ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

SAFETY LIGHT CORPORATION
BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA
EPA FACILITY ID: PAD987295276
AUGUST 24, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

OCTOBER 26, 2009

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

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PUBLIC HEALTH ASSESSMENT

SAFETY LIGHT CORPORATION

BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA

EPA FACILITY ID: PAD987295276

Prepared by:

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Summary

The United States Environmental Protection Agency (USEPA) established the National Priorities List (NPL) to help in identifying the most serious uncontrolled or abandoned hazardous waste sites. The NPL is intended primarily to guide the USEPA in determining which sites warrant further investigation. The Safety Light Corporation Superfund Site (SLC or Safety Light Site) was added to this list of hazardous sites in 2005 after being proposed to the list in 2004.

The Agency for Toxic Substances and Disease Registry (ATSDR) is required by the Congress to prepare a public health assessment for all sites on the NPL. The aim of these assessments is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced.

Throughout its operational history, Safety Light Corporation disposed of waste products through on-site burial, disposal/dilution into the bordering Susquehanna River, and shipments off-site to burial facilities. Many of these disposal actions resulted in contamination of environmental media including surface and subsurface soils and groundwater. The Safety Light site has undergone various efforts to clean up and remediate the contaminants, ultimately resulting in the demolition and removal of all waste containers and many buildings.

ATSDR reviewed available information collected in and around the Safety Light Site beginning in the early 1980s. This information included soil and groundwater sampling on the facility grounds as well as private wells of nearby residents. The contaminants detected included various radioactive substances, metals, and organic compounds.

As part of the private well evaluation, ATSDR reviewed data collected by USEPA in 2005 and 2006. ATSDR identified low levels of arsenic, copper, and bis(2-ethylhexyl)phthalate that exceeded its health-based comparison values and required more detailed evaluation by ATSDR. A more in-depth evaluation of these contaminants by ATSDR as part of this public health assessment indicates that neither non-cancer nor cancer health effects are expected from these exposures (See Tables 9-13).

Radiologic materials were also detected in private drinking water wells. In the most recent sampling of these wells (2005 and 2006), several radioactive constituents were detected at very low levels. ATSDR used the USEPA Drinking Water regulations for public water supplies to evaluate these contaminants as there are no federally enforceable private drinking water regulations. The ultimate finding of ATSDR's evaluation of the radiation in the drinking water was that the levels in the wells were below the Maximum Contaminant Level set by the USEPA; therefore, do not pose a human health hazard (See Tables 7 and 8).

Data available from the building demolition activities indicate that dust and particulates present during demolition activities were well below levels set by regulatory agencies. Therefore, no further actions are needed.

Radon gas in the formerly occupied buildings, however, was determined to be a public health hazard during those times the facility was operational. The radon concentrations in several buildings exceeded the recommended USEPA action level of 4 picocuries per liter (pCi/L) (See Table 5). ATSDR recommends that individuals who worked in these buildings consult their medical care providers as they may have been exposed to contaminants that may have the potential to impact their health.

Purpose and Health Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) is mandated by the US Congress to evaluate and prepare a public health assessment of those hazardous waste sites listed on the National Priorities List (NPL). The NPL is comprised of hazardous waste sites that have undergone a rigorous evaluation by the US Environmental Protection Agency (USEPA).

As part of this public health assessment, ATSDR used the available data for the site to determine if people are exposed to contaminants at levels that may adversely impact their health. This public health assessment considers the radiological contaminants in the water, soils, and air on the Safety Light Site as well as the potential for exposure to contaminants by people living in the vicinity of the site. In addition, it addresses community concerns that have been raised about the overall safety of the drinking water in nearby private wells. Therefore, exposure to non-radiological contaminants has also been addressed for people with nearby private wells. This public health assessment is not meant to be analysis of an individual's health but will discuss the health of the Bloomsburg community in the vicinity of the site as an entity.

Background

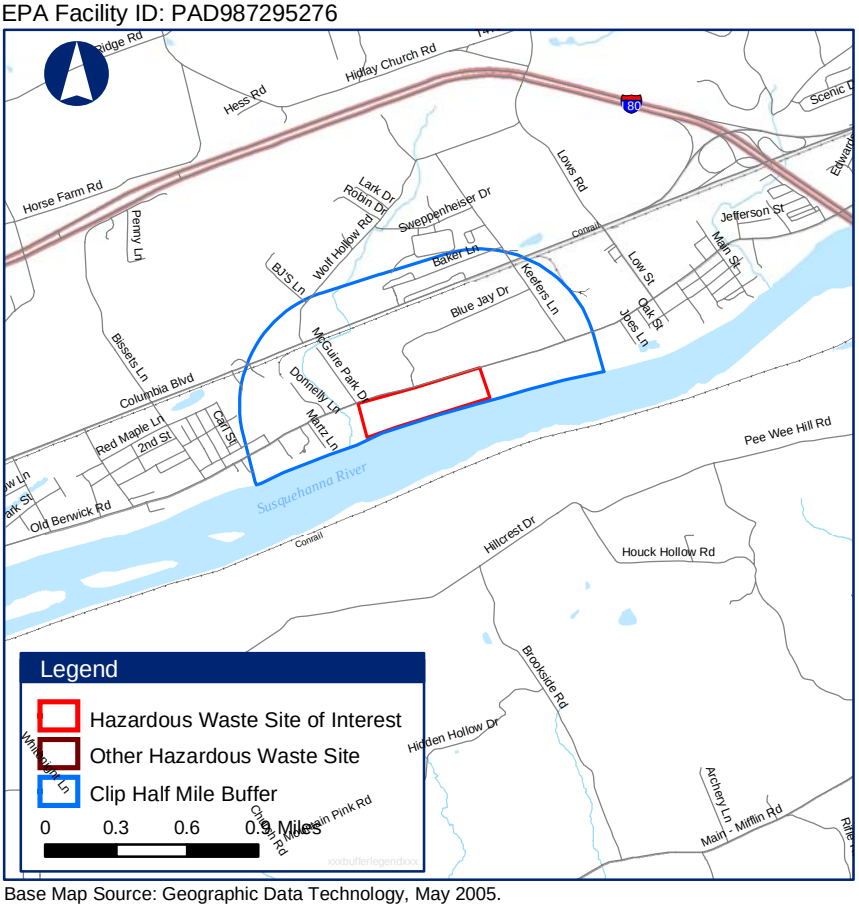
The Safety Light Corporation Superfund Site (SLC, Safety Light Site) is a 10-acre site where radioactive materials were used in manufacturing various devices including radioactive sources for civil defense equipment, US Navy products, and lighting products. SLC was one of three operational facilities within the 10-acre site. The other operations included USR Metals and Multimetals Products Corporation. SLC was the only operation thought to have used radioactive materials. Nonetheless, the majority of the buildings within the 10-acre facility appear to be contaminated with radiologic materials. Operations at the site began in the 1940s and continued until 2008.

SLC is in the South Centre Township of Columbia County near Bloomsburg, Pennsylvania. Although the site encompasses 10 acres, only 2 acres were used for buildings and manufacturing. The site is adjacent to Old Berwick Road on the north, the Susquehanna River on the south and residential properties on the east and west. A chain link security fence surrounds the facility (1). One of the residential properties, the Vance-Walton property on the east side, has been purchased by Safety Light Corporation.

Bloomsburg is the county seat of Columbia County with an estimated population of over 12,500 individuals. Columbia County is in the east central portion of Pennsylvania. The town has become a textile town catering to an international as well as a national market producing carpets, knitted goods, silk fabrics and ladies undergarments. In addition, Bloomsburg is a leader in the cut-flower industry. The town is also the home of Bloomsburg University of Pennsylvania. The Safety Light site is southeast of the center of Bloomsburg. The population within a half mile radius of the site is estimated to be less than 500 people, 490 of these are defined as white by the US Census. The Census also identifies 31 children below the age of 6 and 100 females of childbearing age. The number of housing units in this 1/2 mile radius is estimated at 210. The population map shown on the next page gives more details. Satellite imagery did not show any residential structures on the southern side of the Susquehanna River.

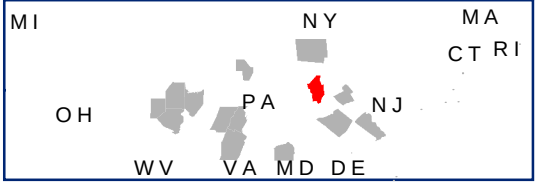
Safety Light Site
Bloomsburg, PA

EPA Facility ID: PAD987295276



Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Geospatial Research, Analysis, and Services Program, Current as of Generate Date (bottom left-hand corner).
Coordinate System (All Panels): NAD 1983 StatePlane Pennsylvania North FIPS 3701 Feet

Site Location: Columbia County, PA

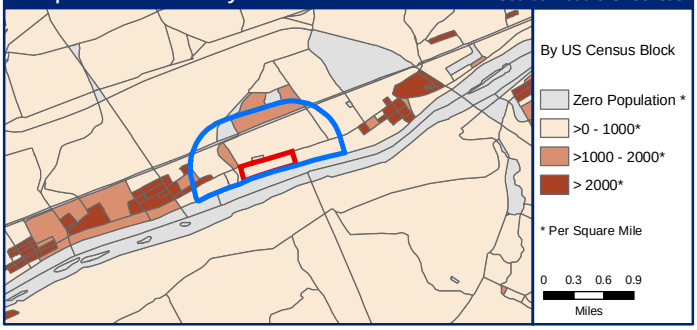


Demographic Statistics
Within Area of Concern*

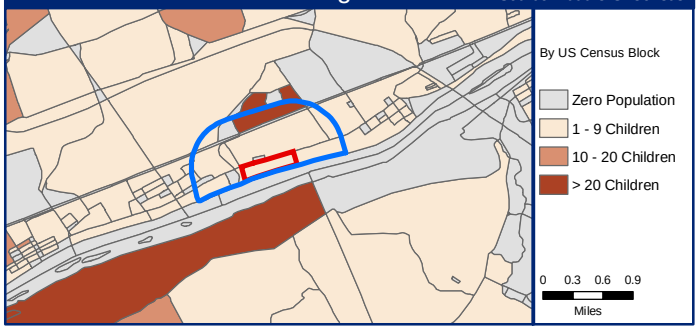
	Inside Half Mile Buffer
Total Population	493
White Alone	490
Black Alone	2
Am. Indian & Alaska Native Alone	0
Asian Alone	0
Native Hawaiian & Other Pacific Islander Alone	0
Some Other Race Alone	1
Two or More Races	1
Hispanic or Latino**	5
Children Aged 6 and Younger	31
Adults Aged 65 and Older	74
Females Aged 15 to 44	100
Total Housing Units	210

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

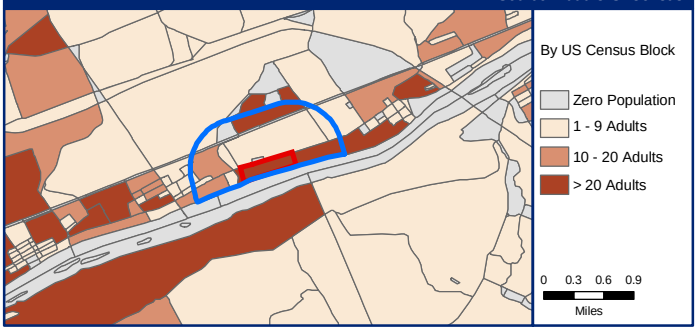
Population Density
Source: 2000 U.S. Census



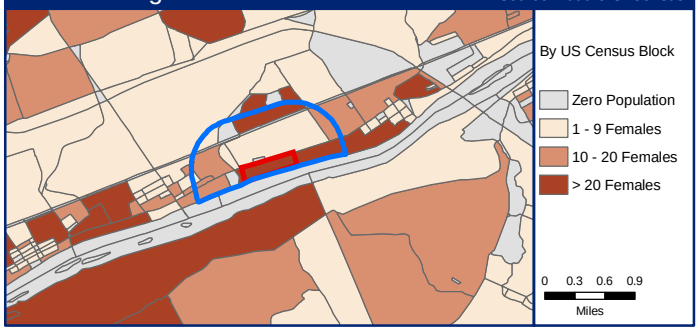
Children 6 Years and Younger
Source: 2000 U.S. Census



Adults 65 Years and Older
Source: 2000 U.S. Census



Females Aged 15 to 44
Source: 2000 U.S. Census



<project=03309><userid=JXA0><geo=Columbia County, PA><keywords=PAD987295276,PAD987295276, Safety, Light>

When ATSDR first visited the site in 2000, several buildings existed on the site although few of these structures were being occupied. At least 3 buildings were in a serious state of disrepair and were considered too dangerous for occupancy. Other buildings contained manufacturing activities or were used to store radioactive waste products, while other buildings contained the administrative offices or activities not associated with radioactive materials (Figure 1). Other facility areas of note include an abandoned nurse's station, a lagoon running along the river, and two lagoons that were reportedly used for radioactive waste disposal sites (1).

Figure 1. Safety Light Corporation Site physical structures

In its early history, SLC used radium 226 (Ra 226) and polonium 210 for light sources or other manufacturing processes beginning in 1948. The USEPA states in their Hazard Ranking Documentation that manufacturing at the facility used hydrogen 3 (tritium, H 3), carbon 14, cobalt 60, nickel 63, krypton 85, cesium 137 (Cs 137), promethium 144, thallium 202, and Ra 226 which was the most widely used radionuclide (1). In the 1960s, unspecified processes replaced the use of Ra 226 with americium 241 (Am 241) (2). Later, strontium 90 (Sr 90) and Cs 137 were used for civil defense devices and deck markers for the US Navy, respectively. The H 3 was used for emergency lighting devices. SLC held two licenses for use of radioactive material issued by the US Nuclear Regulatory Commission (USNRC) or its predecessor, the Atomic Energy Commission. The licenses, License Number 37-00030-02 (for the cleanup) and License Number 37-00030-08 (tritium use) expired on December 31, 2007 (3).

During the production of the various devices made by SLC during the 1950s, radioactive solid wastes consisting of contaminated glassware and laboratory wastes including Ra 226, Sr 90,

Cs 137, and tritium were placed in two underground silos, on the southern portion of the site, which were 12 feet deep by 10 feet wide. The SLC staff believed these silos either had no solid base or the base was either metal or concrete (2). When the silos were closed in 1960, the wastes were shipped off-site to licensed radioactive waste burial facilities. No further remediation was undertaken at that time.

Although the Safety Light Corporation is a licensee of the USNRC, the site was added to the USEPA NPL in 2005. NPL listing basis was in response to the presence of the containers and drums, ground water and surface water contamination, and soil contamination on the property. Because the site is also a USNRC licensee, ATSDR believes that the Memorandum of Understanding[1] between the USEPA and the USNRC will help define the roles and responsibilities of these regulatory agencies. In 2008, the state of Pennsylvania became an USNRC Agreement State. Under the agreement, the USNRC transferred to the state the responsibility for licensing, rulemaking, inspection and enforcement activities for: (1) radioactive materials produced as a result of processes related to the production or utilization of special nuclear material (SNM); (2) uranium and thorium source materials and; (3) other radioactive materials under NRC jurisdiction provided by the Energy Policy Act of 2005[2]. Currently, the state through a Cooperative Agreement Grant from USEPA, is providing radiological protection support for USEPA activities at the site.

Site-related landmarks and structures

Canals lagoons, and Dump Areas

Along the Susquehanna River, a canal traversed the SLC property. The canal, in its entirety, ran from Sunbury to Scranton, a distance of about 90 miles. Available information states that the portion of the canal along the SLC property may have consisted of at least 7 lagoons. SLC used the former canal and some of the associated lagoons as liquid waste disposal areas. Liquid wastes produced on the site were routed to a nearby abandoned canal associated with the Susquehanna River where they were filled with river water, allowing the wastes in them to be diluted prior to discharging into the river. Other wastes were transferred to a holding tank and evaporator system (4). The concentrated liquid wastes were allowed to evaporate, and the dry residuals were transferred to a waste company. During the 1960s, three of the lagoons on the eastern side of the facility were remediated and backfilled. Currently, two lagoons are considered to be active on the site. The East Lagoon received both sewage and radioactive wastes until 1954. In 1972 during the Susquehanna flooding, the wastes remaining in the lagoon were probably distributed on the surrounding soils. The West Lagoon is believed to have received wastes associated with metal plating activities and in 1972 these wastes most likely were dispersed as well by the flooding.

Two dump areas also have been identified on the site. The East Plant Dump is between the east and west lagoons and received radiological contaminated ductwork and scrap materials. The West Plant Dump adjacent to the west fenceline also was used for solid waste disposal. The

[1] Memorandum of Understanding between the Environmental Protection Agency and the Nuclear Regulatory Commission. Consultation and finality on decommissioning and decontamination of contaminated sites. Signed October 9, 2002. Available on line at http://www.nrc.gov/reading-rm/doc-collections/news/2002/mou2fin.pdf (accessed January 6, 2009).

[2] Federal Register Announcement. 73 FR 19261, April 9, 2008.

materials known to have been dumped in this location include Ra 226 dials and Sr 90 deck markers. SLC states that 78 drums of contaminated soils were shipped from this area in either the 1960s or 1970s.

Other buildings of interest on the site include:

1. Etching Building where acids were used in the assembly and manufacture of radium and tritium instruments and dials. Some areas of the building were used for support services, such as silverplating, chemical storage, maintenance activities, machining tools and dies, and office space;
2. An old house built in the 19th century. The house was struck by lightning, burned and collapsed upon itself. In 1978, a survey by the USNRC indicated widespread radiologic contamination;
3. The Radium Vault was thought to be used for working with lead as well as various radium compounds. The regulatory agencies believe all radiologicals have been removed from the vault but its condition is too dangerous for personnel to enter as it is structurally unsound;
4. Machine Shop and Tritium Building were used in the manufacture of tritium containing products. In 1969, the tritium operations were moved from the machine shop to the tritium building. After the move, the machine shop did not perform any work with radioactive materials;
5. The personnel office or nurses' station, located in front of the main building was used for administrative purposes but later was used to store radium materials. It is thought that a cellar below the building may be contaminated;
6. The main building housed the administrative activities of the company. However, the upper floors were used to hand-paint radioactive materials onto various products. That floor as well as ductwork in the facility is contaminated;
7. Waste processing and holding structures including the carpenter shop, Multimetals waste processing building, solid waste buildings, and an above ground metal silo to the rear of the facility were used to store various types of wastes, contaminated equipment, and radioactive materials such as Cs 137 and Sr 90; and
8. The Lacquer storage building where solvents had been stored.

As of early 2009, most of the buildings on the site were razed and the wastes removed by the US Army Corps of Engineers under contract with the USEPA.

Other Site activities

Since the 1960 timeframe, various clean up efforts have been undertaken including decontamination of buildings, backfilling of on-site lagoons and removal of soils contaminated with Ra 226. Several events occurred that have resulted in the spread of contamination on the site. These include a flood in 1972 that destroyed the holding tank and evaporator as well as impacting the former canal and east lagoon (2).

Several environmental assessments and sampling investigations have been conducted at the SLC either by SLC or the USNRC. In 1979, SLC conducted a hydrogeologic investigation of the alluvial ground water system for the installation of permanent monitoring wells to determine the depth to ground water, water table gradients, flow directions, existing water quality with the extent of radiological contamination and to propose pollution abatement techniques. During this investigation, two test pits were dug in the vicinity of the former canal. While these pits were being dug, water was encountered at a depth of about 5 feet (1.5 meters, m) below ground surface. Old fill material from the canal was encountered within the ground water, including wood and radioactive debris. An oily odor also was noted during excavation of an onsite test pit. Ground water flow direction on the SLC property was noted to be heading toward the Susquehanna River.

In 1981, the USNRC conducted an environmental survey of the Safety Light Site. This survey was to determine the accuracy of routine measurements performed by the facility and to evaluate the adequacy of the facility's environmental control and monitoring program. During the USNRC environmental assessment, they measured radiation levels in unrestricted areas around the SLC facility, monitored tritium releases in air stacks and liquid effluents from SLC activities, and measured levels of radiation in the environment as a result of past and present operations at the SLC facility. The USNRC also collected baseline soil and water samples to compare to soil and water samples collected on-site and in the vicinity of the SLC facility (6).

Surface water samples collected from the east lagoon and an on-site drainage ditch contained elevated Ra 226 concentrations above the baseline water samples. The H 3 concentration in the east lagoon also was significantly greater than the maximum level detected in the baseline water samples as were levels in groundwater samples from on-site monitoring wells. Other radiologic contaminants found in monitoring wells above the baseline levels included Ra 226, Cs 137, and Sr 90 (6).

The USNRC collected surface and subsurface soils from the southwest portion of the site showed the highest concentrations of radiologic contaminants. These surface soil samples exhibited contaminants including Ra 226, Cs 137, and Sr 90. Subsurface samples collected at various depths to about 9 feet (2.7 m) showed elevated concentrations of these same three contaminants as well as H 3. The USNRC thus concluded that these media were contaminated and had been used as waste deposition areas. When coupled with the contamination in water samples, the USNRC also concluded that contaminant migration had occurred (6).

In 1990, SLC installed new monitoring wells, sampled existing on-site monitoring wells, conducted a magnetic survey to identify buried objects, conducted soil coring for radiological analyses, and collected rainwater samples. Analyses of the ground water samples showed elevated H-3 throughout the property, and especially in the southeastern portion of the facility. Numerous buried magnetic objects were detected on the property adjacent to the facility on the east, near the southeastern fence line and within the suspected boundaries of the abandoned canal. High concentrations of H 3 and Sr 90 were detected in surface and subsurface soil samples. Samples on the southern border along the bank of the Susquehanna River and in the vicinity of drill sites contained elevated levels of H 3.

The USEPA was notified of the contamination issues in 1991 through their discovery process. They conducted soil and groundwater sampling in 1993 and 1994. Analyses of soil samples indicated the presence of elevated concentrations of inorganic contaminants including antimony,

arsenic, cadmium, chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, zinc and extractable hydrocarbons.

Another site characterization by SLC in 1995 to provide sufficient information for the subsequent closure (decommissioning) followed by a later release of all or part of the facility for unrestricted use. The characterization included the determination of the extent of radiological contamination on the SLC grounds, whether radioactive materials are buried on-site, and the extent of radiological contamination inside on-site buildings; access to the underground silos and information on their contents; and install boreholes and wells and collect more ground water and subsurface soil samples. The radioactive contaminants found in this study included Ra 226, Cs 137, and Am 241. The non-radioactive contaminants detected included cadmium, chromium, copper, nickel, lead, and zinc as well as organic hydrocarbons. Additional studies for metallic objects detected the presence of small metallic objects buried in the west dump.

The examination of the underground silos indicated that the east silo contained material to within a foot of its concrete lid. Both silos contained glass jars, bottles, and watch dials. Re-crystallization was observed in both silos indicating that their insides were once moist. In the boreholes/wells installed during the characterization activities, the soils collected from the boreholes showed elevated concentrations of Cs 137, Ra 226, and H-3 were found at various depths and locations. Radionuclides including Ra 226, Cs 137, and tritium were detected in on-site monitoring well samples. Volatile organic compounds were detected in on-site ground water samples and heavy metals were detected in on-site soil and ground water samples.

In 2000, the Pennsylvania Department of Environmental Protection collected water from the monitoring wells and the river. The results of the ground water samples indicated the presence of inorganic constituents and radionuclides at elevated concentrations; however, surface waters analyses from the river did not show the presence of any contamination.

Because of the issues associated with radiological contamination and the proximity of residential areas, the Pennsylvania Department of Health requested that ATSDR review the radiological data associated with on-site contamination and off-site residential wells to determine if the radiological contaminants were present at levels of health concern.

Also in 2000, the USEPA issued a preliminary assessment and began enforcement activities that SLC was to follow to protect the environment and surrounding areas. In 2004, the SLC completed a site stabilization effort intended to stabilize or clean up the site since the USEPA determined the site posed an imminent and substantial threat to human health or the environment.

In February 2003, the USEPA and Safety Light entered into an Administrative Order of Consent (AOC) requiring the emergency removal under Superfund authority. The AOC required SLC to eliminate any releases or threats of release from their facility and to collect, stage, and prepare any wastes for shipment to a disposal facility licensed by the USNRC (5)

Upon listing of the SLC on the NPL in 2005, USEPA initiated a Combined Remedial Investigation/Feasibility Study (RI/FS). This study is the process of data collection and analyses of the site problem, identification of preliminary remedial alternatives, and recommendation of a cost-effective remedy.

Safety Light Corporation no longer performs production activities at this site. They are continuing to perform safety and security activities pursuant to a Unilateral Administrative Order

issued by USEPA. These safety and security activities include maintenance of the site fencing, sprinkler system, and electronic security system.

The USEPA RI/FS is being conducted in three areas called operable units (OU). These units are buildings, the groundwater, and soils, sediments and surface water. The work on OU 1 for the environmental investigation of buildings at the site was substantially completed in 2006. The data is currently being organized and evaluated by USEPA.

The OU 2 field work for the environmental investigation of ground water continues. In 2007, USEPA installed three deep bedrock monitoring wells to complete the ground water data collection. During 2008, groundwater samples were collected from monitoring wells and analyzed for contamination.

OU 3 activities are ongoing. USEPA believes that they will complete the soils/sediment/surface water sample collection, and will submit the samples for laboratory analysis. When ready, data from this sampling effort will be organized and evaluated by USEPA.

All data collected by USEPA has been made available to ATSDR and their regional office in Philadelphia.

Emergency Removal Activities – Silo and Waste Processing Area

As the Safety Light Site is on the NPL and was considered to be an environmental and public health threat, several actions have been taken under an emergency declaration. As previously discussed, the silos contained much radioactive wastes and other debris. According to the Monserco Characterization Report, upon visual inspection, the silos contained crystalline materials, loose dials of various shapes, watch dials, glass jars and bottles, and deck markers (2). Examples of the waste contained in the silos are shown in Figure 2, Figure 3, and Figure 4. Following the discovery of these waste types, the USEPA required the complete removal of radioactive materials exhumed from two underground silos as part of an emergency response activity. Removal of the waste materials required excavation from the silos, segmentation into low radiation and high radiation areas and relocation to a process area to the “pole building” behind the main process building. From the pole building, the waste was placed in the appropriate storage container and held until shipped off site.

An Action Memorandum was completed in 2007 for the demolition of seven unused and unmaintained buildings. USEPA has established an interagency agreement with the United States Army Corps of Engineers (USACE) to accomplish the demolition and off-site disposal of seven buildings at the Site. In 2008, the USACE began demolition of these site structures. The activities included in this demolition included air sampling, soil sampling, and various other samples of the surrounding environment. By July 2009, the demolition was completed.

Figure 2. Silo waste being removed.

Previous Groundwater Investigations

Groundwater investigations at the SLC have been performed over the last 20 years. In 1981, the Oak Ridge Associated Universities (ORAU), under contract with the USNRC sampled 23 monitoring wells and installed an additional 2 wells. ORAU also sampled 4 private wells and the city of Bloomsburg water supply. The sampling results of the off-site wells found H 3, Cs 137, and Ra 226 in water samples. The water from the city water supply did not show any Cs 137 or Ra 226 above detection limits. On-site sampling of the monitoring wells found elevated concentrations of H 3, Sr 90, Cs 137, and Ra 226. Of these contaminants, only Cs 137 did not exceed regulatory limits in place at that time (6).

In 1990, Chem-Nuclear installed wells to assist in the hydrological characterization of the site in support of an on-going radiological evaluation. At that time, both H 3 and Sr 90 were found in the groundwater and the Sr 90 was believed to be originating from the burial silos.

During 1995, Monserco Limited of Canada was hired by Safety Light Corporation to perform another site characterization. Monserco reported 25 monitoring wells existed on the SLC site prior to their involvement and the installation of 13 additional wells. The number of wells and their location was determined following discussions with SLC and the USNRC. The depth to groundwater ranged from 0.7 to about 24 feet below the ground surface and the wells themselves ranged in depths from 11 to about 80 feet.

Figure 3. Luminous materials in concrete

Sampling of these 13 new well waters produced the following general results. Radiological contamination was found in 11 of 13 wells; whereas, volatile organic compounds (VOC) or hydrocarbon materials and heavy metals were reported in all wells. The organics included dichloroethanes, benzene, xylene, toluene, vinyl chloride, dichloroethene, and tetrachloroethene. A partial list of the heavy metals tested for in the water samples included aluminum, arsenic, cadmium, chromium, copper, mercury, nickel, and zinc (7).

Figure 4. Luminous paint waste from silos.

Pathway Analyses

Not every release of a site-related contaminant negatively affects the off-site community. For a contaminant to pose a health problem, an exposure must first occur. That is, a person must come in contact with the contaminant by, for example, breathing, eating, drinking, or touching a substance containing it. If no one comes in contact with the contaminant, then no exposure occurs, and no health effects can occur. Still, even if the site is inaccessible to the public, contaminants can move through the environment to locations where people could come in contact with them. In the case of radiological contamination, because of the emission of radiation, which is a form of energy, exposure can occur without direct contact.

ATSDR evaluates site conditions to determine whether people could have been or could be exposed to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether, through ingestion, dermal (skin) contact, or inhalation, exposure to contaminated media (e.g., soil, water, air, waste, or biota) has occurred, is occurring, or could occur. With regard to radioactive contamination, a person can be exposed to both external radiation and internal radiation. Internal exposures result from radioactive sources taken into the body through the inhalation of radioactive particles or through the ingestion of contaminated food. External exposure results from radiation sources originating outside the body, such as radiation emitted from contaminated sediment. These external sources can sometimes penetrate human skin. Whether an exposure contributes to a person's external or internal exposure depends primarily on the type of radiation—that is, alpha and beta particles or gamma rays—to which that person was exposed. ATSDR also identifies an exposure pathway as completed or potential, or, if neither, eliminates the pathway from further evaluation. Exposure pathways are complete if all

human exposure pathway elements are present. A potential pathway is one that ATSDR cannot rule out because one or more of the pathway elements cannot be definitely proved or disproved. If one or more of the elements is definitely absent, a pathway is eliminated.

The five elements of an exposure pathway are:
1) a source of contamination,
2) an environmental medium,
3) a point of exposure,
4) a route of human exposure, and
5) a receptor population.

The source of contamination is where the chemical or radioactive material was released. The environmental medium (e.g., groundwater, soil, surface water, air) transports the contaminants. The point of exposure is where people come in contact with contaminated media. The route of exposure (e.g., ingestion, inhalation, dermal contact) is how the contaminant enters the body. The people actually exposed comprise the receptor population.

Assessing Health Effects

As stated, exposure does not always result in harmful health effects. The type and severity of health effects that a person might experience depend on the dose, which is based on the person's age at exposure, the exposure rate (how much), the frequency (how often) or duration (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once a person is exposed, characteristics such as age, sex, nutritional status, genetic factors, lifestyle, and health status influence how the contaminant is absorbed, distributed, metabolized, and excreted. An environmental concentration alone will not cause an adverse health outcome—the likelihood that adverse health outcomes will actually occur depends on site-specific conditions, individual lifestyle, and genetic factors that affect the route, magnitude, and duration of actual exposure.

As a first step in evaluating exposures, ATSDR health assessors screen the radiation levels and doses and detected chemical concentrations found in a particular media (i.e., soil, air, or drinking water) against health-based comparison values (CVs). ATSDR develops comparison values from available scientific literature concerning exposure, dose, and health effects. Comparison values represent radiation doses or chemical concentrations that are lower than levels at which, in experimental animals or in human epidemiological studies, no effects were observed. CVs are not thresholds for harmful health effects; rather, they reflect an estimated radiation dose or chemical media concentration that is not expected to cause harmful health effects. Radiation doses and chemical media concentrations at or below the comparison values can reasonably be considered safe. When a comparison value is exceeded, exposures will not necessarily produce undesirable health effects. This screening process enables ATSDR to eliminate safely from further consideration contaminants not of health concern and to further evaluate potentially harmful contaminants.

ATSDR uses comparison values to identify those site-related hazardous substances that are not considered health threats.

If the estimated radiation doses or chemical media concentrations at a site are above selected health-based comparison values, ATSDR proceeds with a more in-depth health effects evaluation. ATSDR scientists now determine whether the doses are large enough to trigger public health action to limit, eliminate, or study further any potentially harmful exposures. ATSDR scientists conduct a health effects evaluation by 1) examining site-specific exposure conditions about actual or likely exposures, 2) conducting a critical review of radiological, toxicological, medical, and epidemiological information in the scientific literature to ascertain the levels of significant human exposure, and 3) comparing an estimate of possible radiation

doses or chemical doses to situations that have been associated with disease and injury. This health effects evaluation involves a balanced review and integration of site-related environmental data, site-specific exposure factors, and toxicological, radiological, epidemiological, medical, and health outcome data to help determine whether exposure to contaminant levels might result in harmful, observable health effects. By weighing scientific evidence and keeping site-specific doses in perspective, the health effects evaluation determines whether harmful effects might be possible in the exposed population.

Additionally, information about the evaluation process can be found in the ATSDR Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/index.html or by contacting ATSDR at 1-800-CDC-INFO. ATSDR's Web-based public health assessment training course is available at http://www.atsdr.cdc.gov/training/pha_professional1/ (Overview 1 - Mission and Community), http://www.atsdr.cdc.gov/training/pha_professional2/ (Overview 2 - Exposure Pathways and Toxicologic Evaluation), and http://www.atsdr.cdc.gov/training/pha_professional3/ (Overview 3 - Evaluating Health Effects Data and Determining Conclusions and Recommendations).

Analysis of Radiologic Samples

Determination of Background Radiation

Radioactivity occurs naturally in the environment so its detection and determination depend on various factors such as how and where the sample was collected, the method of sample treatment in the field and the laboratory, and the procedure whereby the sample was analyzed. The samples collected at the Safety Light Site were sent to a contract laboratory for analysis. The USEPA supplied information to ATSDR relating the methods to be used for the radionuclide analyses. The procedures listed were traceable to methods developed by the Department of Homeland Security, Environmental Measurements Laboratory in the Health and Safety Laboratory Manual, HASL-300[3], USEPA methods for radionuclides in water, or US Department of Energy analytical procedures.

Paramount in the evaluation is the separation of background radiation present in the environment from the radioactive contamination that might be present at a site. In the case of the samples collected from the Safety Light Site, regulators have a very good understanding of the types of radioactive materials used at the site; however, there is little information on the releases from the site operations. The evaluation of background samples for radioactivity is very important because the background samples must be taken in areas that are known not to be impacted by the releases from the Safety Light Site.

Background radiation varies in relation to geology, the area of the country, the nearness of operations that might release radioactive materials such as fossil fueled electricity generating power plants, especially coal operated plants. The USEPA and its contractors selected several sites in the Bloomsburg area to serve as background radiation locations. Eleven soil samples were collected in January 2008, analyzed, and evaluated for quality assurance and control (QA/QC) that the data met the objectives of the sampling requirements. The QA/QC evaluation

[3] Available on the internet at http://www.eml.st.dhs.gov/publications/procman/ (last accessed on April 29, 2009).

checks the data against recognized processes both related to the results as well as the design protocols.

The radionuclides listed in the analytical reports included, but was not limited to, uranium 238 (U 238) and several of its decay products, carbon 14 (C 14), cobalt 60 (Co 60), nickel 63 (Ni 63), strontium 90 (Sr 90), cesium 137 (Cs 137), and americium 241 (Am 241). Of this list, only the U 238 and C 14 are naturally occurring. The others can be found in the environment as they are related to nuclear weapons testing or related activities. For the SLC data, the QA/QC results indicated that much of the data were of questionable use. Each of the reported values was "flagged" with various data qualifiers listed in Table 1. For the analysis of background, ATSDR only used those samples with "U," "UJ," or "J" data qualifiers. A plot of these data is shown in Figure 5.

Background radiation summary: Environmental analyses of the radioactive materials in the area of the Safety Light Site are within the normal range of background found in the United States.

Table 1. Data qualifiers used for radioanalytical evaluation

Data qualifier flag	Description
U	Indicates the constituent was not detected. The data should be considered usable for decision-making purposes
UJ	Indicates the constituent was not detected. Due to a quality control deficiency during data validation, the value reported may not accurately reflect the minimum detected activity (MDA). The data should be considered usable for decision-making purposes.
J	Indicates the constituent was detected. The associated value is estimated due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
UR	Indicates the constituent was not detected; however, due to an identified quality control deficiency the data should be considered unusable for decision making purposes.
R	Indicates the constituent was detected; however, due to an identified quality control deficiency the data should be considered unusable for decision making purposes.

The decay products of U 238 include radium 226 (Ra 226) and polonium 210 (Po 210). Under natural conditions, the concentrations of these radionuclides should be approximately equal as shown in Figure 5. Carbon 14 is produced in the atmosphere via cosmic ray interactions and its presence in the background is one of the bases for estimating the age of archeological relics. Production of H 3 occurs similarly; although, it is a product of both nuclear energy generation and nuclear weapons testing. The presence of actinium 227 (Ac 227) is not unexpected as it is a natural decay product of naturally occurring U 235. Cesium 137 and Sr 90 are associated with atmospheric nuclear testing; these are now considered part of the naturally occurring background radiation although their concentration continuously decreases over time.

The presence of the remaining radionuclides, Am 241, Tl 204, Ni 63, and Co 60 are typically not found in background soil samples. Their identification here is either an error in the laboratory identification, or indication that they were released from the Safety Light Corporation. This is possible since the information garnered from the site operational history indicated Am 241 and Ni 63 were used during the operational time period. Additional evaluation by the USEPA and other regulatory agencies will be necessary to verify the presence of these radionuclides in the soil samples. The following table (Table 2) lists the primary radionuclides at this site, their primary decay mode, half-life, and cleanup guidelines.

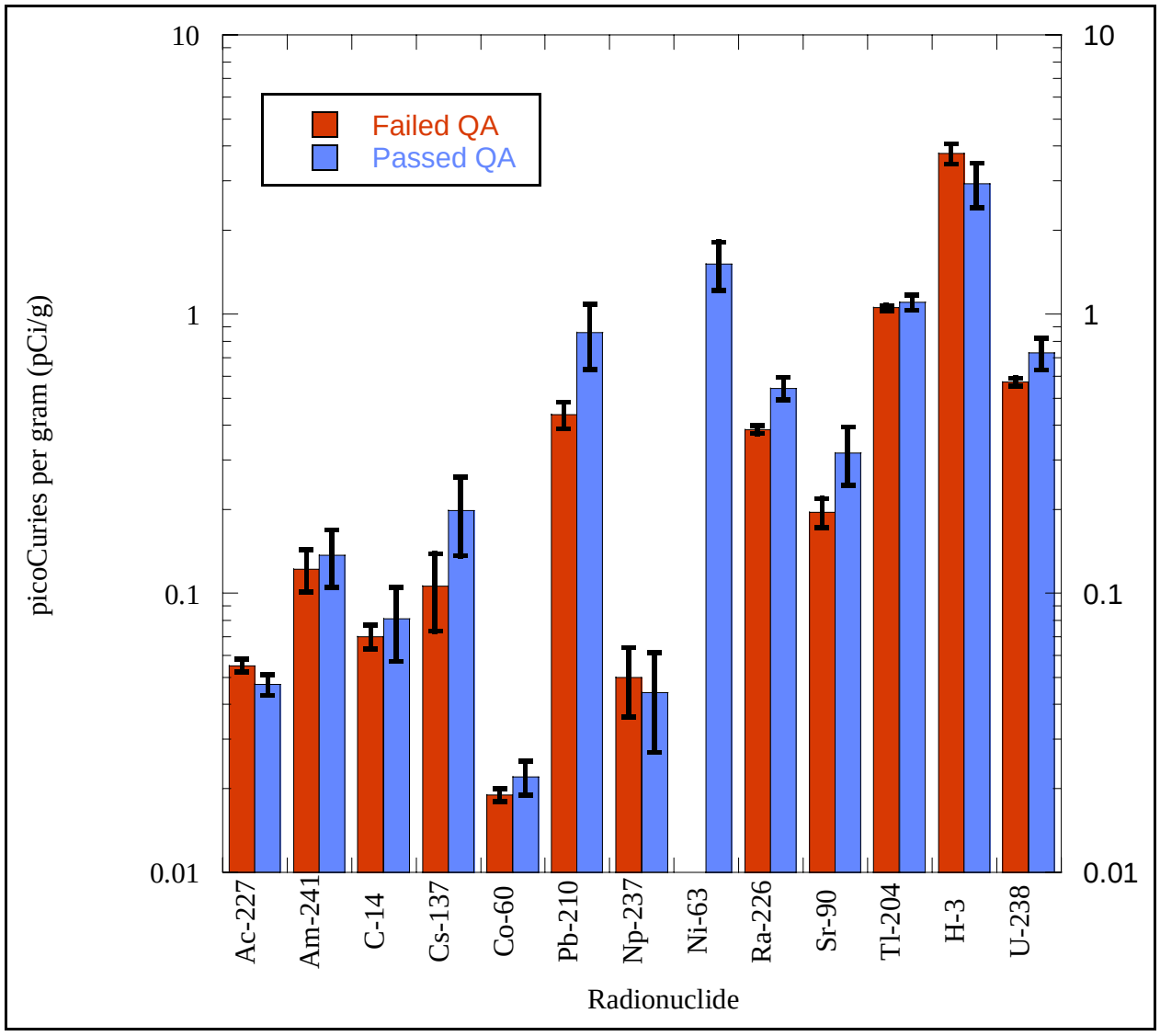


Figure 5. Radionuclides in SLC Background Soils. Soil samples were collected in January 2008 and analyzed for radioactive content. The data were supplied by the USEPA. The values represent the average of samples meeting the QA/QC requirements are shown in the blue bars. Those not passing the QA are shown in the red bars. The error bars represent the standard error of the mean for each individually reported radionuclide

Table 2. Site related radionuclides

Radionuclide and Symbol	Primary Decay mode	Half-life (years)	USEPA Soil cleanup guideline estimate (pCi/g)*	RESRAD Soil guideline†
Actinium (Ac 227)	Beta	21.8	27	9.76
Americium (Am 241)	Alpha	432.7	29	42.7
Cesium (Cs 137)	Beta	30.2	21	13.2
Cobalt (Co 60)	Beta	5.3	13	88
Lead (Pb 210)	Beta	22.37	19	6
Nickel (Ni 63)	Beta	100	42,600	>1000
Radium (Ra 226)	Alpha	1600	5	0.23
Strontium (Sr 90)	Beta	29.1	49	7.2
Thallium (Tl 204)	Beta	3.8	6,300	>1000
Thorium (Th 232)	Alpha	14 billion	320	1
Tritium (H 3)	Beta	12.3	1,000	ND
Uranium (U 238)	Alpha	4.47 Million	254	100

*Cleanup guideline derived from USEPA dose compliant calculations at http://epa-dccs.ornl.gov/ (last accessed on January 4, 2009). The dose used is the CERCLA value of 15 millirem per year.

†The RESRAD model for residual radiation takes into account all pathways combined including radon in the case of Ra 226. The guideline values were calculated for a soil concentration of 10 picocuries per gram and a dose limit of 15 millirem/year using the default parameters.

In the USEPA Hazard Ranking System Documentation Package (1), background values were collected by the US Nuclear Regulatory Commission. Their reported background values and ranges are given in Table 3. Comparing the USNRC values with the values shown in Figure 5 only the values reported for tritium are not comparable.

Table 3. Soil background levels reported by the USNRC*

Radionuclide	Average (pCi/g) ± 2σ†	Potential Range (pCi/g)†
Radium 226	0.48 ± 0.46	0.02 – 0.94
Cesium 137	0.26 ± 0.52	0 – 0.78
Strontium 90	0.63 ± 0.21	0.42 – 0.84
Hydrogen 3 (Tritium)	0.45 ± 0.16	0.29 – 0.61

*Data from the HRS Documentation package prepared by USEPA and dated January 22, 2003.

†Adding or subtracting the two standard deviations values indicates that there is about a 95% confidence that any reported value will be within that range.

Off-site groundwater

The most recent groundwater monitoring of off-site wells occurred in 2005. Along the southern and southeastern border of the site flows the Susquehanna River. Hydrological studies indicate that groundwater flows toward the river so sampling was collected from 7 residential wells on either side of the facility. The location of these wells varied from less than 0.1 miles from the site to at least a mile from the facility. Data from the closest wells were reviewed. These wells were listed as residential Well A on the southwestern side of the site and Wells D and F on the northeastern side located about 0.12 from the site border. Figure 6 represents the groundwater concentrations in these wells. Except for the concentration of radium 226 and thorium 230/232, there is no significant difference between the wells.

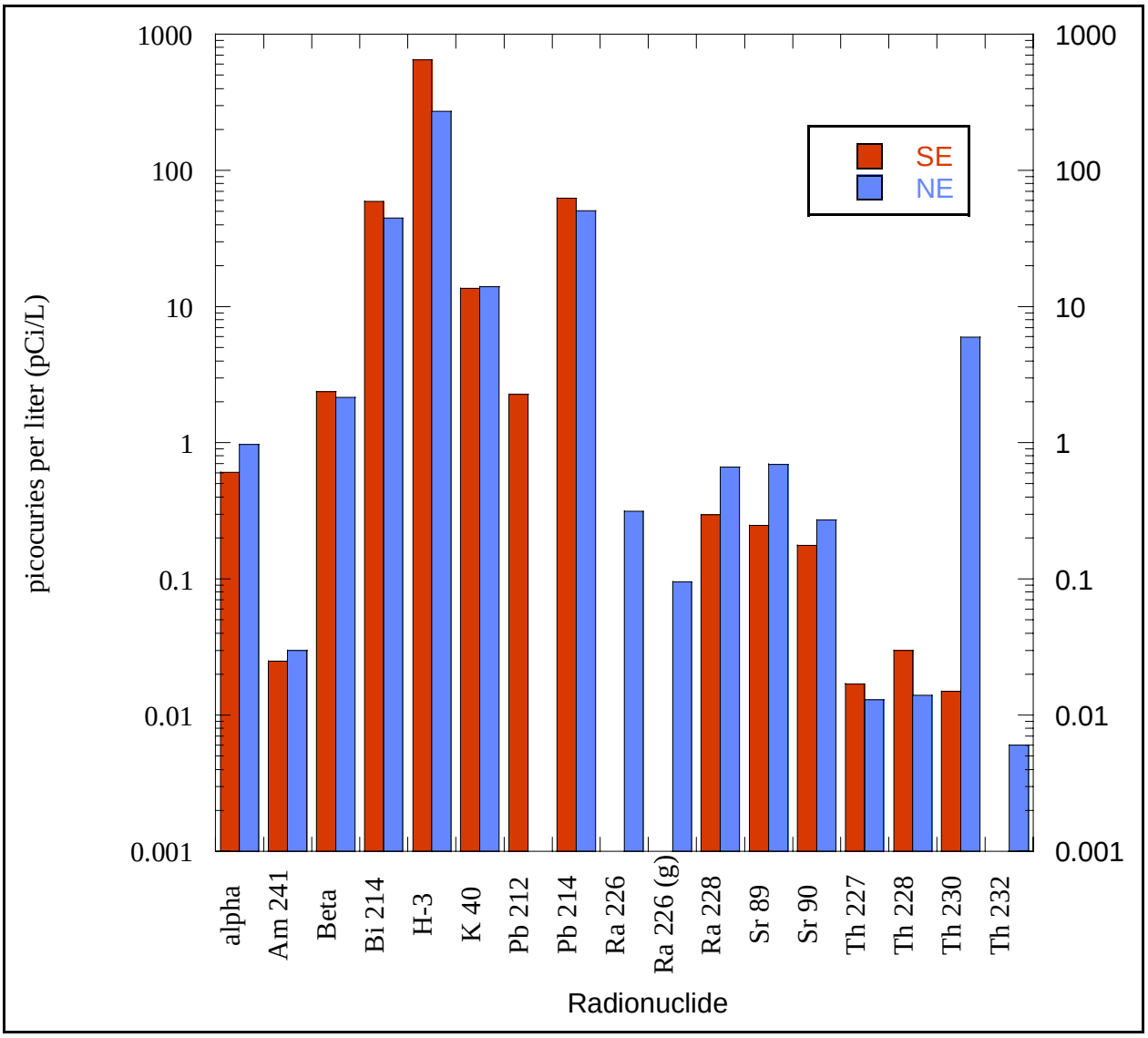


Figure 6. Radionuclides in off-site adjacent residential wells. Wells were sampled in 2005 for the listed radionuclides. The wells closest to SLC were selected for this analysis. The one SE well was within 0.1 mile of the facility. The two NE wells were at an average distance of about 0.12 miles from the facility.

Off-site soil sampling for radionuclides

Beginning in November 2007 and continuing through January 2008, soil samples were collected in several survey units (SU). The off-site SU sampled include SU 21 located on the westerly portion of the site and SU 22, the former Vance/Walton property on the eastern side of the facility. Both SU are directly adjacent to the Safety Light Site. Comparison the SU 21 and SU 22 data to background concentrations of radioactivity (see Figure 7) by subtracting the background shows that for the most part, the concentration of only a few radionuclides exceed background. These results are shown in Figure 7. Soil concentrations of radionuclides in adjacent properties. Soil samples were collected on the western side (SU 21) and eastern site (SU 22) of the Safety

Light Properties. The net activity was determined by subtracting the background values from the measured values. Values less than zero are an artifact of the data manipulation.

The data indicate that only Cs 137, Pb 210, Ra 226, and H 3 appear to be greater than the average background concentrations. Of these, only Pb 210 was not used at the site. Lead 210 with a half life of about 22.3 years is a decay product of U 238, Ra 226, and Rn 222 and will be present in all environmental samples collected at this site.

Summary of off-site levels of radionuclides: ATSDR's review indicates that the levels of radioactive materials other than Cs 137 used at the site have not migrated off-site. Although elevated above local background levels, the environmental levels of off-site Cs 137 are still within the variance found in the United States.

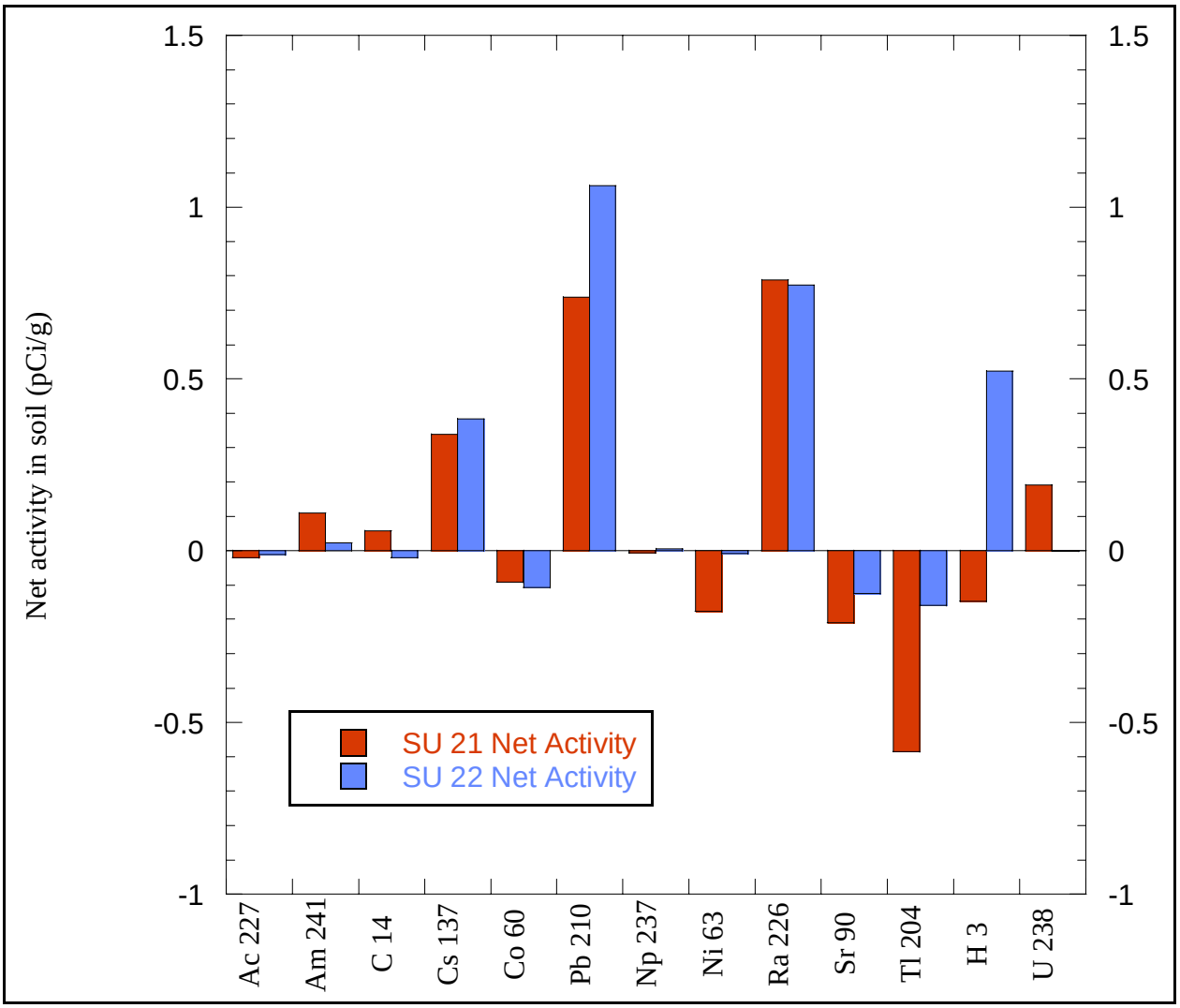


Figure 7. Soil concentrations of radionuclides in adjacent properties. Soil samples were collected on the western side (SU 21) and eastern site (SU 22) of the Safety Light Properties. The net

activity was determined by subtracting the background values from the measured values. Values less than zero are an artifact of the data manipulation.

On-site soil sampling for radionuclides

Limited recent sampling of the soils located around the facility has occurred at the time of this document. USEPA contractors collected soil samples in several of the survey units and analyzed the samples for the constituents mostly used at the site as well as the contaminants that had been detected in the disposal silos which were in the general vicinity of SU 5 and SU 6. The survey units were divided into three major categories ranging from most likely to be contaminated (Soil Classification 1) to least likely to be contaminated (Soil Classification 3). Within these classification units, the soil survey units were developed. The classification system is shown in Figure 8.

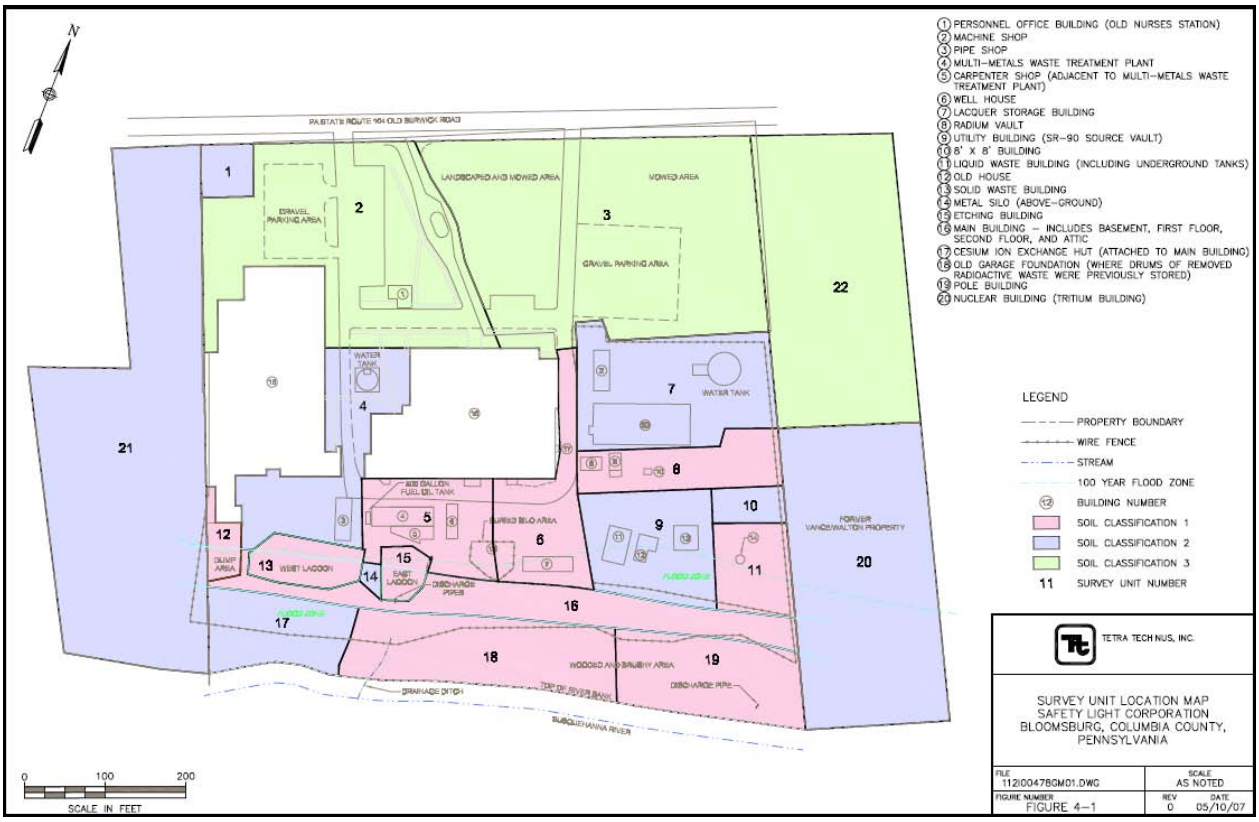


Figure 8 Soil classification and survey units.

From the sampling data reviewed thus far, the data show the majority of the contamination is between the facility and the river. The data analysis of survey units between the facility and Old Berwick Road is shown in the upper (A) panel of Figure 9. The figure shows the net concentration of Ra 226 reached about 6 pCi/g above background. The remainder of the samples measured for radium indicated samples either at background or below the CERCLA-required

remediation level of 5 pCi/g above background in the top 5 centimeters (cm) of soil[4]. Similarly, the net concentrations of other radioactive contaminants were either at background or slightly elevated. For those radionuclides elevated, they were still below the soil guideline values of either the USEPA or the RESRAD model determinations.

For samples collected behind the facility, that is, between the buildings and the Susquehanna River, the net concentrations of all detected contaminants other than tritium were above background. These data are shown in the lower (B) panel of Figure 9. Furthermore, these elevated levels were much higher than the concentrations detected in the front of the facility. The highest concentration of Ra 226 was about 50 times greater than the recommended remediation level of 5 pCi/g in the top 5 cm of soil. Other elevated concentrations detected included Am 241, Pb 210 (a decay product of the radium), Cs 137, Ni 63, Sr 90, and Tl 204.

Atmospheric levels of radionuclides

Air monitoring for radon, the decay product of Ra 226, was performed prior to demolition of the facilities. The radon comparison value used in this public health assessment is an indoor air concentration limit of 4 picocuries per liter (0.15 becquerels per liter). This value is derived from the Indoor Radon Abatement Act of 1988. The value is used as a decision level in which buildings should be modified to reduce the radon levels. Both the US Surgeon General and the USEPA recommend that all houses be tested for the presence of radon gas.

The monitoring locations were both inside structures as well as outdoors. The indoor locations included, but were not limited to, the main building, etching shop, pipe ship, radium vault, nurses' station, and the lacquer building. The typical value of radon found in the outdoor environment range is about 0.4 pCi/L, 10% of the maximum recommended indoor level. However, Ra 226, the precursor to radon 222 gas, used at Safety Light was extensive, the outdoor levels of radon within the site boundaries was elevated about twice above background levels or about 16% of the recommended USEPA indoor limit of 4 pCi/L. In all structures, prior to demolition, elevated levels of radon gas were present with the highest concentrations found within the main building, lacquer building, and the waste silo building. In these buildings, the radon concentrations were 2 or more times higher than the recommended indoor limits for members of the public (Table 4).

[4] This value is promulgated in 40 CFR 192 as a uranium mill tailings standard. ATSDR historically has used this as a guideline for the determination if additional evaluations are necessary. USEPA uses the value as an Applicable or Relevant and Appropriate Requirement as a Superfund guidance for radiation cleanups (http://www.epa.gov/superfund/health/contaminants/radiation/radarars.htm, accessed on January 5, 2009)

Table 4. Radon measurements at SLC

Radon	% of USNRC Derived Air Concentration*	% of USEPA 4 pCi/L Limit
Outdoor Average	657.9	16.4
Etching Building	1100.0	27.5
Well House	720.0	18.0
Nurses Building	650.0	16.3
Pipe Shop	1966.7	49.2
Main Building; SE Dock	25900.0	647.5
Main Building; Cage area	16366.7	409.2
Radium Vault	666.7	16.7
Old house	600.0	15.0
Lacquer Building	600.0	307.5
Waste Silo Building	7964.3	199.1

Radon Conclusion: Because many of the buildings have been demolished, no additional environmental monitoring or follow-up within these structures is possible. ATSDR concludes, however, that workers within these structures in the past received exposure to radon gas in excess of recommended levels. The agency considers these exposures to be a public health hazard. ATSDR recommends that any workers or members of the public who spent significant amounts of time in these structures, follow up with their health care providers to discuss potential lung cancer concerns.

Movement of radioactive materials in the air had the greatest potential for impacting the community. Demolition of the Safety Light Site buildings by the US Army Corps of Engineers began in November and December 2008, although air sampling began toward the end of October. Particulate air sampling stations were established around the perimeter of the site to monitor for dust and contaminants that might be released during the activities. The locations were northeast, southeast, southwest, and northwest of the facility. The samplers operated before, during, and after the demolition activities, essentially during working hours. The air flowed through filters that collected particles in the air. The filters then were evaluated at an on-site laboratory for the presence of alpha radiation emitting radioactive materials and beta radiation emitting radioactive materials. The air sampling continued until the second week of March 2009.

Evaluation of atmospheric concentrations of radioactive materials

Two different federal regulations or guidelines were used to evaluate the results of the atmospheric sampling. The USNRC regulates the exposure to members of the public from

radioactivity in the atmosphere using a system of Derived Air Concentrations (or DAC) values to limit the exposure. The DAC for the public is equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 50 millirem (0.5 milliSieverts). This is equal to one half the ATSDR Minimal Risk Level (MRL) for radiation exposure and one half the federal limit for exposure to the public. For example, a value of 10% of the DAC would be equivalent to 5 millirem or 5% of the ATSDR MRL for ionizing radiation.

The DAC for workers is somewhat different as it is defined as the concentration of a given radionuclide in air which, if breathed by a reference man for 2,000 hours (typical work year) under conditions of light work results in a dose of 5 rem (50 millisieverts), the occupational radiation exposure limit. ATSDR does not have an MRL for worker protection.

During the demolition phase at the site, continuous air monitoring samples were collected and compared to the DAC for members of the public. The results, shown in Table 5, show that during the activities, the air limits were never exceeded indicating that dust and particulate levels were at safe levels. Perimeter air samples were also collected and these would indicate the presence of the dust and particulates that would migrate off the site and into the surrounding community. Comparing the monthly perimeter air values to the public limits for Ra 226 and Sr 90 indicate that the dust and particulate levels around the site were well below the limits established by the USNRC (Table 6).

Conclusion of on-site and perimeter air monitoring: ATSDR considers the releases of dust and particulates to the air during demolition of buildings at the Safety Light Site to be below federally enforceable levels. Furthermore, the values detected were well below the ATSDR MRL (equivalent to 200% DAC) for ionizing radiation. Therefore, no public health impacts are expected. No additional evaluation of the air concentrations of radionuclides in dust or particulates is required.

Table 5. Air monitoring results for sectors around SLC.

	North		Northeast		East		Southeast	
Month	% Ra DAC*	% Sr DAC	% Ra DAC	% Sr DAC	% Ra DAC	% Sr DAC	% Ra DAC	% Sr DAC
February	0.46	0.59	0.26	0.84	0.40	0.60	0.26	0.71
February	0.12	0.31	0.13	0.48	0.12	0.49	0.14	0.52
February	0.09	0.32	0.11	0.52	0.09	0.45	0.04	0.16
February	0.09	0.43	0.16	0.37	0.12	0.42	0.10	0.24
March	0.23	1.85			2.66	10.04	0.17	
	South		Southwest		West		Northwest	
	% Ra DAC	% Sr DAC	% Ra DAC	% Sr DAC	% Ra DAC	% Sr DAC	% Ra DAC	% Sr DAC
February	0.22	0.25	0.28	0.28	0.18	0.38	0.24	0.51
February	0.15	0.33	0.14	0.62	0.10	0.37	0.15	0.66
February	0.10	0.35	0.06	0.24	0.19	0.41	0.06	0.29
February	0.12	0.41	0.13	0.24	0.13	0.43	0.15	0.65
March			0.05	0.10	0.04		0.08	

* Derived air concentration for Ra 226 is 0.0009 pCi/L. The DAC for Sr 90 is 0.03 pCi/L. A DAC value of 1% is equal to 0.5% of the ATSDR MRL for ionizing radiation.

Table 6. Perimeter air monitors

Month	% of Ra DAC*	% of Sr DAC
November	0.033	0.030
December	0.029	0.031
January	0.012	0.030
February	0.024	0.037

* Derived air concentration for Ra 226 is 0.0009 pCi/L. The DAC for Sr 90 is 0.03 pCi/L. A DAC value of 1% is equal to 0.5% of the ATSDR MRL for ionizing radiation.

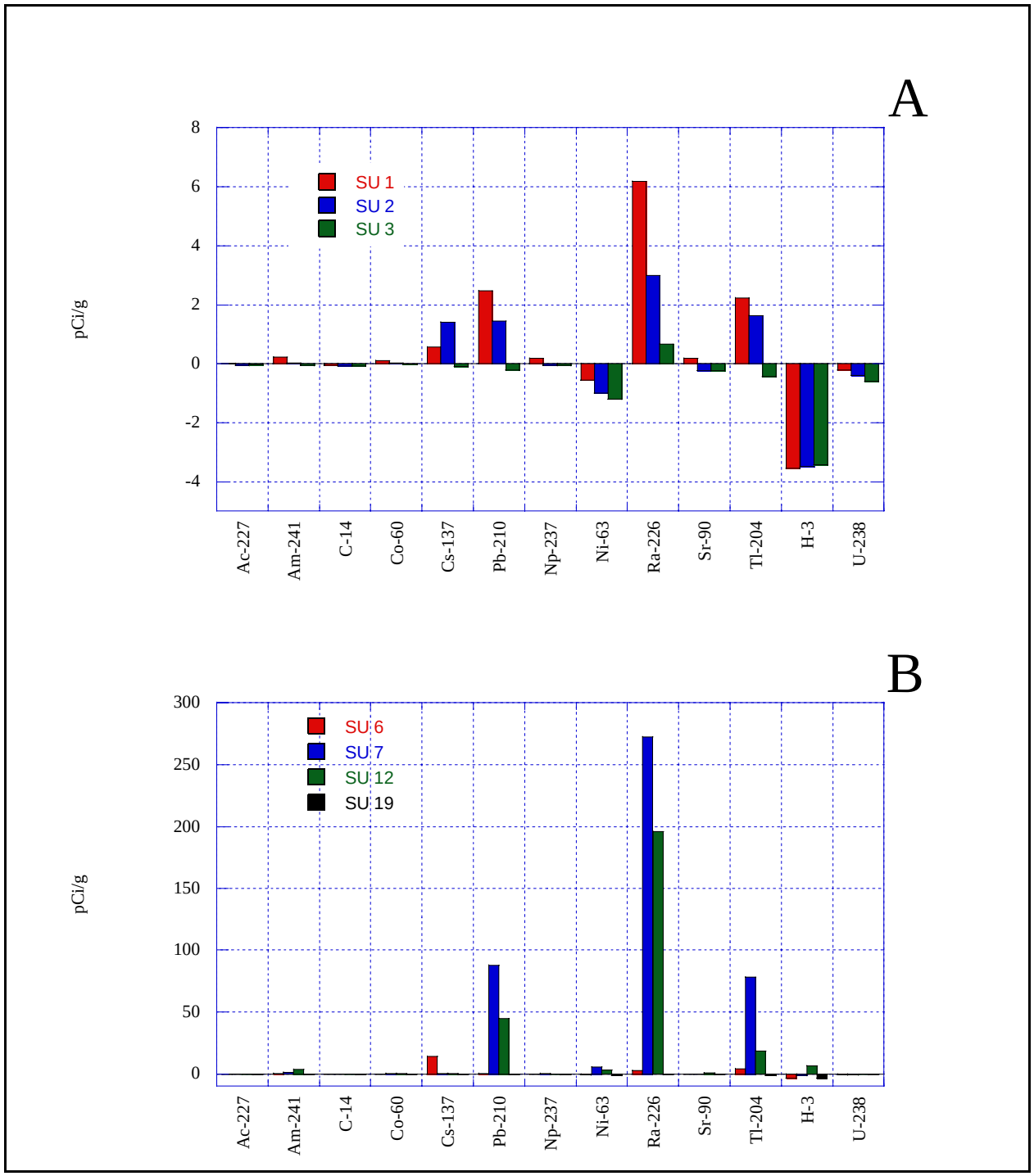


Figure 9. Soil concentrations of radionuclides at on-site locations. The net concentrations were determined by subtracting the background concentrations from each Survey Unit. In Panel A, the survey units are located between the facility and Old Berwick Road. In Panel B, the survey units are between the facility buildings and the Susquehanna River.

Analysis of Radioactivity in Drinking Water Samples

ATSDR evaluated the radioactivity detected in off-site residential wells close to the Safety Light operations. The water samples were collected in February, July, and November of 2005 and in May 2006. The well water was tested for total radioactivity in the forms of alpha and beta radiation as well as many of the radionuclides or their decay products used at SLC. The values listed in Table 7 are the average of the 4 collected samples. All data were subjected to a quality control and quality assurance program to ensure the samples were collected, processed, and evaluated correctly.

Table 7. Radioactivity in Residential Wells*

Isotope	SE 0.1†	NE 0.8a	NE 0.8b	UNK a	NE 0.2	UNK b	NE 0.05	MCL‡
Alpha	0.61	1.12	1.18	1.24	0.17	0.87	1.79	15
Beta	2.37	2.92	2.95	1.53	3.52	1.63	0.79	50
H 3	652	665	339	395	274	311	269	20000
Sr 90	0.18	0.25	0.18	0.24	0.39	0.15	0.16	8
Pb 212	2.26		1.67					248
Pb 214	62.82	43.87	32.67	8.09	50.5			10600
Bi 214	59.05	41.5	30.73		44.95			13300
Ra 226				0.21		0.27	0.31	3
Ra 228	0.3	0.45	0.77			0.28	0.66	2
Th 228	0.03	0.03	0.003	0.02	0.01	0.02	0.02	20.6
Th 230	0.01	5.23	12.17	0.026	11.89	0.11	0.02	7
Th 232		0.004		0.01	0.01	0.004	0.0043	6.4
Am 241	0.030	0.11	0.03	0.04	0.03	0.01	0.03	7.3

*The values in the following table are expressed in terms of picoCuries per liter of water.

†Values in the first row represent the residential wells coded as the approximate compass direction and distance from Safety Light Corporation. Where no value or direction is given, ATSDR was unable to ascertain the well location.

‡The MCL (Maximum Contaminant Level) is the federally enforceable level of specific radionuclides in drinking water. The USEPA set a dose limit of 4 millirem/year for man-made beta/gamma emitters. Where a specific value was not given, ATSDR estimated the MCL from Federal Guidance Report 13 (http://www.epa.gov/radiation/federal/techdocs.html#report13 accessed on April 27, 2009).

Private wells are not regulated for contaminants in water, only public water supplies are regulated. However, ATSDR does apply USEPA Maximum Contaminant Levels (MCLs) to private wells to determine if the water can be considered safe to drink. In the case of multiple radionuclides in drinking water, regulatory agencies require that ratio of the detected radionuclide to its respective MCL be determined and then these ratios be summed. If the value exceeds 1.0, then the water source exceeds the MCL. The following table (Table 8) shows this analysis and indicates which wells exceed the drinking water standard for radionuclides. For this

analysis ATSDR also included the ratios of the alpha and beta radiation to be more conservative in its analysis.

Table 8. Ratio of individual radionuclides to the MCL

Isotope	SE 0.1	NE 0.8a	NE 0.8b	UNK a	NE 0.2	UNK b	NE 0.05
Alpha	0.04	0.07	0.08	0.08	0.01	0.06	0.12
Beta	0.05	0.06	0.06	0.03	0.07	0.03	0.02
H 3	0.03	0.03	0.02	0.02	0.01	0.02	0.01
Sr 90	0.02	0.03	0.02	0.03	0.05	0.02	0.02
Pb 212	0.01		0.01				
Pb 214	0.01	0.004	0.003	0.001	0.004		
Bi 214	0.004	0.003	0.002		0.003		
Ra 226				0.07		0.09	0.10
Ra 228	0.15	0.22	0.38			0.14	0.33
Th 228	0.001	0.001	0.0002	0.001	0.001	0.001	0.001
Th 230	0.002	0.75*	1.74*	0.004	1.77*	0.02	0.002
Th 232		0.001		0.002	0.001	0.001	0.001
Am 241	0.004	0.015	0.004	0.006	0.004	0.001	0.004
sum	0.32	1.19	2.32	0.25	1.86	0.37	0.61

*Each of the elevated wells had one sample collected that was much greater than the 3 other samples. This elevated sample artificially elevated the overall well average resulting in the exceedence.

The evaluation of the private wells indicates that only 3 wells exceed the summed ratio of 1. The wells exceeding this value were northeast of the facility and within 1 mile of the plant, a direction considered upgradient with respect to groundwater flow. Therefore, these contaminants may not be related to site releases. The radionuclide driving these wells to exceed the MCL is thorium-230 (Th 230), a decay product of naturally occurring uranium 238 and an alpha emitter. Because of the method of analysis used for these water samples, ATSDR believes the reported concentrations of Th 230 are artificially elevated. This is determined from the following information:

a) the alpha activity reported in the samples are all below the drinking water standard of 15 pCi/L;

b) other decay products of the uranium were either not detected or detected at levels below their respective calculated MCLs. If the thorium were elevated, ATSDR would expect higher levels of the thorium decay products and;

c) values used in this analysis are the averages of 4 separate sampling events. In each case, only one of the samples was elevated, artificially elevating the average. If this elevated value is omitted from the analysis, all wells are below the target value of 1.0.

ATSDR established a health comparison value for exposure to radioactive materials and the resulting radiological dose, regardless of the radioactive material. This comparison value, ATSDR's MRL, for radiation is 100 millirem per year (1 milliSievert/year).

Conclusion for Radioactivity in Water: The detected levels of radioactivity in water are below the federally mandated Maximum Contaminant Levels for beta/gamma emitters, 4 millirem per year (0.04 milliSieverts/year). Furthermore, this is also below the ATSDR MRL. Although no further evaluation of residential wells is required, ATSDR will discuss additional radioactivity issues in the Community Concerns section of this document.

Analysis of Chemical (Non-Radioactive) Drinking Water Samples

The ATSDR evaluation of potential chemical exposures associated with the SLC focused on the drinking water pathway as this was the most likely route of human exposure to the public. ATSDR evaluated samples collected by USEPA from private drinking water wells located on residential properties adjacent to the site. Samples were collected from seven private drinking water wells during sampling events in February, July, and November 2005, and May 2006. The samples were analyzed for volatile organic chemicals, semi-volatile organic chemicals, inorganic chemicals (metals), and pesticides.

Homes in a nearby residential area use water from private wells for their drinking water source. Adults and children residing in these homes use their private well water for drinking, cooking, bathing, and other typical daily activities. Chemicals in drinking water may be: (1) ingested, (2) inhaled during showering activities if they can easily be released to air, or (3) absorbed through the surface of the skin. Therefore, ATSDR's evaluation considers these three exposure routes for adults and children as part of this public health assessment. It should be noted that some homes may also be connected to the public drinking water supply and use their private wells for irrigation purposes only. To consider the most health-protective scenario, ATSDR assumed that all private wells were used as a drinking water source even if some homes were additionally connected to the public water supply.

The first step in ATSDR's evaluation process, as described in detail in ATSDR's Public Health Assessment Guidance Manual, is to select the chemicals that require further, focused evaluation (8). ATSDR selects chemicals based on whether the maximum detected concentrations of chemicals are found to exceed applicable, health-based comparison values. A chemical found to exceed a comparison value indicates that a more detailed, site-specific analysis is necessary for that chemical. Table 9 summarizes the results of ATSDR's health-based comparison value screening process for the chemicals detected in the private well samples.

Table 9. Residential Drinking Water Well Evaluation – Chemicals detected above health-based comparison values (CVs)

Residential Well Locations	Values in units of micrograms per liter (µg/L)					
	Arsenic Health-based CV=0.020[a]		Copper Health-based CV=100[b]		Bis(2-ethylhexyl)phthalate Health-based CV=3.0[a]	
	Maximum Detected Concentration	Frequency of Detection Above CV[c]	Maximum Detected Concentration	Frequency of Detection Above CV[c]	Maximum Detected Concentration	Frequency of Detection Above CV[c]
Well A	0.29	3/4	129	1/4	NA	NA
Well B	0.37	3/4	NA	0/4	NA	NA
Well C	0.40	3/4	304	4/4	NA	NA
Well D	0.43	2/3	282	4/4	NA	NA
Well E	0.62	3/4	NA	0/4	9.1	1/4
Well F	0.41	3/4	NA	0/4	NA	NA
Well G	0.59	3/4	NA	0/4	NA	NA

[a] Cancer Risk Evaluation Guide (or CREG) is a comparison concentration that is based on the risk of cancerous effects and is derived from USEPA's cancer slope factors.
[b] Intermediate Environmental Media Evaluation Guide Child (or Intermediate EMEG Child) is a comparison concentration below which adverse non-cancer health effects are not expected from 15 to 365 days of exposure to children. These values are derived by ATSDR. Chronic EMEGs (for exposures of one year and greater) are unavailable for copper. Therefore, an intermediate EMEG is used in this evaluation.
[c] Frequency of Detection Above CV = Number of samples in which the chemical was detected above the selected health-based comparison value / Total number of samples collected
NA denotes that the chemical was not detected above health-based comparison values during any of the sampling events.

Only three chemicals have been detected above their health-based comparison value (also referred to as a CV) in the private drinking water wells sampled: arsenic, copper, and bis(2-ethylhexyl)phthalate. The next step in the evaluation process is to further identify the site-specific exposure situations and the likelihood that exposures to these chemicals could pose a health hazard. Therefore, calculations are performed to estimate the possibility of cancer and non-cancer health effects. The calculations consider the activities of people living in the community surrounding the SLC.

In this public health assessment, ATSDR has estimated potential exposure of adult and children residents to chemicals in private drinking water wells by calculating chemical exposure doses

and cancer risk estimates. In general, the same equations have been used for the non-cancer and cancer calculations with the indicated modifications. Note that cancer risk calculated for exposures occurring during adulthood and childhood are combined and expressed as the risk of an individual developing cancer over his or her lifetime. The equations and the assumptions are based on the ATSDR Public Health Assessment Guidance Manual (8), USEPA Risk Assessment Guidance for Superfund, Part A (9), and the USEPA Exposure Factors Handbook (10).

Adults and children using private wells in the vicinity of the SLC may come in contact with arsenic, copper, and bis(2-ethylhexyl)phthalate in drinking water primarily through the ingestion route. Inhalation and direct skin contact with arsenic, copper, and bis(2-ethylhexyl)phthalate are not considered to be significant due to their chemical properties, concentrations, and frequency of detection in the private wells samples. Therefore, the focus of ATSDR's assessment of non-cancer and cancerous health effects focuses on the drinking water ingestion pathway.

The selected assumptions and equation to evaluate drinking water exposure is presented below:

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

where

C = maximum detected concentration of a chemical; See Table 9; micrograms per liter

IR = ingestion rate; 2 liters per day for adults, 1 liter per day for children

EF = exposure frequency; 365 days per year

ED = exposure duration; 30 years for adults, 6 years for children

CF = conversion factor; 0.001 milligrams per micrograms

BW = body weight; 70 kilograms (or approximately 154 pounds) for adults and 16 kilograms (or 35 pounds) for children

AT = averaging time; 10,950 days for non-cancer and 25,550 days for cancer evaluation

Non-Cancer Health Effects Evaluation

The second major phase of the public health assessment process involves comparing the doses calculated for exposure to each individual chemical to established health guidelines, such as ATSDR's Minimal Risk Levels (MRLs) or USEPA's Reference Doses (RfDs), in order to assess whether adverse non-cancer health impacts from exposure are expected. These health guidelines, described in more detail in the following text, are chemical-specific values that are based on the available scientific literature and are considered protective of human health.

Minimal Risk Levels (MRL)

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are developed for different

routes of exposure, such as inhalation and ingestion, and for lengths of exposure, such as acute (less than 14 days), intermediate (15-364 days), and chronic (365 days or greater). At this time, ATSDR has not developed MRLs for dermal exposure. A complete list of the available MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

References Doses (MRL)

An estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. RfDs consider exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. USEPA's RfDs have been developed using information from the available scientific literature and have been calculated for oral and inhalation exposures. A complete list of the available RfDs can be found at http://www.epa.gov/iris.

Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which no adverse health effects will be observed. As a result, the current practice for deriving health guidelines (ATSDR MRLs and USEPA RfDs) is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (or NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The NOAEL is then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated (or applied) to the general human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (for example; children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Thus, exposure doses at or below the established health guideline are not expected to result in adverse non-cancer health effects.

When site-specific exposure doses exceed MRLs and RfDs, it does not necessarily indicate that health effects will occur. Rather, it indicates that a more thorough look at the known toxicological values for the chemical and the site-related exposures is needed. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and USEPA's Integrated Risk Information System (IRIS). A direct comparison of site-specific exposure doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur. This final step in evaluating non-cancer health effects includes an in-depth evaluation performed by comparing calculated exposure doses with known toxicological values, such as the no-observed adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) from studies used to derive the MRL or RfD for a chemical.

It is important to consider that the methodology used to develop these health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer evaluation is necessary for chemicals detected at the SLC that have been associated with cancer, which include arsenic and bis(2-ethylhexyl)phthalate. A more detailed discussion of the evaluation of cancer risks is presented in the following section.

Cancer Risk

As previously stated, cancer risk calculated for chemical exposures occurring during adulthood and childhood are combined and expressed as the risk of an individual developing cancer over his or her lifetime. An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is a mathematical estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular chemical. Therefore, the cancer risk calculation incorporates the equations and parameters (including the exposure duration and frequency) used to calculate the dose estimates, but the estimated value is divided by 25,550 days (or the averaging time), which is equal to a lifetime of exposure (70 years) for 365 days/year. The estimated theoretical increased risk of developing cancer from exposure to chemicals associated with SLC was calculated by multiplying the site-specific adult exposure doses, with a slight modification to the averaging time, by USEPA's chemical-specific cancer slope factors (CSFs or cancer potency estimates) for arsenic and bis(2-ethylhexyl)phthalate, which are available at http://www.epa.gov/iris. The results of these mathematical estimates allow health officials to make certain health-protective decisions about chemicals present at a hazardous waste site, but do not indicate the actual number of cancer cases that may occur from exposure.

There are varying suggestions among the scientific community regarding an acceptable excess lifetime cancer risk, due to the uncertainties regarding the mechanism of cancer. An important consideration when determining cancer risk estimates is that the risk calculations incorporate several very conservative assumptions that are expected to overestimate actual exposure scenarios. For example, the method used to calculate USEPA's CSFs assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. As previously stated, the method also assumes that there is no safe level for exposure. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude. In summary, cancer estimation is a very conservative approach used to help make decisions about the exposures occurring at the site, but does not provide information on actual cases of cancer in a community.

In general, the target risk recommendations of many scientists, as well as ATSDR and USEPA, have been in the risk range of 1 in 1 million to 1 in 10,000 (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases.

- An increased lifetime cancer risk of 1 extra cancer case in 1 million people exposed (or 1×10^{-6}) is generally considered an insignificant increase in cancer risk. This risk estimate may also be expressed as individuals having a 99.999% chance of not developing cancer from the specific chemical exposures.

- An increased lifetime cancer risk of 1 extra cancer case in 10,000 people exposed (or 1×10^{-4}) is generally considered a low increase in cancer risk. This risk estimate may also be expressed as individuals having a 99.99% chance of not developing cancer from the specific chemical exposures.

As the final step in evaluating cancer risk, ATSDR also employs a qualitative approach in evaluating all relevant data. The actual environmental exposures have been given careful and thorough consideration in evaluating the assumptions and variables relating to both toxicity and exposure. A complete review of the toxicological data regarding the doses associated with the production of cancer and the site-specific doses is an important element in determining the likelihood of exposed individuals being at a greater risk for cancer.

The approaches to assessing non-cancer and cancer effects discussed above have been employed by ATSDR to evaluate the chemicals detected in private well samples that exceed health-based comparison values. A description of each of the chemicals and an evaluation of possible health impacts from exposures are provided in the following sections.

Arsenic

General Arsenic Information: Arsenic is a naturally occurring element that is widely distributed in the earth's crust. Elemental arsenic is a steel grey metal-like material. Arsenic is usually found in the environment combined with other elements, such as oxygen, chlorine, and sulfur. It is released to the air by volcanoes, through weathering of arsenic-containing minerals and ores, and by commercial or industrial practices. In industry, arsenic is a by-product of the smelting process from many metal ores, including lead, gold, zinc, cobalt, and nickel. Arsenic has also been used in pesticides and wood preservation products. Chromated copper arsenate, an arsenic-containing product, was used to make pressure-treated lumber, although its use in residential products is no longer permitted (11).

Arsenic Health Effects: Arsenic has been associated with a number of adverse cancer and non-cancer health effects in animal and human studies. Effects on the cardiovascular, neurological, respiratory, pulmonary and reproductive systems, as well as impacts on the gastrointestinal tract, kidneys, liver, blood, and skin have been reported from arsenic exposures. Specifically, long-term ingestion and inhalation of low levels of arsenic has been associated with discoloration and darkening of the skin and the appearance of small corns and warts in humans. Skin contact with higher concentrations of arsenic, such as those associated with occupational exposures, may cause redness, swelling and thickening of skin on the hands and feet (palmoplantar hyperkeratosis). Arsenic is known to cause cancer in humans. Studies of arsenic exposure have reported an increased risk of skin cancer and cancer of the liver, bladder, kidney, and lungs following long-term exposure to arsenic (11).

Arsenic in Private Wells adjacent to SLC: Arsenic was detected in each of the private wells sampled. Arsenic is present in private wells surrounding the SLC at low levels and has been detected at similar concentrations across the wells sampled. The maximum detected concentrations of arsenic in all seven wells, ranging from 0.29 micrograms per liter (µg/L) to 0.62 µg/L, were found to exceed the health-based comparison values selected by ATSDR. The selected comparison value of 0.020 µg/L is ATSDR's Cancer Risk Evaluation Guide (CREG). CREGs are based on the risk of cancerous effects and are derived from USEPA cancer slope factors. CREGs are established to be conservative and health-protective. Therefore, arsenic concentrations that are present above the arsenic CREG does not indicate that cancerous effects will occur to those exposed. Rather, it indicates that ATSDR scientists must take a closer look, as

part of this public health assessment, at the cancer data and the levels of arsenic found in the wells in the vicinity of SLC.

Additional government guidelines are available for arsenic. The USEPA Office of Drinking Water has set an MCL for arsenic in drinking water of 10 µg/L (12). The World Health Organization also recommends a provisional drinking water guideline of 10 µg/L as a practical limit. It should be noted that none of the samples collected from the seven wells (ranging from 0.29 micrograms per liter (µg/L) to 0.62 µg/L) contained arsenic that exceeded the USEPA MCL or the World Health Organization provisional drinking water guideline (13).

ATSDR calculated exposure doses for arsenic detected in private wells. Because arsenic does not readily volatilize (or become airborne) during showering and bathing, and is not easily absorbed by the skin, only exposures from ingesting the water have been calculated. Adult and children exposure doses for arsenic and a summary of the non-cancer health effects evaluation conducted by ATSDR for wells A through G in the vicinity of SLC are presented in Table 10. In summary, none of the calculated doses were found to exceed the selected health guideline and therefore, non-cancer health effects are not expected.

Table 10. Non-Cancer Health Effects Evaluation for Arsenic in Private Drinking Water

Residential Well Location	Calculated Adult Dose (mg/kg/d)	Calculated Child Dose (mg/kg/d)	Selected Health Guideline (mg/kg/d)	Health Guideline Sources[(a)]	ATSDR's Non-Cancer Health Effects Conclusion
Well A	0.000012	0.000018	0.0003	ATSDR MRL USEPA RfD	No health effects expected
Well B	0.000016	0.000023	0.0003	ATSDR MRL USEPA RfD	No health effects expected
Well C	0.000017	0.000025	0.0003	ATSDR MRL USEPA RfD	No health effects expected
Well D	0.000018	0.000027	0.0003	ATSDR MRL USEPA RfD	No health effects expected
Well E	0.000027	0.000039	0.0003	ATSDR MRL USEPA RfD	No health effects expected
Well F	0.000018	0.000026	0.0003	ATSDR MRL USEPA RfD	No health effects expected
Well G	0.000025	0.000037	0.0003	ATSDR MRL USEPA RfD	No health effects expected

(a) Selected health guidelines for arsenic are ATSDR's Chronic Minimal Risk Level and USEPA's Reference Dose.

The available human and animal studies indicate that arsenic has been associated with several different types of cancers including skin, liver, bladder, kidney, and lungs. Therefore, ATSDR evaluated the cancer risk associated with these exposures. The risk of developing cancer from exposure to arsenic in drinking water during childhood and adulthood has been combined and is referred to as a lifetime cancer risk. ATSDR's calculated theoretical cancer risk and cancer assessment for arsenic in Wells A through G are presented in Table 11. In summary, the estimated cancer risk for arsenic in private wells near SLC was considered to be very low. Therefore, cancerous effects from exposure are very unlikely to occur.

Table 11. Cancer Evaluation for Arsenic in Private Drinking Water

Residential Well Location	Increased Cancer Risk Estimate [(a)]	Cancer Risk Conclusion
Well A	5 cases per 100,000 people exposed	Very low risk: 99.995% chance of not getting cancer
Well B	6 cases per 100,000 people exposed	Very low risk: 99.994% chance of not getting cancer
Well C	6 cases per 100,000 people exposed	Very low risk: 99.994% chance of not getting cancer
Well D	7 cases per 100,000 people exposed	Very low risk: 99.993% chance of not getting cancer
Well E	10 cases per 100,000 people exposed	Very low risk: 99.99% chance of not getting chance
Well F	7 cases per 100,000 people exposed	Very low risk: 99.993% chance of not getting cancer
Well G	10 cases per 100,000 people exposed	Very low risk: 99.99% chance of not getting chance

(a) Arsenic cancer risk was assessed by using USEPA's cancer slope factor of 1.5 $(mg/kg/day)^{-1}$ per the USEPA IRIS database accessed on-line at http://www.epa.gov/iris.

Arsenic in Drinking Water Conclusion: Based on ATSDR's evaluation, cancer and non-cancer health effects are not expected to result from arsenic in private drinking water wells in the vicinity of the Safety Light Site. No further assessment of arsenic is necessary.

Copper

General Copper Information: Copper is a reddish metal that occurs naturally in rock, soil, water, and sediment. Copper also occurs naturally in all plants and animals. It is an essential element for all known living organisms including humans and animals at low levels of intake. Metallic copper can be easily molded or shaped. The reddish color of this element is most commonly seen in the U.S. penny, electrical wiring, and some water pipes. Homes with copper piping and an acidic water supply may result in the presence of copper in drinking water. It has been found that copper in piping can be minimized by allowing the water to run for 15-30 seconds before using for the water for drinking and cooking. Copper is also found in many mixtures of metals, called alloys, such as brass and bronze. Copper is extensively mined and processed in the U.S. and is used in the manufacture of wire, sheet metal, pipe, and other metal products. Copper compounds are most commonly used in agriculture to treat plant diseases, like mildew, or for water treatment, as well as preservatives for wood, leather, and fabrics (14).

Copper Health Effects: All humans must absorb small amounts of copper every day because copper is essential for good health. High levels of copper can be harmful. Ingestion of high levels of copper can cause nausea, vomiting, stomach cramps, and diarrhea. Exposure to very high doses of copper can cause damage to the liver and kidneys. Copper has not been found to cause cancer in humans. However, the available scientific literature on copper and cancer is very limited and no adequate human or animal cancer studies are available.

Copper in Private Wells adjacent to SLC: Copper was detected in three of the seven private wells sampled. The maximum detected concentrations of copper in all seven wells, ranging from 129 µg/L to 304 µg/L, were found to exceed the health-based comparison values selected by ATSDR. The selected comparison value of 100 µg/L is ATSDR's Intermediate Environmental Media Evaluation Guide (EMEG). The Intermediate EMEG is derived from exposures of 15 to 365 days. Although residents may have been exposed for more than one year, a chronic EMEG for copper has not been derived. Therefore, the intermediate copper EMEG was selected by ATSDR. Copper concentrations that are present in drinking water above the selected EMEG does not indicate that health effects will occur to those exposed. Rather, it indicates that ATSDR scientists must take a closer look, as part of this public health assessment, at the data and the levels of copper found in the wells in the vicinity of SLC.

Additional government guidelines are available for copper in drinking water. The USEPA Office of Drinking Water has set a maximum contaminant level goal (MCLG) for copper in drinking water of 1,300 µg/L (12). The World Health Organization also recommends a drinking water guideline of 2,000 ug/L. It should be noted that none of the samples collected from the seven wells (ranging from 129 µg/L to 304 µg/L) contained copper that exceeded either the USEPA MCLG or the World Health Organization provisional drinking water guideline (13).

ATSDR calculated exposure doses for copper detected in private wells. Because copper does not readily volatilize (or become airborne) during showering and bathing, and is not easily absorbed by the skin, only exposures from ingesting the water have been calculated. Adult and children exposure doses for copper and a summary of the non-cancer health effects evaluation conducted by ATSDR for wells A, C, and D in the vicinity of SLC are presented in Table 12. Copper was not detected above health-based comparison values in wells B,E,F, and G.

Table 12. Non-Cancer Health Effects Evaluation for Copper in Private Drinking Water

Residential Well Location	Calculated Adult Dose (mg/kg/d)	Calculated Child Dose (mg/kg/d)	Selected Health Guideline (mg/kg/d)	Health Guideline Source[(a)]	ATSDR's Non-Cancer Health Effects Conclusion
Well A	0.0055	0.0081	0.010	ATSDR Intermediate MRL	No health effects expected
Well C	0.013	0.019	0.010	ATSDR Intermediate MRL	Further evaluation is needed
Well D	0.012	0.017	0.010	ATSDR Intermediate MRL	Further evaluation is needed

(a) Selected health guidelines for copper is the ATSDR's Intermediate Minimal Risk Level.

Further Evaluation of Copper Exposures: The calculated exposure doses for copper in Well C (0.013 mg/kg/day for adults and 0.019 mg/kg/day for children) and Well D (0.012 mg/kg/day for adults and 0.017 mg/kg/day for children) have been found to very slightly exceed the selected health guideline, ATSDR's intermediate MRL of 0.010 mg/kg/day. This does not indicate that health effects will result, but rather further evaluation is needed, as previously discussed.

Further evaluation of copper exposure involves comparing the doses calculated specifically for the private wells adjacent to SLC to doses in the scientific literature that have reported adverse health effects. Copper doses calculated for private wells were ten times greater than a study that reported gastrointestinal effects. It is important to note that there were several other studies of copper ingestion, at doses as much as 100 greater than the study reporting effects that did not report gastrointestinal effects. A review of the scientific literature indicates that cardiovascular, hematological (blood), hepatic (liver), renal (kidney), and developmental effects were observed at doses that were thousands of times greater than those associated with private well exposure. Based on further assessment, ATSDR concludes that health effects are not expected to occur as a result of the presence of copper in drinking water at private wells in the vicinity of SLC (14).

As previously stated, there are no studies linking copper exposure to cancerous effects. Therefore, ATSDR has not completed cancer risk estimates for copper. An increased risk of cancer is not expected from exposure to cancer in drinking water in private wells in the vicinity of SLC.

Copper in Drinking Water Conclusion: Based on ATSDR's evaluation, cancer and non-cancer health effects are not expected to result from copper in private drinking water wells in the vicinity of the Safety Light Site. No further assessment of copper is necessary.

Bis(2-ethylhexyl)phthalate

General Bis(2-ehtylhexyl)phthalate Information: Also referred to as di(2-ethylhexyl)phthalate, bis(2-ethylhexyl)phthalate is a manufactured chemical that is commonly added to plastics to make them flexible. It is present in plastic products such as wall coverings, tablecloths, floor tiles, furniture upholstery, shower curtains, garden hoses, some toys, medical tubing, and blood storage bags. Bis(2-ethylhexyl)phthalate is a colorless liquid with almost no odor. It does not evaporate easily and is not easily dissolved in water. Because it is used in many plastic-containing products, it is found widespread in the environment (15).

Bis(2-ehtylhexyl)phthalate Health Effects: Most of the available scientific literature on bis(2-ethylhexyl)phthalate is based on studies of exposed animals. Short-term exposures to high doses have been associated with mild gastrointestinal disturbances. Short-term exposures to very high concentrations have been associated with effects on the sperm of mice and rats. The effects were reversible, but maturity was delayed in animals that were exposed before puberty. Short-term exposures to low levels of bis(2-ethylhexyl)phthalate appeared to have no effect on male fertility. Very high dose animals studies also report health effects mainly to the liver and testes. The possibility of health effects such as thyroid, ovaries, kidneys, and blood are less conclusive and need further research. It is important to note that humans absorb and breakdown this chemical in the body differently than rats and mice. Therefore, many of the effects seen in rats and mice might not occur in humans. No studies have linked cancer with exposure to bis(2-ethylhexyl)phthalate in humans. Eating very high doses of the chemical for a long time has been shown to produce liver cancer in rats and mice (15).

Bis(2-ethylhexylphthalate) in Private Wells adjacent to SLC: Bis(2-ethylhexyl)phthalate was detected in one of the seven private wells sampled. It was only detected during one of the four sampling events for Well E. The other three samples collected during the sampling events indicated no detection of bis(2-ethylhexyl)phthalate. The detected concentration of 9.1 µg/L exceeded the health-based comparison values selected by ATSDR. The selected comparison value of 3 µg/L is ATSDR's Cancer Risk Evaluation Guide (CREG). As previously discussed, CREGs are established to be conservative and health-protective. Therefore, the bis(2-ethylhexyl)phthalate concentration that was detected above the established CREG does not indicate that cancerous effects will occur to those exposed. Rather, it indicates that ATSDR scientists must take a closer look, as part of this public health assessment, at the cancer data and the detection of bis(2-ethylhexyl)phthalate found in the Well E in the vicinity of SLC.

Additional government guidelines are available for bis(2-ethylhexyl)phthalate in drinking water. The USEPA Office of Drinking Water has set a maximum contaminant level (MCL) for bis(2-ethylhexyl)phthalate in drinking water of 6 µg/L (12). The World Health Organization also recommends a drinking water guideline of 8 ug/L (13).

ATSDR calculated exposure doses for bis(2-ethylhexyl)phthalate in Well E. Although a colorless liquid with almost no odor, bis(2-ethylhexyl)phthalate does not readily volatilize (or become airborne) during showering and bathing, and is not easily absorbed by the skin. Therefore, only exposures from ingesting the water have been calculated. Adult and children exposure doses for bis(2-ethylhexyl)phthalate and a summary of the non-cancer health effects evaluation conducted by ATSDR for Well E in the vicinity of SLC are presented in Table 13. Bis(2-ethylhexyl)phthalate was not detected above health-based comparison values in wells A, B, C, D, F, and G.

Table 13. Non-Cancer Health Effects Evaluation for Bis(2-ethylhexyl)phthalate in Private Drinking Water

Residential Well Location	Calculated Adult Dose (mg/kg/d)	Calculated Child Dose (mg/kg/d)	Selected Health Guideline (mg/kg/d)	Health Guideline Source[(a)]	ATSDR's Non-Cancer Health Effects Conclusion
Well E	0.00060	0.0011	0.060	ATSDR Chronic MRL	No health effects expected

[(a)] Selected health guidelines for bis(2-ethylhexyl)phthalate is the ATSDR's Chronic Minimal Risk Level.

Bis(2-ethylhexyl)phthalate was only detected in one private well during one of four sampling events. The available sampling indicates that exposure to bis(2-ethylhexyl)phthalate likely occurred for a very limited period of time. In addition, an evaluation of the one detection of bis(2-ethylhexyl)phthalate in Well E indicates that adult and children doses did not exceed the established health guidelines. Therefore, non-cancer effects are not expected to occur to people drinking water from Well E.

ATSDR has also considered the potential for cancerous effects to occur based on exposure because of the classification of bis(2-ethylhexyl)phthalate as a carcinogen in animal studies. Due to the very limited exposure indicated by the available sampling, ATSDR does not expect exposure to bis(2-ethylhexyl)phthalate to be associated with cancer. Cancer is not expected to result from short-term exposure to the levels of bis(2-ethylhexyl)phthalate found in Well E.

It should also be noted that bis(2-ethylhexyl)phthalate is a common laboratory contaminant. Its detection in only one well during one sampling event indicates the possibility that bis(2-ethylhexyl)phthalate was not actually present in the environment, but rather introduced during the analysis of the sample at the laboratory.

Bis(2-ethylhexyl)phthalate Drinking Water Conclusion: Based on ATSDR's evaluation, cancer and non-cancer health effects are not expected to result from bis(2-ethylhexyl)phthalate in private drinking water wells in the vicinity of the Safety Light Site. No further assessment of bis(2-ethylhexyl)phthalate is necessary.

Community Health Concerns

In 2005, the USEPA developed a community involvement plan and met with members of the community. These individuals did express concerns about the Safety Light Site with respect to contaminant migration and what types of contaminants were present at the site (16).

ATSDR has learned through conversations with local residents and via information obtained from the USEPA Community Involvement Coordinator that there are few concerns raised by the community. The concerns raised have included the impact of historical operations on the community and its impact on the Susquehanna River. Other, more recent concerns, include the emissions of dusts and contamination related to the building demolition during the final months of 2008 and early 2009.

ATSDR was not able to locate any historical records that relate to Safety Light Corporation's or its predecessors releases to the river. However, ATSDR can supply general information on the impact of certain radioactive materials used at the site. This general information follows.

Radiological contaminants of concern

The analyses of private drinking water wells showed the presence of several radiological contaminants in the water. However, further analyses indicated these contaminants did not exceed the federally enforceable Maximum Contaminant Level (MCL) established by the USEPA. Nonetheless, ATSDR believes it is important to inform the public of the nature of two of these contaminants, Strontium 90 and Radium.

These radioactive materials were selected because of their persistence in the environment or their known impacts on human health. The other radioactive substances shown to be in the drinking water, either naturally occurring or produced by man, are not considered a threat to human health.

Strontium 90

Strontium 90 (Sr 90) is formed in nuclear reactors or during the use of nuclear weapons. Typically, Sr 90 used in industrial activities is produced in nuclear reactors; whereas, Sr 90 found in the environment is the result of the nuclear weapons testing. Therefore, it is found nearly everywhere in small amounts from fallout from nuclear explosions and a smaller amount from nuclear accidents such as Chernobyl. You can be exposed to low levels of Sr 90 by eating food, drinking water, or accidentally eating soil or dust that contains Sr 90. Food and drinking water are the largest sources of exposure to Sr 90. Because of the nature of Sr 90, some of it gets into fish, vegetables, and livestock. Grain, leafy vegetables, and dairy products contribute the greatest percentage of dietary Sr 90 to humans. The concentration of Sr 90 in fresh vegetables grown in the United States is less than 9 pCi (or 0.3 Bq) in 1 kg of dried vegetables (in a hot oven). The intake of radioactive strontium 90 for most people will be small.

The National Council on Radiation Protection and Measurements (NCRP) reports there have been no human exposures to Sr 90 other than through fallout so its effects on humans are not easily determined. At the time of the NCRP report, they stated that differentiating Sr 90 effects from naturally occurring effects from background exposures would be difficult and that very large population would be needed. The NCRP also stated that current studies have not shown any significant excesses in individuals exposed to fallout levels of Sr 90 (17).

The harmful effects of radioactive strontium are caused by the high energy effects of its radiation and its decay product. Sr 90 gives off beta particles (sometimes referred to as beta radiation) and turns into yttrium 90 which is also radioactive. The half-life of strontium 90 is 29 years and the half-life of the yttrium 90 is less than 3 days. Since radioactive strontium is taken up into bone, bone itself and the soft tissues nearby may be damaged by radiation released over time. Because bone marrow is the essential source of blood cells, blood cell counts may be reduced if the dose is high, perhaps more than 1000 times higher than the estimated dose one would receive from Safety Light contamination. In studies reported by the NCRP, the studies indicate that cancer induction by strontium is less than 5% the induction rate of radium, based on equal activities within the body (17). That is, radium is 20 times more effective in inducing cancer in humans.

It is not known whether exposure to radioactive strontium would affect human reproduction. Harmful effects on animal reproduction occurred at doses that were more than a million times higher than typical exposure levels for the general population (18).

Radium

Radium is a naturally occurring radioactive element that is produced during the decay of uranium or thorium. Of the many radioisotopes of radium, there are four major naturally occurring radioisotopes of interest, two produced from the decay of uranium (Ra 226 and Ra 223) and two from the decay of thorium (Ra 228 and Ra 224). The radiation released from radium will depend on the specific radioisotope as shown in Table 14.

Table 14. Basic radiation parameters of radium radioisotopes

Radioisotope	Half-life (years)	Major radioactive emissions	Decay product (all radioactive)
Ra 223	0.03	Alpha and gamma	Radon 219
Ra 224	0.01	Alpha and gamma	Radon 220
Ra 226	1600	Alpha and gamma	Radon 222
Ra 228	5.75	Beta and gamma	Actinium 228

Because radium is naturally occurring, the element can be found in many products from natural building products such as stone or brick, man-made materials such as some cinder block and gypsum board, foods, and the water we drink. Radium has also been used in other commercial industries and historically in the medical field. For commercial products such as some produced at the Safety Light Corporation, radium was added to paints or other materials as a self-illuminating product for watches, clocks, and exit signs. The majority of this work occurred between 1915 and 1930 and again in 1940 through 1954. The use of radium in this process essentially ended in 1974 (19). In the medical field radium containing needles were produced to be implanted into the body in attempts to control cancerous tumors or to treat benign conditions such as lupus or skin conditions (20). The radium content of the needles commonly used in the United States ranged from about 1 milligram to 100 milligrams of radium, typically Ra 226.

In the commercial field, radium was used to make glow in the dark watch and clock dials and exit signs. Worker intakes of these types of radium paint in the early 20th century has been estimated to be between 3 and 43 micrograms of radium (19). In the case of Ra 226 this is equivalent to about 3 to 43 microcuries of the radionuclide. The radium was typically mixed into

a paint which would then be applied to the dials or signs. The concentration of radium in the paint varied; however, "UnDark" paint produced by the US Radium Corporation, the apparent parent company of Safety Light Corporation, may have contained up to 4 milligrams of radium[5]. In the silos at SLC, vials of "Undark" were found (see Figure 4).

The human health impacts of radium has been studied for over 100 years. Radium is deposited within our bodies following ingestion or in rare cases, inhalation. Radium can behave similarly to calcium and a portion of the ingested amount can be absorbed through the gut into the blood stream where it is distributed throughout the body. As with calcium, the radium will deposit into the skeleton, remaining for several years. Estimates of retention in the body range from about 2.5 years to 50 years, depending on the tissue or bone. The radium not absorbed by the gut is rapidly removed during bowel movements.

Early studies focused on the external exposures generated by radium and its ability to induce tissue burns and cancers in exposed individuals. As radium use spread, adverse health effects from internal deposition of radium were observed (21). These included bone cancers and, perhaps, leukemia. The largest group of impacted individuals has been occupational workers, the radium dial painters of the early 20th century. Composed mostly of young women of high school age, this group hand-painted clock dials with the radium paint. In many cases, they wetted the brush tips in their mouth to achieve a sharp tip. As a result of this tip-wetting, many of the dial painters developed cancers. The major type of radiation inducing damage from internally deposited Ra-226 is the alpha particle. This decay particle travels very short distances and the majority, if not all its energy is absorbed within the structure where the Ra-226 is deposited. As most of the ingested Ra-226 deposits in bones, the greatest exposure and dose is delivered to bone surfaces and perhaps the blood-forming bone marrow.

Studies have shown that internal deposition of Ra-226 results in the induction of skeletal tumors and paranasal sinus carcinomas (cancer of the sinus cavities) (21, 23). Many of these studies also were reviewed by the International Agency for Research on Cancer (IARC) (19). Argonne National Laboratory and its Center for Human Radiobiology (now closed) have studied the human health effects of radium deposition for over 20 years (22). Stebbing reported that in U.S. white females employed as dial painters, the rates of liver, pancreatic, cervical, and uterine cancers were not related to radium exposure (23). Some cancers of the digestive system may have been indirectly related to radium exposure. They reported that although there was an increase in multiple myeloma (a form of leukemia), indications were that this increase was related more to the length of employment than the amount of radium in the body. This indirectly suggests the myeloma may be due to the external exposure to the gamma radiation emitted during the radioactive decay of Ra-226.

As of 1984, almost 6,000 individuals with all types of exposure to radium had been located throughout the United States (24). Of these numbers, 1,907 dial painters had been located and the radium body burden measured. In this group, there were 44 cases of bone tumors and 19 cases of sinus or mastoid (associated with the head) carcinomas. These totals include 3 individuals with both types of illnesses. The study concluded that these illnesses and skeletal tissue deterioration were nevertheless unquestionably related to the presence of internal radium.

[5] P. Frame. Radioluminescent Paint. Available at http://www.orau.org/ptp/collection/radioluminescent/radioluminescentinfo.htm (accessed on January 16, 2009).

The radium-in-human studies have been combined in attempts to determine what dose is required to induce bone cancers. Evans reported that the appearance of bone is independent of the radiological dose when that dose is high, in excess of 1000 rads. When the dose is below this level, the studies of about 500 individuals over 40 or more years did not show any clinically significant radiation induced injuries (25). The 1000 rad dose is determined by a direct measurement of radium in the bone. For the purposes of a dose assessment, this rad dose is modified by a radiation weighting factor of 20, resulting in a dose of 20,000 rem.

In a review of radium effects on humans, the National Academy of Sciences (NAS) reported that the first case of bone cancer was reported in 1929 in a radium dial painter. Other reports of increased cancer rates in the dial painters appeared in the medical literature after that diagnosis. In the cases where radium was injected for medical therapy, bone tumors were reported in 1962, 11 to 16 years after the injection (21). In other instances of radium uptake into the body, tumors did not appear for over 60 years following intake into the body.

Leukemia studies from the ingestion of radium have not been as definitive as those for bone tumors. NAS concluded that based on limited medical follow-up, it was not clear if the rate of leukemia was from the ingestion of radium or some other contaminant. This is especially true for the intake of Ra 226. In studies of individuals who received Ra 224, the data were more definitive (21). Nonetheless, in a review of radiation-induced leukemia, Finch reported that the ingestion of radium has never been associated with leukemia (26).

As a naturally occurring element, radium in drinking water is a common contaminant that is easily removed with water softening agents. In the majority of public water supplies that receive their water from surface waters, radium does not appear to be an issue; however, water obtained from wells can be quite high in radium (27). Nonetheless, the NAS reported that health effects from the ingestion of radium-containing water have not been conclusive as the effects observed are not in agreement with the studies seen in the longer-term studies of the radium dial painters (21).

The radiologic dose arising from the ingestion of radium 226 can be estimated by the use of specialized models which take into account the age at intake and the total dose one would receive at some time point following the intake. Because the bone is the most sensitive organ to the effects of ionizing radiation from radium, ATSDR evaluated the resulting dose to the bone and to the whole body from ingestion of 1 picocurie (pCi) of radium, independent of the ingestion pathway. We evaluated a 5-year-old, 15-year-old, and adult member of the public for their dose 5 years following intake and the estimated dose at 70 years of age. Table 15 shows the estimated doses from a one-time ingestion to the both the bone and the whole body. This table shows that the most critical age group for radium intake is those individuals in the 15 year group which includes the age range of 12 to 17 years of age.

Table 15 Radiation dose (millirem) to bone and whole body following radium intake*

Age at intake	5 year dose (bone)	5 year dose (body)	Adult dose (bone)	Adult (body)
5-year-old	0.0814	0.0022	0.0851	0.0029
15-year-old	0.0241	0.0044	0.3480	0.0056
adult	0.0174	0.0005	0.0444	0.001

*The intake is based on the individual ingesting 1 picocurie of radium 226, independent of ingestion route. The dose is expressed in millirem. One millirem equals 0.01 milliSievert. Data were derived from the ICRP (28).

Radon

Radon is a naturally occurring radioactive gaseous element that is produced from the decay of radium. Depending on the particular radium isotope, its decay produces radon.

Radon is a naturally occurring odorless, radioactive gas formed from the breakdown of uranium and thorium into radium which then decays into radon. The most common radon produced is Radon 222 (Rn 222) which is the decay product of radium 226 (Ra 226), used extensively at the Safety Light Corporation site. Elevated levels of radon and radon progeny can be found in areas with elevated levels of radium. The half-life of Rn 222 is 3.8 days; whereas, other forms of radon gas have half-lives shorter than 1 minute. Typically in discussions of radon, it is the radon 222 which is the subject of the discussion.

When Rn 222 decays, it produces non-gaseous radioactive elements (progeny) which attach to particles in the air. The progeny of greatest concern are those that emit alpha radiation during their decay as alpha radiation can be very damaging to internal tissues when either ingested or inhaled. When these particles with the radioactive elements attached to them (attached fraction) are inhaled, some of the attached fraction will deposit in the lung, the remaining being exhaled. The attached fraction deposited in the lung continues to decay which results in a radiological dose to the lung. Many scientists believe that the alpha particle radiation dose from long-term exposure to elevated levels of radon and radon progeny in air increases your chance of getting lung cancer. The longer you are exposed to radon, the greater your chance of developing lung cancer. Therefore, exposure to high levels results in an increased risk of lung cancer. Several government and international groups have classified radon as a human carcinogen.

Because radon is naturally occurring, its presence in the atmosphere has been measured and shown to vary with location, time, season, and moisture (29). Estimating the radiation dose to the lung, however, has been considered by many organizations including the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiation Protection, the International Agency for Cancer Research (IARC), and the USEPA. Besides these organizations, epidemiological studies have evaluated uranium miners who were exposed to uranium dust, radon, and other aerosols in the mines, residential studies in Iowa (30), Sweden (31) and other countries. As a result of these studies, the IARC classified radon as a human carcinogen (32) and radon is a major source of human exposure to natural radioactivity. The IARC also reported that there was an inverse dose-rate effect in uranium miners. In this effect, cancer probability per unit of dose appears to increase as the dose rate increases (32).

Studies of residential exposure to radon are much different from studies of uranium miners as individual assessments of each study participant must be performed. Until recently, the radon concentrations were not measured but were based on housing construction methods. More recent studies are based on actual radon measurements and a time-weighted value is calculated to determine the average time one spends in the residence. When these factors are adjusted in the residential studies, results indicate that the risk estimates are similar with predictions based on the risks of underground miners occupationally exposed to radon.

The workers at SLC worked indoors, not in mines, thus their exposure conditions to radon would be similar to individuals who would be exposed in their residences; however, ATSDR believes the radon levels could be higher than typically found in homes because of potentially elevated levels of radium in the facilities.

To protect human health, the USEPA recommends fixing your home if measured indoor levels of radon are 4 or more picocuries per liter of air (4 pCi/L). The USEPA also notes that radon levels less than 4 pCi/L still pose a health risk and can be reduced in many cases. If indoor radon levels need to be reduced, the USEPA recommends using a certified radon mitigation specialist to ensure that appropriate methods are used to reduce radon levels[6].

There are no simple medical tests or laboratory procedures to determine if you have been exposed to radon; however, the National Cancer Institute lists radon as the second leading cause of lung cancer in the United States. In conjunction with cigarette smoking, exposure to radon gas and cigarette smoke creates a greater risk for lung cancer than either factor alone. The majority of radon-related cancer deaths occur among smokers[7]

[6] For more information see the ATSDR TOXFAQ located at http://www.atsdr.cdc.gov/tfacts145.html (last accessed on May 14, 2009).
[7] For more information, see http://www.cancer.gov/cancerTopics/factsheet/Risk/radon (last accessed on May 14, 2009).

Conclusions and Recommendations for the Safety Light Site

BACKGROUND & PURPOSE:

ATSDR conducted this public health assessment in response to the Safety Light Corporation Superfund Site (SLC or Safety Light Site) being placed on the United States Environmental Protection Agency (USEPA) National Priorities List (NPL) in 2005 due to the presence of radioactive contamination in the environment.

ATSDR used the available data for the site to determine if people are exposed to contaminants at levels that may adversely impact their health. This public health assessment considers the radiological contaminants in the water, soils, and air on the Safety Light Site as well as the potential for exposure to contaminants by people living in the vicinity of the site. In addition, it addresses community concerns that have been raised about the overall safety of the drinking water in nearby private wells. Therefore, exposures to non-radiological contaminants have also been addressed for people with nearby private wells.

CONCLUSION 1:

People who worked in the Safety Light Site buildings (on-site) in the past may have been exposed to levels of radon that pose a public health concern.

BASIS FOR CONCLUSION:

Radium used at the Safety Light Site decayed to radon. Data indicate the presence of radon was wide-spread in on-site buildings and administrative areas and at levels high enough to pose a health hazard to workers. National and international organizations have classified radon as a known human carcinogen. Uranium miner studies and radon exposure studies in residential structures have shown a correlation of radon exposure to lung cancer.

RECOMMENDATIONS:

State and local health departments should develop and provide information to former workers to education them about the presence and associated risk of radon exposure.

Former plant workers should consult and discuss their exposures with their personal physicians.

If workers or local residents have removed any property from the Safety Light, it is recommended that they have their properties tested for radon. With regard to the site, no further steps are necessary as the buildings have been demolished.

CONCLUSION 2:	ATSDR concludes that low levels of radiological and chemical contaminants detected in private wells used for a potable water supply for drinking, bathing or other purposes near the Safety Light Corporation NPL site are not expected to harm people's health.
BASIS FOR CONCLUSION:	Low levels of radiological and chemical contaminants detected in private wells are below levels that have been associated with adverse health effects.
RECOMMENDATION:	It is recommended that USEPA conduct periodic sampling of the private wells used for drinking water purposes in the vicinity of the Safety Light Site until its groundwater investigation is completed.

CONCLUSION 3:	ATSDR concludes that releases of dust and particulates to the air during demolition of the buildings on the Safety Light Site does not pose a health risk to people living near the site.
BASIS FOR CONCLUSION:	The results of air sampling conducted by USEPA throughout the demolition process indicate that contaminants were not detected at high enough levels to pose a health concern.
RECOMMENDATIONS:	No recommendations are necessary at this time.

FOR FURTHER INFORMATION	For further information about this public health assessment, please call ATSDR at 1-800-CDC-INFO and ask for information on the Safety Light Corporation Superfund Site. If you have concerns about your personal health, it is suggested that you contact your personal physician.

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ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (USEPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption

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

Acute

Occurring over a short time [compare with chronic].

Acute exposure

Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect

A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect

A change in body function or cell structure that might lead to disease or health problems.

Aerobic

Requiring oxygen [compare with anaerobic].

Ambient

Surrounding (for example, ambient air).

Anaerobic

Requiring the absence of oxygen [compare with aerobic].

Analyte

A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study

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

Antagonistic effect

A biologic response to exposure to multiple substances that is less than would be expected if

the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level

An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Background Radiation

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

Biodegradation

Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study

A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring

Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake

The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing

Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota

Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden

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

CAP

See Community Assistance Panel.

Cancer

Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk

A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen

A substance that causes cancer.

Case study

A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study

A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number

A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system

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

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic

Occurring over a long time (more than 1 year) [compare with acute].

Chronic exposure

Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure].

Cluster investigation

A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)

A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)

Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration

The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant

A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect

A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal

Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact

Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology

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

Detection limit

The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention

Measures used to prevent a disease or reduce its severity.

Disease registry

A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD

United States Department of Defense.

DOE

United States Department of Energy.

Dose (for chemicals that are not radioactive)

The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose, Radiation

The amount of energy imparted to matter by ionizing radiation per the unit mass of matter, usually expressed as the rad, or in SI units, the gray (Gy), 100 rad = 1 Gy

Dose (or Radiation Dose)

A general term denoting the amount of energy from radiation that is absorbed per unit mass of absorber. A generic term meaning absorbed dose, dose equivalent, deep dose equivalent, effective dose, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, equivalent dose, or total effective dose equivalent. For special purposes it must be appropriately qualified. If unqualified, it refers to the absorbed dose.

Dose-response relationship

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

Environmental media

Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism

Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

USEPA

United States Environmental Protection Agency.

Epidemiologic surveillance

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

Epidemiology

The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure

Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment

The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction

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

Exposure investigation

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

Exposure pathway

The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching); and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry

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

Feasibility study

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

Geographic information system (GIS)

A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds

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

Groundwater

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

Half-life ($t_{½}$)

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

Hazard

A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)

The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste

Potentially harmful substances that have been released or discarded into the environment.

Health consultation

A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education

Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation

The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion

The process of enabling people to increase control over, and to improve, their health.

Health statistics review

The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard

The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence

The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion

The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation

The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure

Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro

In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo

Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Isotopes

Any nuclide of the same element having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element, but physical properties such as diffusion through a membrane may differ. This term should not be used as a synonym for nuclide.

Lowest-observed-adverse-effect level (LOAEL)

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

Medical monitoring

A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism

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

Metabolite

Any product of metabolism.

mg/kg

Milligram per kilogram.

mg/cm^2

Milligram per square centimeter (of a surface).

mg/m^3

Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration

Moving from one location to another.

Minimal risk level (MRL)

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

Morbidity

State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality

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

Mutagen

A substance that causes mutations (genetic damage).

Mutation

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

National Priorities List for Uncontrolled Hazardous Waste Sites

(National Priorities List or NPL)

USEPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard

A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)

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

No public health hazard

A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)

A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica

A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume

A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure

The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population

A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)

A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb

Parts per billion.

ppm

Parts per million.

Prevalence

The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey

The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention

Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period

An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public availability session

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

Public health action

A list of steps to protect public health.

Public health advisory

A statement made by ATSDR to USEPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)

An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard

A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories

Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement

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

Public meeting

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

Radiation

The energy propagated through space or through a material medium such as waves; for example, energy in the form of electromagnetic waves or particles of corpuscular emission, such as alpha and beta radiation, or rays of mixed or unknown type, such as cosmic radiation.

Radioisotope

An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide

Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population

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

Reference dose (RfD)

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

Registry

A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation

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

Resource Conservation and Recovery Act (1976, 1984) (RCRA)

This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA

RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD

See reference dose.

Risk

The probability that something will cause injury or harm.

Risk reduction

Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication

The exchange of information to increase understanding of health risks.

Route of exposure

The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample

A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size

The number of units chosen from a population or environment.

Solvent

A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination

The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder

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

Statistics

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

Substance

A chemical.

Substance-specific applied research

A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)

In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water

Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see epidemiologic surveillance]

Survey

A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect

A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen

A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent

Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile

An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology

The study of the harmful effects of substances on humans or animals.

Tumor

An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor

Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard

A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)

Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other Glossaries and Dictionaries

Environmental Protection Agency http://www.epa.gov/OCEPAterms/

National Center for Environmental Health (CDC) http://www.cdc.gov/nceh/dls/report/glossary.htm

National Library of Medicine (NIH) http://www.nlm.nih.gov/medlineplus/dictionaries.html

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