Public Health Assessment for

MIDDLESEX SAMPLING PLANT (USDOE)
MIDDLESEX, MIDDLESEX COUNTY, NEW JERSEY
EPA FACILITY ID: NJ0890090012
MAY 8, 2002

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

PUBLIC HEALTH ASSESSMENT

MIDDLESEX SAMPLING PLANT (USDOE)

MIDDLESEX, MIDDLESEX COUNTY, NEW JERSEY

EPA FACILITY ID: NJ0890090012

Prepared by:

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment 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.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes 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.

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FOREWORD

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

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

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

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

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

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

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

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E56), Atlanta, GA 30333.

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEC	Atomic Energy Commission
ATSDR	Agency for Toxic Substances and Disease Registry
Bq/kg	becquerel per kilogram
Bq/L	becquerel per liter
COC	contaminant of concern
CREG	ATSDR's cancer risk evaluation guide
CV	comparison value
DCG	DOE's derived concentration guide
DOE	U.S. Department of Energy
EMEG	ATSDR's environmental media guide
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
ft	feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
INX	beryl ore
ICRP	Internal Commission on Radiological Protection
LOAEL	lowest-observed-adverse-effect-level
LTHA	Lifetime health advisory for drinking water
µR/hour	microroentgen per hour
m^3	cubic meter
MCL	EPA's maximum contaminant level
MED	Manhattan Engineer District
mg	milligram
mg/kg/day	milligram of contaminant per kilogram body weight per day
MgX	magnesium di-uranate precipitate
MML	Middlesex Municipal Landfill
mrem/yr	millirem/year
MRL	ATSDR's minimal risk level
MSP	Middlesex Sampling Plant
MTBE	methyl-tert-butylether
na	not analyzed

List of Abbreviations (continued)

NCRP	National Council on Radiation Protection and Measurements
nd	not detected
NJDEP	New Jersey Department of Environmental Protection
NJGWQS	New Jersey Ground Water Quality Standards
NOAEL	no-observed-adverse-effect-level
NRC	National Research Council
ns	not sampled
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PAHs	polycyclic aromatic hydrocarbons
PHA	public health assessment
PHAP	public health action plan
PCBs	polychlorinated biphenyls
pCi/g	picocurie per gram
pCi/L	picocurie per liter
ppb	parts per billion
ppm	parts per million
Q-11	uranium ore
RfD	reference dose
RI	remedial investigation
RMEG	ATSDR's reference media evaluation guide
SVOC	semivolatile organic compound
SDWA	Safe Drinking Water Act
TEF	toxic equivalency factor for PAHs
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
VP	vicinity properties
WL	working level
yd^3	cubic yard

SUMMARY

The Agency for Toxic Substances and Disease Registry (ATSDR) has prepared this public health assessment to evaluate the potential for contaminants at the Middlesex Sampling Plant (MSP), Middlesex, New Jersey, to harm people living near or accessing the site. By reviewing existing data, ATSDR determined that soil, sediment, and shallow groundwater at the site, as well as soil in certain off-site locations, is contaminated with arsenic, chromium, lead, and radionuclides at concentrations considered to be of health concern. However, based on its evaluation, ATSDR determined that *no exposures posing public health hazards are occurring now or are likely to occur in the future, as long as safety precautions are followed during future excavation activities at the site. However, ATSDR determined that there might have been past exposures to certain arsenic, lead, uranium and radium contaminated media associated with the MSP site.*

The MSP site occupies about 9.6 acres in Middlesex, New Jersey. Originally, the site served as an asphalt paint manufacturing plant from 1910 until 1943, when it was converted into a government uranium ore sampling and storage facility. From 1943 until 1967, the U.S. Department of Energy used the site primarily for sampling, analysis, storage, and shipment of uranium, beryllium, and thorium ores. Over the years, the buildings and surface soil at the site and on nearby parcels of land became contaminated with metals, including arsenic, lead, and chromium, uranium and radium. Some contaminants leached through the soil to the groundwater beneath the site, migrated with soil/sediment through the on-site culvert system/drainage ditch, or migrated via airborne transport. When the site was leveled in 1947 or 1948, contaminated excess soil was sent to the Middlesex Municipal Landfill for use as cover. Some of this soil was also used as fill at a nearby residence and at the rectory and playground of the Church of Our Lady of Mount Virgin at the corner of Harris and Drake Street in Middlesex Borough. After detecting elevated low levels of uranium in surface-water samples collected downstream, the U.S. Environmental Protection Agency (EPA) placed MSP on the National Priorities List of hazardous waste sites in February 1999.

As part of the public health assessment process, ATSDR conducted site visits and met with representatives from the community, U.S. Army Corps of Engineers, and EPA. During the site visits, ATSDR did not identify any immediate public health hazards, but determined that additional information was needed to more fully evaluate potential exposure to contaminated soil and groundwater, and to a lesser extent to surface water/sediment and air.

ATSDR evaluated available environmental data and information about the MSP site and the surrounding community to assess whether harmful exposures occurred in the past, are occurring, or could occur in the future. ATSDR has determined that former residents of, or visitors to, properties with contaminated fill might have been exposed in the past to site-related contaminants, including arsenic, lead, radium, uranium, and other radionuclides at unknown levels. The primary exposure pathway was inadvertent ingestion of contaminated surface soil. Because radionuclides associated with MSP emit radon gas, radon progeny and ionizing radiation, exposure also might have occurred from breathing indoor air containing elevated radon and its progeny or from exposure to external gamma radiation. Former workers at the MSP site were also at risk from contact with soil, inhalation of radon and dust, and direct contact with

uranium, thorium, and beryllium ores and the byproducts generated during the ore sampling process.

The grassy area on the southern border of the site has a large population of ticks, and special care should be taken by anyone walking through the area to check for ticks on their scalp or skin.

Workers at the site, particularly those who worked in the process building, were exposed to radon gas and airborne particulates during their workday. The full extent of exposure to airborne particulates during former operations remains uncertain due to limited sampling data and information about actual exposure.

Several measures have been taken to remove contaminants from the structures and surface of the MSP site and from nearby affected properties. Any remaining contaminated soils at the site are covered with asphalt and grass, and access is limited. ATSDR concludes that, under these conditions, **the site poses no current public health hazard**.

During future remediation efforts, remedial workers must be adequately protected from contaminants associated with the material buried beneath the site. As an additional precautionary measure, ATSDR further recommends that, until the site is fully remediated and free of potential physical hazards, more efforts should be made to secure the site (e.g., fix gaps in gates) from trespassing. As long as workers are protected and trespassing is restricted during remediation, **no future public health hazards should occur.**

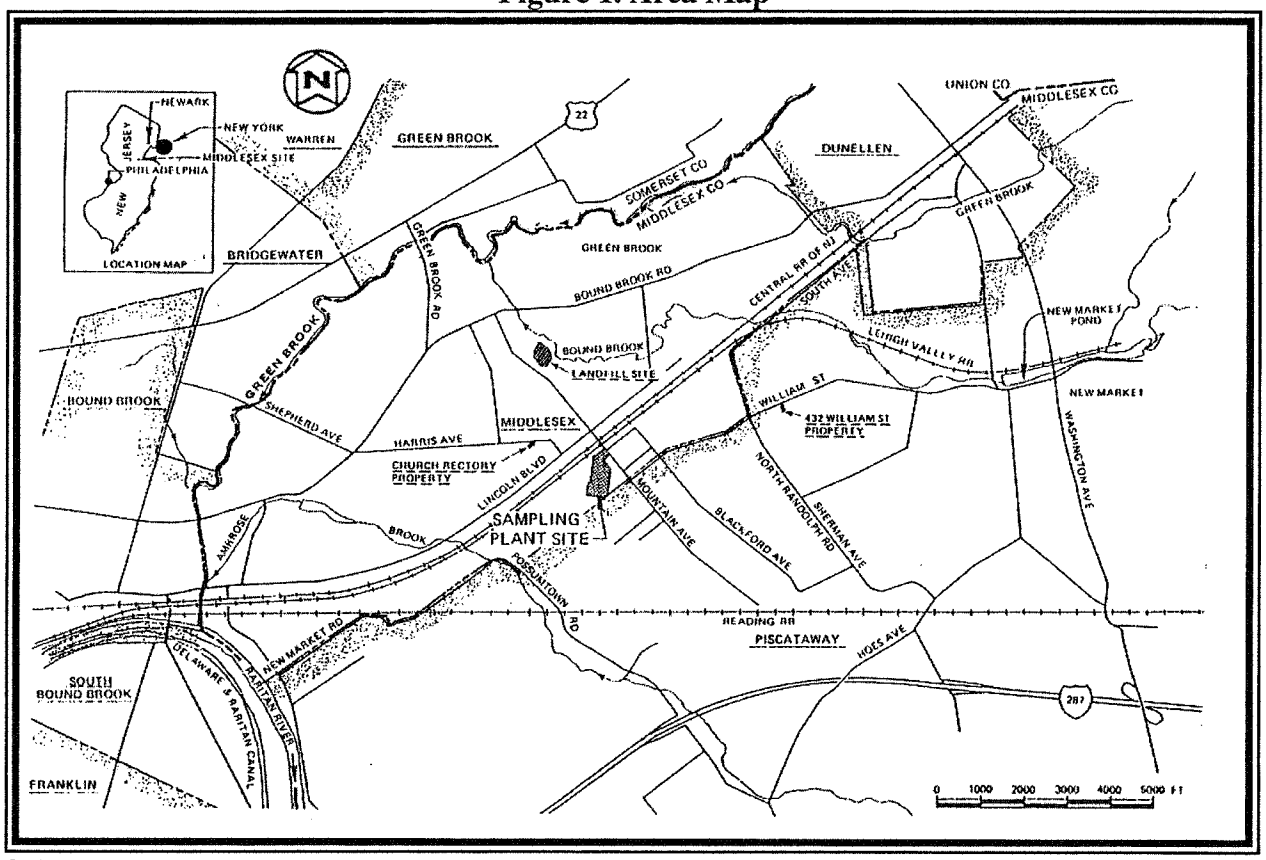
A private well survey indicates that approximately 140 private wells are in the vicinity of the MSP site. Recent monitoring of several private wells near the MSP site found some radionuclides and metals in the well water, but at levels below health concern. Nearby private wells should be regularly monitored for contaminant migration in the future.

BACKGROUND

Site Description and History

The Middlesex Sampling Plant (MSP) is a 9.6-acre site located at 239 Mountain Avenue in the Borough of Middlesex in Middlesex County, New Jersey (see Figure 1). The site is bordered on the east by residential and commercial properties; on the west by a scrap metal facility; on the north by the Lehigh Valley railroad line; and on the south by vacant marshy land and fields. The unoccupied site is surrounded by a 7-foot-high chain-link fence with gates at the main entrance on Mountain Avenue, and at the Wood and Williams Street entrance. Most of the site (70 percent) is covered with asphalt; only an office building, a garage, and two foundation slabs from buildings demolished in 1996 remain on site.

Figure 1. Area Map



SAIC 1995

The 239 Mountain Avenue property was originally developed in 1910 as an asphalt paint manufacturing plant, consisting of a large two-story brick warehouse, a boiler house, a garage, an administration building, a dye warehouse, and four smaller outbuildings. The name of the paint manufacturer is unknown. The company went broke in 1913 and was bought by American Marietta Company. Under new management, the American Asphalt Company became successful, particularly after other colors, such as aluminum, were added to the standard black available (Sloan, 1983).

In October 1943, the U.S. Army Corps of Engineers leased the brick warehouse for the Manhattan Engineer District (MED) as one of the industrial sites chosen to perform different operations as part of the United States' efforts to develop the atomic bomb. In late 1943, a stockpile of 1,200 tons of uranium ore from the Belgian Congo was sent to the MSP site for sampling, weighing, and assaying. Far greater tonnage of uranium, and later beryllium and thorium ores, were gradually shipped from Africa and India into Staton Island and then to the MSP site.

Once the ore was sampled, weighed, and assayed, it was shipped from MSP to the Linde Refinery, Tonawanda, New York, where it was processed into black oxide or sodium di-uranate concentrates. These concentrates were further processed at various locations and eventually shipped to the Hanford nuclear reactors at Richland, Washington, for use in plutonium production. The plutonium was shipped to Los Alamos National Laboratory in New Mexico for use in developing the atom bomb (DOE, 1980).

What radioactive materials were used at Middlesex Sampling Plant (MSP)?

DOE used uranium and thorium ores at MSP. Uranium is a naturally occurring radioactive material. By weight, most natural uranium is the radionuclide uranium-238. It takes about 4.5 billion years for one-half of uranium-238 to break down. As uranium-238 breaks down, or decays, new elements are created—including radium, thorium, and radon—and radiation is released. Thorium is not stable, and it continues to decay until stable lead is formed.

In 1946, the Atomic Energy Commission (AEC) condemned and purchased the leased properties when the MED was deactivated. Uranium oxide (Q-11) remained the chief material processed, but after 1950, magnesium di-uranate precipitate (MgX) and beryl ore (INX) were also processed there (Cahalane, 1958).

Processing of the ores primarily occurred in one of several on-site buildings. These buildings included the original American Marietta warehouse, which was converted to the process building where the ore was sampled and assayed; a concrete thaw house, which stored ore in need of thawing; and a new boiler house, which housed the boiler for the process building. The site also housed a Quonset hut for enclosed storage, an administration building, and a garage.

Wastewater from the process building entered a 500-cubic-foot settling tank, where it was filtered to remove solids and then released to the drainage ditch that carried surface water off site. An underground conduit system also fed the drainage ditch. Process waste might have also entered a sump system that flowed to a catch basin located between the process building and the garage. (see Figure 2). In 1947, the approximately 9.6-acre site was surrounded by a chain-link fence and 8 acres were paved with asphalt to provide a drum storage area (DOE, 1997). By 1955, AEC terminated primary activities at MSP but continued on-site storage and sampling of thorium residues until 1967, when they ceased all activities at the site. From 1969 until 1979, the U.S. Navy used the site as a reserve training center for the U.S. Marine Sixth Motor Transport Battalion training center from 1969 to 1979. No commercial or industrial activities have been conducted at MSP since 1980.

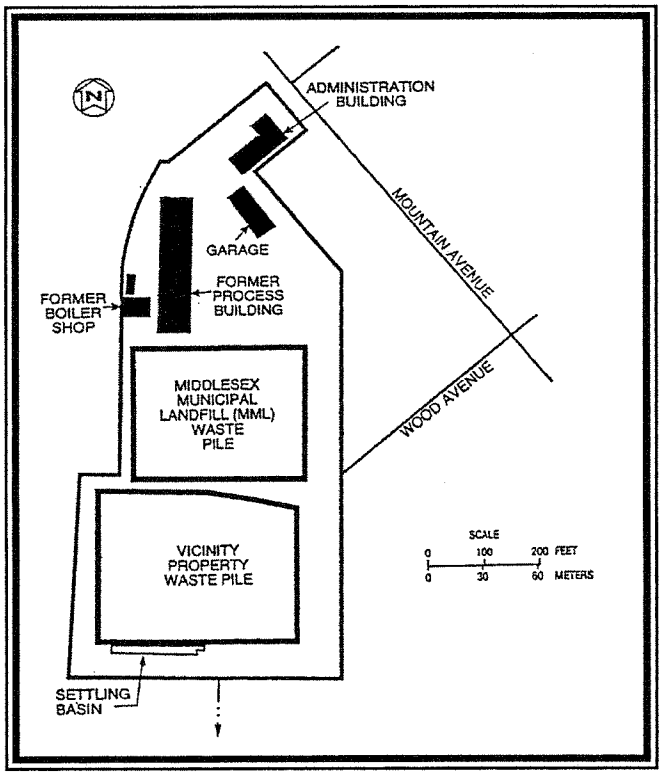
During the years that the MSP was operational, the buildings, grounds, and nearby parcels of land became contaminated mainly from spillage and subsequent migration mechanisms (BNI, 1995). The metal contamination probably resulted from on-site ore sampling processes or from typical operations and past accidental spills at the American Marietta paint manufacturing plant. Some the contamination has leached through the soil to the groundwater beneath the site, migrated with particles through the on-site culvert system/drainage ditch, or migrated through the air. When the site was leveled and asphalted in 1947, excess soil, which was contaminated with spilled ore and metals, was sent to the Middlesex Municipal Landfill (MML) for use as cover. Some of this soil was also used as fill at a nearby residence and at the rectory and playground of the Church of Our Lady of Mount Virgin at the corner of Harris and Drake Street in Middlesex Borough (SAIC, 1995).

MSP Site History

1910	Asphalt Paint Plant is built at the site.
1943	Manhattan Engineer District (MED) leased the site's brick warehouse for sampling and analysis of uranium ores.
1946	The Atomic Energy Commission (AEC), the successor to MED, purchased the leased property.
1950	Sampling of magnesium di-uranate precipitate (MgX) and beryl ore (INX) began.
1954	MSP no longer sampled INX.
1955	AEC terminated sampling and shipment of uranium, thorium, and beryllium ores, but continued on-site storage and sampling of thorium residues. Sampling of Q-11 and MgX was transferred to Fernald, Ohio.
1967	All activities were terminated and the site was decontaminated.
1968	MSP transferred to the GSA.
1969	The U.S. Navy acquired the site and used it for U.S. Marine Corps reserve training.
1979 -	No commercial or industrial activity.

(See Appendix A for a detailed site chronology.)

Figure 2. Site Map



SAIC,1995

Remedial and Regulatory History

After AEC activities stopped in 1967, Isotope, Inc., a contractor for the AEC, decontaminated the site. Isotope sandblasted or cleaned structures at the site, removed a foot of soil from a tunnel under the process building, and cleaned and/or covered the underground settling tank, sump, and various pits. Additionally, portions of the process building, including the loading dock and the conveyor building, were completely removed. Approximately one-half inch of the top of the asphaltic concrete covering about 8 acres of the site was removed, and contaminated soil was excavated. Resulting debris was shipped by railroad cars to an off-site burial area. Following an AEC survey to assess the radiologic conditions at the site, the property was released for unrestricted access (ORNL, 1977).

Remediation Chronology

1947	The site was excavated and fenced, and 8 acres were paved for drum storage.
1960	AEC surveyed the Middlesex Municipal Landfill (MML) and removed 650 yd^3 of radioactive soil.
1967	All activities were terminated and the site was decontaminated.
1976	ORNL initiated surveys of MSP and surrounding properties for radiation levels and radon.
1978	Widespread contamination found at MSP, on surrounding properties, and at three more remote off-site locations.
1980	MSP was placed under DOE's FUSRAP, and environmental investigation and excavation began.
1980	Contaminated soil from surrounding and remote properties was transferred to the "vicinity properties" (VP) storage pile on MSP.
1983	A radiological survey was conducted on site.
1984	Radiologic contaminated soil and waste were removed from the MML site and brought back to MSP for temporary storage (MML pile).
1991	MSP was characterized for non-radiologic contamination in soil.
1998	The MML pile was disposed of at a certified hazardous material landfill.
1999	The U.S. Environmental Protection Agency listed MSP on EPA's National Priorities List. The VP pile was removed.

(See Appendix A for a detailed remediation chronology.)

In 1960, elevated gamma radiation levels were detected at the Middlesex Municipal Landfill by civil defense monitors during a local civil defense exercise. A survey conducted by the AEC found external gamma radiation levels at 20 to 50 times background over an approximate one-half acre area. The AEC removed approximately 650 cubic yards of the contaminated material most near the surface and covered the area with about two feet of uncontaminated dirt, lowering external gamma radiation levels to less than 0.05 mR/hour (ORNL, 1978).

The Oak Ridge National Laboratory (ORNL) conducted another radiological survey of the MSP site in 1976. Elevated concentrations of radon in buildings from elevated levels of radium in soil were identified, suggesting the need for further characterization of on-site conditions (ORNL, 1977). A subsequent aerial survey identified radiologic contamination on adjacent and nearby residential, commercial, and vacant properties.

In 1980, the MSP site was placed under the DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). The FUSRAP identifies and decontaminates sites where radioactive contamination remains after operations are carried out under contract with the MED and AEC. This program was administered by DOE until 1997, when it was transferred to the U.S. Army Corps of Engineers (USACE).

Under the FUSRAP program, DOE began to investigate environmental conditions at the MSP site to determine the nature and extent of radiologic releases to the soil, groundwater, surface water/sediment, and air on and immediately near the site. In 1991, volatile organic compounds (VOCs) and metals were added to the annual environmental surveillance program. Various site investigations and environmental surveillance monitoring indicated that elevated levels of contaminants were present in on-site soil, groundwater beneath the site, and surface water moving through the site. The suspected on-site sources include the facility soil, on-site storage piles (the "vicinity properties" [VP] and the MML piles discussed below), and possible contaminated buried features including the settling tank, the sump, the tunnel under the process building and the partial basement. The original contaminants of primary concern to DOE at MSP were the natural radioactive elements uranium, radium, and, to a lesser extent, thorium. Uranium and radium and their decay products were also detected in off-site locations where MSP soil was used as fill or where contaminants migrated via airborne transport.

After investigations revealed radioactivity in off-site soil, DOE conducted a two-phase removal action. During Phase I, which began in 1980, contaminated soils (and sediments) were removed from four of the most heavily contaminated off-site properties, including the residential property, the rectory of the Church of Our Lady of Mount Virgin in Middlesex Borough, and portions of the church playground. During Phase II, completed in 1981, more contaminated soil and sediment were excavated from the on-site drainage ditch and from 29 adjacent, lesser contaminated properties, where contaminants had settled via airborne transport. The approximately 35,200 cubic yards (yd^3) of contaminated soils from both Phase I and II were placed in the VP pile at the MSP site. In addition, in 1984, approximately 15,600 yd^3 of radiologic contaminated soil and waste (originally from the MSP site) were excavated from the MML site and placed in a separate interim storage pile at MSP, called the MML pile. An additional 15,600 yd^3 were removed from the landfill and added to the on-site MML pile in 1986, bringing the estimated total volume of the pile to 31,200 yd^3. Both the VP and MML piles were constructed on an asphalt base with appropriate "curbing" to control contaminant migration and covered to prevent erosion and airborne transport of contaminated soil (SAIC, 1995). The MML pile was also connected to a newly installed leachate collection system. In 1998, the MML pile was removed from MSP and disposed of at a certified hazardous material landfill. Removal and disposal of the VP pile was completed in 1999.

Starting in 1996, DOE initiated a series of actions to remove or remediate contamination at the MSP site and to further eliminate potential off-site migration. These actions included removing additional sediment from the on-site drainage ditch and demolishing the existing process building (DOE, 1997a). During 1996, monitoring detected total uranium in an off-site monitoring well located south and downgradient of the site and, in 1997, uranium was detected in an off-site surface water body. By February 1999, EPA had listed the MSP site on the National Priorities List of sites because of concerns about radioactive contamination in surface water and contamination of wetlands and a sensitive environment (EPA, 1999).

Agency for Toxic Substances and Disease Registry Involvement

As part of the public health assessment (PHA) process, representatives of the Agency for Toxic Substances and Disease Registry (ATSDR) visited MSP on July 14–16, 1999. During the visit, ATSDR staff members met with representatives of the Middlebrook Regional Health Commission, toured the perimeter of the site, and reviewed the local health department's historical documents pertaining to environmental sampling and remediation activities.

During the site visit, ATSDR staff noted that all three gates at MSP were closed and padlocked. "No Unauthorized Access" signs were prominently displayed at each gate area. Although no holes or gaps in the perimeter fence were noted, it appeared that entry to the site could be gained through a gap between the gate and the fence located at the Wood Avenue entrance on the eastern side of the site. No on-site bike trails or footpaths were evident, but a number of tennis balls were found in the grass around the perimeter of the asphalt pad. The surface soil at MSP is predominantly covered with asphalt, concrete, small shrubs, grass, and other vegetation. No visible airborne dust was observed.

Although high grass and vegetation provide some cover, the south drainage ditch was accessible by ATSDR staff and potentially by the general public (Figure 2). However, there were no obvious signs, such as worn foot paths or bicycle tracks, indicating that access had occurred. The high grass on the southern border of the site has a large population of ticks, and special care should be taken by anyone walking through the area to check for ticks on their scalp or skin.

On December 16, 1999, ATSDR representatives revisited the site, met with representatives of USACE and EPA, and met with community members at a public availability meeting at the Middlesex High School. Following the visit, ATSDR developed a fact sheet to further answer questions about MSP and ATSDR's involvement at the site. ATSDR mailed the fact sheet in January 2000 to more than 4,500 Middlesex and Piscataway community members living in an approximate 1-mile radius of the site. Through the mailing, community members were encouraged to share with ATSDR any health concerns they might have regarding possible exposures to site contamination. ATSDR heard from community members through more than 175 responses, including 106 letters expressing health concerns and questions. ATSDR addresses their concerns in the "Community Health Concern" section of this PHA.

Several of the community members responding to ATSDR's mailing questioned whether their private well water was safe for drinking. Because information about the private wells was not available at the time to answer this question definitively, ATSDR sampled well water from nearby private wells in February 2000 and again in April 2000. The results of the private well sampling are discussed in the "Evaluation of the Groundwater Exposure Pathway" section of this PHA. During the visit in April 2000, ATSDR reviewed the documents in the MSP reading repository located at the Middlesex Library. The repository contains extensive information on the history of the site and on subsequent operations and remediation effort at and around the MSP.

Demographics, Land Use, and Natural Resource Use

ATSDR examines demographic information, or population information, to identify sensitive populations, such as young children and the elderly, in the vicinity of a site. Demographics also provide a particular area's residential history—information that helps ATSDR assess time frames of potential human exposure to contaminants. Demographic information collected by the U.S. Bureau of Census (1990) indicates that 11,318 people live within one mile of the MSP site. Roughly one-tenth (10 percent) of the residents are 6 years or younger and about one-tenth of the population (11 percent) is 65 or older (see Figure 3).

ATSDR also reviewed land use at and near the MSP site to identify valuable information on the activities conducted in the surrounding area and the possibility of exposure through these activities. The land surrounding the MSP site consists of a mixture of residences, commercial, industrial properties, and undeveloped land (see Figures 1 and 2). Auto salvage shops border the site to the immediate northwest and along a portion of the eastern boundary. Most of the nearby residences are located along the eastern side of the site, where the nearest residence sits approximately 100 feet away from the site boundary (SAIC, 1995). The residence on Williams Street, that received contaminated soil from the MSP site is located approximately 1 mile to the east of the MSP site. The Church of Our Lady of Mount Virgin is located approximately one-half mile west, and the MML site is located just less than a mile northwest from the site (see Figure 2).

The nearest surface water to MSP is the Main Stream, which flows just south of the site. The Main Stream, a freshwater tributary of the Raritan River, is classified by EPA and the New Jersey Department of Environmental Protection as a supply source for public drinking water. The nearest drinking water intakes are located in the Raritan River, approximately 3.3 miles south (downstream) of the site. An on-site drainage ditch known as the south drainage ditch converges with the Main Stream about 0.25 miles south of the site, which then flows into Ambrose Brook. (All on-site surface water moved through an underground drainage system ditch either directly to the southern drainage ditch or to a settling basin and then to the drainage ditch.) Ambrose Brook empties into Green Brook just before it joins the Raritan River (SAIC, 1995). Instead of public water, a number of residents near the MSP site rely on private wells for their drinking water and for domestic use. Those private wells draw water from the same aquifer that lies beneath the site. According to a 1990 private well survey, approximately 140 private wells are located within a mile of the MSP (BNI, 1991).

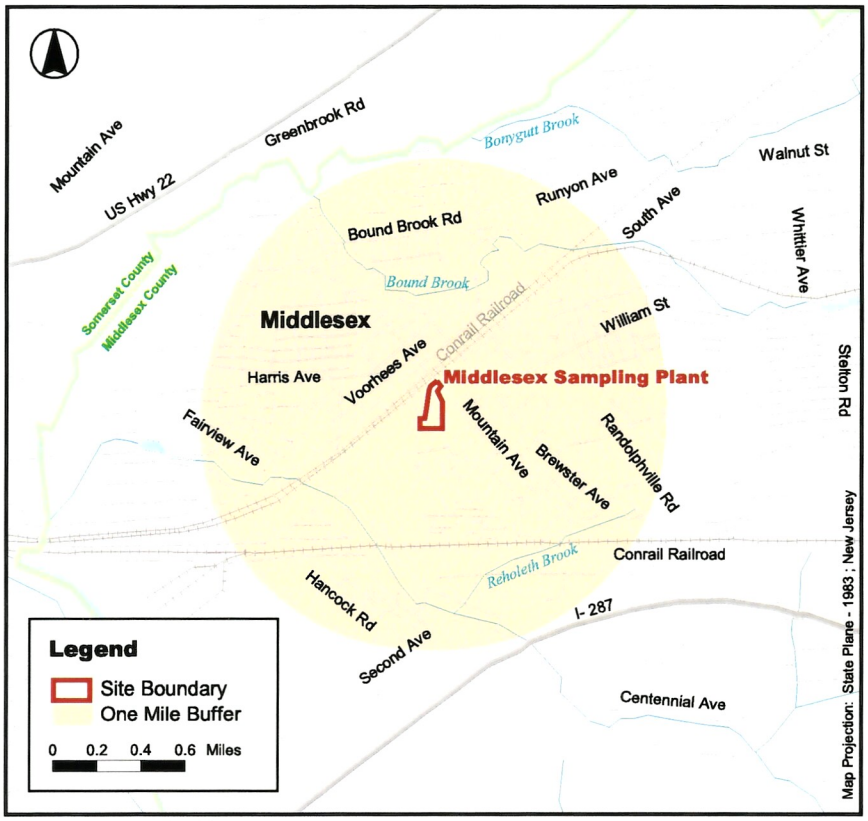
Middlesex County contains many parks, wilderness areas, and golf courses. The county government presently operates 19 county parks, encompassing 7,020 acres. Thirteen of these locations contain active recreational facilities, and five are conservation areas or are being held for future development. The New Jersey Department of Fish, Game, and Wildlife (NJDFGW) stocks the Green Brook and the Raritan River with adult trout for fishing. The NJDFGW has also identified other edible fish in the Raritan, including stripped bass, American shad, and northern pike. Vacant land south of the site abuts the Main Stream and provides habitat for wildlife (e.g., birds, small animals, deer). People have been observed fishing in the Raritan River, but hunting in the area is prohibited.

Middlesex Sampling Plant

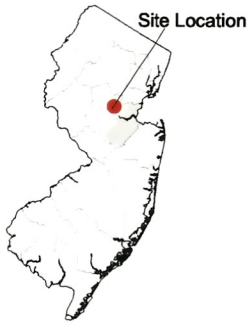
INTRO MAP

Middlesex Borough, New Jersey

EPA Facility ID NJ0890090012



Base Map Source: 1995 TIGER/Line Files



Middlesex County, New Jersey

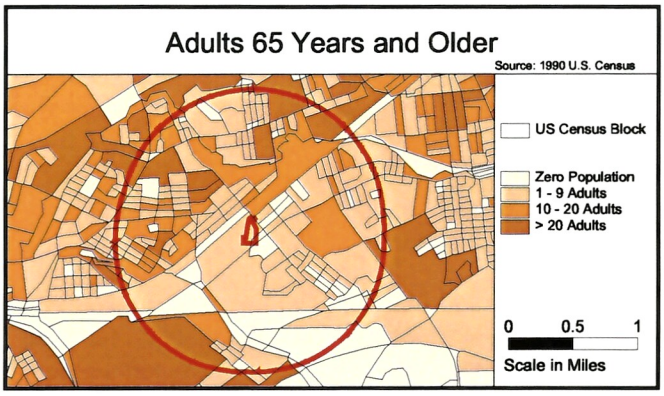
Demographic Statistics Within One Mile of Site*	
Total Population	11318
White	9879
Black	567
American Indian, Eskimo, Aleut	17
Asian or Pacific Islander	763
Other Race	90
Hispanic Origin	434
Children Aged 6 and Younger	1115
Adults Aged 65 and Older	1247
Females Aged 15 - 44	2724
Total Housing Units	4154

Demographics Statistics Source: 1990 U.S. Census
*Calculated using an area-proportion spatial analysis technique

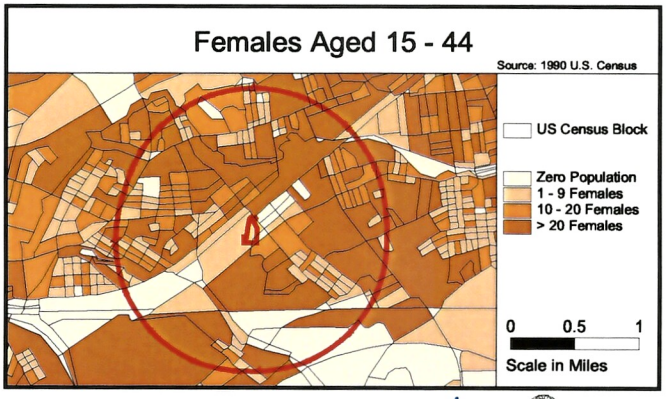
Population Density

Children 6 Years and Younger

Adults 65 Years and Older



Females Aged 15 - 44



ATSDR GIS SAIDS

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ATSDR searched the EPA's Toxics Release Inventory (TRI) database for reports of chemical releases within 3 miles of the MSP site for 1997—the most recent year for which data are available. The TRI database contains extensive emissions data for a wide range of industries. However, the TRI data are self-reported, and the accuracy of the reporting facilities is not known. Also, the TRI regulations require facilities to disclose releases of a wide range of hazardous pollutants, but not for all contaminants released to the environment. Therefore, the data described should not be viewed as a comprehensive inventory of emissions in the area of the MSP site.

Eight facilities in the TRI are located within 3 miles of the MSP site; those sites include one facility in Bound Brook, two facilities in Middlesex and in Plainsfield, and three facilities in Piscataway. Five facilities reported releases to the air of VOCs, semivolatile organic compound (SVOCs), and/or metals; no releases to the surface water or from the on-site landfill were reported. None of the facilities has reported releases of chemicals identified at the MSP or at affected off-site properties (e.g., private home on Williams St. and the church rectory). ATSDR identified 34 facilities in a 5-mile radius of the site, and 72 facilities are within a 10-mile radius, suggesting that the area is highly industrial.

Quality Assurance and Quality Control

In preparing this PHA, ATSDR reviewed and evaluated information provided in the referenced documents. Documents prepared for DOE and USACE's FUSRAP program must meet specific standards for adequate quality assurance and control measures for chain-of-custody procedures, laboratory procedures, and data reporting. The environmental data presented in this PHA are from DOE and USACE, and include investigations of the radiological surveys of on-site and off-site locations, as well as from information provided by New Jersey Department of Environmental Protection (NJDEP). Based on our evaluation, ATSDR determined that the quality of environmental data available in site-related documents is adequate to make public health decisions. Spatial distribution of sampling locations, sampling frequency, concentration changes over time, and the correlation between the selected list of analytical parameters and suspected environmental contaminants are factors considered by ATSDR when determining the contaminants to which individuals could be exposed.

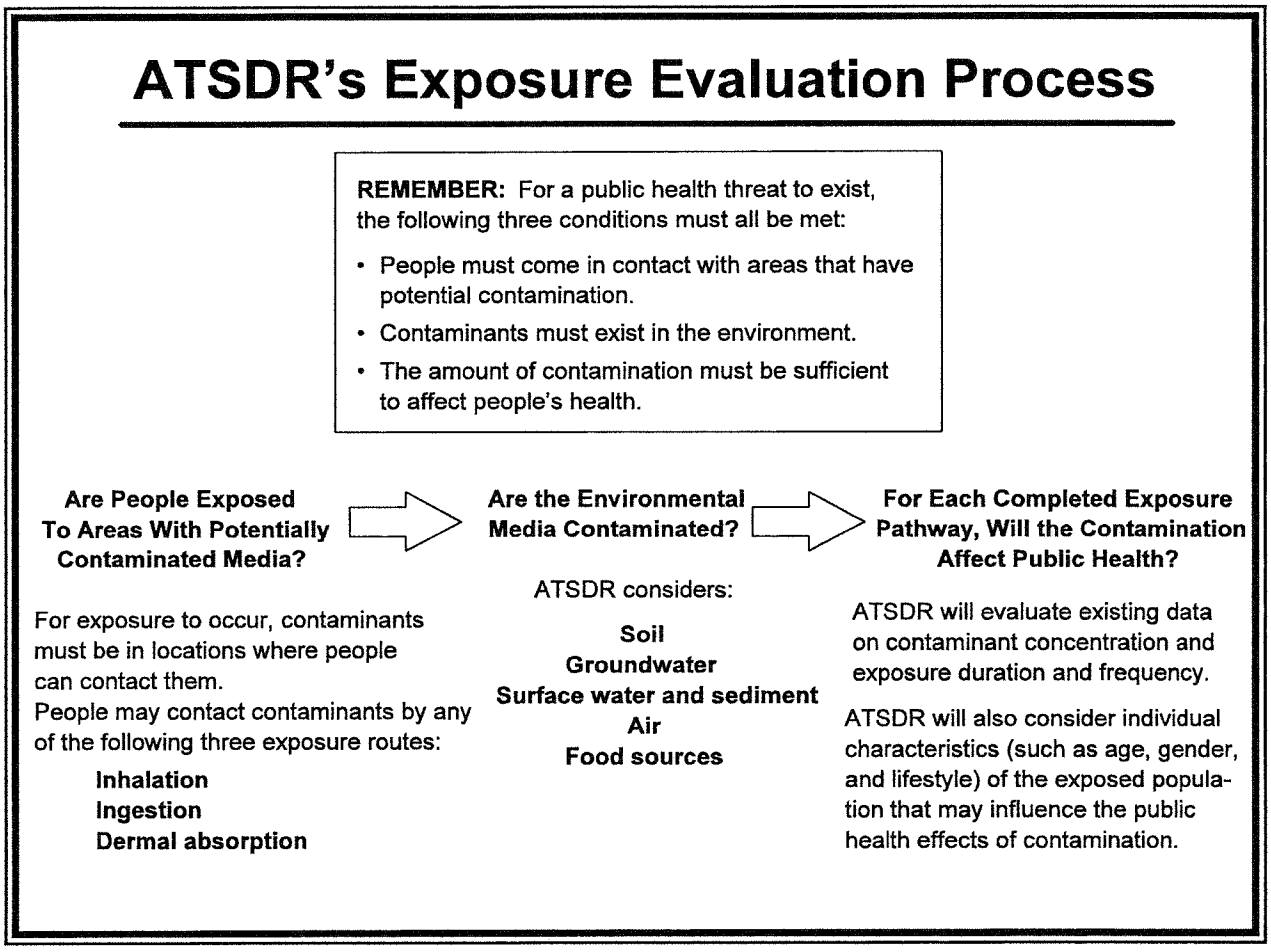
ATSDR also collected groundwater and private well water samples. Sampling and laboratory analysis of these samples were completed using acceptable methods, and data validation was performed using appropriate analytical criteria. The adequacy and number of replicate and blank samples were checked to verify detection of contaminants, and information on background concentrations was accounted for in the interpretation of the analysis data. Laboratory quality controls and procedures used to verify instrument reliability were reviewed.

EVALUATION OF ENVIRONMENTAL CONTAMINATION AND POTENTIAL EXPOSURE PATHWAYS

Introduction

In this section, ATSDR discusses the radionuclides and chemical contaminants detected at or near the Middlesex Sampling Plant (MSP) site. Because a release of a radionuclide or chemical into the environment does not always result in human exposure, ATSDR further evaluated how people might come in contact with these materials/contaminants and the potential for these exposures to cause harm to people. ATSDR uses a conservative exposure evaluation process to consider how people might come in contact with, or be exposed to, contaminated media (see Figure 4). Specifically, ATSDR determines whether an exposure could occur through ingestion, dermal (skin) contact, or inhalation of vapors, and considers the likely length (duration) and frequency of the exposure.

Figure 4. ATSDR's Exposure Evaluation Process



If exposure was, or is possible, ATSDR then considers whether radionuclides or chemicals were or are present at levels that might be harmful to people. ATSDR does this by screening the concentrations of chemical contaminants in an environmental medium against health-based

comparison values (CVs). These CVs are concentrations that health scientists have determined are not expected to cause adverse effects, even when assuming very conservative/safe exposure scenarios. Because CVs are not thresholds of toxicity, environmental levels that exceed comparison values would not necessarily produce adverse health effects. If a chemical is found in the environment at levels exceeding its corresponding CV, ATSDR examines potential exposure variables and the toxicology of the contaminant. ATSDR emphasizes that regardless of the level of contamination, *a public health hazard exists only if people come in contact with, or are otherwise exposed to, harmful levels of contaminated media.*

After an initial review of potential health hazards at the MSP site, ATSDR determined that exposure to contaminated soil, groundwater, surface water/sediment, and air (radon and particulates) required further evaluation. ATSDR selected these pathways because of the evidence of contamination and the potential of human contact with the contaminated media. Following the strategy outlined in Figure 4, ATSDR examined whether human exposure to harmful levels of contaminants via these pathways existed in the past, exists now, or could potentially exist in the future. For the soil, groundwater, and surface water/sediment pathways, ATSDR identified radium (measured as radium-226 or radium-228), uranium (measured as total uranium or uranium-238), arsenic, chromium, and lead as the primary contaminants of concern because their concentration exceeded a comparison value in one or more media/pathways.[1] In this PHA, ATSDR focuses its evaluation on the concentrations of and potential exposures to these contaminants of concern.

- ATSDR did not identify any ***current*** *completed exposure pathways* to radionuclides or metals.

- ATSDR did not identify any *potential future exposure pathways.*

- ATSDR did not identify any completed or potential pathways associated with the food chain pathway.

- ATSDR identified *completed **past** exposure pathways* to site-related radionuclides and metals to include:

    - Inhalation of radon (and radioactive dust particulates by workers).
    - Inadvertent ingestion of soil (and associated exposure to gamma radiation).

ATSDR summarizes its evaluation of completed and potential exposure pathways in Table 2 and describes them in more detail in the discussion that follows. For the terminology used in this report, see Appendices B, C, and D; see Appendix B for an explanation of the different types of CVs; see Appendix C for a glossary of terms used in the PHA; see Appendix D for a discussion on radiation and radioactive material.

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[1] Beryllium, cadmium, thorium-230, thorium-232, and lead-210 were also detected in soil, groundwater, or surface water/sediment, but less frequently and at lower concentrations than the selected contaminants of concern. Where pertinent, ATSDR also presents information on environmental concentrations of these metals and radionuclides.

Evaluation of the Soil Exposure Pathway

Nature and Extent of Contamination

On-Site Surface Soil [2]

Radiologic Contamination: Several investigations have been conducted to characterize the extent of radiologic contamination at the MSP site. In 1976, Oak Ridge National Laboratory (ORNL) surveyed the MSP site and surrounding properties for residual alpha and beta-gamma radiation levels, radon and radon progeny concentrations in on-site buildings, external gamma radiation levels, and radium soil concentrations (ORNL, 1978). (Please refer to Appendix D for a description of radiologic parameters and their decay products). Another assessment was conducted in 1980 as part of Phase I and Phase II "vicinity properties" (VP) pile cleanup activities. An additional radiologic survey followed in 1983 to prepare for the construction of the Municipal Middlesex Landfill (MML) interim storage pile. Soil samples collected through these sampling events were analyzed for radium-226, thorium-232, and uranium-238. Since these sampling activities, most of the site has been covered with asphalt and the interim storage piles have been removed.

ATSDR evaluated the soil sampling results, comparing the radium-226, uranium-238, and thorium-232 levels to available National Council on Radiation Protection and Measurements (NCRP) surface soil guidelines (Report #129, 1999). As shown in Table 3, on-site soils (asphalt and underlying soils) were contaminated, primarily with radium-226, uranium-238, and, to a lesser extent, thorium-232. Radium-226 activity levels ranged up to 736 picocuries per gram (pCi/g), which is above the EPA Standard (per 40 CFR 192) of 5 pCi/g in the first 15 centimeters of soil.[3] The maximum concentrations of uranium-238 (up to 961 pCi/g) and thorium-232 (up to 19.3pCi/g) were also elevated. As much as 17,000 cubic yards (yd^3) of asphalt and underlying soil on the MSP site is reportedly contaminated with radionuclides. The highest radionuclide concentrations were found primarily along the east side of the property in the vicinity of the process building and beneath the MML pile (SAIC, 1995).

Non-Radiologic Contamination: In 1991, the New Jersey Department of Environmental Protection (NJDEP) requested the U.S. Department of Energy (DOE) to characterize the nature and extent of non-radiologic constituents in soil and in the interim storage piles. Prior to that time, monitoring was not conducted because DOE did not suspect that the site had processed or released chemicals and/or metals. The on-site soil was analyzed for volatile organic compounds

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[2] ATSDR typically considers the top 3 inches of soil as representing *surface soil*. No soil samples fitting this definition were collected from the MSP site. Because most of the site was covered with asphalt, soil samples collected from the MSP site and referred to as surface soil samples consisted of a mix of asphalt and underlying soil (up to 2 feet below ground surface).

[3] The units for radiologic contamination is expressed in two systems. One system, referred to as the conventional system, expresses units in picocuries per gram. The other system, known as the Systeme International, uses becquerels per kilogram. One becquerel equals 27×10^{-12} curies.

(VOCs), semivolatile organic compounds (SVOCs), metals, pesticides, and polychlorinated biphenyls (PCBs). ATSDR compared the sampling results to available ATSDR CVs or New Jersey residential remediation standards.

The monitoring revealed that certain metals and polycyclic aromatic hydrocarbons (PAHs) were present in the soil. Lead (up to 382 parts per million [ppm]) was found at concentrations above NJDEP's standard local background concentrations. Arsenic was found at concentrations below NJDEP standards but above ATSDR's CV of 500 ppb (up to 5,430 parts per billion [ppb]). (Also, sampling detected beryllium [up to 1.7 ppm], cadmium [up to 3.1 ppm] at levels above NJDEP standards). Seven individual PAHs thought to have carcinogenic potential, including benzo(a)pyrene (45 ppm), chrysene (51 ppm), and dibenzo(a,h)anthracene (15 ppm), were present in the soil at concentrations greater than their respective ATSDR CV and/or proposed New Jersey soil remediation standards (SAIC, 1995).

Concentrations of other analytes, including VOCs, pesticides, and PCBs, were well below NJDEP residential soil remediation standards—values similar to ATSDR CVs. Seven SVOCs exceeded ATSDR CVs. The SVOCs, all polycyclic aromatic hydrocarbons (PAHs), were found within the top 2 feet of soil on the eastern edge of the two interim storage piles near Wood Street.

MML Pile (Soil)

As noted, about 15,600 yd^3 of radiologic contaminated soil from the MSP site was sent to the MML in 1948. The contaminated soil was eventually returned to the MSP in 1984. Material in the MML pile was analyzed in 1991 at the request of the NJDEP to determine the nature and amount of radiologic and chemical contamination. Based on this evaluation, the MML pile was determined to be co-mingled waste, containing both radioactive material and chemical constituents (SAIC, 1995). The radionuclides radium-226 and thorium-232, and uranium-238 were detected in the pile material, with maximum concentrations exceeding EPA standards (see Table 5). As Table 6 indicates, several metals and PAHs were detected. The maximum concentration of arsenic, cadmium, and lead exceeded ATSDR CVs; chromium was not detected and beryllium was found at levels below its CV. Seven individual PAHs thought to have carcinogenic potential, including benzo(a)pyrene (62 ppm), chrysene (60 ppm), and dibenzo(a,h)anthracene (33 ppm), were present in the soil at concentrations greater than their respective ATSDR CV and/or proposed New Jersey soil remediation standards (SAIC, 1995).

VP Pile (Soil)

The VP pile contained approximately 35,300 yd^3 of contaminated soil that was removed in 1980-1981 from four of the most heavily contaminated off-site properties, including a private home on Williams Street, portions of the playground of the Church of Our Lady of Mount Virgin, the church rectory, and 29 other lesser contaminated properties. The pile has since been removed from the MSP site. Table 7 lists the metals and PAHs detected in the VP pile soil. As noted, the maximum concentrations of arsenic, lead, and six individual PAHs exceeded ATSDR CVs and the proposed New Jersey soil remediation standards (SAIC, 1995).

Off-Site Soil

Radiologic Contamination: A previous owner of a house on Williams Street had notified DOE that he had taken soil from the MSP site to use as fill in the yard in 1948. It is strongly suspected that the same is true for the rectory at the Church of Our Lady of Mount Virgin, located at the corner of Harris and Drake Street in Middlesex Borough. Church records indicate that a rectory was approved for the property in 1947, but the church records lack information on when the rectory was built or if and where the dirt had been placed on the property before construction of the rectory. In 1978, ORNL conducted a one-time sampling of surface (and subsurface) soil for radium-226, and in some cases, for uranium-238, thorium-230, and lead-210 activity levels at the Williams Street locations, the church rectory, and a playground across from church.

ORNL also surveyed portions of Blocks 318 and 319 in Middlesex Borough because of concern about wind and water transport of contaminated materials from the MSP. Block 318 is bounded by Lehigh Valley Railroad to the north; Mountain Avenue, Wood Avenue, and the MSP site to the east; the borough line to the south; and Cedar Avenue to the west. Block 319 is bounded by Wood Avenue, Mountain Avenue, Williams Street, and the MSP site.

No other sampling are available to characterize the non-radiological contamination in off-site soil prior to its removal. The one-time sampling event found levels of uranium and radium above screening levels, and the results are summarized in Table 8. Contaminated soil was removed from these locations during 1980–1981 and placed in the interim storage known as the VP pile at the MSP site.

At high enough levels, radionuclides in the soil can emit *detectable external gamma radiation* (see box). Persons in close contact with contaminated soil might therefore be additionally exposed to radiation released as gamma radiation. ORNL measured radiologic activity as external gamma radiation 1 meter above ground surface at the off-site locations. The results of the monitoring are presented in Table 9. As the table indicates, gamma radiation levels exceeded EPA/DOE standard levels at several of the surveyed properties. The highest levels were found at the Williams Street property and the church rectory. At the Williams Street property, external gamma radiation levels in the house ranged up to 17 microroentgen per hour (μR/hour), or about twice the natural background concentrations, while levels in the front yard ranged from 50 to 300 μR/hour, which is as much as 40 times greater than background. Elevated levels of external gamma radiation were measured inside the rectory (up to 44 μR/hour) and its surrounding property (up to 220 μR/hour). According to the environmental analysis report completed in 1979, the radiological survey measurements do not indicate that homes on these properties are contaminated with radioactivity, but rather that contamination exists near the surface of these properties (ORNL, 1978).

What is external gamma radiation?

Gamma radiation, or gamma rays, result from the release of excess energy from an unstable atom. *External* gamma radiation suggests a source outside the body. Gamma rays consist of moving energy and have no mass or charge. They can travel long distances and move through the air, body tissue, or other materials. A gamma ray can pass through the body without hitting anything inside of it, or it can hit atoms in its path and cause them to ionize. Gamma rays are the primary type of radiation that can harm people when they are exposed to it externally. (See Appendix D for more details.)

Evaluation of Potential Public Health Hazards

On-Site Soil

Past Exposure: Radium, uranium, other radionuclides, and metals were detected in the surface (and subsurface soils) at the MSP site. Workers from 1943 to 1967 and Marines in training at the site from 1969 to 1979 could have come in contact with harmful levels of contaminated soil during their routine responsibilities. *Adequate information on the frequency, duration, and magnitude of potential exposures is not available to allow an evaluation of this exposure.* Frequent public exposure (non-worker) to the on-site soil contamination in the past was highly unlikely due to access restrictions at the site. Specifically, the 7-foot chain-link fence that surrounds the MSP site limits unauthorized access to the site. Furthermore, signs stating "No Unauthorized Access" are prominently displayed at the entrance gates to ensure continued limited access. Although there was (and still is) a noticeable gap between the gates at the Wood Avenue entrance, any exposure to soil contaminants by trespassers in the past was probably infrequent and brief and not of health concern.

Current and Future Exposures: Today, little, if any, chance of exposure to contaminated soil exists because most of the contaminated surface soil was removed from the site, and the site is largely covered with asphalt. Currently inaccessible contaminated subsurface soil could be exposed during future excavation or construction. No harmful exposures are expected in the future as long as the site is secured from trespassing, and construction or remediation workers are adequately protected during future site activities.

Off-Site Soil

Elevated levels of radiologic material (radium, uranium, and other radionuclides), metals (i.e., arsenic, lead, and uranium [as a metal]), and PAHs were detected or suspected to be present in the past in the surface soil at three off-site locations: 1) a private residence on Williams Street; 2) the playground; and 3) the MML site. The contaminated soil was removed in 1980–1981, therefore *no exposures to contaminated soil at off-site locations are occurring now or are expected to occur in the future.*

Past Exposure: To determine whether harmful exposures to contaminants in off-site soil could have occurred in the *past*, ATSDR estimated exposures doses for radionuclides, metals, and PAHs using hypothetical exposure scenarios at these locations. ATSDR assumed that incidental ingestion was the primary route of exposure in the past. Deriving exposure doses requires evaluating contaminant concentrations to which people might have been exposed and how often and how long exposure to those contaminants occurred. However, ATSDR lacks complete information about exposures at these locations. For example, ATSDR does not know how much, if any, radionuclide surface contamination was washed or blown away prior to sampling in 1978. In the absence of sufficient historical sampling data prior to removal, ATSDR assumed that an individual incidentally ingested soil containing the highest concentrations of radionuclides, metals, and PAHs detected in the waste piles (worst-case scenario).

For the Williams Street address and the playground, ATSDR evaluated exposure of three different age groups because of difference in behavior patterns by age: a pica child (age 1-6 years), a non-pica child (age 1-6 years), an older child (age 10 years), and an adult. Pica behavior refers to the

repeated ingestion of non-nutritive items such as soil. Young children tend to exhibit pica behavior because of their frequent hand-to-mouth activity that occurs during play. ATSDR assumed that pica and non-pica children came in contact with contaminated soil at the Williams Street residence, even though it is not certain whether any children lived or played at this property before the contaminated soil was removed. ATSDR also evaluated hypothetical exposures via landfill worker and trespasser exposure (a non-pica child) at the MML site.

ATSDR then compared the estimated doses to health-based guidelines to determine whether exposure could pose harmful effects. When evaluating exposure to lead in soil, ATSDR estimated blood lead levels because ATSDR's health guideline for lead is based on blood lead levels rather than on an exposure doses.

Based on ATSDR's assessment of hypothetical exposures at off-site locations, *exposures to the maximum concentrations of PAHs resulted in exposure doses below health-based guidelines* and are, therefore, not of public health concern. Certain estimated exposures to metals resulted in doses greater than health guidelines. For example, exposure based on the hypothetical exposure of a trespasser to arsenic at the MML site and for exposures of children and adults to uranium (as a metal) at the Williams Street property and at the playground (based on estimated maximum concentrations) resulted in exposure doses greater than their minimal risk level or reference dose. Other exposures of children and adults at the Williams Street property/playground and for the trespasser at the MML site were all below health-based guidelines. Exposure doses to PAHs and metals for the landfill workers were above health-based guidelines.

When evaluating exposures to radionuclides in off-site soil, ATSDR found that the estimated doses would not exceed any health guidelines as a result of exposures at the playground and at the MML site and when assuming exposure at the Williams Street property resulted from incidental ingestion of the average concentrations of radionuclides in soil.

Based on this evaluation, ATSDR finds that routine exposure in the *past* to the highest levels of radionuclides in soil (and external gamma radiation) and certain metals at the Williams Street property, and the highest levels of certain metals and PAHs at the MML site, could have potentially caused harmful effects to individuals.

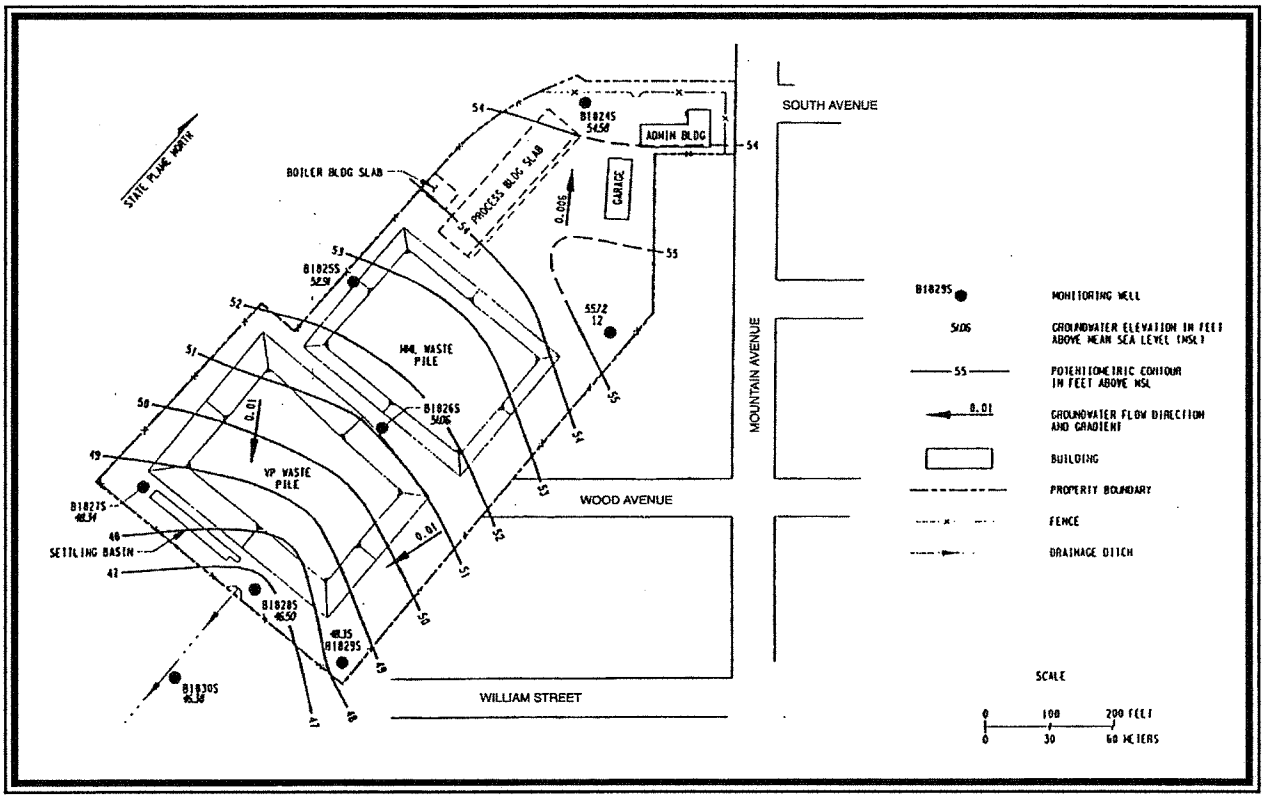
Current and Future Exposures: No off-site exposures to site-related radionuclides or metals in surface soil are occurring now, nor are they expected to occur in the future because the contaminated soil was removed from off-site locations in 1980–1981. Currently inaccessible contaminated subsurface soil could be exposed during future excavation or construction. No future public health hazards are expected as long as the site is secured from trespassing and construction or remediation workers are adequately protected during future site activities.

Evaluation of the Groundwater Exposure Pathway

Hydrogeology and Groundwater Use

The Passaic Formation is a major aquifer in the western part of Middlesex County and adjoining Essex County. The portion of the aquifer, or groundwater system, beneath the MSP site was originally described as a "single aquifer composed of unconsolidated material (both sediment and weathered bedrock) and fractured bedrock." More recent interpretations suggest that the aquifer in the area of the MSP site consists of a leaky, multiunit (seven units, including two weathered bedrock units) aquifer system that allows groundwater to move through fractures in two weathered bedrock units to the underlying deeper (unweathered) bedrock (SAIC, 1997). The presumed existence of this multiunit system suggests that the water table fluctuates within the two weathered bedrock units, coming in contact with contaminated fill and sediment associated with the on-site process building sump (SAIC, 1997). As the shallow aquifer moves through the site, it very likely comes in contact with contaminated subsurface fill materials. As of 1997, groundwater was present between approximately 2 feet and 8 feet below ground surface (BNI, 1998). Groundwater in the upper part of the aquifer might discharge to an adjacent water stream that is south of the site. As indicated by a groundwater divide, groundwater flows both north and south from the sump near the process building (see Figure 5) (SAIC, 1997). Water flowing northward from the sump trends toward a northwesterly direction, and water flowing southward generally trends southwestwardly, except under conditions of low groundwater elevations, when the groundwater shifts to a more southeasterly direction (BNI, 1998).

Figure 5. Groundwater Flow Beneath the MSP Site



SAIC 1997

The groundwater beneath the MSP site is part of an aquifer used for domestic, municipal, and industrial water supplies in Middlesex County and surrounding counties. As of 1992, approximately 140 private water-supply wells existed within 1 mile of the MSP, and most of these wells draw from the deeper aquifer. Also, 19 municipal wells were located within a 4-mile radius of the site. The nearest public well field to the site, the Elizabethtown Water Company's Sebring's Mills well field, is located approximately 1.25 miles northwest and upgradient of the site. This well field, however, has not operated since 1978 (SAIC, 1995).

Nature and Extent of Contamination

Summary of Groundwater Monitoring Activity

Since the early 1980s, groundwater beneath the MSP site and in its immediate vicinity has been monitored to characterize the nature and extent of environmental contamination. In 1980–1981, DOE installed 20 groundwater monitoring wells, 18 on-site wells and 2 downgradient off-site wells. These wells were originally used to support geotechnical evaluations, but some wells were also sampled sporadically to characterize contamination beneath the site and to track contaminant movement. Starting in 1982, DOE established a standardized groundwater surveillance program. Between 1982 and 1993, DOE sampled 19 of the 20 wells (17 on site and 2 off site) quarterly for radium-226 and total uranium. In 1985, DOE also started sampling 12 monitoring wells in the network for New Jersey priority pollutants (VOCs and SVOCs); in 1990, DOE added metals and thorium-232 to the analyses. After achieving consistent results over several years from the 19 wells in the monitoring network, DOE reduced its sampling to seven wells on an annual basis (SAIC, 1995).

In 1994, DOE abandoned the existing wells (except one) and upgraded the groundwater monitoring well network to meet more stringent standards by adding seven new shallow (upper bedrock) wells near on-site waste areas (six on-site wells, B18W24S to B18W29S, and one immediately downgradient off-site well, B18W30S). All of the new wells were screened between 11 and 15 feet. Since 1994, the water samples collected annually from these wells have been analyzed for radium-226, radium-228, thorium-230, thorium-232, total uranium, VOCs, SVOCs, and metals.

Independent of the DOE sampling, ATSDR sampled a subset of the private and monitoring wells in February and April 2000. In February 2000, ATSDR sampled two on-site wells, one off-site well, and 14 nearby private wells. ATSDR resampled three of the private wells in April 2000, along with three additional private wells and all of the MSP monitoring wells. Samples were analyzed for radium-226, radium-228, uranium-238, arsenic, chromium (total and hexavalent), lead, and manganese, and selected samples were analyzed for uranium-234 and uranium-235. ATSDR focused its evaluation of groundwater on the five contaminants of concern: radium, uranium, arsenic, chromium, and lead. The results from these sampling programs/events are discussed below.

On-Site Groundwater

Radiologic Contamination: ATSDR reviewed the monitoring data for radionuclides in on-site groundwater (see Table 10) and compared the detected concentrations to EPA maximum contaminant level (MCL) and/or DOE drinking water criteria. Of the radiologic contaminants measured, total uranium has been detected most frequently at concentrations above EPA's MCL of 30 µg/L (micrograms per liter). All the data for total uranium, reviewed by ATSDR, was reported in the units pCi/L (picocurie per liter). EPA's MCL for total uranium is roughly equivalent to 20 pCi/L.

Between 1982 and 1993, elevated total uranium levels were consistently detected in one well located between the northern edge of the MML and the process building sump (maximum annual average of 143 pCi/L) and fairly consistently measured in another well, located near the southeastern edge of the MSP site (maximum annual average of 192 pCi/L).[4] Total uranium concentrations in these wells increased until the mid-to-late 1980s, when they started decreasing but never falling below uranium's CV. Other radiologic constituents were detected infrequently, and generally in low concentrations. With the exception of sporadic detections of radium-226 and thorium-232, most levels in groundwater were well below screening levels.

Since 1994 (when the new well monitoring system was installed), elevated levels of total uranium have again been detected in the northern portion of the site, where total uranium levels in one well (B18W24S) reached 275.68 pCi/L in 1997, declined to 206 pCi/l in 1998, and then rose to 391 pCi/l in 2000. In another well (B18W25S) located on the northwest perimeter, total uranium concentrations increased from 16.15 pCi/L in 1997 to 178 pCi/L in 1999, but had dropped to 53 pCi/L during the April 2000 sampling event (BNI, 1997, 1998, 1999a, 1999b; ATSDR, 2000a, 2000b).

Non-Radiologic Contamination: As shown in Table 11, arsenic, lead, and chromium have been found in on-site groundwater at levels above ATSDR CVs or EPA action levels. Total chromium, possibly used in paint pigments and/or ore assays, has been detected at substantially increasing concentrations in a monitoring well (B18W29S) located along the southern boundary of the site. The February 2000 sampling round found up to 25,700 ppb, concentrations well above ATSDR's CV of 100 ppb. Hexavalent chromium, the most toxic form of chromium to humans, was not detected during the sampling and the chromium (total) concentrations dipped to 1,400 ppb in April 2000. Aluminum, iron, and manganese routinely exceeded their CVs. These metals are common constituents of soils, and their presence is probably not related to an on-site source (SAIC, 1995).

Sampling also found VOCs, including trichloroethylene (TCE), benzene, and methyl-tert-butylether (MTBE) sporadically at levels above ATSDR's CVs along the western-southern boundary of the site. Because of the nature of the VOCs and their sporadic occurrences on site,

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[4] Sampling conducted in 1980 and 1981—before the groundwater surveillance program was standardized—indicates that three wells (of 19 sampled) along the eastern edge of the MSP also contained radium-226 at levels slightly above the combined MCL for radium-226 and radium-228.

they have not been linked to a specific on-site source. They might have migrated from soil containing gasoline, lubricating fluids, or petroleum-based constituents, such as those found at nearby upgradient industrial facilities.

Off-Site Groundwater

Off-Site Groundwater Monitoring Wells

Between 1982 and 1993, DOE monitored two downgradient off-site groundwater monitoring wells (14 and 15) on a quarterly basis. Since updating the monitoring network in 1994, DOE reduced their monitoring to one off-site well located approximately 150 feet downgradient from the site and near the drainage ditch (B18W30S) on an annual basis. Off-site samples have been analyzed for the same parameters as the on-site samples.

As Table 12 indicates, only very low levels of radionuclides were detected in off-site monitoring wells between 1982 and 1993. Elevated levels of radionuclides beyond site boundaries first became apparent in 1996, when 144 pCi/L of total uranium was measured in the monitoring well (B18W30S) located just south of the site. The elevated concentration of total uranium was possibly attributed to dissolved uranium moving through the shallow groundwater from the nearby drainage ditch. DOE removed the contaminated sediments from the drainage ditch between August and September 1996. The total uranium concentrations in the monitoring well water decreased in the next sampling round to 19.7 pCi/L, and was most recently detected at levels below 10 pCi/l in April 2000 (BNI 1997a; ATSDR, 2000a, 2000b).

Off-site concentrations of arsenic, chromium, and lead, in the MSP monitoring wells have varied over the years. Although metals have been detected sporadically at concentrations above ATSDR CVs and/or EPA MCLs (see Table 13), the levels are much lower than on-site concentrations.

Private Wells

After detecting high concentrations of total uranium in the off-site monitoring well in 1996, DOE began monitoring two private drinking water wells (one shallow well and one deep well) located on a private residential property immediately south and downgradient of the MSP site, and near the monitoring well. DOE analyzed the samples for the same parameters as the on-site samples. Also, in response to nearby residents' concerns about their private well water, ATSDR sponsored sampling of private wells within an approximate 1 to 1.25-mile radius of the MSP site. In February 2000, ATSDR sampled 14 private wells, and in April 2000, ATSDR sampled three additional wells and resampled three of the previously sampled wells. At each private well sampling location, two samples were collected: one sample from the kitchen cold water tap (immediately after turning on the faucet) and the other sample from the tap closest to the well head (after the well had been purged for 15 minutes). ATSDR analyzed the unfiltered samples for a subset of analytes, including arsenic, total chromium, hexavalent chromium, lead, manganese, uranium, gamma spectroscopy, radium-226, and radium-228, and uranium (uranium-238, uranium-234, and uranium-235).

Private well monitoring results for radionuclides are presented in Table 12. As shown in the table, radiologic constituents were detected in private well water, but at levels below comparison values.

During ATSDR's February 2000 sampling, radium was detected in water drawn from the kitchen tap at one residence at a concentration of 2 pCi/L, but still below EPA's MCL of 5 pCi/L for radium-226 and radium-228 combined. Follow-up sampling in April 2000, indicated lower levels of radium-226 (less than or equal to 0.2 pCi/L) were present in this well and in all other tested private wells (ATSDR 2000a, 2000b). Uranium (total) concentrations were less than the EPA MCL of 30 pCi/l.

Arsenic was detected at concentrations of 3.9 ppb and 8.1 ppb in water drawn from the kitchen taps of two residences. (Arsenic was also detected at concentrations up to 2.5 ppb in the flush samples taken from taps located near the well heads of these two residences and at a third residence.) These arsenic concentrations are less than EPA's current MCL of 50 ppb. Chromium and lead were also detected in the kitchen tap samples, but at concentrations below their respective ATSDR's CV and EPA's action level.[5] Estimated concentrations of uranium (as a metal) in private well water were below EPA's MCL of 20 ppb.

Evaluation of Potential Public Health Hazards

On-Site Groundwater

Past, Current, and Future Exposures: Groundwater beneath the site is contaminated with radium, uranium, metals (e.g., arsenic, chromium, and lead) and VOCs (e.g., benzene, MTBE). The date the site was connected to the municipal water system is unknown. Prior to that, it is not known whether the paint manufacturer or MSP relied on private wells for drinking water. If at one time these facilities obtained their drinking water from on-site private wells that drew from groundwater, former employees might have been exposed to contaminants when they drank water or otherwise used the water for washing.

No exposures to contaminated groundwater immediately beneath the site are occurring or are expected to occur in the future. The site obtains its drinking water from the municipal water supplier; no on-site private wells currently draw water from the contaminated groundwater; and there are no plans to use this groundwater in the future.

Off-Site Groundwater

Past, Current, and Future Exposures: Many people in the area of the MSP site obtain their drinking water from the Elizabeth Water Company, which relies on groundwater sources. Drinking water supplied by the Elizabethtown Water Company has met and continues to meet drinking water standards. The Elizabethtown Water Company, as with any large municipal water supplier, is required under EPA's Safe Drinking Water Act and state and local regulations to regularly test the public water supply and maintain safe water.

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[5] Lead was detected at 16 ppb—and just slightly above EPA's action level of 15 ppb—in a flush sample taken from a tap near the well head. No lead was reported in the sample collected from this residence's kitchen tap. This indicates that the lead in the sample is leaching from the pipes in the house, not from the groundwater.

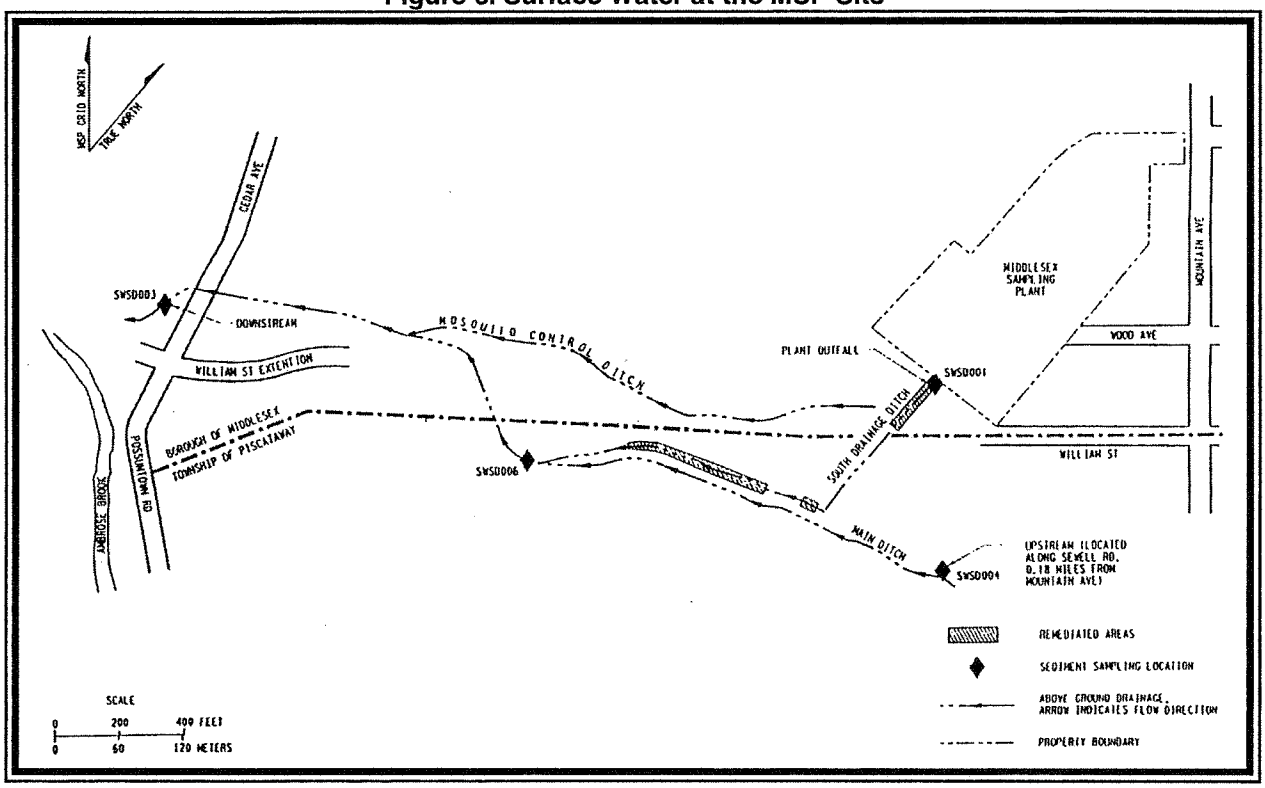
Several residents who live near the MSP site obtain their drinking water from private wells. Monitoring revealed that water from all of these wells contained radium-226 and uranium, but at levels *below EPA's drinking water standards.* The origin of the radium and uranium is unknown and could possibly be related to naturally occurring sources. Arsenic was also detected in well water from two kitchen taps at levels above ATSDR's comparison value (0.02 ppb) but below EPA's current MCL of 50 ppb. Because ATSDR's CVs are screening tools, and the value for arsenic is based on very conservative assumptions about prolonged exposure, exposure to arsenic in well water at concentrations below the comparison values would not be expected to result in harmful health effects. To evaluate whether arsenic at levels measured in the private wells is associated with any unhealthy effects, ATSDR derived exposure doses using conservative assumptions on how often people drink water and how much they drink. Because some uncertainty exists regarding how long arsenic has been in the well—no sampling data prior to February 2000—ATSDR conservatively assumed that an adult consumed well water for 30 years and a child for 6 years. These conservative estimates allow ATSDR to safely evaluate the likelihood, if any, that arsenic in the private well water could cause harm.

ATSDR's review of the toxicologic literature for arsenic suggests that the levels in the private well water are generally much lower than arsenic levels shown to cause cancer or other adverse health effects in humans exposed to arsenic in their drinking water.

Evaluation of Surface Waters/Sediment Exposure Pathway

Surface water runoff and any sediment leave the MSP site through a small drainage ditch located near the middle of the southern boundary of the site (see Figure 6). The drainage ditch extends southward approximately 500 feet, where it turns southwestward and parallels the course of the main ditch for approximately 800 feet before it converges with the Main Stream. The Main Stream empties into Ambrose Brook, which then empties into Green Brook just before joining the Raritan River. After detecting radionuclides in sediment exceeding DOE criteria (surface soil cleanup), DOE excavated approximately 150 feet of the ditch south of the outfall and installed an activated carbon groundwater filter at the outfall in 1996. DOE also removed smaller, isolated areas of contamination located between the bend in the ditch and the main ditch (BNI, 1998).

Figure 6. Surface Water at the MSP Site



BNI 1998

Nature and Extent of Contamination

Summary of Surface Water/Sediment Monitoring Activity

Between 1980 and 1993, surface water and sediment samples were routinely collected from the south drainage ditch and analyzed for radium-226, and selected samples were analyzed for metals, total uranium, radium-228, thorium-230, and thorium-232. Sampling resumed in 1996 to evaluate the performance of the activated carbon groundwater treatment system at the outfall. Samples were generally taken at the outfall, near the confluence of the drainage ditch leaving the site and the main ditch and farther downstream. DOE conducted more extensive sediment sampling several times to better define the extent of radiologic contamination in sediment along the ditch.

Surface Water

Radionuclides have been detected in surface water samples taken from the drainage ditch (see Table 14). The highest concentrations of radium-226 and uranium were measured between 1980 and 1993 at the plant outfall; substantially lower concentrations were measured at all other sampling sites and during later sampling events (BNI, 1997, 1998; SAIC, 1995). Radium and thorium concentrations were generally indistinguishable from upstream or background surface water concentrations. Metals were a common constituent of surface waters, and elevated levels were detected in the Main Stream and in the drainage ditch leading off the MSP site. Between 1990 and 1993, elevated levels of lead were found near the outfall. Even higher concentrations of lead were found in an upstream sample, possibly suggesting other off-site sources of lead. Much lower concentrations of arsenic and lead were detected in 1996 and 1997 (ATSDR, 2000b).

Sediment

Sediment monitoring results are presented in Table 15. Elevated levels of radium-226 were measured in all downstream sediment samples. The radium-226 contamination appeared to be confined to the top 0.5 feet of ditch sediment. Contaminated sediment above background levels was detected as far as 175 feet downstream from the MSP site. In general, radium-226 and total uranium concentrations decreased with time, but the other radionuclides lacked a discernable pattern. Migration of on-site sediments through surface water drainage does not appear to be the primary source of ditch contamination, rather contaminated soil beneath MSP is most likely the source of contamination in the south drainage ditch. Metals, including arsenic and lead, were not elevated above screening levels (BNI, 1997, 1998; SAIC, 1995).

Evaluation of Potential Public Health Hazards

Past, Current, and Future Exposures: Surface water at the plant outfall and in the Main Stream contained arsenic, lead, and radionuclides. However, it is unlikely that harmful exposure to contaminated surface water or sediment occurred. First, any exposure is minimal because there is no known use of the Main Stream or outfall area for routine recreational purposes, such as swimming or fishing. Second, contaminant concentrations detected in the surface water and sediment are too low to pose a health hazard for sporadic and infrequent exposures, typical of trespassing.

The grassy area on the southern border of the site, around the drainage ditch, has a large population of ticks, and special care should be taken by anyone walking through the area to check for ticks on their scalp or skin.

Evaluation of the Air Exposure Pathway

Past operations at MSP—such as the sampling, storing, and shipping of radioactive ore, and both the construction and removal of the interim storage piles resulted in the release of wind-blown soil particles and radon gas. In the following section, ATSDR discusses available monitoring data and potential health consequences of exposure to particulate matter originating from the site and from radon gas released from site-related soil.

Nature and Extent of Contamination

Radon

On-Site Radon Levels

What is radon ?

Radon is a naturally occurring gas that can be found in fairly large amounts near uranium processing sites. Radon gas is released during the decay of radium, which is a breakdown product of uranium.

Limited sampling suggest that high levels of radon gas were once present at the site. In 1976, ORNL measured radon in on-site buildings using both grab and continuos monitoring techniques (ORNL, 1977). Later, between 1982 and 1993, DOE surveyed buildings and the outdoor environment for radon gas as part of their environmental surveillance program (SAIC, 1995). As Table 16 indicates, radon (up to 29 pCi/L) at levels above EPA's indoor guideline of 4 pCi/L were detected in on-site buildings. Monitoring found the highest levels in the lower level of the process building in 1977. Lower levels, but still above EPA's guideline, were found in 1982–1993. Uranium- and radium-contaminated soil beneath and adjacent to the building was the suspected source of radon. Outdoor concentrations of radon at the site from 1982 to 1993 reached 5 pCi/L—with the highest detected levels just slightly exceeding the DOE outdoor guideline of 3 pCi/L. The highest outdoor concentrations of radon-222 were detected near the external wall of the process building, and much lower concentrations were found along the site perimeter. In 1996, DOE demolished the process building. Radon monitoring resumed in 1996 and 1997, and as expected, lower levels (up to 1.6 pCi/L) below EPA and DOE guidelines were found at on-site sampling locations (four perimeter locations of the site, an on-site location, and in the administration building) (BNI, 1998; SAIC, 1995).

Off-Site Radon Levels

In June 1978, ORNL surveyed radiologic parameters at the rectory of the Church of Our Lady of Mount Virgin (ORNL, 1978). Radon monitoring was not conducted at the Williams Street residence or at other off-site locations. Continuous measurement of radon-222 activity levels were made for 10 days in the basement and for 3 days in a street-level bedroom of the four-level structure. Radon concentrations in the rectory basement reached 92 pCi/L, well above EPA's action level for radon-222 of 4 pCi/L, and levels in the bedroom reached 2.5 pCi/L. Radon had apparently entered the rectory through a sump in the concrete floor in the basement (ORNL, 1978).[6] The suspected source of radon, the contaminated fill, was removed in 1980–1981.

[6] The short-term radon measurements might not be representative of radon concentrations in the air inside the rectory over a period of a year. In particular, the first level of the rectory was very well ventilated during the summer months, when sampling occurred. Therefore, the measured radon concentrations on that street level might be higher during colder months, when ventilation in the rectory is not as good (ORNL, 1978).

Particulate Emissions

On-Site Particulate Emissions

As previously noted, historical operations at MSP— such as the sampling, storing, and shipping of radioactive ore, and the construction and removal of the two interim storage piles— resulted in wind-blown dust and emissions of radioactive particles, organic compounds and metals. In 1996 and 1997, DOE estimated potential emissions from multiple sources, including wind erosion, excavation of soil from the streambed and plant outfall, transfer of soil for off-site disposal, and demolition of two on-site buildings. (The airborne particulate release rates were estimated using historical site soil contaminant concentrations, but it is not known if the average or maximum values were considered.) The model results suggest that an individual living 240 feet (80 meters) east of the site would have incurred a maximum whole body dose of 0.04 mrem/yr in 1996 and 0.00096 mrem/yr in 1997, doses that are well below the EPA and DOE standard of 10 mrem/yr for airborne particulates containing radionuclides (BNI, 1998).

Evaluation of Potential Public Health Hazards

On-Site

Past Exposure: Workers at the site, particularly those who worked in the process building, were exposed to radon gas and airborne particulates during their workday. As with worker exposure to on-site soil, the full extent of exposure to airborne particulates during former operations remains uncertain due to limited sampling data and information about actual exposure.

Current and Future Exposures: No harmful exposures are occurring, nor are they expected to occur in the future. Recent monitoring of radon and particulate levels have not detected concentrations that would pose a public health hazard at the perimeter of the MSP site.

Off-Site

Past Exposure: Anyone living at the rectory at the Church of Our Lady of Mount Virgin was likely exposed to radon gas that had entered the rectory from the surrounding soil. (Although radon monitoring is not available for the Williams Street residence, ATSDR assumes that the same is true of that location.) Monitoring during June 1978 revealed radon (up to 92 pCi/L) inside the rectory at levels above EPA's guideline of 4 pCi/l. The highest levels were found in an office in the basement. Because the sampling occurred during warm weather months, even higher exposure could have occurred during cold weather months, when the structure was less ventilated. Most residents did not reside at the rectory for a very long time. With the exception of one resident who lived at the rectory for 24 years, most of the other 15 residents (since 1944) lived there for 2 years or less, according to information from the Church of Our Lady of Mount Virgin. ATSDR reviewed the toxicologic literature on radon to further assess whether the levels might have posed a public health hazard to former residents of the church rectory.

Based on our review of the toxicologic literature, people exposed to elevated levels of radon could be at risk of developing lung cancer. Smoking history is one of the major risk factors that influence the development of lung cancer from exposure to radon gas. If residents of the rectory

(or at the Williams Street residence) smoked and were exposed to very high levels of radon and progeny, they could be at an elevated risk of developing lung cancer.

The risk to a smoker from radon and progeny is considerably greater than that to a non-smoker, but the risk to the non-smoker at high exposure levels is not zero. Smoking potentiates the risk of radon induced lung cancer. The risk of radon induced lung cancer is small and typically has a long latency period, and is dose dependant.

Current and Future Exposure: No harmful exposures are occurring, nor are they expected to occur in the future. The suspected source of radon—the contaminated soil—was removed in 1980–1981.

Evaluation of the Biota Food Chain Pathway

The MSP site is surrounded by residential areas, light industrial/business areas, and park areas. Biota are considered a potential human exposure pathway because site-related contaminants can be taken up from water, sediment, and food by aquatic organisms and by terrestrial animals through the food chain or ingestion of sediment and soil. For example, some of the heavy metals and radionuclides that have been detected in the sediment, groundwater, and surface water can accumulate and concentrate in aquatic biota (e.g., fish and mussel). The Raritan River has several species of edible fish, including trout, bass, shad, and pike. During the investigation, ATSDR learned that the trout in the Raritan are raised in fish farms and stocked by New Jersey and would not pose a public health hazard. Sampling of the other edible fish species would be necessary to completely eliminate this pathway from further consideration. However, ATSDR does not consider this a significant pathway because of the low concentrations of contaminants that have been detected in the surface water and sediment and because it is unlikely that anyone is subsisting on fish caught in the Raritan River.

The area around the MSP site is not used for farming or ranching. Although there is evidence of deer and smaller game in the vicinity of the MSP, hunting in the area is prohibited.

COMMUNITY HEALTH CONCERNS

As of part the public health assessment process for the Middlesex Sampling Plant (MSP) site, ATSDR has gathered information about health concerns related to the MSP site. In gathering the information, ATSDR met with members of the Middlesex community at a public availability meeting; interviewed local, state, and federal agency representatives who are responsible for addressing community issues; and contacted residents in a 1-mile radius of the MSP site.

Cancer:
Many community members expressed concern about the numbers of people in the area with cancer and wanted to know if it is related to exposure to contaminants from the MSP site. They were concerned about the following specific cancers, either because the respondent, a friend, or a family member had been diagnosed with the cancer or because there was a concern about the number of people in the community with the condition. The number enclosed in parenthesis indicates the number of persons expressing the concern.

- Breast Cancer (9)
- Testicular Cancer (6)
- Prostate Cancer (4)
- Brain Cancer (2)
- Colon Cancer (2)
- Leukemia (1)
- Ovarian Cancer (2)
- Acinic Cell Carcinoma Cancer (parotid gland—large saliva gland) (1)
- Cervical Cancer (1)
- Lung Cancer(1)
- Throat Cancer (1)
- Tongue Cancer (lateral side) (1)
- Canine (dog) died from cancer (1)
- Unspecified Cancer (70)

Other Illnesses:
Residents reported a range of noncarcinogenic conditions that they suspect might be caused by living near the MSP site, working at the MSP site either when it was operating or during the cleanup, or playing on or near the MSP site as children. The number enclosed in parenthesis indicates the number of persons expressing the concern.

- Kidney Failure (5)
- Children with Asthma (12)
- Asthmatic Problems (4)
- Headaches (2)
- Irritable Bowel Syndrome (2)
- Thyroid Nodule (2)
- Chronic Fatigue (1)
- Cold Urticaria (1)
- Difficulty Breathing (1)
- Fractured Ribs (1)

- Hyper-reactive Airway Disease (RADS) (1)
- Hypothyroidism (1)
- Legally Disabled (1)
- Lung Disease (1)
- Lupus (1)
- Nausea (1)
- Respiratory Problems (1)
- Savcadosis (1)
- Sinus Infections (1)
- Stomach Problems (1)
- Thyroid Problems (1)

The contaminants identified at a sufficiently high concentration to be a potential health hazard included lead, arsenic, uranium and radium. Following ingestion and/or inhalation, lead and arsenic have been associated with lung diseases, neurological, reproductive developmental, nausea and kidney failure. Uranium either ingested or inhaled has potentially been associated with kidney damage and kidney failure, and exposure to ingested radium has been linked to specific types of bone cancer and postulated to cause various types of other cancers such as lung cancer. ATSDR, however, was not able to determine if any additive or synergistic effects on humans exist following intakes of one or more of these contaminants. External exposure to gamma radiation from materials such as radium, are known to cause leukemia; however, those exposures are in excess of 10 rem delivered over a short period of time (less than 5 years).

Also, ATSDR determined that the presence of these contaminants in areas outside the boundaries of the Middlesex plant were not at a sufficiently high concentration to cause adverse health effects individually. However, based on our analysis of the on-site data and operational history of the plant, ATSDR believes that workers would be the only population group that might have sufficient exposure to these materials to suffer adverse health effects.

HEALTH OUTCOME DATA REVIEW

The New Jersey Department of Health and Senior Services (NJDHSS) conducted a cancer incidence analysis of populations living near the Middlesex Sampling Plant (MSP), at the request of ATSDR.[7] The request was made because the MSP was recently added to EPA's National Priorities List of Superfund sites and because of excess cancer concerns perceived by local citizens. The strategy for this investigation was to conduct a parallel analysis of a recent NJDHSS study of other Superfund sites across New Jersey with similar contamination.[8] In the MSP evaluation, as in the earlier study of cancer in communities with radiologically contaminated Superfund sites, total cancer incidence and 11 select site-specific cancer groupings were evaluated. The select cancer types analyzed included: bladder, brain, central nervous system, pancreas, lung and pleura, leukemia, non-Hodgkin's lymphoma, liver, bone, kidney, thyroid, and breast. These site-specific cancers were chosen by ATSDR and NJDHSS staff because they represent groupings that might be more sensitive to the effects of radiation.

The study area consisted of four census tracts: the census tract where the MSP facility resided and three surrounding census tracts where off-site contamination occurred. Standardized incidence ratios (SIRs) were calculated for all cancers combined and the 11 site-specific cancers for 2 evaluation time periods. The first evaluation time period, 1979–1991, corresponds to the earlier study conducted by the NJDHSS. The second evaluation time period, 1992–1998, represents the remaining years of available data. The four census tracts were evaluated together and each separately. Expected numbers were calculated using average state incidence rates and U.S. census data to estimate the population.

For the time period 1979–1991, total cancer incidence and the incidence for many site-specific cancer groups for the populations living near the MSP were lower than expected for the entire study area and each census tract. The only SIR significantly elevated was in census tract 1 (Middlesex Borough) for leukemia in males (SIR=1.92; confidence interval =1.02, 3.28). During the later time period (1992–1998), total cancer incidence was higher than in the earlier period, particularly in the two Piscataway census tracts. Leukemia incidence in males from census tract 1 was not elevated (SIR=0.27) from 1992–1998.

Total cancer incidence for the entire study area during the period 1979–1991 was not significantly higher than expected when compared to average state incidence rates. The higher SIRs detected for the period 1992–1998 could be due to the aging of the population and/or population growth. Significant population growth occurred in Piscataway Township's study area as evidenced by the increased number of census tracts designated for that area from 1980–1990. Because there was little agreement in the results across the four census tracts or between time periods, it is not likely that the few elevations detected are related to site contamination. Consequently, no further follow-up of cancer incidence appears warranted for this site at this time.

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[7] Agency for Toxic Substances and Disease Registry. 2001. Public health consultation analysis of cancer incidence near the Middlesex Sampling Plant. Atlanta: U.S. Department of Health and Human Services.

[8] Agency for Toxic Substances and Disease Registry. 1999. Cancer incidence in populations living near radiologically contaminated superfund sites in New Jersey. Atlanta: U.S. Department of Health and Human Services.

ATSDR CHILD HEALTH INITIATIVE

ATSDR recognizes that infants and children might be more sensitive than adults to environmental exposure in communities faced with contamination of their water, soil, air, or food. This sensitivity is a result of the following factors: (1) children are more likely to be exposed to certain media such as soil when they play outdoors; (2) children are shorter and therefore might be more likely to breathe dust, soil, and vapors close to the ground; and (3) children are smaller than adults and therefore might receive a higher dose of chemical exposure relative to their body weight. Children also can sustain permanent damage if exposed to toxic substances during critical growth stages. ATSDR is committed to evaluating children's special interests at sites such as the MSP site as part of its Child Health Initiative.

ATSDR has attempted to identify populations in the vicinity of the MSP site and any completed exposure pathways to these children. Children are not typically present at the MSP site, the site is inactive and access is restricted by a perimeter fence. Like other people living at or near property containing fill from the MSP site, children might have inadvertently ingested contaminated soil, been exposed to gamma radiation, or inhaled or ingested airborne particulates. These exposure pathways are discussed in detail in "Evaluation of Environmental Contamination and Potential Exposure Pathway" section of this PHA.

CONCLUSIONS

Conclusions regarding potential past, current, and future exposures to various environmental media on and in the vicinity of the Middlesex Sampling Plant (MSP) site are based on a thorough evaluation of remedial site investigation data, groundwater and surface-water monitoring data, private well water data, and observations made during site visits. On the basis of its evaluation, ATSDR reached the following conclusions:

- Former workers and former marines in training likely came in contact with contaminated media during their routine responsibilities at the MSP site in the past. Adequate information is not available to fully evaluate past exposure of the workers or marines to site radionuclides or other contaminants.

- ATSDR has determined that *no public health hazard* is associated with:

  - Current and future uses of the site. Today, no exposure is occurring because the site is inactive; most of the contaminated soil has been removed; little exposed soil remains at the site; and only low levels of radon have been detected. No harmful future exposures are expected as long as the site is secured and workers are adequately protected during any future remediation activities.

  - Surface-water/sediment pathway. Surface water in the immediate area of the site is not used in ways (i.e., recreational uses) that would encourage long-term or frequent contact with surface water or sediment. Contaminant concentrations detected in the surface water and sediment are too low to pose a health hazard from any potential sporadic and infrequent exposures.

  - Groundwater/drinking water pathway. Although groundwater beneath the site is contaminated, it has never been used for drinking and there are no plans to use the groundwater in the future. Recent monitoring indicates that elevated concentrations of uranium and arsenic have migrated to a downgradient off-site monitoring well. In light of this finding, water from selected, nearby private wells has been tested and found to not have elevated levels of contaminants, and all were below EPA's current drinking water standards.

- ATSDR has determined a *past indeterminate* exposure to radionuclides and metals in soils.

- ATSDR has determined that the grassy area on the southern border of the site, around the drainage ditch, has a large population of ticks that could pose a potential health threat from tick-borne illnesses.

RECOMMENDATIONS

ATSDR recommends the following actions to ensure that people are not exposed to unhealthy levels of contaminants on or near the Middlesex Sampling Plant (MSP) site:

- Available information suggests that subsurface structures/materials from the former paint manufacturing facility are buried beneath the MSP site. In the event that these structures/materials are removed in the future, remedial workers must be adequately protected from possibly harmful levels of contaminants associated with the buried items.

- Until the site is fully remediated and free of potential physical hazards, additional efforts should be made to secure the site (e.g., fix gaps in gates) from unauthorized (trespasser) access.

- No follow-up community study activity(s) are warranted at this time, because:
  1) ATSDR has determined that no public health hazard is associated with current and future uses of the site, and
  2) it is not feasible to identify the select individuals who may have had past off site exposures (i.e., residents of or visitors to the properties that might have received fill, trespassers to the MML pile. However, if additional information becomes available (i.e., list of individuals/addresses that received contaminated fill, years lived at address, usual occupation), the feasibility of a health study will be evaluated.

- Based on ATSDR's conclusions that former workers and former marines in training likely came in contact with contaminated media during their routine responsibilities at the MSP site in the past, a follow-up health study may be warranted for the former workers and marines. If additional information becomes available (i.e., worker list, dates employed, routine responsibilities), the feasibility of a health study will be evaluated.

- Nearby private wells should be regularly monitored for contaminant migration in the future.

- Special care should be taken by anyone walking through the tall grassy area south of the site, to check for ticks on their scalp or skin.

PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) for the Middlesex Sampling Plant (MSP) site contains a description of actions taken and those to be taken by ATSDR, the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency, and the New Jersey Department of Environmental Protection at and in the vicinity of the site after the completion of this PHA. The purpose of the PHAP is to ensure that this PHA not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The public health actions that are completed, being implemented, or planned are as follows:

Completed Actions:

1. DOE and ORNL have conducted several soil monitoring events to characterize the nature and extent of contamination in soil at the site and in the vicinity.

2. DOE removed most structures from the site and covered the site with a layer of asphalt.

3. In 1980–1981, DOE excavated contaminated soil from properties in the vicinity of the MSP site known or suspected to have been affected by MSP contaminants and excavated sediment from the south drainage ditch. DOE stockpiled the excavated material on site in a covered pile known as the "vicinity property" pile. USACE removed the pile in 1999.

4. In 1981, DOE excavated soil and waste from the MSP site (which originated from the MSP site) and stored these materials in a separate covered interim storage pile at MSP known as the Municipal Middlesex Landfill (MML) pile. USACE (DOE) removed this pile from the site in 1998.

5. ATSDR visited the site in July and December 1999 and met with representatives of the USACE, the agency currently responsible for the cleanup of the site. During the December 1999 visit, ATSDR provided information to and addressed questions from community member residents attending a public availability session (coordinated by USACE) held at a local school.

6. In January 2000, ATSDR mailed a fact sheet to each residence within a 1-mile radius of the site. ATSDR received health concerns via mail and phone calls from more than 90 community members with questions or concerns about the MSP site. ATSDR reviewed each concern and question submitted by the public.

7. In February 2000, ATSDR sampled 14 area private wells and 3 groundwater monitoring wells. ATSDR sampled an additional three wells and resampled three previously sample wells in April 2000.

8. In June 2000, ATSDR requested that the NJDHSS conduct a cancer incidence analysis of populations living near the MSP. This analysis was completed and the final report was made available in January 2001.

Ongoing/Planned Actions:

1. The USACE will complete a remedial investigation/feasibility study of the MSP site.

2. ATSDR will hold a public availability meeting in Middlesex Borough to further address community health concerns about the MSP site.

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TABLES

Table 1. Evaluation of Potential Source Areas at Middlesex Sampling Plant

Potential Source Areas	Source Description	Suspected Releases				Current Status
		Soil	Groundwater	Surface Water	Air	
Paint Company/ American Marietta Company	Original owner of the property.	Possible (arsenic, chromium, lead).	Possible (chromium).	Possible.	Unknown.	No longer operating. Property was sold to Manhattan Engineer District in 1943.
Facility Soil	Approximately 11,000 cubic yards of soil is contaminated at the MSP site. An area of 196,523 square feet was contaminated with radiologic material and 128,472 square feet was contaminated with chemical contamination.	Yes. Site soil was inadvertently contaminated primarily with radionuclides and metals over years of site operation.	Yes.	Yes. Contaminants, primarily total uranium have been carried via overland flow.	Yes. Both radon gas and particulate emissions.	Approximately 70% of the site is now covered with asphalt, leaving little exposed soil.
Middlesex Municipal Landfill (MML) Pile	The MML pile, located in the central section of the site, consisted of 31,200 cubic yards of soil contaminated with radioactive material and other hazardous substances. The pile was constructed between 1984 and 1986 with soil removed from the Middlesex Municipal Landfill, which had originally received the soil as fill from the MSP site.	Minimal. The pile was constructed with a geotextile liner and it sat on an asphalt pad to minimize erosion and contaminant transport. The pile also contained a leachate collection system.	Minimal. The pile was constructed with a geotextile liner and it sat on an asphalt pad to minimize erosion and contaminant transport. The pile also contained a leachate collection system.	Minimal. The pile was constructed with a geotextile liner and it sat on an asphalt pad to minimize erosion and contaminant transport. The pile also contained a leachate collection system	No. The pile was covered to reduce emissions.	The MML pile was removed from the MSP site and disposed of at a certified hazardous material landfill in 1998.

Potential Source Areas	Source Description	Suspected Releases				Current Status
		Soil	Groundwater	Surface Water	Air	
Vicinity Property (VP) Pile	The VP pile, located in the southern portion of the MSP site and southwest of the MML Pile, was constructed in 1948. The pile consists of 35,000 cubic yards of soil excavated from contaminated off-site properties and covered approximately 98,000 square feet. The pile was covered and constructed on an asphalt pad.	Minimal. The pile was covered and constructed on an asphalt pad.	Yes.	Yes. Via overland flow.	No. The pile was covered to reduce emissions.	The VP pile was removed from the site in 1999.

Source: DOE, 1997a, 1998.

Table 2. Exposure Pathways Evaluation Table

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	Time Frame of Exposure	
Completed Exposure Pathways							
On-Site Surface Soil	Middlesex Sampling Plant.	Soil - Radium, uranium, and other radionuclides. Also, metals and polycyclic aromatic hydrocarbons (PAHs).	On-site soil.	Ingestion (and external exposure to gamma radiation).	Workers.	Past.[1]	Workers from 1943 to 1955 and marines in training at the site could have come in contact with harmful levels of contaminated soil during their routine responsibilities. Information on the frequency, duration, and magnitude of potential exposures is not available to allow a detailed evaluation of this exposure.
Off-Site Surface Soil	Middlesex Sampling Plant.	Soil - Radium, uranium, and other radionuclides, and associated external gamma radiation. Also, metals and polycyclic aromatic hydrocarbons (PAHs).	Residential yards, a playground and a nearby commercial property.	Ingestion (and external exposure to gamma radiation).	Local-area residents whose yards were contaminated through the transfer of soil or from migration of contamination from MSP and children playing at an area playground.	Past.[1]	In 1948, soil contaminated with elevated levels of radionuclides was transported from the MSP site to nearby residential and private properties for use as fill. Residents of or visitors to the properties might have contacted contaminated soil via incidental ingestion or from external gamma radiation. No exposure is believed to have occurred after 1980–1981 when the contaminated soil was removed.

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	Time Frame of Exposure	
Middlesex Municipal Landfill (MML) Pile	Middlesex Sampling Plant.	Soil - Radium, uranium, and other radionuclides. Also, metals and polycyclic aromatic hydrocarbons (PAHs).	On site.	Ingestion (and external exposure to gamma radiation).	Trespassers.	Past.[1]	Contaminated soil was stock piled in the MML pile. ATSDR has reports that people accessed the site in the past and played on the MML pile. Trespassers to the property might have contacted contaminated soil via incidental ingestion or inhalation of dust. Sufficient information is not available to determine whether exposure occurred at levels of health concern.
On-Site Air (Radon and particulates)	Middlesex Sampling Plant.	Soil - Radium and uranium (and other radionuclides).	On site.	Inhalation.	Workers.	Past.[1]	Workers from 1943 to 1955 and marines in training at the site could have come in contact with harmful levels of radon or particulates of contaminated soil during their routine responsibilities. Information on the frequency, duration, and magnitude of potential exposures is not available to allow a detailed evaluation of this exposure.

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	Time Frame of Exposure	
Off-Site Air (Radon)	Middlesex Sampling Plant.	Indoor.	The Rectory of the Church of Our Lady of Mount Virgin. (Also, likely exposure to occupants of a home on Williams St. but data are not available.)	Inhalation.	Residents of the rectory at the Church of Our Lady of Mount Virgin.	Past.[1]	In 1948, soil contaminated with elevated levels of radium and uranium was transported from the MSP site to nearby residential and private properties for use as fill. Radon released from the contaminated soil entered the rectory. Residents of the rectory were exposed to elevated levels of radon gas. Reduced exposure, if any, are believed to have occurred after 1981, when the contaminated soil was removed.
On-Site Groundwater	Middlesex Sampling Plant.	Groundwater	None	Ingestion	None	None	
Off-Site Groundwater	None	Groundwater	Private Wells	Ingestion	Residents with private wells.	None	No contamination found.

[1] No exposure to harmful levels of contaminants is occurring or is expected to occur because the contaminated media has been removed.

Table 3. Summary of Radionuclide Concentrations in On-Site Surface Cover (asphalt and underlying soils)

Radionuclide	Concentration pCi/g (Bg/kg)		Comparison Value pCi/g (Bq/kg)
	Maximum	Mean	
Radium-226	736 (27,232)	13.2 (844.4)	15 (600)[1]
Thorium-232	19.3 (714.1)	1.7 (62.9)	1.9 (73)[2]
Uranium-238	961 (35,557)	41.7 (1,542.9)	105.4 (3900)[2]

Source: SAIC, 1995.

1 EPA Standard for Uranium Mill Tailings per 40 CFR 192 (1983)
2 Recommended Screening Limits for Contaminated Surface Soil, NCRP Report #129, National Council on Radiation Protection And Measurements 1999. Construction, Commercial and Industrial Scenario

Key: Bq/kg = becquerel per kilogram
pCi/g = picocuries per gram
NCRP = National Council on Radiation Protection and Measurements.

Table 4. Summary of Metal and PAH Concentrations in On-Site Surface Cover (in situ soil)

Metal	Concentration (ppm)		Comparison Value (ppm)		
	Range	Mean	ATSDR Comparison Value		Proposed NJ Soil Remediation Standards
Metals					
Arsenic	not sampled		200	EMEG (adult)	
Beryllium	0.23 – 1.7	0.64	1,000	RMEG (adult)	1
Cadmium	0.65 – 3.1	0.55	100	EMEG (adult)	1
Chromium	not sampled		no value		
Lead	5.8 – 382	52.24	400	EPA SSL	100
Uranium (estimated)	2,953 (maximum)	128	no value		
PAHs					
Benzo(a)anthracene	up to 41	1.6	0.9	EPA SSL	500
Benzo(a)pyrene	up to 45	1.7	0.09	CREG	0.66
Benzo(0b)fluoranthene	up to 64	2.4	9	EPA SSL	0.9
Benzo(k)fluoranthene	up to 36	1.8	9	EPA SSL	0.9
Chrysene	up to 51	2.1	88	EPA SSL	0.9
Dibenzo(a,h)anthracene	up to 15	0.7	0.09	EPA SSL	0.9
Ideno(1,2,3-cd)pyrene	up to 37	1.7	0.9	EPA SSL	0.9

Source: SAIC, 1995.

Key: EMEG = environmental media evaluation guide
EPA SSL = Environmental Protection Agency soil screening level
ppm = parts per million
RMEG = reference media evaluation guide.

Table 5. Summary of Radionuclide Concentrations in the MML Pile

Radionuclide	Concentration pCi/g (Bq/kg)		Comparison Value
	Maximum	Mean	
Radium-226	55.1 (2,038.7)	18.9 (699.3)	15 (600)[1]
Thorium-232	<3.3 (<122.1)	1.9 (70.3)	1.9 (73)[2]
Uranium-238	45.3 (1,676.1)	19.5 (721.5)	105.4 (3900)[2]

Source: SAIC, 1995.

1 EPA Standard for Uranium Mill Tailings per 40 CFR 192 (1983).
2 Recommended Screening Limits for Contaminated Surface Soil, NCRP Report #129, National Council on Radiation Protection And Measurements 1999. Construction, Commercial and Industrial Scenario

Key: Bq/kg = becquerel per kilogram
pCi/g = picocuries per gram
NCRP = National Council on Radiation Protection and Measurements.

Table 6. Summary of Metal and PAH Concentrations in the MML Pile

Metal	Concentration (ppm)		Comparison Value (ppm)		
	Maximum	Mean	ATSDR Comparison Value		Proposed NJ Soil Remediation Standards Surface Soil
Metals					
Arsenic	500	189.5	100 0.5	RMEG (child) CREG	2
Beryllium	2.40	0.78	100	RMEG (child)	1
Chromium	nd	nd	no value		
Cadmium	2,090	90.65	10	C-EMEG (child)	1
Lead	7,500	2,710	400	EPA SSL	100
Uranium (estimated)	139	60			
PAHs					
Benzo(a)anthracene	55	3.1	0.9	EPA SSL	500
Benzo(a)pyrene	62	3.2	0.09	CREG	0.66
Benzo(b)fluoranthene	24	2.6	9	EPA SSL	0.9
Benzo(k)fluoranthene	14	2.4	9	EPA SSL	0.9
Chrysene	60	3.3	88	EPA SSL	0.9
Dibenzo(a,h)anthracene	33	2.7	0.09	EPA SSL	0.9
Ideno(1,2,3-cd)pyrene	23	2.7	0.9	EPA SSL	0.9
TOTAL PAHs*	271	20			
TOTAL PAH TEF EQUIVALENT	**239**	**17.8**			

Source: SAIC, 1995

Key: C-EMEG = chronic environmental media evaluation guide for a child
CREG = cancer risk evaluation guide
ppm = parts per million
RMEG = reference dose media evaluation guide
nd = not detected above NJDEP standard
SSL = EPA soil screening level
TEF = toxic equivalency factor for PAHs

Table 7. Summary of Metal and PAH Concentrations in the VP Pile

Metal	Concentration (ppm)		Comparison Value (ppm)		
	Maximum	Mean	ATSDR Comparison Value		Proposed NJ Soil Remediation Standards Surface Soil
Metals					
Arsenic	74.5	18	100 0.5	RMEG (child) CREG	2
Lead	275	108	400	EPA SSL	100
PAHs					
Benzo(a)anthracene	8.5	1.1	0.9	EPA SSL	500
Benzo(a)pyrene	14	2.3	0.09	CREG	0.66
Benzo(b)fluoranthene	3.5	1.2	9	EPA SSL	0.9
Benzo(k)fluoranthene	4.4	1.2	9	EPA SSL	0.9
Chrysene	8.3	1.8	88	EPA SSL	0.9
Dibenzo(a,h)anthracene	3	0.9	0.09	EPA SSL	0.9
TOTAL PAHs	41.7	8.5			
TOTAL PAH TEF EQUIVALENT	**30.7**	**7.2**			

Source: SAIC, 1995

Key: C-EMEG = chronic environmental media evaluation guide for a child
CREG = cancer risk evaluation guide
ppm = parts per million
RMEG = reference dose media evaluation guide
nd = not detected above NJDEP standard
SSL = EPA soil screening level
TEF = toxic equivalency factor for PAHs

Table 8. Summary of Radionuclide Concentrations in Off-Site Surface Soil

Radionuclide	Maximum Concentration at Off-Site Locations pCi/g (Bq/kg)				NCRP Soil Screening Value[3] pCi/g (Bq/kg)
	Williams Street Residence[1]	Church Rectory	Playground	Other Properties	
Lead-210	ns	ns	ns	1,117 (41,329)	1.5 (59)
Radium- 226	4,800 (177,600)	830 (30,710)	810[2] (29,970)	2,401 (8,837)	0.14 (5.4)
Thorium-230	ns	ns	ns	1,689 (62,493)	0.4 (15)
Uranium-238	5,800 (214,600)	15,000 (555,000)	6.5[2] (240.5)	5,280 (195,360)	56.7 (2,100)

Source: SAIC, 1995.

[1] The geometric means for radium-226 and uranium-238 in soil at this address are 45.6 pCi/g and 116 pCi/g, respectively.
[2] A sample collected from the playground contained 20,000 pCi/g radium-226 and 21,000 pCi/g uranium-238. These high levels were associated with a rock.
[3] Recommended Screening Limits for Contaminated Surface Soil, NCRP Report #129, National Council on Radiation Protection And Measurements 1999. Suburban Scenario with Private Gardens.

Key: Bq/kg = becquerel per kilogram
NCRP= National Council on Radiation Protection and Measurements
ns = not sampled
pCi/g = picocuries per gram

Table 9. Summary of Indoor and Ambient (Near Ground Surface) Gamma Radiation Levels at Off-site Locations[1]

Location	Indoor External Gamma Levels (µR/hour)		Ambient External Gamma Levels (µR/hour)	
	Maximum	Average	Maximum	Average
Williams Street Residence	17	11	330	75.0
Church Rectory	44	19.0	220	33.0
Playground	na	na	16	16

Source: ORNL, 1977, 1978.

[1] Data were collected during a survey conducted by Oak Ridge National Laboratories in 1978. Background external gamma readings taken at 1 meter above ground at points between 0.5 and 25 miles from the site were in the range of 5 to 10 µR/hour (ORNL, 1977).

Key: na = not applicable
µR/hour = micro roentgens per hour

Table 10. Summary of Radionuclide Concentrations in On-Site Groundwater Monitoring Wells

Radionuclide	Concentration pCi/L (Bq/L)					Standards pCi/L (Bq/L)	
	Maximum Annual Average[1] 1982–1993		Maximum[2] 1994–1999		2000[3]	EPA MCL	DOE DCG
	pCi/L (Bq/L)	year	pCi/L (Bq/L)	year			
Radium-226	7 (0.2)	1989	6.1 (0.2)	1994	4.0 (0.1)	5[4] (0.1)	4 (0.1)
Radium-228	3.6 (0.1)	1993	3.1 (0.1)	1995	<M 1	5[4] (0.1)	4 (0.1)
Thorium-230	0.44 (0.01)	1993	9.63 (0.35)	1999	ns	no value	12 (0.4)
Thorium-232	2.1 (0.07)	1991	4.72 (0.17)	1999	ns	no value	2 (0.07)
Total Uranium	192 (7)	1988	316.43 (12)	1999	391 (14)	30 (1)	24 (0.8)

Sources: BNI, 1997, 1998, 1999a, 1999b; ATSDR, 2000a, 2000b.

[1] Unfiltered samples were collected quarterly from 1982–1993 from a groundwater monitoring network consisting of 17 on-site wells; not every well was sampled each quarter or year. For on-site wells, thorium-232 was added to the analyses in 1990 and radium-228 was added in 1993.
[2] Unfiltered samples were collected annually from 1994–1999 from six on-site monitoring wells (B18W24S-B18W29S).
[3] Unfiltered samples were collected from two on-site shallow monitoring wells in February 2000 and from seven on-site monitoring wells in April 2000 (BW18W24S–29S and MW12).
[4] The MCL is for combined radium-226 and radium-228.

Key: Bq/l = becquerel per liter
DOE DCG = Department of Energy's drinking water equivalent guidelines (4 percent of derived concentration guide)
MCL = EPA's maximum contaminant level
nd = not detected
pCi/l = picocuries per liter.
ns = not sampled

Table 11. Summary of Metal Concentrations in On-Site Groundwater Monitoring Wells

Metal	Concentration (ppb)[1]			Comparison Value (ppb)			
	1985–1993[2]	1994–1999[3]	2000[4]	ATSDR		EPA MCL or Action Level	NJ GWQC
Arsenic	5 J	9.3	13	0.02	CREG	50	0.02
Trivalent Chromium	26	591	25,700	no value		100	100
Lead	505	23.3	17	no value		15	10
Uranium (estimated)	590	971	138	no value		30	

Sources: BNI, 1997, 1998, 1999a, 1999b; ATSDR, 2000a, 2000b.

[1] BNI laboratory flags: J indicates that the reported value is estimated
B indicates the presence of trace concentrations of the constituent in the associated laboratory blank.

[2] Unfiltered samples were collected quarterly from 1985–1993 from 12 on-site monitoring wells; metals added in 1990.

[3] Unfiltered samples were collected annually from 1994–1999 from six on-site monitoring wells (B18W24S–B18W29S).

[4] Unfiltered samples were collected from two on-site wells (B18W24S and B18W29S) in February 2000 and from seven on-site monitoring wells (B18W24S–29S and MW 12) in April 2000.

Key: CREG = ATSDR's cancer risk evaluation guide
EPA MCL = EPA's maximum contaminant level
NJ GWQC = New Jersey groundwater quality criteria
ppb = parts per billion

Table 12. Summary of Radionuclide Concentrations in Off-Site Groundwater Monitoring Wells and Private Wells

Radionuclide	Concentration pCi/L (Bq/L)					Comparison Value pCi/L (Bq/L)		
	Off-Site Monitoring Wells			Private Wells				
	1982–1993[1]	1994–1999[2]	2000[3]	1996–1998[4]	2000[5]	ATSDR	EPA MCL	DOE DCG
Radium-226	1.9 (0.07)	0.55 (0.02)	0.3	0.13 (0.004)	2 (0.07)	no value	5[6] (0.1)	4 (0.1)
Radium-228	ns	0.94 (0.03)	nd	ns	< 1	no value	5[6] (0.1)	4 (0.1)
Thorium-230	ns	0.92 (0.03)	ns	0.57 (0.02)	ns	no value	no value	12 (0.4)
Thorium-232	ns	0.34 (0.01)	ns	0.26 (0.009)	ns	no value	no value	2 (0.07)
Total Uranium	12.9 (0.4)	144 (5)	6.8 (0.2)	0.64 (0.02)	2.9 (0.1)	no value	30 (1)	24 (0.8)

Sources: BNI, 1997, 1998, 1999a, 1999b; ATSDR, 2000a, 2000b.

[1] Values represent maximum annual average concentrations. Unfiltered samples were collected quarterly from 1982–1993 from two off-site wells (14 and 15). Thorium-232 analyses for off-site samples was added in 1990.
[2] Values represent maximum concentrations. Unfiltered samples were collected annually from 1994–1999 from one off-site well (B18W30S). Radium-228 and thorium-230 analyses for off-site samples were added in 1994.
[3] An unfiltered sample was collected from one off-site shallow monitoring well (B18W30S) during ATSDR's February 3–5, 2000, sampling.
[4] Unfiltered samples were collected from two private wells—one shallow and one deep—located on residential property south of the site.
[5] Samples were collected from 14 private wells/taps in February 2000. In April 2000, ATSDR resampled three wells and sampled three additional private wells.
[6] The MCL is for combined radium-226 and radium-228.

Key: Bq/L = becquerel per liter
DOE DCG = Department of Energy's drinking water equivalent guideline (4% of the derived concentration guide [DCG])
MCL = EPA's maximum contaminant level
nd = not detected
ns = not sampled
pCi/l = picocuries per liter

Table 13. Summary of Metal Concentrations in Off-Site Groundwater Monitoring Wells and Private Wells

Metal	Maximum Concentration (ppb)					Comparison Value (ppb)		
	Off-Site Monitoring Wells			Private Wells		ATSDR	EPA MCL or Action Level	NJ GWQS
	1990–1993[1]	1994–1999[2]	2000[3]	1996–1998[4]	2000[5]			
Arsenic	2.6	12.3	2.2	ns	8.1	0.02	50	0.02/8
Hexavalent Chromium	ns	ns	nd	ns	nd	30	no value	
Total Chromium	19.7	11.7	nd	ns	19	no value	100	100
Lead	16.7	1.2	nd	ns	16	no value	15	5/10
Uranium (estimated)	39	196	10	0.9	1.5	no value	30	

Sources: BNI, 1997, 1998, 1999a, 1999b; ATSDR, 2000a, 2000b.

[1] Values represent maximum annual average concentrations. Unfiltered samples were collected quarterly 1990 to 1993 from two off-site wells (14 and 15).
[2] Unfiltered samples were collected annually from 1994–1999 from one off-site well (B18W30S).
[3] An unfiltered sample was collected from one off-site well (B18W30S) during ATSDR's February and April 2000 sampling.
[4] Unfiltered samples were collected from two private wells—one shallow and one deep—located on residential property south of the site.
[5] Samples were collected from 14 private well/taps in February and April of 2000.
[6] Analytes that have published practical quantitation limits (PQLs) that are higher than the groundwater quality criteria (GWQC) are noted as such GWQC/PQL.

Key: MCL = EPA's maximum contaminant level
NJ GWQC = New Jersey groundwater quality criteria
ns = not sampled
ppb = parts per billion

Table 14. Summary of Radionuclide and Metal Concentrations in Surface Water

Analyte	Concentration					Comparison Value		
	Maximum Average Annual[1] 1980–1993		Maximum[2] 1996–1997		April 2000[4]	ATSDR	EPA MCL/ ACTION LEVEL	DOE DCG
	Conc.	year	Conc.	year	Conc.			
Radionuclides pCi/l (Bq/l)								
Radium-226	26.9 (0.9)	1992	6.34 (0.2)	1996	0.3	no value	5[3] (0.1)	100 (3.7)
Radium-228	4.5 (0.7)	1992	3.06 (0.1)	1996	nd	no value	5[3] (0.1)	100 (3.7)
Thorium-230	2.9 (0.1)	1992	2.60 (0.09)	1996	63	no value	no value	300 (11)
Thorium-232	1.3 (0.04)	1992	0.27 (0.009)	1996	nd	no value	no value	50 (1.8)
Total Uranium	134.4 (4)	1980	32.6 (1)	1996	nd	no value	30	600 (22)
Metals (ppb)								
Arsenic	8.7	1993	2.9	1996	nd	0.2 (CREG)	50	no value
Chromium	6.6	1993	unknown		45	100 (LTHA)	100	no value
Lead	636	1991	15.8	1996	2.2	no value	15	no value
Uranium (est.)	413.3	1980	100	1996	6.7		30	

Sources: BNI, 1997, 1998; SAIC, 1995; ATSDR, 2000b.

[1] Samples were collected quarterly 1980–1993 from four downstream and one upstream location and analyzed for total uranium and radium-226; radium-228, thorium-230, and thorium-232 were added to the analyses in 1990.
[2] Samples were collected quarterly in 1996 and 1997 from three downstream and analyzed for total uranium and radium-226, radium-228, thorium-230, and thorium-232, and metals.
[3] The guideline is the MCL for combined radium-226 and radium-228.
[4] Three surface samples were collected during ATSDR's April 2000 sampling.

Key: DOE DCG = Department of Energy's drinking water equivalent guideline (4% of the derived concentration guide [DCG])
pCi/L = picocuries per liter
ppb = parts per billion
CREG = cancer risk evaluation guide
LTHA = lifetime health advisory.

Table 15. Summary of Radionuclide and Metal Concentrations in Sediment

Analyte	Concentration				Comparison Value	
	Maximum Average Annual[1] 1980–1993		Maximum[2] 1996–1997		ATSDR	DOE
	Conc.	year	Conc.	year		
Radionuclides pCi/g (Bq/kg)						
Radium-226	16 (592)	1991	5.08 (187.96)	1996	0.16 (6.1)	5 (185)
Radium-228	2.1 (77.7)	1991	7.61 (281.57)	1996	1.6 (60)	5 (185)
Thorium-230	4.1 (151.7)	1992	4.26 (157.62)	1997	0.5 (17)	5 (185)
Thorium-232	2 (74)	1992	1.23 (45.51)	1996	1 (37)	5 (185)
Total Uranium	142.4 (5,268.8)	1980	30.03 (1,111)	1997	81 (3000)	100 (3,700)
Metals ppm						
Arsenic	ns		8.2	1997	200 (EMEG)	
Chromium	ns		35.4	1997	no value	
Lead	ns		239 J	1997	400 (EPA SSL)	

Sources: BNI, 1997, 1998; SAIC, 1995.

[1] Samples were collected quarterly during 1980–1993 from four downstream locations and one upstream location and analyzed for total uranium and radium-226; radium-228, thorium-230, and thorium-232 were added to the analyses in 1990.

[2] Samples were collected quarterly in 1996 and 1997 from three downstream locations and analyzed for total uranium and radium-226, radium-228, thorium-230, and thorium-232, and metals.

Suburban, No Private Gardens Scenario

Key: EMEG=environmental media guide
EPA SSL = EPA soil screening level
J = estimated value
ppm = parts per million
pCi/g = picocuries per gram
ns = not sampled

Table 16. Summary of Radon Gas Concentrations

Location	Radon Gas Concentration (as radon-222) pCi/L (Bq/L)						Standards (pCi/L)	
	Maximum 1976 –1978[1]		Maximum Average Annual 1982–1993 [2]		Maximum Average Daily 1996–1997 [3]		EPA Action Level (indoor)	DOE (outdoor)
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor		
On-site	29 (1)	ns	18.9 (0.6)	5 (0.1)	1.4 (0.05)	nd	4 (1)	3 (1)
Off-site: Church Rectory	92 (3.4)	ns	ns	ns	ns	ns	4 (1)	3 (1)

Sources: BNI, 1998; SAIC, 1995; ORNL, 1978.

[1] Data were collected during a survey conducted by Oak Ridge National Laboratories June 2–12, 1978.
[2] Data were collected outdoors and at the site annually from 1982–1993 and indoor samples were collected annually from 1990–1993.
[3] Data were collected as part of the Environmental Surveillance program at the MSP site.

Key: nd = not detected
ns = not sampled
pCi/l = picocuries per liter
Bq/l = becquerel per liter

APPENDIX A. Site History

1910	Asphalt paint plant built (name and owner unknown).
1913	Original paint company goes broke; American Marietta Corporation buys asphalt paint company; diversifies from standard black into metal-based paint such as aluminum.
1943	A brick warehouse is leased from the American Marietta Corporation for the Manhattan Engineer District (MED) and is used for sampling and analysis of uranium ores in the effort to develop the atomic bomb. Renamed the Middlesex Sampling Plant (MSP), ores were thawed, crushed, dried, screened, stored, sampled, weighed, and then shipped to refineries. Tailings containing more than 10 percent uranium oxides were stored at MSP or Oak Ridge. Workers dressed as though they were working at the paint company and were sworn to secrecy regarding their jobs.
September 1946	The Atomic Energy Commission (AEC, the successor to MED) purchased by condemnation the leased property from the American Marietta Corporation for $197,000.
1947/1948	MSP was leveled and excess soil was sent to the Middlesex Municipal Landfill (MML). The 9.6-acre MSP site was fenced and 8 acres were paved for drum storage. Some excess soil was used as fill at a private residence in Piscataway and a church rectory (Our Lady of Mount Virgin, Middlesex Borough). A 500-cubic-foot settling tank was installed to collect wastewater from the process building floor. The purpose of the tank was to remove solids and allow effluent to go to the drainage ditch. A sump system under the process building flowed to a catch basin between the process building and garage.
1950	Prior to 1950, uranium oxide (Q-11) was the chief material sampled; after 1950, magnesium di-uranate precipitate (MgX) and beryl ore (INX) were also sampled. Control of site operations was contracted to National Lead Company and a health physicist was hired to monitor employee safety and health. Process building workers subsequently were issued respirators.
1954	MSP no longer sampled INX.
1955	AEC terminated primary activities (sampling, analysis, storage, and shipment of uranium, thorium, and beryllium ores), but continued on-site storage and sampling of thorium residues. Sampling of Q-11 and MgX was transferred to Fenald, Ohio.
1960	AEC surveyed the MML and removed 650 cubic yards of radioactive soil.
1967	All activities were terminated, and the site was decontaminated by a government contractor, Isotopes, Inc. Portions of the paved yard and underlying soil were excavated for transfer to an off-site burial area. The

	process building crusher and smaller pits were cleaned and covered; in the underground tunnel, the dirt floor was excavated to approximately one foot and the walls were scrubbed; the walls and floor of the men's lavatory were sandblasted and scrubbed; and sampling areas—including the first floor and partial basement, located in the center of the process building—were cleaned.
February 1968	MSP was given to the General Services Administration.
1969	The U.S. Navy acquired the site and used it for U.S. Marine Corps reserve training. Remodeling and construction activities were performed. Specific records were not kept, although later reports indicate that a kitchen, numerous offices, and a basketball court was installed in the process building. Additionally, drawings made by a government contractor in 1979 indicate the existence of a gasoline storage tank and a septic leach field underneath the site.
1976	Oak Ridge National Laboratory surveyed MSP and surrounding properties for residual alpha and beta-gamma radiation levels, radon and radon daughter concentrations in on-site buildings, external gamma radiation levels, and radium soil concentrations.
1978	A flyover detected widespread contamination at the MSP site and on surrounding properties and at 3 more remote locations: the Middlesex Municipal Landfill, a church rectory and associated playground, and a private residence on Williams Street.
1980	The MSP site was transferred to the Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). Phase I of the environmental investigations began, and it included removing contaminated soils and sediments from the most heavily contaminated off-site properties. The environmental surveillance program began in an effort to detect potential contaminant migration in the air and water.
1981	Phase II of the environmental investigations began, and it included excavating soil from the on-site drainage ditch and properties adjacent to MSP. During the Phase I and II remedial actions, the vicinity properties (VP) pile was created on MSP property to temporarily store contaminated soil.
1983	A radiological survey was conducted to characterize the extent of contamination on the grounds.
1984	Radiologic contaminated soil and waste were removed from the MML site and brought back to MSP for temporary storage. This created what was known as the MML pile.
1986	More radiologic contaminated soil and waste were removed from the MML site and brought back to MSP's MML pile.
1991	At the request of the New Jersey Department of Environmental Protection, MSP was characterized for non-radiologic contamination in

	soil at the site. Additionally, the nature and levels of radiologic and chemical contamination of the VP and MML piles was determined.
1996	Radiological contamination was detected in the sediment in the drainage ditch south of the site. DOE removed the contaminated sediment and installed a carbon filter at the plant outfall to prevent future contamination from the site drainage system to migrate off site. Private wells of two residences immediately south of the site were sampled; results indicated uranium activity levels of 0.35 and 0.43 pCi/L; both were offered alternative drinking water supplies.
1997	Custody of MSP was transferred to the Army Corps of Engineers.
1998	The MML pile was disposed of at a certified hazardous material landfill.
February 1999	The U.S. Environmental Protection Agency (EPA) listed the MSP site on the National Priorities List after EPA was notified that uranium was detected in the Raritan River approximately 3 miles south of the site.
August 1999	Removal of the VP pile was initiated.
September 1999	ATSDR initiated the Public Health Assessment for MSP.
December 1999	ATSDR mailed 4,700 fact sheets to residents in a 1-mile radius of the site.
January 2000	ATSDR received 175 responses from the MSP community—including 80 letters expressing health concerns and questions.
February 2000	ATSDR sampled 3 on-site wells and 14 private wells.
April 2000	ATSDR sampled eight on-site wells; six private wells; and three surface water locations.
January 2001	At ATSDR's request, the NJDHSS completed a cancer incidence analysis of populations living near the MSP.

APPENDIX B. List of Types of Comparison Values

Comparison values represent media-specific contaminant concentrations that are used to select contaminants for further evaluation to determine the possibility of adverse public health effects. The conclusion that a contaminant exceeds the comparison value does not mean that it will cause adverse health effects. The following presents a description of the comparison values (CVs). When evaluating potential health hazards, ATSDR compares concentrations of a contaminant in a particular medium to the most conservative media-specific comparison value available for that particular contaminant.

Cancer Risk Evaluation Guides (CREGs)
Estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed over a 70-year life span. ATSDR's CREGs are calculated from EPA's cancer potency factors (CPFs).

Environmental Media Evaluation Guides (EMEGs)
EMEGs are based on ATSDR minimal risk levels (MRLs) and factors in body weight and ingestion rates. A MRL is an estimate of daily human exposure to a chemical (in milligrams of contaminant per kilogram of body weight per day [mg/kg/day]) that is likely to be without noncarcinogenic health effects over a specified duration of exposure.

Reference Media Evaluation Guides (RMEGs)
ATSDR derives RMEGs from EPA's oral reference doses (RfDs). The RMEG represents the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

Risk-Based Concentration (RBC)
The RBCs were developed by EPA Region 3. RBCs for tap water, air, and soil were derived using EPA RfDs and CPFs combined with standard exposure scenarios—such as ingestion of 2 liters of water per day—over a 70-year life span. RBCs are contaminant concentrations that are not expected to cause adverse health effects over long-term exposures.

Soil Screening Level (SSL)
Generic SSLs were derived by EPA (as described in the *Soil Screening Guidance: Technical Background Document*, EPA document number EPA/540/R-95/128) for nationwide application to sites used for residential areas. SSLs are estimates of contaminant concentrations that would be expected to be without noncancerous health effects over a specified duration of exposure or to cause no more than one excess cancer in a million (10^{-6}) persons exposed over a 70-year life span. Direct ingestion SSLs were selected for use in this PHA.

Maximum Contaminant Level (MCL)
The MCL is the drinking water standard established by EPA. It is the maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet. MCLs are considered protective of public health over a lifetime (70 years) for people consuming 2 liters of water per day. MCLs are standards enforceable by EPA.

APPENDIX C. Glossary

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect: A change in body function or the structures of cells that can lead to disease or health problems.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia, that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Biota: Used in public health, things that humans would eat – including animals, fish and plants.

Cancer: A group of diseases that occur when cells in the body become abnormal and grow, or multiply, out of control.

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: Contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than 1 year to be *chronic.*

Completed Exposure Pathway: See **Exposure Pathway**.

Comparison Value: (CVs) Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food, and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund.** This act concerns releases of hazardous substances into the environment and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might harm people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant.**

Delayed Health Effect: A disease or injury that happens as a result of exposures that might have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (see **Route of Exposure**).

Dose: The amount of a substance to which a person might be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day."

Dose / Response: The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Media: Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people disease will occur.

Exposure: Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having five parts:

1. Source of Contamination.
2. Environmental Media and Transport Mechanism.
3. Point of Exposure.
4. Route of Exposure.
5. Receptor Population.

When all five parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these five terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time: for example, every day, once a week, or twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (see **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (see **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

Malignancy: See **Cancer**.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time – to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being evaluated to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that studies chemicals at a hazardous waste site and determines if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Plume: A line or column of air or water that contains chemicals moving from the source to areas farther away. A plume can be a column or clouds of smoke from a chimney, or it can be contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). For example: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area, or the number of people in a certain area.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories that indicate whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:

1. Urgent Public Health Hazard.
2. Public Health Hazard.
3. Indeterminate Public Health Hazard.
4. No Apparent Public Health Hazard.
5. No Public Health Hazard.

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with the chemicals (see **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily lifetime exposure of human populations to a possible hazard that is <u>not</u> likely to harm the person.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:

1. Breathing (also called inhalation).

2. Eating or drinking (also called ingestion).
3. Getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to harm people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who might be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Superfund Site: See **NPL**.

Synergistic effect: A health effect from an exposure to more than one chemical, and in which one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

APPENDIX D. Radiation and Radioactive Material

What is radioactivity?

Radioactivity is the spontaneous emission of radiation from the nucleus of an unstable atom. Atoms are the smallest units of an element that have the same properties as the element. All matter is made up of atoms, and atoms are made up of protons and neutrons (found in the nucleus of the atom) and electrons. The number of protons in an atom of a particular element is always the same, but the number of neutrons can vary. Whether an atom is unstable, or *radioactive*, is determined by the ratio of neutrons to protons. *Isotopes* are forms of the same element with different numbers of neutrons. The number of protons and neutrons in the atom are added to name the isotope. For example, an atom of cobalt that has 27 protons and 33 neutrons is called cobalt-60. Cobalt-60 is radioactive and is therefore called a radioisotope or a *radionuclide*.

Where does radioactivity come from?

All elements heavier than lead (which contains 82 protons) are naturally radioactive. Atoms, such as hydrogen-3 (tritium) and carbon-14, can also become radioactive through natural processes in the environment. Everyone is exposed to naturally occurring radiation from space and from radioactive materials in the ground. Humans can also create radioactive atoms of most elements. For example, humans create radioactive atoms to use as tracers to help measure the flow of materials in the environment. Radioactive material can travel through the air as particles or gases and can also enter soil, water, plants, and animals. The greatest dose from environmental radiation is from radon and its progeny. Radon is an alpha emitter that results from decaying radium-226, which comes from the radioactive decay of natural uranium-238.

What is radiation?

Radiation is the emission of waves or particles from an unstable atom undergoing a transformation to stabilize the number of protons compared to the number of neutrons in its nucleus. This transformation changes the radioactive atom into a stable atom. For example, a proton in a cobalt-60 atom might change into a neutron, emit radiation, and become a nickel-60 atom.

What radioactive materials were used at Middlesex Sampling Plant (MSP)?

DOE used uranium, a naturally occurring radioactive material, at MSP. Naturally occurring uranium may be present as three different radioisotopes: uranium-234, uranium-235, and uranium-238. By weight, 99.3% of natural uranium is uranium-238. When uranium breaks down, it gives off radiation and changes, or decays, to a new element called a daughter product. It takes about 4.5 billion years for one-half of uranium-238 to break down. During the uranium-238 decay processes, a series of new elements are created, including thorium, radium, and radon isotopes, which are also radioactive. Thorium, the daughter product of uranium, is not stable, and it continues to decay until stable lead is formed (ATSDR, 1999).

What are alpha particles, beta particles, and gamma radiation?

Alpha particles can be emitted by atoms that are more massive than lead, such as radium. Alpha particles are comprised of two protons and two neutrons and have a large charge, which can pull electrons off neighboring atoms (or cause them to ionize). Alpha particles cannot penetrate the skin, but can be taken into the human body if they are contained in the air people breathe, or the food or drink people consume. If they enter the human body, alpha particles can be absorbed in the blood, incorporated into molecules in the body, and deposited in living tissue.

Beta particles are electrons that result from a neutron changing into a proton. Some beta particles have very little energy and cannot pass through the dead outer layer of a person's skin, but most can do so and expose the living tissue underneath the outer layer of skin to radiation. Beta particles cannot travel all the way through the human body, however. Exposure to beta radiation can also result from inhaling air or ingesting food or liquids containing radioactive elements that give off beta particles.

Gamma rays result from the release of excess energy when an atom gives off an alpha or beta particle. Gamma rays consist of moving energy and have no mass or charge. They can travel long distances and move through the air, body tissue, or other materials. A gamma ray can pass through the body without hitting anything inside of it, or it can hit atoms in its path and cause them to ionize. Gamma rays are the primary type of radiation that can harm people when they are exposed to it externally.

Source: ATSDR. 1999. Agency for Toxic Substances and Disease Registry. Toxicological profile for Ionizing Radiation. September 1999.