic Substances and Disease Registry's (ATSDR's) quantitative evaluation of exposures at the chemical plant site and nearby areas considered media-specific and activity-specific rates for soil and water ingestion and for fish, wildlife, and vegetable (e.g., corn) consumption. ATSDR staff calculated the radiation doses by first estimating a person's annual intake of radioactive material from an exposure scenario. They then multiplied the annual intake rate (i.e., exposure) of a particular medium by its maximum concentrations of radionuclides found in nearby areas. Finally, they compared the estimated annual intake to the public's annual limit on intake (ALI)[1], which infers the annual radiation dose to a hypothetical individual.

For radiation dose resulting from inhalation of radioactive material, ATSDR staff modified existing inhalation dose estimates to correspond to the exposure scenarios in this public health assessment. They did this because the Department of Energy (DOE) air data transmitted to ATSDR were not compatible with the computer formats used by the ATSDR Federal Facilities Information Management System.

For external exposures at the chemical plant site, ATSDR staff assumed the primary external source at chemical plant site and associated areas is soil and that the soil is evenly contaminated throughout to a depth of 15 centimeters. ATSDR's quantitative evaluation of exposure to adults consisted of multiplying the gamma ray exposure factor for each radionuclide found in the soil by its maximum concentration and the time spent in the contaminated area (see exposure scenarios).

Radionuclide Concentrations in Media

The remedial investigation for the Chemical Plant Area indicates that the site is contaminated with uranium and possibly thorium. This investigation shows that concentrations of uranium and thorium are higher than expected background in some areas, but that subsequent decay products in the same areas are not as high, indicating uranium and thorium contamination.

In soils, ATSDR assumed, for the Uranium-238 (U-238) decay series, that U-238 was in radioactive equilibrium with its next three decay products [Thorium-234 (Th-234), Protactinium-234m (Pa-234m), and Uranium-234 (U-234)]; and that the Thorium-230's (Th-230) activity was four times as great as the activity of its successive decay products, which were all in radioactive equilibrium with each other [Radium-226 (Ra-226), Radon-222 (Rn-222), Polonium-218 (Po-218), Lead-214 (Pb-214), Bismuth-214 (Bi-214), Lead-210 (Pb-210), Bismuth-210 (Bi-210), Polonium-210 (Po-210), and Lead-206 (Pb-206)]. One exception to this assumption is at the Conservation Areas where ATSDR investigators did not assume the 4:1 ratio because they knew the actual Th-230 concentration.

For the Uranium-235 (U-235) decay chain, ATSDR assumed that U-235 was in radioactive equilibrium with its immediate decay product, Thorium-231 (Th-231), and that the subsequent decay products (of the U-235 contamination) do not have quantities sufficient for assessment. For the Thorium-232 (Th-232) decay chain, ATSDR assumed that all of the decay products were in radioactive equilibrium with Th-232 [note that Polonium-212's (Po-212) concentration is 64% of Th-232's and that Thallium-208's (Tl-208) concentration is 36% of Th-232's because of the natural branching ratio in the Th-232 decay scheme]. Table C.1 (page C-9) shows the maximum radionuclide soil concentrations at the chemical plant site and nearby areas.

However in water, fish, and wild game, radioactive equilibrium for the decay chains may not exist because there are different water solubilities, hydrological conditions, and bio-availability uptake and retention mechanisms. Therefore, in these media, ATSDR evaluated only the dose contribution from the measured radionuclide and not the contribution from other members of the decay chain. Table C.2 (page C-10) shows the maximum radionuclide concentrations in water, fish, and wild game at the chemical plant site and nearby areas.

For inhalation, ATSDR did not calculate doses based on concentrations of radionuclides in air, but rather calculated them based on published results of the Weldon Spring Historical Dose Estimate [11].

The time frames of interest for this health assessment include past (1969-1982), present (1983-1995), and future (1996 and beyond) exposures. The historical dose estimates also covered three time periods: 1957-1966, 1967-1969, and 1969-1982. ATSDR based its inhalation dose on the results of the 1969-1982 dose estimates. The inhalation doses for that time frame are based on airborne resuspension of radioactive particles and are estimated to be 0.2 millirem per year (mrem/yr) to the maximally exposed individual (here taken as a worker in the County Extension Center exposed for 8 hours per day, 5 days per week, for 50 weeks per year [2,000 hours per year]).

TABLE C.1. MAXIMUM REPORTED OR CALCULATED RADIONUCLIDE SOIL CONCENTRATIONS

Radionuclide	Maximum Soil Concentration (pCi/g)[1, a]	
	Training Area	Conservation Areas
U-238[2]	29,530	3,020
Th-234	29,530	3,020
Pa^m-234	29,530	3,020
U-234	29,530	3,020
Th-230	160.4	10,100
Ra-226[2]	40.1	430
Rn-222	40.1	430
Po-218	40.1	430
Pb-214	40.1	430
Bi-214	40.1	430
Po-214	40.1	430
Pb-210	40.1	430
Bi-210	40.1	430
Po-210	40.1	430
Th-232[2]	450	240
Ra-228	450	240
Ac-228	450	240
Th-228	450	240
Ra-224	450	240
Pb-212	450	240
Bi-212	450	240

U-235[2]	1,388	49.7
Th-231	1,388	49.7

[a] pCi/g = picocurie per gram.
1. To convert pCi/g to becquerel per gram (Bq/g), multiply by 0.037.
2. Values retrieved from the Weldon Spring Site Remedial Action Project database and transmitted to the Agency for Toxic Substances and Disease Registry or taken from published reports. All other values were calculated based on the radionuclide equilibrium assumption stated in the text for soil. Only one exception exists which is in the case of Thorium-230's soil concentration at the Conservation Areas. In that case, the concentration was reported in a document published by the Department of Energy.

TABLE C.2. MAXIMUM RADIONUCLIDE CONCENTRATIONS IN OTHER MEDIA

Radionuclide	Quarry or Raffinate Pits	Conservation Areas[1]			Crops	Off-Site[2]Private Wells
	Surface Water (pCi/L)[3, a]	Surface Water (pCi/L)[3, a]	Fish (pCi/g)[3, a]	Wild Game (pCi/g)[3, b]	Corn (pCi/g)[3, b]	Ground-water (pCi/L)[3, a]
U-238	2580	500.00	0.936	0.00	n.a.	n.a.
U-234	2430	378.00	0.892	0.146	n.a.	n.a.
Th-230	756	8.80	0.03	n.a.	1.49	45.1
Ra-226	164	6.42	0.15	n.a.	0.24	10.3
Pb-210	4.1	83.20	n.a.	n.a.	n.a.	n.a.
Po-210	1.3	2.30	n.a.	n.a.	n.a.	n.a.
Th-232	36.3	2.20	0.00	n.a.	0.193	8.5
Ra-228	32	15.00	n.a.	n.a.	0.836	4.0
Th-228	3.7	2.20	n.a.	n.a.	0.221	n.a.
U-235	322	38.00	0.035	0.005	n.a.	n.a.
Ac-227	5	12.7	n.a.	n.a.	n.a.	n.a.

[a] pCi/L = picocurie per liter.
[b] pCilg = picocurie per gram.
1. Values retrieved from the Weldon Spring Site Remedial Action Project database and transmitted to the Agency for Toxic Substances and Disease Registry (ATSDR).
2. ATSDR Weldon Spring database does not contain any data appropriate to evaluate exposure to radionuclides through ingestion of water from off-site private wells. However, ATSDR received off-site well monitoring data from Missouri Department of Health (unpublished data), and ATSDR used the maximum radionuclide concentrations from this data set to evaluate exposures to radionuclides in off-site wells.
3. To convert picocurie (pCi) to becquerel (Bq), multiply by 0.037.
n.a. denotes radionuclide not found in medium.

<u>Exposure Scenarios and Exposure Factors</u>

This section presents ATSDR's method of determining an individual's exposure to radioactive materials. Exposure to radioactive materials is defined in this section as the total contact one has with or spends in close proximity to radioactive materials in a year.

For each location where person(s) may have exposure to or were potentially exposed to radioactive materials, ATSDR describes the exposure scenario. The exposure scenario includes the location, area, or site of the potential exposure; the activity that people engage in that can result in potential exposure(s); the frequency and duration of the activity, the identification of the contaminated media and the radioactive contaminants; and activity-based, media-specific exposure rates. ATSDR staff members use this information to calculate an individual's exposure to radioactive materials and the resulting radiation dose.

ATSDR believes exposure to radioactively contaminated material may have occurred in several locations--Quarry or Raffinate Pits, Weldon Spring Training Area, Conservation Areas, off-site private wells, and Francis Howell High School--and in crops grown nearby. The following exposure scenarios contain the agency's rationale and calculation of activity-based, media-specific exposure quantities.

Quarry or Raffinate Pits

Swimmers Scenario

At the Quarry or Raffinate Pits, community members identified swimmers in the Quarry or Raffinate Pits as a potentially exposed population. The swimmers might have been exposed to soil (ATSDR's Federal Facilities Information Management System database contains no values for soil contamination at the Quarry or Raffinate Pits), surface water, and external radiation while swimming.

Based on anecdotal reports by concerned community members, ATSDR believes that in the past, swimmers swam in the Quarry or Raffinate Pits seven times per year for two hours per swimming event. ATSDR used an incidental water ingestion rate of 25 milliliters (mL) per swimming event (an estimate of 1/3 mouthful of water). ATSDR also determined a dose modifying factor (i.e., the inhalation scaling factor), which scales the extension center worker's inhalation dose to appropriate levels to account for possible inhalation exposures to swimmer in the Quarry or Raffinate Pits. Note: The scaling factor accounts only for the amounts of time persons spent in the area and does not account for differences in breathing rates.

Surface Water:

7 swims/year (yr) x 25 mL_{water}/swim = 175 mL_{water}/yr or 0.175 L_{water}/yr

External irradiation:

7 swims/yr x 2 hours (hrs)/swim = 14 hrs/yr

Weldon Spring Training Area

U.S. Military Reservist Scenario

At the Training Area, ATSDR identified one potentially exposed population: past U.S. military reservists. The U.S. military reservists might have been exposed to soil, air, and external radiation while performing reserve field training exercises.

ATSDR staff members believe that, in the past, reservists performed field exercises for seven days per week, 24 hours per day, 2 weeks per year. The reservists probably performed field activities (i.e., in dusty and soil covered areas) with the potential for above average incidental soil ingestion rates. Therefore, ATSDR used the incidental soil ingestion rate of 500 milligrams (mg) per day. ATSDR also determined a dose modifying factor (i.e., the inhalation scaling factor), which scales the extension center worker's inhalation dose to appropriate levels to account for possible inhalation exposures to the reservists. Note: The scaling factor accounts only for the amounts of time persons spent in the area and does not account for differences in breathing rates.

Soil:

2 weeks/yr x 7 days/week x 500 mg_{soil}/day = 7,000 mg_{soil}/yr or 7 g_{soil}/yr

External irradiation:

14 days/yr x 24 hrs/days = 336 hrs/yr

Inhalation Scaling Factor:

(14 hrs/yr) / (2,000 hrs/yr) = 14/2,000

Conservation Areas

At the Conservation Areas, the ATSDR considered the three major activities that occur in the areas and the exposures that are most likely to occur: fishing, hunting, and hiking.

Anglers Scenarios

Anglers at the Conservation Areas might have been exposed to surface water, soil, air, and external radiation while fishing. The anglers might also have been exposed by eating their catch.

The ATSDR used the annual fishing rate at the Conservation Areas of 3.5 days per year and believes anglers may fish 10 hours per fishing trip. ATSDR also believes the anglers might have accidentally ingested 0.1 liters (L) of surface water and incidentally ingested 0.1 grams (g) of soil per fishing trip. ATSDR also assumed anglers caught four fish per fishing trip, consumed all of their catch; and the average fish weighs 1 pound (454 grams). ATSDR also determined a dose modifying factor (i.e., the inhalation scaling factor), which scales the extension center worker's inhalation dose to appropriate levels to account for possible inhalation exposures to the anglers. Note: The scaling factor accounts only for the amounts of time persons spent in the area and does not account for differences in breathing rates.

Surface water:

3.5 fishing trips/yr x 0.1 L_{water}/fishing trip = 0.35 L_{water}/yr

Soil:

3.5 fishing trips/yr x 0.1 g_{water}/fishing trip = 0.35 g_{water}/yr

Fish:

3.5 fishing trips/yr x 4 fish/trip x 100%(consumption) x 454 g/fish = 6,356 g_{fish}/yr

External Irradiation:

3.5 fishing trips/yr x 10 hrs/fishing trip = 35 hrs/yr

Inhalation Scaling Factor:

(35 hrs/yr)/(2,000 hrs/yr) = 35/2,000

Hunters Scenarios

Hunters at the Conservation Areas might have been exposed to soil, air, and external radiation while hunting. The hunters might also have been exposed by eating their catch.

This exposure scenario assumes that (1) persons hunted 10 times per year for 10 hours per visit, (2) the hunter always catches wild game at a yield of 1.25 catches per visit, (3) the hunter eats all edible portions of the animal he/she catches, and (4) the average weight of the animals caught is 28.6 pounds [13 kilograms (kg)]. Hunters might also have incidentally ingested soil at a rate of 100 mg per hunting trip. ATSDR also determined a dose modifying factor (i.e., the inhalation scaling factor), which scales the extension center worker's inhalation dose to appropriate levels to account for possible inhalation exposures to the hunters. (Note: The scaling factor accounts only for the amounts of time persons spent in the area. It does not account for differences in breathing rates.)

Soil:

10 hunting trips/yr x 100 mg_{soil}/hunting trip = 1,000 mg_{soil}/yr or 1 g_{soil}/yr

Wild game:

10 hunting trips/yr x 1.25 game/trip x 13 kg/game x 100%(consumption) = 162.5 kg_{game}/yr

External irradiation:

10 hunting trips/yr x 10 hrs/hunting trip = 100 hrs/yr

Inhalation Scaling Factor:

(100 hrs/yr)/(2,000 hrs/yr) = 100/2,000

Hikers Scenarios

Hikers at the Conservation Areas might have been exposed to soil, air, and external radiation while hiking.

ATSDR believes hikers visit the site 10 times per year for 4 hours per visit and might have incidentally ingested soil at a rate of 100 mg per outing. ATSDR also determined a dose modifying factor (i.e., the inhalation scaling factor), which scales the extension center worker's inhalation dose to appropriate levels to account for possible inhalation exposures to the hikers. Note: The scaling factor accounts only for the amounts of time persons spent in the area. It does not account for possible differences in breathing rates.

Soil:

10 hikes/yr x 100 mg_{soil}/hike = 1,000 mg_{soil}/yr or 1 g_{soil}/yr

External irradiation:

10 hikes/yr x 4 hrs/hike = 40 hrs/yr

Inhalation Scaling Factor:

(40 hrs/yr)/(2,000 hrs/yr) = 40/2,000

Off-Site Private Wells

Off-Site Private Owner Scenario

ATSDR identified an exposed population as those persons who drank water from off-site private wells and breathed resuspensed air in the past.

ATSDR believes that persons may have consumed well water, via ingestion of drinking water or water-based foods, at a rate of 2 L per day for 365.25 days per year in the past. ATSDR also determined a dose modifying factor (i.e., the inhalation scaling factor), which scales the extension center worker's inhalation dose to appropriate levels to account for possible inhalation exposures to the off-site private well owners. In this case, ATSDR assumed the well users breathed the air 24 hours every day. Note: The scaling factor accounts only for the amounts of time persons spent in the area and does not account for possible differences in breathing rates.

Groundwater:

365.25 days/yr x 2 L_{water}/day = 730.5 L_{water}/yr

Inhalation Scaling Factor:

(24 hrs/day x 365.25 days/yr) / 2,000 hrs/yr = 8,766/2,000

Francis Howell High School

Student and Staff Scenarios

At the Francis Howell High School, inhalation was the most significant route of exposure identified by ATSDR staff. Because ATSDR could not fully integrate and use the DOE air data for the exposure calculation at the high school, ATSDR used dose estimates for the staff and students from the Weldon Spring Historical Dose Estimate [11] publication.

ATSDR staff members believe that, in the past, people might have been exposed to radioactive airborne particles 8 hours per day, 5 days per week, 48 weeks per year (which includes summer school) [11].

Crops Grown Nearby

Consumers of Corn

Based on concerns from members of the public, ATSDR identified an exposed population as those persons who consume corn grown near the Weldon Spring Site. The EPA Exposure Factors Handbook reports that persons may consume corn at a rate of 0.82 pounds per week.

Corn:

(52 weeks/yr) x (0.82 pounds/week) x (454 g/pound) = 19,359 g_{corn}/yr

Radiation Dose: Internal and External

Radiation dose is the measure of energy deposited in material from ionizing radiation, and it has units of energy per unit mass. Radiation dose is usually divided into two categories, internal and external. Internal doses result from exposure to radioactive sources inside the body; external doses result from exposure to radioactive sources outside the body.

Internal Radiation Dose

The International Commission on Radiological Protection (ICRP) recommendations specify an Annual Limit on Intake[2] (ALI), defined as the amount of a radionuclide that delivers the occupational effective-dose limit, 20 millisievert (mSv) [2,000 millirem (mrem)] per year, from ingestion or inhalation exposures. The ALI is calculated using the average career span of an occupationally exposed person : 50 years. ICRP recommends using the average lifetime of an individual (70 years) and the public's effective-dose limit, 1 mSv (100 mrem) per year, to determine the public's annual limit on intake (PALI) by way of ingestion or inhalation.

These calculations are based on remarks contained in ICRP Publication 26, that using an integration period of 50 years versus 70 years is adequate for members of the public because the correction factor could be no more than 70/50 (1.4). Therefore to be conservative on behalf of the public's health, ATSDR applied the 1.4 correction factor to fifty-year doses to project seventy-year doses.

The following is the general formula for the ALI:

ALI = annual effective dose limit (2,000 mrem/yr) / committed effective dose in 50 years

and for exposures to the public:

PALI = annual effective dose limit (100 mrem/yr) / committed effective dose in 70 years

PALI = ALI/(20 x 1.4)

The internal radiation dose a person receives is proportional to the amount of radionuclides in the person's body. By calculating the PALIs, ATSDR determined how much of a particular radionuclide delivers 100 mrem/year to the average person. By manipulating that, ATSDR can infer doses for the proposed exposure scenarios at the chemical plant site. Estimated internal radiation doses for each radioactive contaminant and its progeny follows.

Intake of Radionuclides

At the chemical plant site, the intake of radionuclides consisted of two routes of exposure (i.e., entrances into the body); ingestion and inhalation.

To determine the total amount of internal radionuclide intake, ATSDR multiplied the annual ingestion or consumption rate by the maximum concentration (or the calculated concentration based on equilibrium assumptions) of radionuclides for each medium to establish the amount of each radionuclide ingested per year in each medium. After the annual amounts of ingested radionuclides in each medium were calculated, the amount from each medium for each radionuclide was added to yield the total annual amount of each radionuclide ingested (presented in Table C.3, page C-20).

ATSDR health physicists then calculated the PALI for each potentially ingested radionuclide. After determining the annual intake of radionuclides and each PALI, ATSDR health physicists calculated an internal radiation dose based on each exposure scenario. Table C.4 contains the results (page C-21).

TABLE C.3. TOTAL ANNUAL INTERNAL INTAKE OF RADIONUCLIDE THROUGH INGESTION

Radionuclide	Quarry or Raffinate Pits	Training Area	Conservation Areas			Off-site private wells	Crops
	Swimmer	U.S.Military Reservist	Angler	Hunter	Hiker	Owner of well	Corn
U-238	17	7,600	260	110	110	n.a.	n.a.
Th-234	n.a.	7,600	39	110	110	n.a.	n.a.
U-234	16	7,600	250	990	110	n.a.	n.a.
Th-230	4.9	40	140	370	370	1,200	1100
Ra-226	1.1	10	41	16	16	280	170
Pb-214	n.a.	10	5.6	16	16	n.a.	n.a.
Bi-214	n.a.	10	5.6	16	16	n.a.	n.a.
Pb-210	0.026	10	6.6	16	16	n.a.	n.a.
Bi-210	n.a.	10	5.6	16	16	n.a.	n.a.
Po-210	0.0084	10	5.6	16	16	n.a.	n.a.
Th-232	0.23	110	3.1	8.8	8.8	230	140
Ra-228	0.207	110	3.3	8.8	8.8	110	600
Ac-228	n.a.	110	3.1	8.8	8.8	n.a.	n.a.

Th-228	0.024	110	3.1	8.8	8.8	n.a.	160
Ra-224	n.a.	110	3.1	8.8	8.8	n.a.	n.a.
Pb-212	n.a.	110	3.1	8.8	8.8	n.a.	n.a.
U-235	2.1	360	11	35	5.2	n.a.	n.a.
Th-231	n.a.	360	1.8	5.2	5.2	n.a.	n.a.
Ac-227	0.032	n.a.	0.2	n.a.	n.a.	n.a.	n.a.
Bi-212	n.a.	110	3.1	8.8	8.8	n.a.	n.a.

Above values are in becquerel per year (Bq/yr).
n.a. denotes intake not applicable because this radionuclide was not measured in contaminated media nor was its concentration estimated based on equilibrium conditions.

TABLE C.4. ANNUAL INTERNAL RADIONUCLIDE DOSE THROUGH INGESTION

Radionuclide	Annual Limit on Intake (Bq)[a]	Public Annual Limit on Intake (Bq)[a]	Swimmer	U.S. Military Reservist (mrem/yr)[b]	Angler (mrem/yr)[b]	Hunter (mrem/yr)[b]	Hiker (mrem/yr)[b]	Owner of well (mrem/yr)[b]	Consumers of Corn (mrem/yr)[b]
U-238	8×10^{5}	30,000	---	25.3	0.9	0.4	0.4	n.a.	n.a.
Th-234	4×10^{6}	200,000	n.a.	3.8	---	---	---	n.a.	n.a.
U-234	7×10^{5}	30,000	---	25.3	0.8	3.3	0.4	n.a.	n.a.
Th-230	3×10^{5}	20,000	---	0.2	0.7	1.9	1.8	6.1	5.3
Ra-226	9×10^{4}	4,000	---	0.3	1.0	0.4	0.4	7.0	4.3
Pb-214	1×10^{8}	4,000,000	n.a.	---	---	---	---	n.a.	n.a.
Bi-214	2×10^{8}	8,000,000	n.a.	---	---	---	---	n.a.	n.a.
Pb-210	2×10^{4}	800	---	1.3	0.8	2.0	2.0	n.a.	n.a.
Bi-210	1×10^{7}	400,000	n.a.	---	---	---	---	n.a.	n.a.
Po-210	9×10^{4}	4,000	---	0.3	0.1	0.4	0.4	n.a.	n.a.
Th-232	5×10^{4}	2,000	---	5.8	0.2	0.4	0.4	11.5	6.9
Ra-228	7×10^{4}	3,000	---	3.9	0.1	0.3	0.3	3.6	20
Ac-228	4×10^{7}	2,000,000	n.a.	---	---	---	---	n.a.	n.a.
Th-228	3×10^{5}	20,000	---	0.6	---	---	---	n.a.	0.8
Ra-224	3×10^{5}	20,000	n.a.	0.6	0.1	---	---	n.a.	n.a.
Pb-212	2×10^{6}	80,000	n.a.	0.2	---	---	---	n.a.	n.a.
U-235	7×10^{5}	30,000	---	1.2	---	---	---	n.a.	n.a.
Th-231	5×10^{7}	2,000,000	n.a.	---	---	---	---	n.a.	n.a.
Ac-227	9,000	400	---	n.a.	---	n.a.	n.a.	n.a.	n.a.

Bi-212	9×10^7	4,000,000	n.a.	---	---	---	---	n.a.	n.a.
Total			---	68.8	4.7	9.1	6.1	28.2	37.3

[a] Bq = becquerel.
[b] mrem/yr = millirem per year.
n.a. denotes internal dose not applicable because this radionuclide was not measured in contaminated media nor was its concentration estimated based on equilibrium conditions.
--- denotes individual internal doses were not greater than or equal to 0.1 mrem/yr and were considered insignificant.

Health physicists used this formula to calculate internal radiation doses:

[(100 mrem/yr)/PALI] x annual intake of radionuclide = dose.

An example follows for each exposed population for the radionuclide that contributed the largest internal dose.

Swimmers (Uranium-238)

(100 mrem/yr)/(30,000 Bq/yr) x 17 becquerel (Bq)/yr = 0.056 mrem/yr 0.0 (< 0.1, insignificant)

Military Reservist Scenario (Uranium-238)

(100 mrem/yr)/(30,000 Bq/yr) x 7,600 Bq/yr = 25.3 mrem/yr

Angler Scenario (Radium-226)

(100 mrem/yr)/(4,000 Bq/yr) x 40 Bq/yr = 1.0 mrem/yr

Hunter Scenario (Uranium-234)

(100 mrem/yr)/(30,000 Bq/yr) x 990 Bq/yr = 3.3 mrem/yr

Hiker Scenario (Thorium-230)

(100 mrem/yr)/(20,000 Bq/yr) x 370 Bq/yr = 1.8 mrem/yr

Off-Site Private Well Owner Scenario (Thorium-232)

(100 mrem/yr)/(2,000 Bq/yr) x 230 Bq/yr = 11.5 mrem/yr

Consumers of Corn (Radium-228)

(100 mrem/yr) / (3,000 Bq/yr) x (600 Bq/yr) = 20 mrem/yr

Inhalation Dose Estimates

For this public health assessment, ATSDR determined an appropriate inhalation scaling factor and multiplied it by the extension center worker's dose. The worker's dose estimates are based on the ALI method for workers; therefore, ATSDR applied a 1.4 correction factor to account for exposures to members of the public.

ATSDR staff used the following formula to calculate inhalation dose estimates:

extension workers annual dose x inhalation scaling factor x 1.4 = inhalation dose estimate.

Calculation of the inhalation dose estimates follow. (Note: The on-site inhalation dose from 1957 through 1966 was 46 millirem per year (mrem/yr), while the off-site inhalation dose since 1969 is 0.2 mrem/yr.)

Swimming Scenario

46 mrem/yr x 14/2,000 x 1.4 = 0.45 mrem/yr

U.S. Military Reservist Scenario

0.2 mrem/yr x 336/2,000 x 1.4 = 0.04 mrem/yr

Angler Scenario

0.2 mrem/yr x 35/2,000 x 1.4 < 0.01 mrem/yr

Hunter Scenario

0.2 mrem/yr x 100/2,000 x 1.4 = 0.01 mrem/yr

Hiker Scenario

0.2 mrem/yr x 40/2,000 x 1.4 = 0.01 mrem/yr

Off-Site Private Well Owner Scenario

0.2 mrem/yr x 8,766/2,000 x 1.4 = 1.23 mrem/yr

Francis Howell High School Staff and Student Scenarios

0.2 mrem/yr x 1920/2,000 x 1.4 = 0.27 mrem/yr

Table C.5 contains the total internal radiation dose for each potentially exposed population. Health physicists tabulated these values by adding the annual internal radiation dose via ingestion (from Table C.4) and the inhalation dose for each potentially exposed group.

TABLE C.5. TOTAL INTERNAL RADIATION DOSE

Potentially Exposed Person	Annual Internal Radiation Dose via Ingestion (mrem/yr)[a]	Annual Internal Radiation Dose via Inhalation (mrem/yr)[a]	Total Annual Internal Radiation Dose (mrem/yr)[a]
Swimmer	---	0.45	0.4
U.S. Military Reservist	68.8	0.04	68.8
Angler	4.7	---	4.7
Hunter	9.1	0.01	9.1
Hiker	6.1	0.01	6.1
Consumer of Private Well Water	28.2	1.23	29.4
Francis Howell High School Staff and Students	n.a.	0.27	0.3
Consumers of Locally Grown Corn	37.3	n.a.	37.3

[a] mrem/yr = millirem per year.
n.a. denotes not applicable because ingestion or inhalation of radionuclides is an incomplete exposure pathway.
--- denotes radiation doses are insignificant.

External Radiation Dose

Health physicists also calculated external doses for the populations identified in the exposure scenarios. In these calculations, to permit the use of the dose conversion factors of Federal Guidance Report No. 12, ATSDR staff members assumed the areas were homogeneously contaminated with the maximum radionuclide concentration at the surface and up to a depth of 15 centimeters. To correct the overestimation of external doses, ATSDR applied a correction factor of 10^{-4} to scale the external dose appropriately. The correction factor takes into account the fact that not all of the property is contaminated. In this case, ATSDR assumed that the ratio of the area of radiologically contaminated properties to nonradiologically contaminated properties is 1:10,000. Tables C.6 (page C-26) and C.7 (page C-27) contain external radiation dose estimates for each radioactive contaminant and its progeny.

TABLE C.6. ANNUAL EXPOSURE HOURS PER YEAR (HRS/YR) AND EXTERNAL RADIATION DOSE

Radionuclide	External Dose Conversion Factor (mrem*m^3/Bq s)[a]	Training Area		Conservation Areas					
		U.S. Military Reservist		Angler		Hunter		Hiker	
		Time Exposed per Year (hrs/yr)[b]	External Radiation Dose (mrem/yr)[c]	Time Exposed per Year (hrs/yr)[b]	External Radiation Dose (mrem/yr)[c]	Time Exposed per Year (hrs/yr)[b]	External Radiation Dose (mrem/yr)[c]	Time Exposed per Year (hrs/yr)[b]	External Radiation Dose (mrem/yr)[c]
U-238	5.52×10^{-17}	336	0.00001	35	0.0000001	100	0.0000003	40	0.0000001
Th-234	1.29×10^{-14}	336	0.002	35	0.00002	100	0.00005	40	0.00002
Pa^m-234	4.20×10^{-14}	336	0.008	35	0.00009	100	0.0002	40	0.0001
U-234	2.14×10^{-16}	336	0.00004	35	0.0000004	100	0.000001	40	0.0000004
Th-230	6.39×10^{-16}	336	0.000001	35	0.000005	100	0.00001	40	0.000005
Ra-226	1.65×10^{-14}	336	0.000005	35	0.000005	100	0.00001	40	0.000005
Rn-222	1.14×10^{-15}	336	0.0000003	35	0.0000003	100	0.000001	40	0.0000003
Po-218	2.63×10^{-17}	336	0.000000007	35	0.000000008	100	0.00000002	40	0.000000009
Pb-214	6.70×10^{-13}	336	0.0001	35	0.0002	100	0.0005	40	0.0002
Bi-214	4.30×10^{-12}	336	0.001	35	0.001	100	0.002	40	0.001
Po-214	2.40×10^{-16}	336	0.00000006	35	0.00000007	100	0.0000002	40	0.00000008
Pb-210	1.31×10^{-15}	336	0.0000003	35	0.0000004	100	0.000001	40	0.0000004
Bi-210	1.86×10^{-15}	336	0.000001	35	0.000001	100	0.000003	40	0.000001
Po-210	2.45×10^{-17}	336	0.000000007	35	0.000000007	100	0.00000002	40	0.000000007
Th-232	2.78×10^{-16}	336	0.000001	35	0.00000004	100	0.0000001	40	0.00000004
Ra-228	0.00	336	0.00	35	0.00	100	0.00	40	0.00
Ac-228	2.76×10^{-12}	336	0.008	35	0.0004	100	0.001	40	0.0004
Th-228	4.17×10^{-15}	336	0.00001	35	0.000001	100	0.000003	40	0.000001
Ra-224	2.62×10^{-14}	336	0.00008	35	0.000005	100	0.00001	40	0.000005
Rn-220	1.10×10^{-15}	336	0.000004	35	0.0000001	100	0.0000003	40	0.0000001
Po-216	4.87×10^{-17}	336	0.0000001	35	0.000000008	100	0.00000002	40	0.000000009
Pb-212	3.62×10^{-13}	336	0.001	35	0.00006	100	0.0001	40	0.00006
Bi-212	5.36×10^{-13}	336	0.001	35	0.00009	100	0.0002	40	0.0001
Po-212	0.00	336	0.00	35	0.00	100	0.00	40	0.00
Tl-208	9.68×10^{-12}	336	0.01	35	0.0006	100	0.0001	40	0.0006
U-235	3.75×10^{-13}	336	0.003	35	0.00004	100	0.0001	40	0.00004
Th-231	1.94×10^{-14}	336	0.0001	35	0.000002	100	0.000006	40	0.000002
Total of significant doses (i.e. 0.01)		0.01		---		---		---	

[a] mrem*m^3/Bq s = millirem cubic meters per becquerel second.

[b] hrs/yr = hours per year.
[c] mrem/yr = millirem per year.
n.a. denotes external dose not applicable (see explanation in text for owner of off-site private well external dose calculations).
--- denotes individual external doses were not greater than 0.01 mrem/yr and were considered insignificant. As a result, the sum of the insignificant doses is itself insignificant.

TABLE C.7. ANNUAL EXPOSURE HOURS PER YEAR (HRS/YR) AND EXTERNAL RADIATION DOSE

Radionuclide	External Dose Conversion Factor (mrem*m^3/Bq s)[a]	External Dose Factor for the Skin (mrem*m^3/Bq s)[a]	Quarry or Raffinate Pits		
			Swimmers		
			Time Exposed per Year (hrs/yr)[b]	External Radiation Dose (mrem/yr)[c]	Radiation Dose to the Skin (mrem/yr)[c]
U-238	7.95×10^{-16}	6.83×10^{-15}	14	6.12×10^{-6}	5.26×10^{-5}
U-234	1.75×10^{-15}	9.55×10^{-15}	14	1.27×10^{-5}	6.92×10^{-5}
Th-230	3.94×10^{-15}	1.01×10^{-14}	14	8.89×10^{-6}	2.27×10^{-5}
Ra-226	6.95×10^{-14}	9.31×10^{-14}	14	3.4×10^{-5}	4.6×10^{-5}
Rn-222	4.16×10^{-15}	4.90×10^{-15}	14	4.18×10^{-5}	4.92×10^{-5}
Pb-210	1.31×10^{-14}	3.00×10^{-14}	14	1.6×10^{-7}	3.67×10^{-7}
Po-210	9.03×10^{-17}	1.04×10^{-16}	14	3.5×10^{-10}	4.03×10^{-10}
Th-232	1.99×10^{-15}	7.65×10^{-15}	14	2.17×10^{-7}	8.29×10^{-6}
Ra-228	0.00	0.00	14	0.00	0.00
Th-228	2.05×10^{-14}	3.18×10^{-14}	14	2.26×10^{-7}	3.51×10^{-7}
U-235	1.59×10^{-12}	1.89×10^{-12}	14	0.0015	0.0018
Ac-227	1.3×10^{-15}	2.23×10^{-15}	14	1.94×10^{-8}	3.33×10^{-8}
Total of significant doses (i.e. 0.01)				---	---

[a] mrem*m^3/Bq s = millirem cubic meters per becquerel second.
[b] hrs/yr = hours per year.
[c] mrem/yr = millirem per year.
--- denotes external doses were not greater than 0.01 mrem/yr and were considered insignificant. As a result, the sum of the insignificant doses is itself insignificant.

Health physicists used the following formula to calculate external radiation doses:

external dose conversion factor x soil (or water) density x exposure time

x correction factor = dose.

An example follows for each exposed population for the radionuclide which contributed the largest external dose.

Swimmers Scenario (Uranium-235)

In this case, ATSDR considered two types of external radiation exposures: the radiation dose to the body and the radiation dose to the skin. ATSDR considered the skin doses because of the direct contact swimmers could have with radionuclides in the Quarry or Raffinate Pits.

To the body

(1.59×10^{-12} mrem * m^3/Bq second) x (1.6×10^6 g/m^3) x (L^{water}/1000 g_{water}) x (12 Bq/L) x (14 hrs x 3600 seconds/hr) = 0.0015 mrem/yr

To the skin

(1.89×10^{-12} mrem * m^3/Bq second) x (1.6×10^6 g/m^3) x (L^{water}/1000 g_{water}) x (12 Bq/L) x (14 hrs x 3600 seconds/hr) = 0.0018 mrem/yr

U.S. Military Reservist Scenario (Thallium-208)

(9.68×10^{-12} mrem * m^3/Bq second) x (36%) x (1.6×10^6 g/m^3) x (16.65 Bq/g_{soil}) x (336 hours/yr) x (3600 seconds/hour) x 10^{-4} = 0.0112 mrem/yr

Angler Scenario (Bismuth-214)

(4.30×10^{-12} mrem * m^3/Bq second) x (1.6×10^6 g/m^3) x (15.91 Bq/g_{soil}) x (35 hours/yr) x (3600 seconds/hour) x 10^{-4} = 0.0013 mrem/yr

Hunter Scenario (Bismuth-214)

(4.30×10^{-12} mrem * m^3/Bq second) x (1.6×10^6 g/m^3) x (15.91 Bq/g_{soil}) x (100 hours/yr) x (3600 seconds/hour) x 10^{-4} = 0.0039 mrem/yr

Hiker Scenario (Bismuth-214)

(4.30×10^{-12} mrem * m^3/Bq second) x (1.6×10^6g/m^3) x (15.91 Bq/g_{soil}) x (40 hours/yr) x (3600 seconds/hour) x 10^{-4} = 0.0016 mrem/yr

Off-Site Private Well Owner Scenario

The external dose calculations were performed for those persons exposed to external radiation emanating from the soil. Because ATSDR has no soil data for the off-site private well locations, no external dose calculations were performed for these locations. In addition, ATSDR does not believe external dose emanating from the well water is significant at those locations.

Francis Howell High School Scenario

ATSDR does not believe external dose emanating from the soil is significant at the Francis Howell High School. Although no external dose calculations were performed explicitly for the school (because ATSDR has not located any soil data for this area), the external doses in all of the cases evaluated thus far have been insignificant.

Table C.8 (page C-31) lists the total radiation dose for each potentially exposed population. Health physicists tabulated the values by adding the total internal radiation dose and the annual external radiation dose.

TABLE C.8. TOTAL ANNUAL RADIATION DOSE

Potentially Exposed Person	Total Annual Internal Radiation Dose (mrem/yr)[a]	Annual External Radiation Dose (mrem/yr)[a]	Total Annual Radiation Dose (mrem/yr)[a]
Swimmer	0.4	---	0.4
U.S. Military Reservist	68.8	0.01	68.8
Angler	4.7	---	4.7
Hunter	9.1	---	9.1

Hiker	6.1	---	6.1
Consumer of Private Well Water	29.4	n.a.	29.4
Francis Howell High School Staff and Students	0.3	n.a.	0.3
Consumers of Locally Grown Corn	37.3	n.a.	37.3
[a] mrem/yr = millirem per year. n.a. denotes not applicable because pathway is incomplete. --- denotes radiation doses are insignificant.			

Findings

(1) Because the internal doses of the exposed populations are much greater than the external doses, adding the two does not substantially change the total effective doses for the circumstances described. Thus, external doses are insignificant.

(2) The total effective doses, including background for exposed populations, are less than the ICRP's recommended 100 mrem/year [9] for limiting public exposures to radioactive material, and health effects associated with those doses are unlikely.

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APPENDIX D: GLOSSARY

Ci	A curie (Ci) is the basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium.
CREG	Cancer Risk Evaluation Guides (CREGs) are the estimated contaminant concentrations that would result in one excess cancer in a population of a million persons exposed over a lifetime (70 years). CREGs are calculated from the U.S. Environmental Protection Agency's (EPA's) cancer slope factors.
Effective Dose	The sum of the products of the dose equivalent to the organ or tissue and the weighing factors applicable to each of the body organs or tissues that are irradiated.
EMEG	Environmental Media Evaluation Guides (EMEGs) are values used to select chemical contaminants of potential health concern. The Agency for Toxic Substances and Disease Registry calculates EMEG values using conservative exposure assumptions designed to protect the most sensitive segment of the population.
Gy	Gray (Gy) is the unit of absorbed dose (1 Gy = 100 radiation absorbed dose [rad] units) developed by the International System (SI) of weights and measures.
Ionization	Ionization is the process of adding one or more electrons to or removing one or more electrons from atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiations can cause ionizations.
MCL	Maximum Contaminant Levels (MCLs) are contaminant concentrations that EPA deems protective of public health over a lifetime (70 years) at an exposure rate of 2 liters of water per day.
mrem	Millirem, or one-thousandth part of a Roentgen equivalent man (rem) unit.
mg/kg	Milligrams per kilogram, equivalent to parts per million (see below).
mSv	Millisievert, or one-thousandth part of a sievert.
$\mu g/m^3$	Microgram per cubic meter.
μCi	Microcurie. A microcurie is equivalent to one-thousandth of a curie
pica	An abnormal craving to eat substances not fit for food, as clay or paint.
pCi	Picocurie (pCi) is equivalent to one trillionth part of a curie.

Progeny Progeny refers to isotopes formed by the radioactive decay of some other isotope.

R Roentgens (R) are units used to measure exposure to ionizing radiation. A roentgen is the amount of gamma rays or X rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions.

rad Radiation absorbed dose (rad) is a unit used to measure how much radiation an object absorbs after it is exposed to radiation.

rem Roentgen equivalent man (rem) is a unit used to measure the radiation effectiveness in man. It is a function of the radiation absorbed dose (rad) and the type or quality of radiation.

RfD Reference doses (RfDs) are estimates of the daily exposure to a contaminant unlikely to cause adverse health effects.

RMEG Reference Dose-based Media Evaluation Guide (RMEGs) are values calculated using EPA's Reference Dose (RfD) (see definition above).

Sv Sievert (Sv) is the SI unit of radiation effectiveness in man. The dose equivalent in sieverts is equal to the absorbed dose in gray multiplied by the quality factor (1 Sv = 100 rem).

APPENDIX E: ATSDR DOCUMENTS

PRELIMINARY PUBLIC HEALTH ASSESSMENT

WELDON SPRINGS SITE

ST. CHARLES, MISSOURI

CERCLIS NO.'S

M05210021288

DECEMBER 15, 1988

AMENDED

M03210090004 (DOE)
M05210021288 (DOD)

THE ATSDR HEALTH ASSESSMENT: A NOTE OF EXPLANATION

Section 104 (i) (7) (A) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, states "...the term 'health assessment' shall include preliminary assessments of potential risks to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure. The Administrator of ATSDR shall use appropriate data, risks assessments, risk evaluations and studies available from the Administrator of EPA."

In accordance with the CERCLA section cited, ATSDR has conducted this preliminary health assessment of the data in the site summary form. Additional health assessments may be conducted for this site as more information becomes available to ATSDR.

The conclusion and recommendations presented in this Health Assessment are the result of site specific analyses and are not to be cited or quoted for other evaluations or Health Assessments.

PRELIMINARY HEALTH ASSESSMENT

WELDON SPRING QUARRY

WELDON SPRING, MISSOURI

NOVEMBER 18, 1988

Prepared by:
Office of Health Assessment
Agency for Toxic Substances and Disease Registry (ATSDR)

Background

The Weldon Spring Site (WS) is listed by the U.S. Environmental Protection Agency on the National Priorities List (NPL). The 9-acre site is an abandoned limestone quarry located in Weldon Spring (St. Charles County), Missouri. WS contains approximately 95,000 cubic yards of radiological and chemically contaminated soil, rubble, debris, and equipment. Part of WS, the training area, is controlled by the U.S. Department of Defense (e.g., U.S. Army). The other portion of WS is under control of the U.S. Department of Energy. The site boundaries will be expanded to include the chemical plant and raffinate pits as part of the existing NPL site. The chemical plant was a former ordnance production facility in the late 1940's, and was used for uranium processing in the late 1960's. The raffinate pits are unlined areas used for the disposal of wastes from the production of pure uranium. These pits have been reported to contain silica, uranium, and thorium. Access to the site is restricted. Removal actions have not occurred.

The following documents were reviewed by ATSDR: (1) Radiological Report, September 1985, (2) Research Investigation of Hazardous Waste, February 1987, (3) Chemical Characterization Report, August 1987, (4) Hydrology and Water Quality Report, December 1987, (5) Water Quality Phase I Assessment, December 1987. These documents form the basis of this Preliminary Health Assessment.

Environmental Contamination and Physical Hazards

Preliminary on-site soil sampling results have identified radium-226 (1,200 pCi/g), thorium-230 (6,800 pCi/g), uranium (2,400 pCi/g and 8,350 ppm), 2,4,6 trinitrotoluene TNT) (1,600 ppm), 2,4 dinitrotoluene (DNT) (33 ppm), 2,6 DNT (68 ppm), polynuclear aromatic hydrocarbons (PAHs) (1,000 ppm), polychlorinated byphenyls (PCB's 120 ppm). In addition, uranium was identified in groundwater (8,800 pCi/L) and surface water (2,100 pCi/L).

Preliminary off-site groundwater sampling results have identified uranium (4,692 pCi/L); 2,4,6, TNT (15 to 377 ppb); 2,4 DNT (0.5 ppb); 2,6 DNT (3 ppb), and 1,3,5 trinitrobenzene (TNB) (7 ppb). In addition, uranium was detected in surface water (116 pCi/L). Physical hazards were not reported.

Potential Environmental and Human Exposure Pathways

Potential environmental pathways include contaminated groundwater, surface water, soil and sediment, and volatilization of contaminants or contaminants entrained in ambient air. In addition, bioaccumulation of contaminants in fish, water fowl, livestock, and commercial agricultural products may be another environmental pathway.

Potential human exposures to contaminants include ingestion of and direct contact with groundwater, surface water, soil, and possible ingestion of bioaccumulated contaminants in the food chain. In addition, inhalation of volatilized contaminants or contaminants entrained in air is another potential source for human exposure.

Demographics

It is unknown as to how many people live within a 2-mile radius of the site. The distance from WS to the nearest residence has been estimated to be less than 2 miles. The well field, a water source for 58,000 people, is less than a mile from WS. A high school is located approximately 3 miles from the quarry.

Evaluation and Discussion

Soil surface contamination by explosives and groundwater contamination from the quarry are extensive. There are reportedly areas of radioactive contamination in the army training area. On-site, soil concentrations of Ra-226 exceeds the limits expressed in 40 CFR 192 for uranium by-products by a factor of approximately 1,000. In addition, Radon-222 emanating from this site is assumed to exceed these limits (20 pCi/m^2 per second). It is unclear if the Army currently conducts training on-site. Direct contact and possibly inhalation of potentially hazardous materials poses an imminent public health concern to soldiers training on-site. The U.S. Department of Energy (DOE) intends to collect waste materials currently in the Army training area. Moreover, DOE intends to deposit the waste materials with the other radioactive waste currently present in the raffinate pits and quarry area.

Soil sampling information confirms the presence of site-related contaminants off-site. Off-site contamination reportedly is not extensive, but off-site soil sampling information was not reported. Off-site soil sampling information is necessary to determine the extent of exposure of site-related contaminants to area residents. It was reported that on-site exposure is unlikely since the area is fenced. It was also reported that air sampling measurements were performed on-site, but air sampling information was not reported. Entrainment of contaminants in airborne dust may be a possible exposure pathway to area residents as well as persons having authorized access to the site.

Private wells in use within several miles of the site are not reported to be contaminated. The private wells in the vicinity of WS are reported to be in "a separate hydrogeological system". Sampling information confirming the absence of site-related contaminants in area private wells was not reported. Various site-related contaminants (TNT, DNT, TNB, and uranium) were identified in off-site groundwater and there have been unsubstantiated reports that the aquifer of concern may be fractured. Therefore, sampling of area private wells is necessary to rule out exposure and possible health concerns to area residents. Production wells are not contaminated. However, sampling information confirming the absence of site-related contaminants has not been supported. Municipal wells within the vicinity of WS are not contaminated. Public system data have confirmed the absence of site-related contaminants in municipal well water.

A small stream adjacent to WS is reported to be contaminated. The stream flows less than 1 mile to the Missouri River. It has been reported that contamination is migrating downstream to the Missouri, "but probably not migrating in large enough concentrations to impact the quality of the river." Surface water uranium concentrations do not exceed 10 CFR 20 values for the maximum concentration above natural background for the general public. However, surface water values are about twice that normally found in fresh water (usually no more than 70 pCi/L). Sediment sampling information was not reported and is necessary to define the extent of off-site contamination. Moreover, fishing occurs in the adjacent stream and in the Missouri River. Fish flesh sampling (e.g., edible portions) information is also needed to determine the amount of possible exposure to area residents. In addition, hunting occurs in the area and it is reported that deer, pheasant, water fowl, and rabbits are likely to be contaminated. Biota samples have been taken but the sampling results are not currently available.

Conclusions and Recommendations

Based on available information, this site is considered to be of public health concern because of the risk to human health caused by the likelihood of human exposure to hazardous substances. On-site exposure to gamma radiation poses a significant public health risk to persons having access to the site. In addition, areas directly adjacent to the site may pose serious public health concerns because of ingestion of levels of radium in either surface or groundwater. Direct contact with and incidental ingestion of contaminated soil by authorized personnel and area residents are the exposure pathways of concern. Other probable exposure pathways include inhalation of contaminants entrained in air, ingestion of bioaccumulated contaminants in the food chain, and direct contact, ingestion with, and inhalation of off-site soil and sediment. Ingestion of groundwater may also be another possible exposure pathway.

Additional information on contaminants released, populations potentially exposed, and environmental pathways through which the contaminants can reach these populations is necessary. At a minimum, future investigations of this site should include a characterization of the site and site contaminants to include air sampling measurements, area food chain sampling, and off-site soil and sediment sampling, an updated area well survey, and a characterization of the hydrogeology of the area.

Further environmental characterization and sampling of the site and impacted off-site areas during the Remedial Investigation and Feasibility Study (RI/FS) should be designed to address the environmental and human exposure pathways discussed above. When additional information and data such as the completed RI/FS are available, such material will form the basis for further assessment by ATSDR as warranted by site-specific public health issues.

March 29, 1990

Environmental Health Scientist, Emergency Response and Consultation Branch (ERCB), Division of Health Assessment and Consultation, ATSDR (E32)

Addendum to Preliminary Public Health Assessment:

Weldon Spring Chemical Plant,
Weldon Spring, St. Charles County,
Missouri
CERCLIS NO. M03210090004

David A. Parker
ATSDR Regional Services, Region VII
Through: Chief, ERCB, DHAC, ATSDR (E32) ___
Chief, RPB, DHAC, ATSDR (E32) ___

Attached is an Addendum to the Weldon Spring Health Assessment. This should satisfy your request for consultation for the above mentioned site.

Please contact me if you have any questions regarding this Addendum.

John E. Abraham Ph.D., M.P.H.

ATSDR:DHAC:ERCB:JEABRAHAM:veb:2/29/90:ext. 0615
Doc. WELDON

The Weldon Spring Chemical Plant Site

Weldon Spring, St. Charles County, Missouri

BACKGROUND AND STATEMENT OF ISSUES

The Weldon Spring Chemical Plant Site is listed by the U.S. Environmental Protection Agency (EPA) on the National Priorities List (NPL). The 17,000-acre site is located in Weldon Spring (St. Charles County), Missouri. A portion of the site, 1,700 acres, has been designated a training area for troops in the U.S. Army Reserve. "Approximately 1 year ago, partially in response to ATSDR's and EPA's expression of concern regarding troop training activities in potentially contaminated areas, the Army closed the Weldon Spring Training Area to troop training."

The ATSDR received a request on March 2, 1990 (through Mr. David Parker, ATSDR Regional Representative) from EPA Region VIII Superfund Remedial Branch regarding the resumption of training of U.S. Army Reserve troops on-site. The EPA would like ATSDR to address whether a health threat exists from exposure to lead and trinitrotoluene (TNT), and its related compounds on-site to Army Reservists training in the designated on-site areas.

DOCUMENTS REVIEWED

1. Preliminary Health Assessment, Weldon Spring Quarry, ATSDR, March 30, 1989.

2. Memorandum to Mr. Gregory McCabe, WSTM/SPFD/PREP, EPA Region VII from Mr. Edward J. Skowronski, ATSDR Regional Representative, EPA Region VII, Re: Health Consultation for the Weldon Spring Training Area, Weldon Spring, Missouri, August 5, 1988.

3. Report, IT Corporation, Chicago Illinois. Project No. 312052, Re: Addendum to Draft Remedial Investigation, Weldon Spring Training Area, October 1989.

4. Memorandum to Commander, U.S. Army Engineer Center and Fort Leonard Wood, ATTN: ATZT-DEH-EE/Scott Murrell, Fort Leonard Wood, Missouri from CEMARK-ED-TD, Re: Identification of Areas to be Re-opened for Training at the Weldon Spring Training Area, January 5, 1990.
5. Memorandum, to Mr. David Parker, ATSDR Regional Representative, EPA Region VII, from Mr. Greg McCabe, Weldon Spring Ordnance Works Remedial Project Manager, EPA Region VII, Re: Reopening of Weldon Spring Training Area to Troops, no date given.

DISCUSSION

The designed training areas in question are located outside TNT production areas; moreover, based on historical use, these areas have a low probability for contamination. The Army has performed lead and TNT soil sampling within the proposed training area. A subset -- 99 samples -- of the 1,070 soil samples that were considered to be the "most highly contaminated samples" were analyzed (personal communication March 15, 1990, between Dr. Abraham and Mr. Parker, ATSDR, EPA Region VII). The soil samples from the 18 designated training areas were analyzed for 6 explosives (TNT, dinitrotoluene, nitrotoluene, trinitrobenzene, dinitrobenzene, and nitrobenzene).

Analytical results demonstrated TNT levels of less than 10 ppm in over 90 percent of 1,070 samples; however, 13 samples demonstrated TNT levels between 20 to 55 ppm. One soil sample revealed 1,000 ppm of lead; however, the area where sampling occurred is overgrown with vegetation.

The ATSDR is concerned over the possibility of radioactive contamination existing at this site. Weldon Spring Quarry, a different Operable Unit on-site, received radioactive wastes from the St. Louis Airport Storage Site, the Hazelwood Interim Storage Site, and the Futura Coatings Site. These wastes consisted of thorium and radium wastes from uranium processing in the 1940's and 1950's. The U.S. Department of Energy (DOE) only characterized areas where there was reasonable expectations of radioactive contamination. Radioactive contamination is not expected to be present in the areas designated for training according to DOE and EPA (personnel correspondence between Dr. Abraham, ATSDR and Mr. Greg McCabe, RPM, EPA Region VII, March 12, 1990). However, a radiological survey is warranted to rule out an unexpected exposure to possible radioactive contaminants that may exist at the designated training areas. We have discussed our concerns with Dr. Paul Charp, Health Physicist, ATSDR who agrees that a walkover survey is necessary, before troops are allowed access to the site.

The draft Remedial Investigation (ref. 3) mentioned that Building G-24 may contain asbestos. This building is located within the designated training area and currently is not occupied. This building is restricted until sampling reveals the absence of asbestos.

Troops training on-site may be exposed through direct contact, ingestion, and inhalation of contaminants. However, it does not seem likely that such exposure would be significant to warrant concern. The scenarios described (ref. 3) overestimate the opportunity for contact with, inhalation of, and ingestion of contaminated soil from the site; The general population will not have access to the site.

CONCLUSION

Based on the information reviewed, lead and TNT and related compounds from the designated training areas on-site pose minimal health risks to U.S. Army Reservists. Exposure to contaminated soils through direct contact, inhalation, and ingestion is possible but not probable under conditions described.

There is a possibility of radioactive contaminants existing on the designated training areas because of past disposal activities within the nearby vicinity. Moreover, the possible presence of asbestos in Building G-24 may pose a health risk to soldiers or other on-site personnel. Exposure to contaminated soils through direct contact, inhalation, and ingestion is possible but not probable under the conditions described.

The conclusion reached for the exposure scenarios evaluated in the Addendum are reasonable risk estimates. However, the assumptions used probably do not represent actual conditions of risk and may or may not overestimate the risk of chronic exposure to the troops training on-site.

RECOMMENDATIONS

1. Perform a radiological survey of the designated areas to rule out the possibility of exposure to radioactive contaminants to soldiers.

2. Confine activities to only those designated training areas described in the Draft Remedial Investigation.

3. Periodic monitoring of the training area should be implemented if disruption of the present environmental conditions occurs (e.g., digging trenches, etc.).

4. Continue to restrict Building G-24 until inspection reveals the absence of asbestos.

PREPARER OF REPORT

Environmental and Health Effects Assessor:	John E. Abraham, Ph.D, M.P.H. Environmental Health Scientist Emergency Response and Consultation Branch
Regional Representative:	David A. Parker Public Health Advisor Regional Services Region VII

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Toxicologist Emergency Response Branch, Office of Health Assessment, ATSDR

April 24, 1989, Health Consultation: Fish Data, Chemical Plant Site St. Charles County, Missouri.

Mr. David Parker
Public Health Advisor
EPA Region VII Kansas City, Missouri
Through: Chief, Emergency Response Branch, OHA, ATSDR

<u>BACROUND</u>

The United States Department of Energy (DOE) has completed a fish survey of lakes and ponds at the Weldon Spring Site (WSS) in St. Charles County, Missouri. The WSS is a DOE surplus facility which was previously operated as an ordnance facility by the Department of the Army and as a uranium processing facility by the Atomic Energy Commission. Several ponds are suspected of having elevated heavy metal contamination resulting from surface water run-off from previous site activity. The Environmental Protection Agency (EPA) has requested the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the fish data for human health concerns.

DOCUMENTS REVIEWED

Radiological and Chemical Uptake by Selected Biota at the Weldon Spring Site, Draft, November 1988, Department of Energy, DOE/OR/21548-044,

DISCUSSION

The Food and Drug Administration has estimated the average consumption rate of commercial fish for the typical American is around 19 grams per day. The consumption rate for the upper 95th percentile is estimated to be 27 grams of fish per day. While the typical American will consume commercial fish from a variety of sources, sports fishermen and subsistence fishermen are more likely to consume greater quantities of fish than the average American and to consume fish from a restricted geographic area. Therefore, these two subpopulations may be at increased risk when consuming contaminated fish from a particular area. Studies on sports fishermen in the Great Lakes area have shown that, on average, 32 pounds. of sport caught fish are consumed each year with certain individuals consuming as much as 3 to 5 times this average amount. This average fish consumption rate is equivalent to 1 fish meal per week which approximates 280 grams of fish per week or 39.8 grams per day.

Proportionate, composite, fillet samples of sunfish, bass, and crappie were collected from WSS lakes. Catfish were not included in composite samples. Using 39.8 grams fish per day to approximate the fish intake for sport fishermen, one can calculate daily and weekly intake for mercury (Table 1), lead (Table 2) and arsenic (Table 3).

Sport and subsistence fishermen may have a favorite lake or fishing spot from which they obtain the majority of their fish; therefore, the most conservative approach in this case is to assume that the fish consumed are from the lakes with detectable levels of the metal of concern. A great deal of variation can exist in calculated intakes levels. Because these are average values from composite samples, levels are higher in half the fish sampled. Also, variation in heavy metal content in fish fillets certainly exists both within species (depending upon age) and between species (depending upon feeding habits and pharmacokinetics). The manner in which the fillet is prepared for analysis also affects the quantitative results. Therefore, it would be prudent not to rely strictly upon the quantitative results.

The FDA has calculated the dietary intake of mercury in the typical American diet to be 3.2 ug/day. For the adult who consumes one contaminated fish meal per week, the weekly intake for mercury from lakes 34, 35, 36, and 37 would range from 44 - 75 ug/week or 6 - 11 ug/day (see Table 1). This intake is greater than the acceptable intake from water based upon EPA's Maximum Contaminant Level (MCL) of 2 ug/l and is similar to EPA's Rfd for mercury of 0.158 ug/kg/day which is equivalent to an intake of 11 ug/day for a 70 kg adult male. The World Health Organization has established a maximum tolerable intake of 0.3 ug organic mercury/kg/day for adults. This corresponds to 15 to 21 ug of organic mercury per day for adult females and males. The WHO maximum tolerable level was based upon the observation that the long-term daily ingestion of approximately 250 ug per day of mercury as methyl mercury has been observed to cause the onset of neurological impairment. For individuals consuming 1 fish meal per week from fish caught at the WSS, intake levels appear to be below levels that may cause adverse health effects. This conclusion may not be valid for individuals who are consuming fish from WSS on a more frequent basis.

Table 1. Daily and weekly intake values for mercury are depicted for fish consumption where 39.8 g/day of contaminated fish are consumed. This intake level approximates 1 fish meal per week for sport and subsistence fishermen.

lake	composite concentration (ug/g)	daily intake (ug/day)	weekly intake (ug/week)
34	0.27	10.7	75.2

35	0.24	9.5	66.9
36	0.16	6.4	44.6
37	0.23	9.2	64.1

The FDA has estimated an intake of 57 ug/day of lead for the typical American diet. From lead in fish from lakes 34 and 36, the estimated intake from 1 contaminated fish meal per week is approximately 1100 ug/week or 160 ug/day. This intake exceeds the intake of 100 ug/day using EPA's MCL for lead of 50 ug/l and assuming a 2 l/day water consumption rate for the average adult. Populations at increased risk to lead exposure include children and pregnant women, since lead is capable of crossing the placental barrier. For each 100 ug per liter of oral lead intake, an increase of 4-5 ug of lead per 100 ml of blood is expected. WHO has estimated that this intake level may cause a significant number of children to exceed the recommended blood lead level of 25 ug per 100 ml blood. Lead from fish taken from lakes 34 and 36 has the potential for increasing lead exposure to children and pregnant women who consume the contaminated fish.

Table 2. Daily and weekly intake values for lead are depicted for fish consumption where 39.8 g/day of contaminated fish are consumed. This intake level approximates 1 fish meal per week for sport and subsistence fishermen.

lake	composite concentration (ug/g)	daily intake (ug/day)	weekly intake (ug/week)
34	4.0	159	1,114
36	4.2	167	1,170

The FDA has calculated that the average American dietary intake for arsenic (As) is 46 ug/day. The predominant food source is seafood which ranges from 2 to 10 ug As/g. It is very unusual for freshwater fish to have higher levels than those found in seafood.

For the adult who consumes 1 contaminated fish meal per week from fish taken from lakes 35 and 37, the weekly intake of arsenic is about 3,800 ug/week or 550 ug/day. This intake is much greater than the intake established by EPA's drinking water MCL of 50 ug/l, which is equivalent to 100 ug/day based upon a 2 l/day water consumption rate. An intake of 550 ug/day would be quite unacceptable were the exposure occurring through drinking water. For subsistence fishermen and sport fishermen who have more than 1 fish meal per week from fish taken from lakes 35 and 37, the intake of arsenic obviously would be greater.

Table 3. Daily and weekly intake values for arsenic are depicted for fish consumption where 39.8 g/day of contaminated fish are consumed. This intake level approximates 1 fish meal per week for sport and subsistence fishermen.

lake	composite concentration (ug/g)	daily intake (ug/day)	weekly intake (ug/week)
35	13.9	553	3,872
37	13.6	541	3,788

Daily intake from contaminated fish at the WSS site has been calculated from the mean fish consumption rate for sport fishermen. Some sport fishermen will have higher intake than those used in these calculations. Also, it is very likely that subsistence fishermen in the area will consume more locally caught fish when compared to sport fishermen. Therefore, their intake of these metals will be increased thus increasing their risk to adverse health outcome.

A problem does exist in the manner in which the fish were collected. The logic was used that fish are eaten according their proportional population within each lake. This logic does not seem reasonable to me for estimating fish consumption patterns since some residents may have a preference for certain species in their diet. In addition, catfish were not sampled in the survey for heavy metal content. It is very likely that catfish comprise a major portion of fish in the diet of subsistence fishermen. Catfish are also likely to have increased levels of heavy metal because of their close association with sediment feeding, which is the sink for heavy metals in ponds and lakes.

CONCLUSION

All individuals receive some quantity of mercury, arsenic, and lead from both dietary and environmental exposure routes. Quantitation of the environmental exposure route (i.e., air and soil ingestion) is not precise and depends largely upon local conditions.

Quantitation of dietary intake has been made by FDA from food baskets surveys. The intake of heavy metals found in fish at the WSS is in addition to this background exposure.

The occurrence of heavy metals in composite fish samples from the WSS does not present a public health threat to area residents who have occasional fish meals from locally caught fish. However, sport fishermen and subsistence fishermen may be at increased risk to adverse health effects if a major portion of the fish in their diet comes from the lakes with heavy metal contaminated fish. A great deal of variation exists in the fishing and eating habits of these two populations; therefore, it is difficult to quantitate their metal intake with certainty. By using the average consumption rate for sport fishermen from the Great Lakes area, one can obtain some quantitative idea of the potential intake levels. However, because of uncertainty in estimating dietary fish intake, one should not rely strictly upon the quantitative results which tends to indicate a potential problem. The major concern involves those individuals and their families who rely heavily on fish from the WSS. This population has the potential for exceeding the safety factor used in establishing acceptable heavy metal intakes.

RECOMMENDATIONS

1. Collect composite samples of species specific fish from lakes in the WSS. Include catfish as a separate species to be evaluated.

2. Identify subpopulations, like sport fishermen and subsistence fishermen who might use the lakes at the WSS and educate them to the potential hazard.

3. Fish from the WSS should not be consumed more than once per month.

David N. Mellard, Ph.D.

ATSDR Record of Activity

February 10, 1993, Health Consultation

UID #:s j h 0 Date:02/10/93 Time:10:00 am X pm

Site Name: Weldon Spring City:Weldn Sprng Cnty:St Charles State:MO **CERCLIS #:** Cost Recovery #: 703S Region:07

Site Status (1) X NPL Non-NPL RCRA Non-Site specific Federal

(2) Emergency Response Remedial X Other

Activities

Incoming Call Public Meeting X Health Consult Site Visit

X Outgoing Call Other Meeting Health Referral Info Provided

Conference Call Data Review Written Response Training

X Incoming Mail Other

Requestor and Affiliation:(1) Cecilia Tapia EPA Region VII

Phone: (913) 551-7733 Address:

City: Kansas City State: KA Zip Code: 66101

Contacts and Affiliation

(31) Dave Parker ( ) ( ) ( )

1-EPA	2-USCG	3-OTHER FED	4-STATE ENV	5-STATE HLT
6-COUNTY HLTH	7-CITY HLTH	8-HOSPITAL	9-LAW ENFORCE	10-FIRE DEPT
11-POISON CTR	12-PRIV CITZ	13-OTHER	14-UNKNOWN	15-DOD
16-DOE	17-NOAA	18-OTHR STATE	19-OTHR COUNTY	20-OTHR CITY
21-INTL	22-CITZ GROUP	23-ELECT. OFF	24-PRIV. CO	25-NEWS MEDIA
26-ARMY	27-NAVY	28-AIR FORCE	29-DEF LOG AGCY	30-NRC
31-ATSDR				

Program Areas

Health Assessment Health Studies Tox Info-profile Worker Hlth

Petition Assessment Health Survellnc_Tox Info-Nonprofil_Admin

Emergency Response Disease Regstry Subst-Spec Resch Other

X Health Consultation Exposr Regstry Health Education

Narrative Summary: EPA requested that ATSDR comment on the health implications of lead, arsenic, and mercury in fish caught at the Weldon Spring site. Whole fish and fish fillets (edible portion) were analyzed for the three metals using a detection limit of 0.10 mg/kg.

Lead was found in two whole fish samples above the detection limit at a maximum concentration of 0.176 mg/kg. Mercury was found in a fish fillet at a maximum concentration of 0.212 mg/kg. Arsenic was not found in any whole fish or fish fillet samples above the detection limit.

Action Required/Recommendations/Info Provided: I advised EPA that the lead, arsenic, and mercury did not represent a health threat to persons eating the fish. I also advised EPA that, at the reported concentrations, harmful effects from subsistence consumption of fish would not be expected.

cc: Ed Skowronski
RIMB
Dave Parker

1993 Letter on Proposed Cleanup Levels

Mr. Stephen H. McCracken
U.S. Department of Energy
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

Dear Mr. McCracken:

The Agency for Toxic Substances and Disease Registry has been asked to provide written comments to you concerning the public health aspects of the "Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site". This document proposes remedial actions for contaminated materials, soil cleanup standards, and identifies a disposal decision for wastes generated during remediation. This letter will address the adequacy of the proposed soil cleanup standards and the potential for human exposures to those waste materials.

The public health concerns of the proposed remedial actions are specifically addressed in an ATSDR Health Consultation, which is currently in internal review. This letter is to insure that ATSDR comments are received during the public comment period for the proposed plan. The Health Consultation will also be forwarded to you as soon as possible.

ATSDR has two primary concerns with the proposed plan. First, the off-site (or vicinity) properties which have been determined to have radiological contamination have not been evaluated for non-radiological contaminants. Although cleanup of radiological contaminants at these sites may remove/remediate non-radiological contamination, these are the sites for which there is current exposure potential and DOE will not retain access restrictions. Additionally, several of the off-site areas may have been subject to prior contamination by Ordnance Works operations, which presents the potential for significant remedial worker exposure and safety hazards. ATSDR recommends, that in the off-site areas, non-radiologic soil contaminant screening be conducted and that site remediation be coordinated with ongoing Ordnance Works site characterization.

The second concern is the proposed cleanup standards (ALARA Goals). The ALARA Goals for arsenic, chromium VI, dinitrobenzene, nitrobenzene, trinitrobenzene, and trinitrotoluene exceed health-based comparison values for ingestion exposures for pica children (assumed soil ingestion rate of 5,000 mg/day). The ALARA Goals for dinitrobenzene, nitrobenzene, and trinitrobenzene are also greater than comparison values for non-pica children (assumed soil ingestion of 200 mg/day). Arsenic, PAHs [benzol(a)pyrene], and PCBs (Aroclor 1248, 1254, and 1260) are known or suspected carcinogens and the proposed ALARA Goals are greater than appropriate comparison values.

Calculation of the comparison values assumes chronic exposure to the contaminated soil. Currently, there are no chronic exposures to Chemical Plant Site soils for the public because site access is restricted. However, the cleanup goals were derived assuming unlimited public access. Under the scenario of residential occupation of the contaminated area, the proposed cleanup goals would not be protective of human health. Thirdly, the proposed plan has not demonstrated that future potential doses due to radioactive materials at the site will be within the recommendations of the International Commission on Radiation Protection (ICRP Publication 60). Calculation of radiation dose includes the accumulation of radioactive materials within the body throughout one's expected life (i.e. 70 years). The proposed plan does not detail how or if that was completed.

Using the Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site (BHA) as an indicator, the BHA included calculations for doses over an individuals working-life-span of 50 years for either 10 year or 30 year exposure scenarios. Those scenarios do not include dose estimates for the pca-child nor are they representative of the public's expected life-span. To determine whether the ALARA Goals for the radioactive soil are protective of public health, exposure scenarios should account for pica-child, child, and adult activities. The doses from those scenarios should be evaluated for the expected life-span of an individual, 70 years, as specified by the ICRP.

Accidental or intermittent exposure to soils remediated to ALARA Goals should not be of public health concern if safety procedures and site access restrictions, as outlined in the "Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site", are maintained.

Respectfully yours,

Sally L. Shaver
Chief
Federal Programs Branch
Division of Health Assessment
and Consultation

January 20, 1994, Health Consultation

Record of Decision for Quarry Bulk Wastes, Weldon Spring Remedial Action Project, (703S)

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

January 20, 1994

BACKGROUND AND STATEMENT OF ISSUES

The Agency for Toxic Substances and Disease Registry (ATSDR) was requested by the United States Department of Energy (DOE) to evaluate the human health hazards posed by its Interim Remedial Action Plan for removing bulk wastes from the Weldon Spring quarry. As described in the Record of Decision [ROD; 1], the plan calls for bulk wastes to be removed from the quarry, using standard equipment and procedures, and transported to a temporary storage area at the Chemical Plant site using a private road. This ROD does not include information or remedial alternatives for the following: 1) permanent disposal of the bulk wastes, 2) the quarry proper, 3) surface water, or 4) groundwater.

A. Background

The Weldon Spring quarry is a 15-acre area of the Weldon Spring Quarry/Plant/Pits site (220 total acres) that was listed on the EPA National Priorities List (NPL) in July 1987. In March 1989, this listing was expanded to include the chemical plant and raffinate pits. The quarry is about 4 miles south-southwest of the chemical plant area, 5 miles southwest of the city of Weldon Spring, 1 mile west of the Missouri River, and about ½ mile northwest of the St. Charles County wellfield. The quarry is on Missouri Route 94, but public access is restricted by a fence and 24-hour security guard. The quarry is about 1,000 ft. long, 450 ft. wide, covers an area of two acres, and the depth varies from about 30 to more than 100 ft. [2].

Before 1942, the quarry was used as a source of construction limestone. From 1942 to 1957, the Army (or its contractors) used the quarry to dispose of off-specification explosives and explosive-contaminated materials. From 1957 to 1969, the quarry was used to dispose of building rubble, soil, and sludges contaminated with radioactive materials. The Remedial Investigation for Quarry Bulk Wastes [3] summarizes contaminant concentrations and distributions and estimates the total volume of waste within the quarry is 95,000 cubic yards. The Baseline Risk Evaluation [2] identifies specific contaminants of concern, average concentrations, ranges, and estimated waste volumes.

B. Statement of Issues

Several studies, as summarized in the Remedial Investigation [3] and the Baseline Risk Assessment [2], have identified the bulk wastes in the Weldon Spring quarry as hazardous because of radiological and chemical contamination. ATSDR previously identified the quarry as a public health concern because of the potential for on-site radiation exposure, bioaccumulation of contaminants in food chain, and migration of contaminants to the St. Charles County wellfield [4]. Excavating the waste material and transporting it to temporary storage at the chemical plant site is the alternative specified in the ROD [1]. The basic issue addressed in this consultation is whether the proposed activity is protective of public health.

DISCUSSION

Remedial workers may be exposed to quarry bulk wastes during the excavation, transport, and storage processes. The use of dust suppression techniques, site and waste monitoring, worker training, and other standard procedures for minimizing worker exposures as indicated in the Feasibility Study [5] should eliminate the potential for adverse health effects. Mitigative measures to be used for worker protection include: 1) developing an activity-specific environmental, safety, and health plan; 2) monitoring worker health/exposure; 3) monitoring the workplace environment; and 4) making available and using protective equipment, such as respirators, protective clothing, and showers (if necessary). Public and worker exposures during quarry excavation will be mitigated by keeping inactive excavation areas covered, wetting the active excavation area and materials, and covering surfaces and materials.

The waste materials will be transported in closed containers on a private haul road so that public exposures do not occur during transport. Public exposure during excavation is unlikely because there are no residents or businesses adjacent to the quarry. Worker exposure is possible as a result of radon inhalation and transportation accidents; however, mitigative measures to prevent such accidents will include: 1) transport in closed, leakproof trucks (DOT approved for transport of low-specific activity materials), 2) vehicle decontamination before quarry departure, 3) a 20 mph speed limit, 4) personal protective equipment, and 5) pressurized truck cabs.

Public exposure to bulk wastes during temporary storage at the chemical plant is not likely because of access restrictions, site monitoring, and the design characteristics of the storage area [5]. The temporary storage area (TSA) at the chemical plant site is within a patrolled, chain-link/barbed wire fence enclosure. Sludge retention areas within the TSA will be double-lined with stormwater runoff and leachate diverted to lined collection ponds and the water-treatment plant. Areas of the TSA susceptible to wind-erosion will be covered and dust-suppression techniques will be used for the entire area [5]. The TSA contains site monitors for air particulates, radon, and radon-decay products, and groundwater monitoring of chemical and radioactive contaminants.

CONCLUSIONS

The quarry is a public health concern and overall remediation of the site requires excavating and removing bulk wastes. Based on available data, the excavation, transport, and temporary storage of the quarry bulk wastes will not present a potential for public exposures to hazardous wastes. There is a potential, however, for worker exposure, but that can be minimized if existing standard procedures for dust suppression, site monitoring, worker training, and safety procedures are followed. These conclusions are specific to the quarry bulk wastes and should not be considered applicable to quarry surface water, groundwater, or residual contamination after removal of bulk wastes.

RECOMMENDATIONS

ATSDR recommends that the following steps be taken to protect public health: > excavation, transport, and temporary storage of quarry bulk wastes should be considered the first step in remediating the quarry;

- standard dust suppression techniques and other procedures proposed for minimizing worker exposures should be used during all phases of the remediation activity. Also, because of the potential for worker exposures to hazardous materials, the existing activity-specific safety plan should be followed during the remedial action.

PREPARER OF REPORT:

Mark W. Evans, Ph.D
Environmental Geologist
Energy Facilities Assessment Section
Federal Programs Branch
Division of Health Assessment and Consultation

REFERENCES

1. Environmental Assessment and Information Sciences Division, Argonne National Laboratory. Record of Decision for the Management of Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri. June 1990.

2. Environmental Assessment and Information Sciences Division, Argonne National Laboratory. Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri. January 1990.

3. MK- Ferguson Company and Jacob Engineering Group. Remedial Investigations for Quarry Bulk Wastes (Revision 1). December 1989.

4. Agency for Toxic Substances and Disease Registry. Preliminary Health Assessment for Weldon Springs Site. St. Charles County, Weldon Spring, Missouri. Atlanta: ATSDR, December 1988

(amended March 1990).

5. U.S. Department of Energy, Oak Ridge Operations Office. Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri. February 1990.

August 30, 1994, Health Consultation

Evaluation of Potential Radiation Exposures at the Francis Howell High School from the Weldon Spring Site, Weldon Spring Remedial Action Project, (703S)

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation

August 30, 1994

BACKGROUND AND STATEMENT OF ISSUES

The St. Charles Countians Against Hazardous Waste have requested the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate potential exposure of the Francis Howell High School students and staff to radioactive materials from the Weldon Spring Site (WSS). The high school has approximately 2,300 students and staff members and is located approximately one-half mile east of the WSS [1]. Demolition of buildings contaminated with uranium (U), thorium (Th), or radium (Ra) is underway and may be a source of airborne particulates.

The WSS is an inactive uranium processing facility that is currently managed by the Department of Energy (DOE) as a U.S. Environmental Protection Agency (EPA) Superfund site. The site includes four processing waste lagoons (raffinate pits), the Chemical Plant buildings and grounds, a nearby quarry used for mixed waste disposal, and other off-site areas containing radioactively contaminated soils [1]. The WSS was built on part of a 17,000 acre WWII era ordnance plant (Weldon Spring Former Ordnance Works; WSFOW) that manufactured TNT and DNT munitions and resulted in widespread chemical contamination [2]. The former ordnance works is also an EPA Superfund site that is being cleaned up by the U.S. Army.

The WSS is in St. Charles County, Missouri, 30 miles west of St. Louis and about 2 miles west of the Weldon Spring and Weldon Spring Heights communities [1]. The WSS is bordered by state-owned wildlife management areas to the north, south and east, and by the Weldon Spring Training Area (WSTA) to the west. The former ordnance works included all of the wildlife management areas, the WSS and the WSTA. The WSTA is controlled by the Army and used for troop training activities. People hunt, fish, and hike in the wildlife management areas, which include some areas of radioactive and chemical contamination [3]. A state-owned highway maintenance facility is adjacent to the WSS along the east boundary.

Radioactive and chemical contamination of both on- and off-site soil, sediment, surface water, and groundwater at the WSS have resulted from past operations of the uranium refining facility and the ordinance manufacturing facility [2]. However, both surface waters and groundwater from the site flow north or south and away from the high school, and the resulting contaminated lake and stream sediments follow the same drainage pattern to the north and south [1].

ATSDR reviewed a 1986 survey of radioactive contamination which indicated that the only significant sources for airborne releases at WSS and nearby areas lie within the boundaries of the WSS [4]. The study did not report any data for the high school property; however, Highway 94, which leads to the high school, was monitored and no elevated gamma readings were found on Highway 94 near the high school.

DOE has collected the following environmental data which ATSDR reviewed for this consultation. ATSDR reviewed the annual alpha air monitoring data which are used to monitor migration of radionuclides which decay through alpha emission (i.e., uranium, thorium, and their decay products). In 1989 and 1990, WSS reported gross airborne alpha concentrations in a manner consistent with DOE guidelines at the time: if the measured alpha radioactivity was below the "lower level of detection" (LLD) of the analyzing instrument, the LLD was reported instead of the measured activity. These data are preceded by the less than symbol (<) [5,6]. In 1991, WSS, consistent with changing DOE guidelines, stopped the use of LLD values when reporting gross alpha concentrations [7]. ATSDR reviewed ambient radon concentrations near the Francis Howell High School and background locations reported by WSS for the years 1989 - 1991. ATSDR also reviewed particulate radionuclide concentrations in air [4]. Isotopic analysis of air samples collected from the Francis Howell High School and background locations were performed by WSS from 1990 to 1993. The radionuclides measured by WSS include U-238, U-235, U-234, Th-230, Ra-226, Th-232, Ra-228, and Th-228.

DISCUSSION

ATSDR compared gross[3] alpha air concentrations at different locations to determine if alpha-emitting radionuclides are migrating from their source locations. If the measured gross alpha air concentrations are greater than that of background, then migration of alpha emitting radionuclides may be occurring from source areas. (Gross alpha data alone are not sufficient for calculating radionuclide concentrations in air.)

Because WSS reported the gross alpha concentrations with LLDs ("<") prior to 1991, data reported prior to 1991 can not be compared to data collected subsequently. Therefore, ATSDR has used 1991, 1992, and 1993 gross alpha data; and their averages are tabulated below in Table 1.

TABLE 1. AVERAGE ANNUAL GROSS CONCENTRATIONS IN AIR (10^{-15}Ci/ml).

Monitoring Location	1991	1992	1993
Chemical Plant & Raffinate Pits	1.40	1.18	1.14
Quarry	1.52	1.10	1.11
High School	1.36	1.06	1.04
Background	1.37	1.23	1.02

μCi/ml - microcurie per milliliter

The 1991, 1992, and 1993 average gross alpha concentrations at the perimeter of contaminated areas are essentially the same as levels at the high school and background locations. This indicates that no migration above background of alpha-emitting radionuclides in air occurred from the chemical plant, the raffinate pits, or the quarry towards the high school between 1991 and 1993 [this includes the recent period of building demolition at the site].

ATSDR also compared the range of radon concentrations (alpha track results reported 1989 - 1991) in background areas to the range at the high school. The range of radon concentrations in background areas is 0.04 - 1.3 picocurie per liter (pCi/L) of air, and the range at the high school is 0.1 - 0.8 pCi/L. The range of radon concentrations at the high school is within that of background areas; therefore, radon emissions from the WSS do not appear to impact persons at the high school. Furthermore, radon levels at both the high school and WSS do not represent a public health concern.

In 1990, WSS began performing isotopic analyses of particulate air samples [6]. The results of isotopic analyses are at or near the analytical detection limits, and the uncertainty associated with the results are large [10]. Therefore, ATSDR did not use these data.

CONCLUSIONS

1) ATSDR concludes that contamination from WSS and building demolition does not pose a public health concern for persons at the Francis Howell High School. This conclusion is based on the following information: the characterization study, which indicates that property at the high school is not contaminated; gross alpha measurements, which show that no airborne migration of alpha-emitting radionuclides is occurring from the site to the high school; and radon data, which indicate that radon emissions from WSS do not contribute to radon exposures at the high school.

RECOMMENDATIONS

1) Continue monitoring airborne radionuclides at appropriate locations in order to ensure public confidence in the waste management processes at the WSS.

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REFERENCES

1. Environmental Assessment and Information Sciences Division, Argonne National Laboratory. Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site. November 1992.

2. MK-Ferguson Company and Jacob Engineering Group. Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site (DOE/OR21548-074). November 1992.

3. U.S. Department of Energy, Oak Ridge Field Office WSSRAP. Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site (DOE/OR21548-091). November 1992.

4. U.S. Department of Energy, Division of Remedial Action Projects. Radiological Survey of the August A. Busch and Weldon Spring Wildlife Areas. April 1986.

5. U.S. Department of Energy. Annual Site Environmental Report for Calendar Year 1989 for the Weldon Spring Site Remedial Action Project (DOE/OR/21548-129). Oak Ridge: U.S. Department of Energy. November 1990.

6. U.S. Department of Energy. Annual Site Environmental Report for Calendar Year 1990 (DOE/OR/21548-193). Oak Ridge: U.S. Department of Energy. September 1991.

7. U.S. Department of Energy. Weldon Spring Site Environmental Report for Calendar Year 1991 (DOE/OR/21548-283). Oak Ridge: U.S. Department of Energy. May 1992.

8. U.S. Department of Energy. Weldon Spring Site Environmental Report for Calendar Year 1992

(DOE/OR/21548-372). Oak Ridge: U.S. Department of Energy. June 1993.

9. U.S. Department of Energy. Weldon Spring Site Environmental Report for Calendar Year 1993 (DOE/OR/21548-436). Oak Ridge: U.S. Department of Energy. March 1994.

10. Letter from Stephen H. McCracken, DOE, St. Charles Missouri, to Dr. Mark Evans, ATSDR, Atlanta Georgia. April 15, 1994.

APPENDIX F: RESPONSE TO PUBLIC COMMENT

ATSDR released the Public Comment draft of the Public Health Assessment of the Weldon Spring Quarry/Plant/Pits (USDOE) on September 30, 1996. The comment period ended November 29, 1996. During that period, we received one comment from the public. A summary of that comment and our response is provided below.

Comment: "...There is one area which I believe has been omitted in trying to identify a reason for the excessive leukemia rate in St. Charles County. As shown in some of the County's wells, radioactive contamination is a factor due to underlying bedrock in St. Charles County. Apparently there lies a bed of radioactive rock some 300 feet below the surface, which has contaminated some wells in the county. Could someone look into the possibility of radon arising from this deeply buried layer of radioactive materials? At this point, some further studies could be done by placing radon monitors in many basements and homes in the County where actual cases of leukemia have occurred. If this proves to identify no radon, then one more cause can be ruled out...."

Response: Generally, an excessive leukemia rate would not be attributed to radon emanating from a bedrock 300 feet below the surface for two reasons, (1) radon sources located more than a few meters (6.5 - 10 feet) below ground are unlikely to increase radon concentrations at the surface[1], and (2) although leukemia has been linked to radiation exposure, specifically elevated gamma and x-ray exposure, it has not been causally linked to radon exposure.

[1]. From the National Council on Radiation Protection and Measurements, Report No. 103, p. 5.

FOOTNOTES

[1]. The annual limit on intake (ALI) of the public is used as the annual amount of a radionuclide a member of the public can inhale or ingest which delivers the annual public dose limit of 100 mrem per year.

[2]. ATSDR uses the most current ALIs listed in ICRP 61.

[3]. Gross alpha concentrations = net concentrations due to source + concentrations due to background