Public Health Assessment for

MONTCLAIR/WEST ORANGE RADIUM SITE
MONTCLAIR/WEST ORANGE, ESSEX COUNTY, NEW JERSEY
CERCLIS NO. NJD980785653
AUGUST 8, 1995

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

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.

Agency for Toxic Substances and Disease Registry............................David Satcher, M.D., Ph.D., Administrator
Barry L. Johnson, Ph.D., Assistant Administrator

Division of Health Assessment and Consultation....................................Robert C. Williams, P.E., DEE, Director
Juan J. Reyes, Deputy Director

Exposure Investigations and Consultations Branch......................................Edward J. Skowronski, Acting Chief

Federal Facilities Assessment Branch...Sandra G. Isaacs, Acting Chief

Petitions Response Branch..Cynthia M. Harris, Ph.D., Chief

Superfund Site Assessment Branch...Sharon Williams-Fleetwood, Ph.D., Chief

Program Evaluation, Records, and Information Services Branch..................................Max M. Howie, Jr., Chief

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PUBLIC HEALTH ASSESSMENT

MONTCLAIR/WEST ORANGE RADIUM SITE

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CERCLIS NO. NJD980785653

Prepared By:

New Jersey Department Of Health
Environmental Health Service

Under A Cooperative Agreement With
The Agency For Toxic Substances And Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, is an agency of the U.S. Public Health Service. It 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. (The legal definition of a health assessment is included on the inside front cover.) 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 cooperataive agreements.

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 then evaluate whether or not there will be any harmful effects from these exposures. The report focuses on public health, or the health impact on the community as a whole, rather than on individual risks. Again, ATSDR generally makes use of existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries. 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 research studies are needed.

Conclusions: The report presents conclusions about the level of health threat, if any, posed by a site and recommends ways to stop or reduce exposure in its 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, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When infomed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

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 (E-56), Atlanta, GA 30333.

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SUMMARY

This Public Health Assessment analyzes the potential for adverse health effects as a result of contamination present at the Montclair/West Orange/Glen Ridge (MWG) radium contamination site. The Montclair site consists of 100 acres in Montclair and West Orange Townships. The West Orange site consists of 20 acres solely in West Orange Township. The Glen Ridge site consists of 90 acres in the Townships of Glen Ridge and East Orange Townships. Two hundred thirty-six out of 747 homes which were screened in the three study areas are contaminated with radioactive material (i.e., radon-222, radium-226) resulting in above background levels of alpha and/or gamma radiation. Some homes in the Montclair site contain building materials contaminated with radium-226/thorium-230. Between 1915 and 1926, the U.S. Radium Corporation extracted and purified radium-226 from carnotite ore and then painted watch and instruments with luminous paint containing radium-226. The company employed women to do the painting on and off-site. The plant processed 1.5 to 2.0 tons of ore daily and large quantities of process wastes and tailings containing high levels of radioisotopes were dumped in rural areas which were subsequently developed. All of the communities use city water supplies.

The first Operable Unit (OU) for the MWG site addresses the removal of contaminated soil containing radium-226 or other uranium-238 decay products. The second OU will address contamination of the groundwater. In April 1985 the USEPA completed the draft RI/FS for the MWG sites. The Centers for Disease Control (CDC) prepared a Public Health Advisory for Montclair and Glen Ridge in December 1983. A Health Assessment was also conducted by the CDC for the MWG site in November 1986. Community concerns focused upon the public health impacts of radiation exposure, remediation of the site, and the impact to property values. The New Jersey Department of Health (NJDOH) conducted an epidemiological study in 1988 for the MWG sites and found possible elevated lung cancer rates for white males.

The ATSDR and the NJDOH consider the MWG site to be a public health hazard in the past to residents of homes containing elevated radiation levels and to the residents of Glen Ridge who frequented Barrow's Field, and an indeterminate public health hazard in the past and the present for the residents of homes in the study areas that have not yet been screened for elevated radiation levels. Chronic exposure to excessive radon-222 concentrations may have occurred for up to 30 years via the inhalation route of exposure. Chronic exposure to radium-226/thorium-230 may have occurred for up to 30 years by the ingestion and/or dermal absorption pathways. The exposed population risks lung tissue damage and lung cancer via inhalation of excessive radon, and anemia and osteosarcomas via exposure to radium-226/thorium-230. The ATSDR and the NJDOH concur with the USEPA's plans to screen all of the houses in the study areas. ATSDR's Health Activities Recommendation Panel determined that the community health education being conducted by the U.S. EPA is appropriate and that a review of cancer health statistics for the study areas is indicated. The NJDOH conducted a public comment period for the Public Health Assessment for the Montclair/West Orange/Glen Ridge Radium Contamination site from September 23, 1994 to October 28, 1994.

BACKGROUND

A. SITE DESCRIPTION AND HISTORY

Several areas in Essex County have been found to contain above background levels of radiation resulting from the presence of radon-222, polonium-218, thorium-230, radium-226. These areas are noncontiguous and consequently have been separated into three discrete study areas to facilitate investigations. They comprise the Montclair/West Orange/Glen Ridge (MWG) National Priority List site (Appendix 1), located in Essex County, New Jersey.

The Montclair study area consists of approximately 100 acres located in the Townships of Montclair and West Orange (Appendix 2). There are mainly one family homes in this study area with a few two-family homes. There are no parks and no commercial properties except for two gas stations (8).

The West Orange study area consists of about 20 acres in the Township of West Orange (Appendix 3). In this study area are only one-family homes, a bus company, and a garden condominium complex. There are no parks or other commercial businesses (8).

The Glen Ridge study area consists of approximately 90 acres in the Townships of Glen Ridge and East Orange (Appendix 4). There are only one-family houses and no commercial properties in this study area. Additionally, there is an actively used park used for recreational purposes (7).

Between 1915 and 1926, the U.S. Radium Corporation (previously called the Radium Luminous Materials Corporation) extracted and purified radium-226 from carnotite ore ($K_2(UO_2)_2(VO_4)_2 3H_2O$) and then painted watch and instrument dials, gun sights, and survey equipment with luminous paint containing radium-226. The company employed more than 100 workers, the majority of them women who painted the equipment.

The plant was able to process between 1.5 to 2.0 tons of ore daily. Thus, large quantities of process wastes and tailings containing radioisotopes were temporarily stored on-site near the railroad tracks and later on transported to rural areas where they were dumped along with other refuse. These rural areas were eventually developed primarily with residential homes. Increasing awareness of the hazards of radium and the discovery of richer uranium ore in the Belgian Congo (Zaire) caused operations to cease in 1926.

During an investigation of former radium processing facilities in the State, the New Jersey Department of Environmental Protection and Energy (NJDEP) realized that wastes could have been disposed at locations distant from these facilities. The NJDEP then requested that the United States Environmental Protection Agency (USEPA) conduct an aerial gamma radiation survey in eastern Essex County. This survey was done in 1981. Several areas were detected with elevated levels of gamma radiation. This was confirmed by ground investigations conducted by the NJDEP in 1983. Several houses were identified with high radiation levels.

The residential development of the area has been well documented by compiling historical tax records, atlas maps, old photographs, sewer and road design drawings, and local historical writings. From this information, a "core area" of contamination for each study area was identified. During the development of the residential area, channeling and diversion of surface drainage occurred and earth was moved during the construction of roads and houses. The contaminated soil has, thus, become mixed with uncontaminated soil and fill material.

The sites are above a superficial overburden layer. Beneath this shallow aquifer is a deep fractured bedrock aquifer which supplies water to public wells for several communities. All of the townships cited in this study supply their residents with city water.

The investigation was expanded to include the West Orange Study Area in April 1984. In October, 1984, the Montclair/West Orange and Glen Ridge Radium sites were proposed for the Superfund National Priorities List. In November 1984 the USEPA began the RI/FS (8).

The USEPA and NJDEP initiated a joint pilot study, in May 1984, to determine the feasibility of excavation and off-site disposal of radium-contaminated soil to Nevada for 12 properties. The USEPA decided to postpone the study because the RI/FS had been initiated. The NJDEP proceeded with the excavation (Phase I Cleanup) in June 1985. After four properties had been remediated the State of Nevada revoked the NJDEP's disposal permit. This forced the NJDEP to leave the contaminated soil in 9500 drums and 51 containers in a facility in Kearny, New Jersey and 4902 drums and 33 containers at the partially excavated properties in Montclair. The containers were removed from the properties in September 1987 and the soil stored in Kearny was transported out-of-state during the summer of 1988.

The MWG site has been divided into two Operable Units (OU's). The Remedial Investigation/Feasibility Study (RI/FS) addresses the first OU which consists of contaminated soil containing radium-226 or other uranium-238 decay products. The second Operable Unit will address contamination of the groundwater.

The Centers for Disease Control (CDC) issued a Health Advisory on December 6, 1983 quantifying the risks for residents and setting specific time periods to implement remedial actions. The USEPA then began preliminary investigations to determine the extent of contamination and to implement emergency remedial actions. These actions consisted of installing ventilation systems in houses with elevated radon decay product concentrations and placing lead shielding in houses with elevated gamma radiation levels.

In April 1985 the USEPA completed the RI/FS for the Montclair/West Orange and Glen Ridge Radium sites (8). The RI/FS was made public on September 13, 1985. A public meeting was held on the RI/FS on November 13, 1985. In January 1986, the EPA initiated additional field investigations to fill the data gaps identified during the 1985 RI/FS. These were completed in November 1986.

A Health Assessment for the Montclair/West Orange/Glen Ridge site was prepared by the CDC for the ATSDR in November 1986 (Appendix 5). In addition, ATSDR prepared and released a Site Review and Update (Revised June 2, 1993) that recommended a public health assessment for the site be undertaken. The Record of Decision (ROD) for MWG was originally signed in June of 1989 and was then replaced by a second ROD in June 1990 (9). A Community Action Plan was signed for the Montclair/West Orange/Glen Ridge site in 1984 and was updated in June 1992 (10).

B. SITE VISIT

On January 22, 1993, Howard Rubin, of the NJDOH and the Case Manager from the USEPA conducted a site visit at the Montclair/West Orange/Glen Ridge Radium sites. There were no unusual or outstanding features for any of the sites. They all appeared to be normal, well-maintained residential areas that were indistinguishable from surrounding areas.

There is a bus company and a condominium complex in the West Orange study area which the USEPA determined contained only background levels of radioactivity. The Glen Ridge study area contains an active park, Barrow's Field, that contains several ball fields. The USEPA found that the park is highly contaminated with radium-226/thorium-230.

C. DEMOGRAPHICS, LAND USE AND NATURAL RESOURCE USE

The areas of contamination in the Montclair/West Orange/Glen Ridge site consist of well established residential neighborhoods primarily consisting of one or two-family homes. Table 1 shows the demographic breakdown for the Montclair/West Orange/Glen Ridge study areas.

Table 1 - Demographic Breakdown for the Montclair/West Orange and Glen Ridge Radium Sites.

Study Site	Total Population (1000's)	Avg Age (Years)	Avg Income ($1000's)	Avg Housing Price ($1000's)
Montclair	26.1	41.4	40.5	84.7
West Orange	38.9	41.6	45.8	78.0
Glen Ridge	7.4	38.7	51.3	82.9

Adapted from: Montclair/West Orange and Glen Ridge, NJ Community Relations Plan, September 1992.

The average age of the residents is about 40 years old. This suggests that current occupants of these dwellings are not original owners. The current residents earn an average annual household income in the mid forty thousand dollar range. The average value of the houses in this area is in the low $80,000.00 range.

All three study areas are densely populated and are in one of the most densely populated parts of the United States. These areas were once highly industrialized, but the industrial base has progressively diminished with time. This has corresponded to an increase in the residential/commercial base. However, a small diverse manufacturing and service base still exists.

Table 2 shows the size of the sites and the number of residences that are affected for each study area. These sites comprise a total of 210 acres containing about 750 residences and approximately 1,800 people. To date, a total of 236 residences and approximately 600 people have been documented to have been exposed to elevated radiation levels from contaminated soil and/or contaminated building debris. However, the USEPA estimates that over 100 additional houses in the study areas need to be screened (10).

Characterization of additional potentially affected areas are continuing, so estimates of potentially affected populations may increase. Contamination has been found in commercial areas, residential areas and a park. No schools or hospitals are located in the study areas.

Table 2 - Number of Screened Homes and Estimated Population in the Study Areas.

Study Area	Size (Acres)	Total Screened		Contaminated	
		No. of Homes	*Estimated Population	No. of Homes	*Estimated Population
Montclair/ West Orange	**100	366	915	133	333
West Orange	20	75	188	24	60
Glen Ridge	90	306	765	79	198
TOTALS:	210	747	1788	236	591

* Based on 2.5 residents per house.

** Actual area is unknown because investigations are ongoing.

D. HEALTH OUTCOME DATA

There are multiple sources of health outcome data in New Jersey. State and local data for health outcome information include the New Jersey State Cancer Registry, Adverse Pregnancy Outcomes Registry, Vital Statistics Records, Renal Dialysis Network and hospital discharge reports. Federal databases such as those maintained by the Department of Health and Human Services (National Cancer Institute, NIOSH and ATSDR) are not site-specific, but may be used for comparison and evaluation purposes.

An epidemiological health study was conducted for the Montclair, West Orange and Glen Ridge study areas by the N.J. Department of Health in 1988 (5). This was a study that attempted to correlate excess radon exposure with historical cohort mortality rates on 752 former and present residents of the MWG study areas. The study focused on people who lived in 45 homes documented as of December 1983 to have radon-222 concentrations above 4 pCi/L in at least one location. Residency histories, vital status, death certificates, and causes of death were collected for the study. The findings of this investigation are discussed in the Health Outcome Data Evaluation section.

COMMUNITY HEALTH CONCERNS

Public meetings have been held in the various communities. The concerns of the communities focused on three major categories: 1) Health concerns; the public health impacts resulting from chronic exposure to excess radiation; 2) Concerns about cleanup and restoration efforts; the length of time needed for remediation of the residences and storage and disposal of the contaminated soil; and 3) Economic concerns; the effects on property values.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

In the data tables that follow under the On-Site Contamination subsection and the Off-Site Contamination subsection, the listed contaminant does not mean that it will cause adverse health effects from exposures. When selected as a contaminant of concern in one medium, that contaminant will be reported in all media.

Definitions are given below for radiological expressions:

Alpha Particle - A positively-charged particle of two neutrons and two protons emitted by certain radioactive material.

Beta Particle - Charged particle emitted from the nucleus of an atom that is smaller than alpha particles.

Curie (Ci) - A unit of the amount of radioactivity. It is equivalent to 3.7×10^{10} nuclear disintegrations per second.

Gamma Ray - A very high energy form of electromagnetic radiation with great penetrating power, similar to X-rays, emitted from the nucleus of an atom.

Half-life - The time it takes for one-half of the number of radioactive atoms to disintegrate.

Rad - A unit of dose absorbed by body tissues. Rad refers to doses from both external penetrating radiation and from radionuclides contained within the body, but do not measure specific biological damage.

Radioactivity - Spontaneous emission from the nucleus of an unstable atom. These emissions could include alpha particles, neutrons, beta particles, or photons.

Rem - (Roentgen Equivalent Man) Considered the most appropriate measure of biological damage from radiation, this measure reflects the fact that some forms of radiation create more damage for a given absorbed dose than others. The REM is calculated by multiplying the absorbed dose by modifying factors calculated on considerations of certain physical factors and ionization of the tissue involved.

Roentgen (R) - A unit of exposure to gamma or X-rays. Relates to the number of ionizations in the air or the amount of energy deposited in a specified volume of air.

The site is contaminated primarily with radium-226 and thorium-230 which emit ionizing radiation. Radon-222 (a decay product of radium-226) is mainly an alpha particle emitter while radium and thorium are alpha and gamma emitters. They are moieties of the uranium-238 decay chain (Appendix 6). An alpha particle is a positively charged particle. Gamma radiation is electromagnetic energy rather than particles with properties similar to X-rays and other electromagnetic waves. An alpha particle cannot penetrate the skin. Gamma rays are the most penetrating type of ionizing radiation because it is non-particulate and, therefore, has less interaction with the material in which it passes through. Gamma radiation disperses its energy over a relatively long distance (4,7).

The environmental contamination section includes sampling data from a variety of media sources.

A. ON-SITE CONTAMINATION

Refer to the Health Assessment document for Montclair, Glen Ridge and West Orange, November 12, 1986 (Appendix 5), for basic information regarding on-site contamination. Further sampling has been conducted subsequent to these Preliminary Health Assessments.

The total number of houses in the various study areas that have been documented to be contaminated will change because additional surveys are to be conducted. The USEPA estimates that a minimum of 290 additional properties will undergo outdoor gamma radiation surveys in the MWG site, 456 homes will undergo indoor gamma radiation surveys, and at least 450 homes will be surveyed for excess radon (8). This affects a total of over 3,000 residents.

Residential Properties

Residential Structural Contamination

A total of 38 out of 237 houses were found to contain building materials such as mortar, cement, gravel and wood that were either contaminated with radium-226 or had natural levels of thorium, and/or uranium at concentrations producing gamma exposure rates greater than 15 μR/hour (Table 3). Background levels of gamma radiation average approximately 8 μR/h in Essex County. For 131 out of 368 homes, the soil adjacent to and/or under the house was the source of gamma radiation.

The houses were analyzed for above background levels (Approximately 1 pCi/L) of radon. However, a radon analysis was not conducted on residential yard soils because the USEPA believes that there is a minimum of risk resulting from excess radon in open areas.

Table 3 - Number of Homes with Air Contaminated by Radon and Gamma Radiation.

STUDY AREA	NUMBER OF HOMES				
	RADON ≥4 pCi/L	GAMMA RADIATION			
		INDOOR (Per hour)		OUTDOOR (Per hour)	
		≤30 μR	>30 μR	≤30 μR	>30 μR
[1]Montclair	84	100	19	170	64
West Orange	33	42	8	9	20
West Orange	12	22	2	41	9
[2]Glen Ridge	80	70	9	138	37
East Orange	4	3	0	10	1
TOTALS:	213	237	38	368	131

1 - Montclair/West Orange Study Area
2 - Glen Ridge Study Area

Air

Radon emitted by contaminated soil can enter a house from a variety of routes (Appendix 7). Radon was detected at indoor airborne concentrations equal to or greater than 4 pCi/L in 213 homes (Table 3). The USEPA guideline for radon concentration in residential structures is 4 pCi/L. In the Montclair study area, a total of 117 houses had more than 4 pCi/L but no more than 310 pCi/L of radon. In West Orange, 12 houses were contaminated with radon at more than 4 pCi/L of radon, but not greater than 48.4 pCi/L. In Glen Ridge, 84 houses were found to contain radon at greater than 4 pCi/L with a maximum level of 57.4 pCi/L. (Table 4)

Soil

The U.S. Radium Corp. produced approximately 1.5 cubic yards of tailings per day as waste resulting from the extraction of radium-226 from the ore. Large quantities of tailings were dumped nearby at what were, then, undeveloped areas. Table 4 lists the maximum levels of contaminants found in properties at the different sites.

Table 4 - Maximum Radiation concentrations.

Area	Radon Air (pCi/L)	Radium-226/Thorium-230 Soil (pCi/g)
Montclair	310.0	2315
West Orange	48.4	530
Glen Ridge	57.4	688
Barrow's Field (Glen Ridge)	NA	1500

NA - Not analyzed

In the Montclair/West Orange study area, a total of 27 homes had indoor gamma radiation levels exceeding 30 μR/h (Table 3). This level was exceeded for outdoor gamma radiation in 84 homes. In the West Orange study area 9 homes exceeded outdoor gamma radiation levels at more than 30 μR/h, 2 houses were contaminated at this level via indoor gamma radiation.

The USEPA clean-up level (in 40CFR192) for radium-226 is a maximum concentration of 5 pCi/g for the first six inches of soil (surface) and 15 pCi/g at depths greater than six inches (subsurface) above background averaged over an area of 100m^2. The amount of soil exhibiting elevated concentrations of gamma emitting isotopes ranged from isolated pockets of contaminated soil found in the yard to large volumes of contaminated soil underlying detached garages and basement floors (Appendix 8).

In April and May 1986, the USEPA collected seven surface soil samples from various residential properties in Montclair and West Orange and had them analyzed for radium-226 and thorium-230. The samples ranged from background levels to a maximum of 4.6 pCi/g of radium-226 and 5.5 pCi/g of thorium-230. Then, in September 1988, an additional 22 surface soil samples were collected from residential properties. Two samples were from the West Orange study area, 12 samples came from the Montclair study area and the remaining samples were obtained from the Glen Ridge Study area. All of the samples had radium-226 concentrations levels greater than the USEPA clean-up level of 5 pCi/g (40 CFR 192), with the highest levels being 2315 pCi/g in Montclair, 530 pCi/g in West Orange, and 688 pCi/g in Glen Ridge (Table 4).

Gamma logging data indicated that the contaminated material was limited to the upper three feet of soil. Thorium-230 was found to be at background levels for all samples taken. Only one property had a thorium concentration of 159 pCi/g. (8)

Groundwater

Preliminary groundwater studies have been conducted for the different study areas (8). A comprehensive analysis of the groundwater quality is planned in future Operable Units since all of the municipalities use public water supplies. The superficial aquifer is not likely to become highly contaminated since radium and thorium are not easily leachable. If these radioactive chemicals were leachable, the U.S. Radium plant would have been able to remove them during their radium recovery process. The residents of all of the affected communities are on public water supplies.

Public Areas

In March 1987 the USEPA collected 13 surface soil samples from a playground in Glen Ridge, Barrow's Field, and analyzed the samples for the presence of gamma emitting isotopes. Results ranged from 0.5 pCi/g to a high of 1500 pCi/g (Table 4). Eight out of the 13 samples contained gamma emitting isotopes at levels greater than the USEPA clean-up level (5 pCi/g) for radium-226. Subsequently, 16 subsurface borehole samples showed evidence of above background soil concentrations. The highest concentration found at Barrow's Field was 1500 pCi/g (Table 4).

Non-Radiological Investigations

Few analyses have been performed to determine the presence of non-radiological contamination of the soil. In July 1984, the USEPA had Barrow's Field analyzed for metals (7). All results were below the health comparison values (i.e., levels not expected to result in adverse health effects upon exposure). In March 1985, samples were collected from two properties in Montclair and one property in Glen Ridge and analyzed for toxicity, ignitability, corrosivity and reactivity. Again, all samples were below the comparison values. The final non-radiological samples were collected during the summer of 1986, by the NJDEP, from drums filled with material collected during their Phase I excavation program. They were from four properties in Glen Ridge and one property in Montclair. Ten samples were composited and then analyzed for priority pollutants including volatiles, semi-volatiles, pesticides, and inorganics. Lead was found to be in concentrations ranging from 96.9 to 635 ppm, uranium ranged from less than 100 ppm to 626 ppm, and vanadium ranged from 81.8 to 862 ppm. The actual values for the tested compounds cannot be determined nor can the location of the contaminated soils be determined because of the large number of samples composited.

B. OFF-SITE CONTAMINATION

All of the study areas were contaminated as a result of the radium industry. No visible markings exist that can be used to delineate the contaminated sites from the adjacent non-contaminated sites. Each study area covers many acres. Therefore, it is impossible to distinguish between "on-site" and "off-site" in the traditional way. It is more appropriate to distinguish between contaminated and non-contaminated areas.

C. QUALITY ASSURANCE/QUALITY CONTROL

The NJDOH relied on the information provided by the NJDEP and the USEPA for quality assurance/quality control (QA/QC) information. Thus, it must be assumed that the proper procedures were followed with regard to chain-of-custody, laboratory analyses and data reporting if there were no negative declarations.

Environmental samples were analyzed under the guidelines of the USEPA Certified Laboratory Program. Analytical data were validated either by the NJDEP or the USEPA. While proper quality assurance and control measures were generally followed during sample collection and analyses, the quality of the data may have been affected by quality control sample contamination for some of the samples.

D. PHYSICAL AND OTHER HAZARDS

Physical hazards exist at the study sites due to the activities needed to remediate the sites. These hazards include deep holes, heavy machinery and miscellaneous equipment.

E. TOXIC CHEMICAL RELEASE INVENTORY DATA

The Toxic Chemical Release Inventory (TRI), developed by the USEPA, estimates the annual release of toxic substances into the environment (air, water, and soil) by industries. The NJDOH conducted a search of the TRI, from 1987 through 1990, to identify facilities that had toxic chemical releases near the sites. No discharges were found pertinent to the MWG sites.

PATHWAY ANALYSES

To determine whether nearby residents are exposed to contaminants migrating from the site, the NJDOH evaluates the environmental and human components that lead to human exposure. Pathway analysis consists of five elements: A source of contamination, transport through an environmental medium, a point of exposure, a route of exposure, and an exposed population.

The NJDOH categorizes an exposure pathway as a completed or potential exposure pathway if the exposure pathway cannot be eliminated. Completed pathways require that the five elements exist and indicate that exposure to a contaminant has occurred in the past, is currently occurring, or will occur in the future. Potential pathways, however, require that at least one of the five elements is missing, but could exist. Potential exposure pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. Table 5 identifies the completed exposure pathways. Table 6 identifies the potential exposure pathways. The discussions that follow these tables incorporate only those pathways that are important and relevant to the site.

A. COMPLETED EXPOSURE PATHWAYS

Operations began for U.S. Radium Corp. in 1915 extracting radium from ore for use as a luminescent paint on various equipment. They deposited the tailings as fill at undeveloped areas around their facility which were subsequently developed. Painting the luminescent paint became a cottage industry in which many people did the work at home, resulting in radioactive contamination. The NJDOH considers the length of time that a person is a resident of a house is 30 years. Thus, the assumed duration for chronic exposures in the study areas is assumed to be 30 years.

Health concerns derive from radiation exposure. Radon gas is mainly an alpha emitter while radium and thorium emit alpha particles and gamma rays. Completed exposure pathways are limited to those pathways associated with soil, indoor air, and/or building materials containing above background levels of radioactive contamination (Table 5).

Residential Air

The primary route of exposure is via inhalation of radon-222 and its decay progeny, particularly polonium, in the lung. All houses known to have elevated indoor radon levels have been temporarily abated until they can be remediated. Remediation will continue until all of the affected properties are cleaned up.

Approximately 290 residents (ATSDR assumes that there are 2.5 residents per home) in the Montclair study area, 30 residents in the West Orange study area, 210 residents in the Glen Ridge study (A total population of approximately 530) have been exposed to excessive radon concentrations (Table 3) for up to 30 years in the past. The properties have been abated until the USEPA can fully remediate .

Residential Soil

The primary route of exposure is by the ingestion of radium-contaminated soil. Ingestion occurs if food containing contaminated dust or soil particles is eaten or if oral contact is made with soil-laden hands. Adults may ingest small amounts of soil (usually around 100 mg/day) while children may ingest somewhat more (approximately 200 mg/day).

A second route of exposure for radium-226, thorium-230, or the uranium-238 decay products is via exposure of the entire body to penetrating gamma radiation. Individuals at risk are those in direct contact with, or close to, soil containing gamma emitting isotopes.

Exposure to soil emitting gamma radiation may occur in the yards of homes that have not yet been remediated. The exposed population via this pathway are the residents that live in those houses.

Residents were exposed to radioactive soil in the past for up to 30 years and at the present time. This consists of the approximately 290 residents of Montclair, 30 residents of West Orange, and 210 residents of Glen Ridge.

Public Areas

There are excessive concentrations of radium-226 at Barrow's Field in Glen Ridge. The playfield contains soil contaminated with up to 1500 pCi/g of radium-226/thorium-230. There is a possibility that the Township residents who frequented the field over a prolonged period of time may have become exposed to significant levels of gamma radiation. Residents had direct access to radioactive soils or may have entered contaminated areas during athletic activities. It is also possible that they could have repeatedly walked over these radioactive soils. It is estimated that 100 township residents may have been exposed through ingestion, dermal absorption, and whole body penetration exposure to the contamination at Barrow's Field in the past during a period of 30 years. Presently the park has been closed pending remediation, minimizing any current potential for exposure.

Residence Construction Materials

At the MWG site, there are houses that contain building materials, such as mortar, cement, gravel and wood contaminated with radium-226, thorium-230, and/or uranium-238 at concentrations greater than 15 pCi/g. The route of exposure is via whole body penetration by gamma radiation. These houses were contaminated as a result of the cottage industry that was built around U.S. Radium Corporation. Thirty-eight houses are contaminated and have a total of approximately 100 residents. Exposure occurred in the past for up to 30 years. Temporary abatement measures have been implemented.

B. POTENTIAL EXPOSURE PATHWAYS

Soil Pathway

Residents who live adjacent to properties that contain radioactive soil are subject to potential exposure in the past and at the present time. The number of people in this category is assumed to be large but is not known.

Table 5 - Completed Exposure Pathways.

EXPOSURE PATHWAY ELEMENTS					
SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION	TIME
U.S. Radium Corp.	Air	Interior of Homes	Inhalation	Residents of homes	Past
U.S. Radium Corp.	Soil	Residential Yards	Ingestion, Whole body Penetration	Residents of homes	Past, Present
U.S. Radium Corp.	Soil	Barrow Field	Ingestion, Dermal or Whole body Penetration	Township Residents	Past
U.S. Radium Corp.	Construction Materials	Homes	Whole body Penetration	Residents of Homes	Past

Table 6 - Potential Exposure Pathways.

EXPOSURE PATHWAY ELEMENTS					TIME
SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION	
U.S. Radium Corp.	Soil	Residential Yards	Ingestion, Whole Body Penetration	Neighborhood Residents	Past, Present

PUBLIC HEALTH IMPLICATIONS

In this section, the NJDOH will discuss the health effects in persons exposed to specific contaminants, evaluate state and local health databases, and address specific community health concerns. To evaluate health effects, ATSDR has developed a Minimal Risk Level (MRL) for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily human exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRL's are developed for each route of exposure, such as ingestion and inhalation, and for the length of exposure, such as acute (less than 14 days), intermediate (15 to 364 days) and chronic (greater than 365 days). ATSDR presents these MRL's in Toxicological Profiles. These chemical-specific profiles provide information on health effects, environmental transport, human exposure, and regulatory status. In the following discussion, ATSDR Toxicological Profiles were used for several different radioisotopes.

No MRL's have been established for radon or for radium/thorium. The ATSDR Toxicological Profiles were used to determine if the radioisotopes found at the sites were in sufficient concentrations to cause chronic adverse health effects.

A. TOXICOLOGICAL EVALUATION

The toxicological effects of the contaminants detected in the soil and building materials have been considered singularly. The cumulative or synergistic effects of mixtures of contaminants may serve to enhance their public health significance. Additionally, individual or mixtures of contaminants may have the ability to produce greater adverse health effects in children as compared to adults. This situation depends upon the specific chemical being ingested or inhaled, its pharmacokinetics in children and adults, and its toxicity in children and adults.

All ionizing radiation can cause damage by ionization of organic molecules (especially DNA), thus, producing chemical rearrangements that may lead to cellular damage. This can result in carcinogenic, mutagenic and/or teratogenic effects.

Radon

Radon-222 is a naturally occurring odorless, tasteless and colorless radioactive gas with a half-life of 3.8 days (2, 11). It results from the radioactive decay of radium-226 (Appendix 6). Radon gas can move through the interstitial spaces of soil and rock and can penetrate a house through cracks and/or openings in the building's foundation floor or walls. After Rn-222 decays, the progeny are electrically charged and will attach to particulates in the lung, e.g., moisture, dust, or the lining of the lungs. As the polonium-218 decays, lead-214 and bismuth-214 are sequentially produced which are beta and gamma emitters. Then, polonium-214 is produced which emits alpha radiation (Appendix 6). Thus, damage to the lung tissue and lung cancer is caused primarily by radon's progeny rather than by radon gas directly. Even though some of the progeny are short-lived decay products, they are continuously being replenished by the decay of radon-222.

In the past, residents of homes containing elevated levels of radon gas have been exposed for a maximum duration of 30 years. The population exposed to excess radon consists of approximately 530 residents at the MWG site (Table 3). Radon-222 was found in air samples at maximum concentrations of 310.0, 48.4 and 57.4 pCi/L for the Montclair, West Orange, and Glen Ridge study areas, respectively (Table 4).

There is no current chronic oral Minimum Risk Level (MRL) or USEPA oral Reference Dose (RFD) values for radon or its progeny. However, a conservative estimation is that there is no threshold level for human exposure for radioactivity. The USEPA clean-up level for residential radon levels is 4 pCi/L. This was exceeded in homes for all three study areas.

Based upon maximum levels of radon detected in indoor air samples, the estimated chronic exposure dose is significantly below the Lowest Observed Adverse Effect Level (LOAEL) for animals. It is unknown if radon was at sufficient levels in the four study areas to have caused direct or indirect adverse non-cancer health effects.

An excess cancer incidence, associated with chronic excess radon exposure, is documented in the literature among people who resided in homes contaminated with excess radon between two and 30 years (2). At a concentration as low as 1.5 pCi/L, increases in the incidence of lung cancer were observed. This was the lowest concentration that resulted in elevated lung cancer rates due to excess radon exposure as reported in the ATSDR Profile for Radon (2). Elevated lung cancer rates were observed via occupational exposure to 30 pCi/L or greater of radon for more than ten years. Other human studies indicated that increased rates of lung cancer occurred when humans were exposed to radon between one month and 30 years at concentrations of up to 400 pCi/L.

Radium/Thorium

Radium is a virtually ubiquitous naturally occurring metal in soil (1). It is naturally found in water and rock-forming minerals at low concentrations. The half-life of radium-226 is 1600 years (Figure 1). Four isotopes of radium are naturally occurring, radium-223, -224, -226 and -228. Radium-226 is the most prevalent natural isotope. Radium can replace calcium in the bones, therefore, bones are target organs and an excess radium dose can result in bone and bone marrow cancers. The lungs are target organs when radium is deposited in the lungs during inhalation exposure. Similarly, the gastrointestinal tract may also be a target organ system when radium contaminated soil is ingested. Thus, the type of cancer that may be contracted is directly related to the route of entry into the body (1).

Thorium is a ubiquitous naturally occurring radioactive metal (3). The predominant naturally occurring isotope of thorium is thorium-232, with a half-life of 1.4 X 10^{10} years. Thorium-230, with a half-life of 80,000 years, breaks down to radium-226 (Appendix 6).

The major exposure pathways for gamma radiation are ingestion of radium-226/thorium-230 containing soils and whole body penetration. The population exposed to radium-226/thorium-230 consists of approximately 600 residents at the MWG site (Table 3). The duration of exposure is assumed to be 30 years in the past and may continue to occur at the present time in unabated residences. The maximum concentration of radium-226/thorium-230 detected in soil samples was 2, 315, 530, and 688 pCi/g for the Montclair, West Orange, and Glen Ridge study areas, respectively (Table 4).

The source of gamma radiation was residential soils that contained radium-226 and, less frequently, thorium-230. At the Montclair study area 38 homes were contaminated with radioactive building materials. The only non-residential exposure occurred at Barrow's Field in Glen Ridge, a public playground. It was frequented by approximately 100 children and adults for up to 30 years.

There is no current chronic oral Minimum Risk Level (MRL), Cancer Risk Evaluation Guide (CREG), or Lowest Observed Adverse Effect Level (LOAEL) cited in the ATSDR Toxicological Profile for ingestion exposures and consequent radiation of chronic duration to radium or thorium. In 40 CFR 192.12, the maximum allowable exposure is 25 mR/yr for uranium and thorium mill tailings. There are no health guidelines for non-cancer effects for radium given by either the ATSDR or the USEPA. Thus, the likelihood for adverse chronic carcinogenic and non-carcinogenic effects cannot be quantified.

There are few human studies regarding chronic exposure to radium via the ingestion and inhalation routes, and, similarly, no studies have been reported for chronic dermal absorption (3). Animal studies have centered on carcinomas via ingestion. Radium dial painters, who ingested radium, were found to have had anemia, osteosarcomas, and head carcinomas. Chronic oral exposure in humans has been associated with osteosarcomas. Men who had chronic oral exposure to radium at concentrations higher than those found at this site have exhibited non-cancerous effects such as leukopenia, bronchopneumonia, secondary anemia, necrosis of the jaw, brain abscesses, and death. However, other etiologies may have had an impact.

Elderly human subjects who ingested mock radium dial paint containing $^{224}RaSO_4$ excreted approximately 80% of the radium with the feces ten days after ingestion. The remaining radium was retained and systemically distributed. Other studies have shown that retained radium is deposited in the skeletal system. Thus, chronic exposure may result in the maintenance of elevated levels of radium in the body.

Animal studies have shown that the chronic inhalation of high concentrations of thorium dust (Concentrations greater than that found at the study areas) may result in cancer of the lung, bone or pancreas, genetic damage, lung damage, and death from metal poisoning (3). Thus, the potential for adverse health effects resulting from thorium exposure from soil cannot be determined at the study areas.

It is possible that residents may have cultivated and subsequently ingested vegetables that were grown in radium/thorium contaminated soil. This would add to the total gamma radiation body burden. No data were available for review and evaluation regarding bioaccumulation from edible plants and vegetables.

It is possible for passersby to be exposed to gamma radiation emitted from a contaminated yard. Gamma radiation dosage is a function of duration of exposure, contaminant depth in the soil, and distance from the source. Normally, a passerby would be exposed for a very short duration (from seconds to minutes). The contaminated soil is usually found between one to three feet below the surface. The amount of radiation is inversely proportional to the square of the distance from the source. Thus, a resident of a study area casually walking past a source of contamination should not be exposed to a sufficient dose of gamma radiation from radium/thorium to result in adverse health effects.

Barrow's Field in Glen Ridge has been used by the community as a recreational park for the past 30 years. The Township residents probably spent several hours at a time at the park picnicking, walking around, and/or playing ball. Since the residential turnover rate for the community is very low, it is expected that the Township residents have probably used the park for much of their lives. Barrow's Field was found to contain a maximum concentration of radium/thorium of 1500 pCi/g of soil. Thus, the possibility exists that the residents who frequented the park for extended periods of time may have been exposed to gamma radiation at levels above background.

Residents of 55 homes contaminated with radioactive building materials have been exposed as a function of the duration that they were in the proximity of the source of gamma radiation. The houses contained at least 30 μR/h of gamma radiation versus a background level of 8 μR/h. Such exposure over a period of 30 years may result in an elevated cancer risk.

There is considered to be no threshold level for gamma radiation. The concentrations of gamma radiation detected in soil samples and in homes with contaminated building materials are orders of magnitude greater than background concentrations. Thus, an elevated excess cancer risk may be associated with past chronic exposure to the contaminated residences and Barrow's Field resulting from exposure to radium and thorium.

B. HEALTH OUTCOME DATA EVALUATION

Available health outcome data were presented in an epidemiological study conducted by Klotz, Petix and Zagraniski of the NJDOH (5). This study was a historical cohort mortality analysis of the Montclair, West Orange and Glen Ridge study areas. This study investigated mortality patterns of 752 persons who lived for a minimum of one year, between 1923 and 1983, in 45 homes contaminated by radon gas over 4 pCi/L at the time of the initial assessment in 1983. An increase in the rate of lung cancer was found for white males in the study group but was not statistically significant due to the small size of the study population. However, there is sufficient human epidemiologic data to indicate that the excess lung cancer observed is consistent with the size of the population exposed and the estimated amount of exposure.

C. COMMUNITY HEALTH CONCERNS EVALUATION

Community concerns regarding the MWO radium contamination site may be summarized as follows:

1. Citizens are concerned about cleanup efforts and the length of time needed for remediation.

The USEPA is trying to remediate the site as rapidly as possible. Remediation efforts are lengthy due to the large amount of work needed to be done at each property and due to the precautions that must be taken to assure worker and residential protection. The USEPA intends to continue their screening of houses for elevated radiation levels until they have screened all of the houses in the study areas.

2. Citizens want to know the effects of the discovery of elevated radioactivity levels on property values.

The effect of discovering elevated radioactivity levels could initially exert a negative effect on property values. However, remediation of these houses should restore and perhaps even increase their values because the houses no longer have significant radioactivity levels and the work done to remediate the houses should improve the overall condition of the houses.

3. Citizens are concerned about the possibility of cancers resulting from excess radon and gamma radiation exposure.

It is possible that significant amounts of exposure has occurred in the past. It is, likewise, possible that elevated rates of cancer incidence have occurred. The epidemiological study reported in the Health Outcome Data Evaluation section indicates that elevated levels of lung cancer may have occurred. However, this cannot be determined from the existing information.

Public Comment Period

The New Jersey Department of Health (NJDOH) conducted a public comment period for the Public Health Assessment for the Montclair/West Orange/Glen Ridge Radium Contamination site from September 23, 1994 to October 28, 1994. The Public Health Assessment was placed in local repositories to facilitate commentary and reaction from the public at large. Additionally, the Public Health Assessment was circulated to the Bloomfield Twp. Board of Health, West Orange Department of Health, East Orange Board of Health, and the Montclair Health Department for the purpose of soliciting commentary by local health officials.

The NJDOH did not receive commentary regarding the public health assessment for the Montclair/West Orange/Glen Ridge Radium Contamination site during the public comment period.

CONCLUSIONS

1. Based upon the review of site data and information, ATSDR and the NJDOH have concluded that the Montclair/West Orange/Glen Ridge Radium Contamination site posed a public health hazard in the past (Prior to the remedial activities completed or underway at the site[s]). Chronic exposure to excess radon and its progeny occurred in residences, and the presence of radium in residential soils and building materials resulted in chronic exposure to gamma radiation in excess of background levels. Furthermore, the site(s) currently are evaluated to be an indeterminate public health hazard to occupants of those residences in sections of study areas which remain to be screened during future remedial activities.

2. The remedial activities which have been conducted at the site by the USEPA were appropriate and effective in eliminating the human exposure pathways identified at those properties which have been screened, and are consistent with protection of the public health.

3. The Health Assessment for the MWG study areas (Appendix 5) considered the sites to be of public health concern. Additional information and community concerns were sufficient to warrant a new public health assessment.

4. For 30 years in the past and at the present time, until all surveys and abatements are completed, about 290 residents at the Montclair site, 30 residents at the West Orange site, 210 residents at the Glen Ridge site, and 100 Glen Ridge residents who frequented Barrow's Field may have been exposed to hazardous concentrations of radon and/or radium/thorium.

5. Community health concerns focused on remediation efforts, adverse health effects, and property values.

6. Passersby who walk past soils contaminated with excess radium/thorium probably receive an insufficient exposure to warrant health concerns.

7. The potential for adverse health effects resulting from groundwater contamination is not considered to be a viable concern because the residents in the site use city water supplies.

However, the potential for adverse health effects exist if the bedrock aquifer becomes contaminated with radium/thorium.

8. Many houses in the three study areas have not yet been evaluated for elevated radiation levels. Residents of these houses may continue to be exposed to excess radiation until the houses are screened and abated.

9. Preliminary analyses found that non-radioactive toxicants were in elevated concentrations. Thus, they may be of concern. There is insufficient information to determine the possibility that non-cancer health effects may have occurred as a result of toxic exposures.

RECOMMENDATIONS

Cease/ Reduce Exposure Recommendations

1. The exposed residents should be educated regarding the health issues of past exposure to the relevant contaminants.

Site Characterization Recommendations

1. The ATSDR and the NJDOH concur with USEPA's remedial plan for the site(s), and encourage the following specific actions:

   * Completion of the screening of all homes at the MWG sites for elevated radiation levels;

   * Continuation of temporary abatement measures for all additional homes found to be contaminated with excess radon and/or radium/thorium;

   * Determination of the nature and extent of any nonradioactive chemical toxicants that emanated from the U.S. Radium facility.

Health Activities Recommendations Panel (HARP) Statement

The data and information developed in the Public Health Assessment for the Montclair/West Orange/Glen Ridge sites, East Orange Townships, New Jersey, has been evaluated by ATSDR's Health Activities Recommendation Panel (HARP) for appropriate follow-up with respect to health activities. The panel determined that the community health education being conducted by the U.S. EPA is appropriate. In addition, the panel determined that because of the limited cancer data, a health statistics review is needed.

Public Health Action Plan

The Public Health Action Plan (PHAP) for the Montclair/West Orange/Glen Ridge site contains a description of actions to be taken by the NJDOH and/or the ATSDR at the site subsequent to the completion of this public health assessment. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment by the NJDOH and the ATSDR to follow-up on this plan to ensure that it is implemented.

A. Public Health Actions Taken

1. Environmental data and proposed remedial activities have been evaluated within the context of human exposure pathways and relevant public health issues.

B. Public Health Actions Planned

1. NJDOH will work with the ATSDR to develop a mechanism to fund a health statistics review to further evaluate the incidence of cancer in the community.

2. ATSDR and the NJDOH will coordinate with the appropriate environmental agencies to develop plans to implement the cease/reduce exposure and site characterization recommendations contained in this health assessment.

3. ATSDR will provide an annual follow-up to this PHAP, outlining the actions completed and those in progress. This report will be placed in repositories that contain copies of this health assessment, and will be provided to persons who request it.

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

CERTIFICATION

The Public Health Assessment for the Montclair/West Orange/Glen Ridge Radium Contamination sites was prepared by the New Jersey Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was initiated.

Gregory V. Ulirsch

Technical Project Officer, SPS, SSAB, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Public Health Assessment and concurs with its findings.

Lisa C. Hayes /for

Division Director, DHAC, ATSDR

PREPARERS OF REPORT

Preparers of Report:

Howard E. Rubin, Ph.D.
Research Scientist
New Jersey Department of Health

ATSDR Regional Representatives:

Arthur Block
Senior Regional Representative
Regional Services
Office of the Assistant Administrator

ATSDR Technical Project Officer:

Gregory V. Ulirsch
Environmental Health Engineer
Superfund Site Assessment Branch
Division of Health Assessment and Consultation

Any questions concerning this document should be directed to:

James Pasqualo, ATSDR Project Manager
The New Jersey Department of Health
Environmental Health Service,
210 South Broad St.
CN 360
Trenton, NJ 08625

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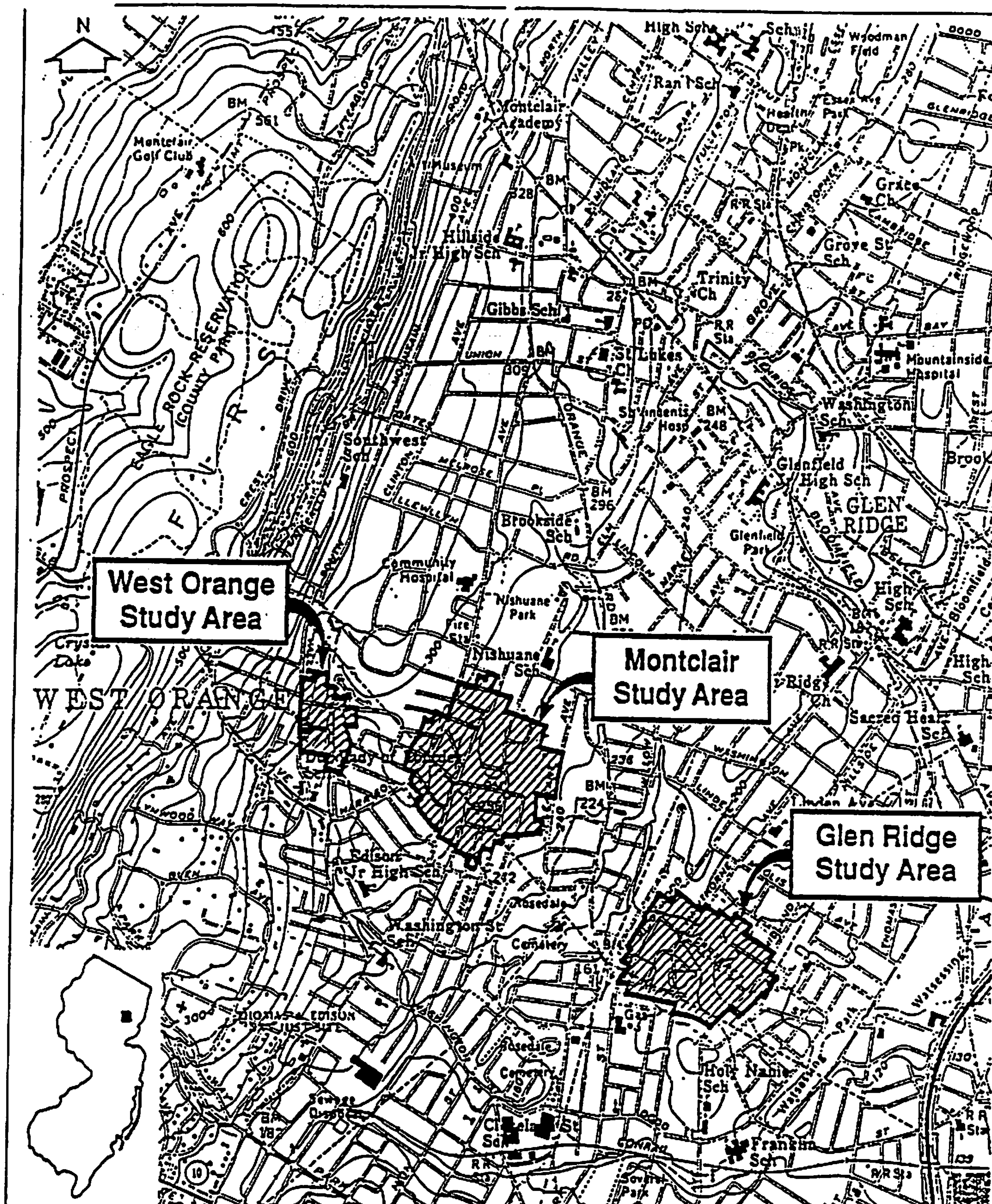
APPENDICES



Scale: 1"=2,000'

Source: U.S.G.S. Orange, N.J. Quadrangle

CDM

environmental engineers, scientists, planners & management consultants

Figure 1-1

Location of Three Study Areas

Montclair/West Orange and Glen Ridge Radium Sites

CDM

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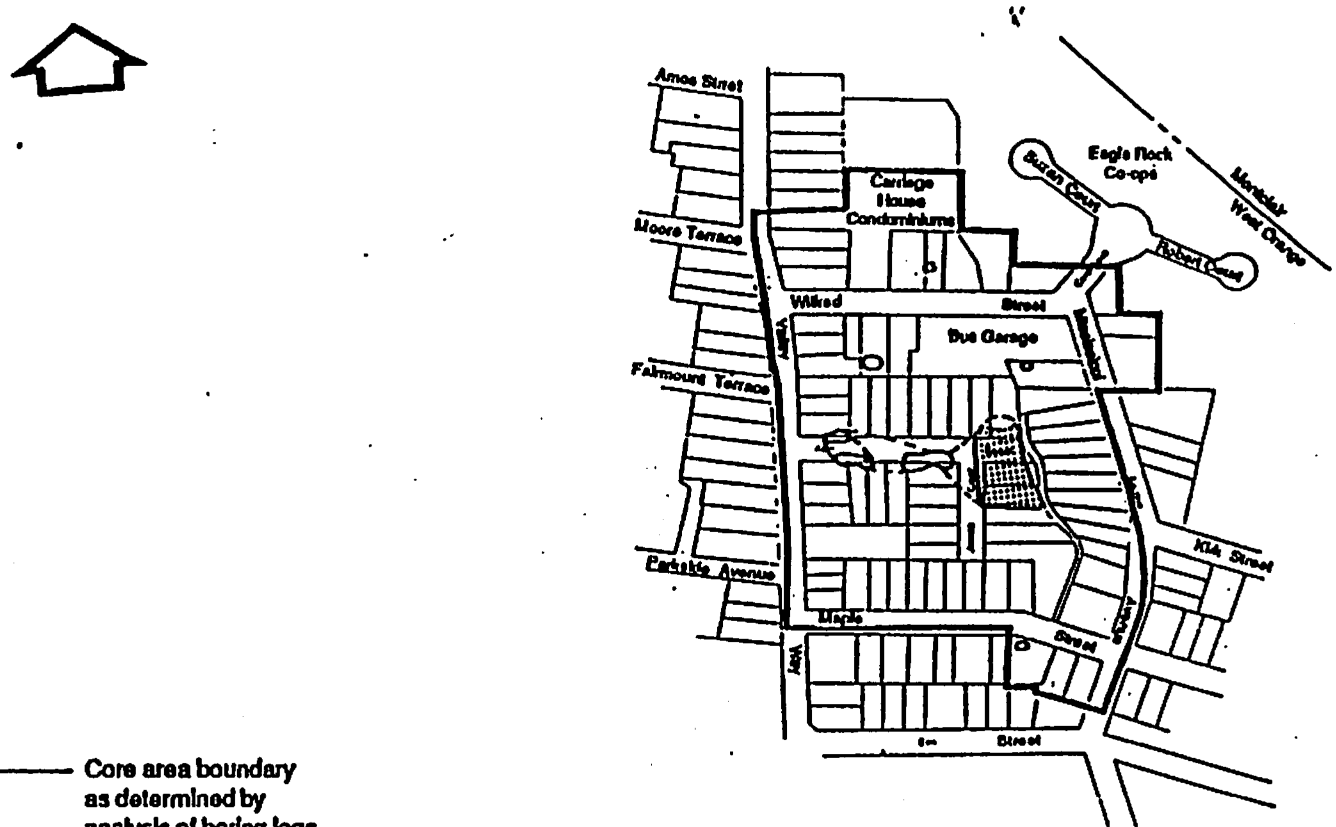
Montclair Study Area

Montclair/West Orange and Glen Ridge Radium Sites



——— Core area boundary as determined by analysis of boring logs.

– – – – Estimated boundary of redistributed core material as determined by analysis of indoor and outdoor gamma levels.

Core areas.

Study area perimeter

Discrete pockets of contamination as determined by borings.

0 500
scale feet (approximate)

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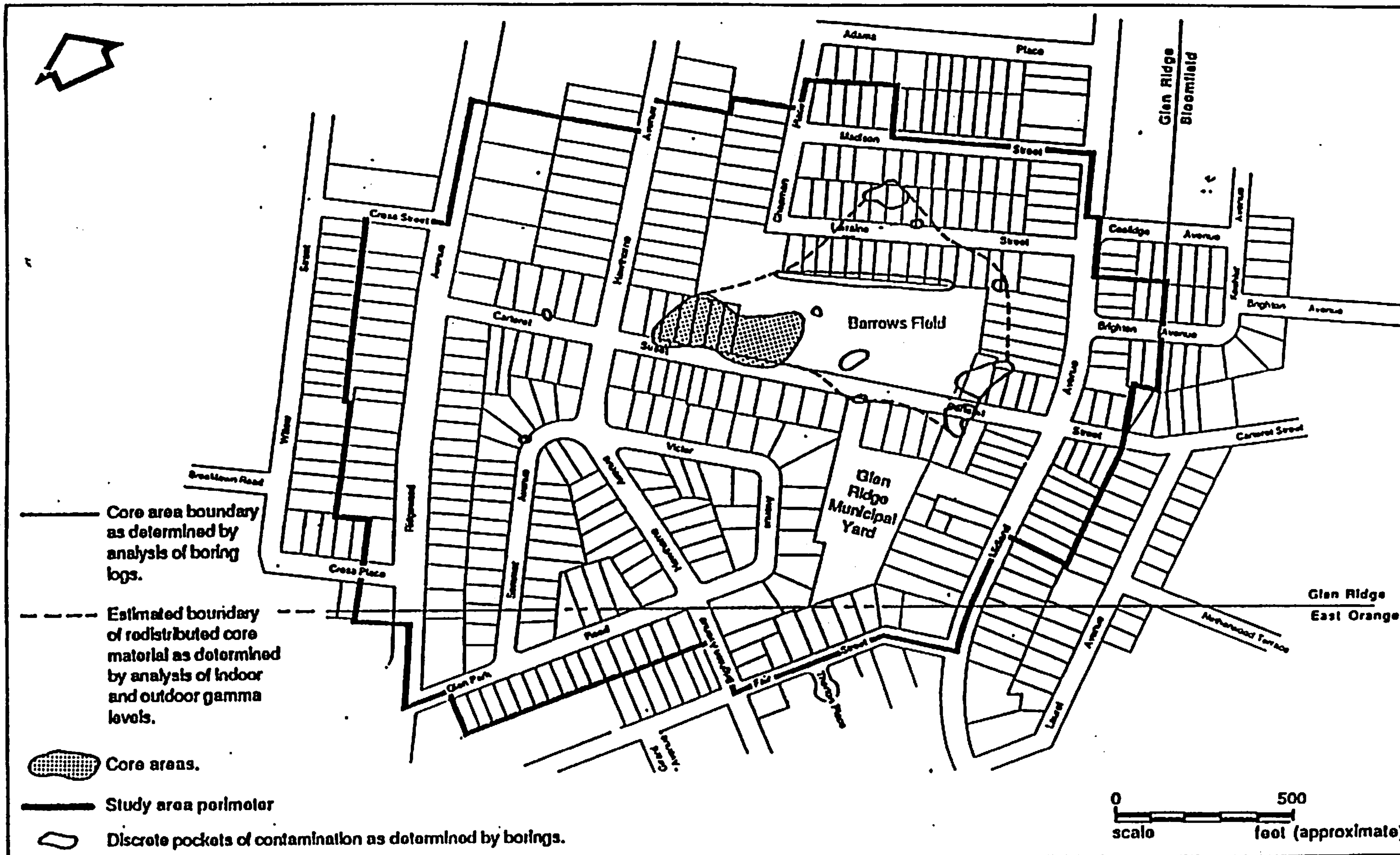
West Orange Study Area

Montclair/West Orange and Glen Ridge Radium Sites



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Glen Ridge Study Area

Montclair/West Orange and Glen Ridge Radium Sites

APPENDIX 5

Health Assessment for
Montclair, Glen Ridge and West Orange, N.J.

November 12, 1986

Center for Environmental Health
Centers for Disease Control

Background

In the past, health assessments by the Centers for Disease Control[1] for residents of Montclair, West Orange and Glen Ridge, New Jersey have assumed that future exposure would be limited to a relatively short period (about two years) rather than extending over a long period of time. Over a short time, residents may alter their behavior in order to lower their risk, but over many years a number of factors can change that make reliance on changes in behavior an unreliable way of decreasing exposures. Some of these factors are:

1. necessary repairs or alterations in the house or repairs to driveways, sidewalks, etc.

2. changes in living patterns
   addition of children
   change in age of children
   retirement - increased leisure time
   addition of pets
   change in economic status
   sale or lease of the home

3. changes in perception of risk over time.

The following assessment was designed to evaluate the long-term risks to residents of Montclair and Glen Ridge and to evaluate new environmental and exposure data that have become available. This assessment was based on data provided by the U.S. EPA region II, Emergency Response and Remedial Division and Region II REM contractor, Camp Dresser and McKee Inc. This assessment considers exposures due to soil ingestion, vegetable ingestion, soil disturbance, whole-body external gamma radiation, radon, and water contamination. The risks given in this assessment are excess risks and do not include the background risk for cancer.

Soil Ingestion

The direct ingestion of soil can be an important environmental pathway of radiation exposure for children in Montclair, West Orange and Glen Ridge. Children may ingest soil including sub-surface soil during play if their activities involve digging or if the ground has been cultivated. In Glen Ridge, core samples analyzed at depths from 0.5 to 1.0 feet ranged from 45 to 2,200 pci/gm for radium^{226} and in Montclair up to 2,000 pci/gm. (Data are not available for West Orange.) While surface samples were not taken, a limited number of organic soil samples at 0.5 ft. had an average concentration of 100 pci/gm indicating that elevated concentrations do exist at the surface so that children may ingest contaminated soil. Other radioactive isotopes are also present above background levels and will be ingested along with radium including isotopes of uranium, thorium and lead. The equilibrium ratios for each isotope relative to radium ^{226} are given in Table A of the appendix for the most important isotopes.

In calculations of the risk to children, we assumed that children ages 1 to 6 ingest from 0.181 grams to 1.8 grams of soil per day.[3] The activity ingested for each isotope is given in the appendix in Table B. Actual exposures to children will vary widely. Children playing on highly contaminated areas could easily ingest the average surface concentration daily and peak concentrations regularly. Children playing on less contaminated areas may ingest background levels primarily mixed with occassional extreme exposures. However, for all children the potential for exposure to elevated levels is substantial. We have assumed that children are exposed to 100 pci/gm or 40 pci/gm daily and to concentrations of 2,000 pci/gm for 7 days each year. For exposures at average soil concentrations of 100 pci/gm or 40 pci/gm plus occasional exposures to peak concentrations of 2,000 pci/gm, the total committed dose to bone is 62 and 38 rem respectively (this includes 19 rem from the 7 day exposure to 2000 pci/gm). The 50 year committed dose to bone from selected isotopes is given in Table 1[2]. Estimates for the lifetime risk of dying from bone cancer range from 5 $X10^{-6}$ per rem [4] to 27 X 10^{-6} per rem [5] to bone. The excess risk of dying from bone cancer for individuals who ingested dirt as children for 5 years at 100 pci/gm or 40 pci/gm (plus 7 day/yr exposures to 2,000 pci/gm) of each isotope in Table 1 is 3 - 16 X 10^{-4} and 2 - 10 X 10^{-4} respectively.

Table 1
Fifty year committed dose in REM to bone from direct soil ingestion by children over ages 1 - 6

Isotope	soil concentration (pci/gm) 100	40
Ra^{266+D}	9.0 - 90	3.9 - 39
Th^{232+D}	0.054 - 0.54	0.023 - 0.23
Th^{230+D}	0.060 - 0.60	0.026 - 0.26
Pb^{210+D}	0.45 - 4.5	0.20 - 2.0
total	9.6 - 96	4.1 - 41
median	43 rem	19 rem

3.0 X 10^5 mrem/microcurie ingested (ref. 2)

Prevention of soil ingestion on any long term basis would imply constant supervision of children or not allowing them to play outside. Both of these alternatives are unrealistic. Restriction of areas of high contamination in the form of behavior changes or physical barriers does not seem feasible in most instances because without physical barriers children will not avoid "forbidden" areas when unsupervised and because some "hot" areas surround significant portions of residences.

Ingestion of Radium - 226 through vegetables

Gardens located in areas of contamination will lead to the ingestion of radium^{226} through vegetable consumption for both adults and children. Table 2 gives the lifetime risk of death from bone cancer from eating vegetables grown at various soil concentrations from radium^{226} only. These calculations assume that residents obtain 50% of their vegetables from their own garden or 56 kgm each year per person in the average household.[2]

Table 2
Lifetime risk of death from bone cancer from ingestion of vegetables grown in radium^{226} contaminated soil over 60 years+

radium content of soil(pci/gm)	50 yr. committed dose per year of ingestion (Rem)	lifetime risk 60 year exposure	lifetime risk one year exposure
2,000	25.6	$8 - 42 \times 10^{-3}$	$1 - 7 \times 10^{-4}$
500	6.4	$2 - 10 \times 10^{-3}$	$3 - 17 \times 10^{-5}$
100	1.3	$4 - 21 \times 10^{-4}$	$6 - 35 \times 10^{-6}$
40	0.5	$1 - 7 \times 10^{-4}$	$2 - 11 \times 10^{-6}$

+ 3.0×10^5 mrem/microcurie ingested (ref. 2)
1.4×10^{-3} (pci/kgm plant)/(pci/kgm soil)

The risks from bone cancer and doses to bone associated from the ingestion of Pb^{210} in vegetables are given in Table 3. It is expected that Ra^{226} and Pb^{210} will provide the most significant exposures through this route.

Table 3
Lifetime risk of death from bone cancer from ingesting vegtables grown in soil contaminated with Pb^{210}

lead -210 content of soil(pci/gm)	50 yr. committed dose per year of ingestion (Rem)	lifetime risk 60 year exposure	lifetime risk for one year exposure
2,000	114	$3 - 18 \times 10^{-2}$	$5 - 30 \times 10^{-4}$
500	28	$8 - 43 \times 10^{-3}$	$1 - 7 \times 10^{-4}$
100	6	$2 - 9 \times 10^{-3}$	$3 - 15 \times 10^{-5}$
40	2	$7 - 36 \times 10^{-4}$	$1 - 6 \times 10^{-5}$

6.8×10^{-2} (uci/kg plant)/(uci/kg soil)
1.5×10^4 mrem/uci ingested

Table 4 gives the total lifetime risk of dy... ..om bone cancer for vegetable ingestion routes. Each year residents live on contaminated porperty, their excess risk of dying from bone cancer may increase by 0.13 - 37 X 10^{-4} from vegetable consumption.

Table 4
Total Lifetime risk of dying from bone cancer from vegetable ingestion pathways

soil concentration (pci/gm)	lifetime risk 60 year exposure
2,000	4 - 22 X 10^{-2}
500	1 - 5 X 10^{-2}
100	2 - 11 X 10^{-3}
40	8 - 42 X 10^{-4}

Radium^{226} and Pb^{210} and their decay products give significant doses to organs other than bone when ingested. Ratio's between doses to other organs and to bone are given in Table C in the appendix. The organ doses from ingestion of vegetables at various soil concentrations of radium and lead are given in Table 5 for radium and lead. The risks from these exposures are difficult to predict because of the uncertainty in risk estimates for some organs. However, the dose to some organs is considerable even at moderately elevated levels.

Table 5
Committed dose in rem to organs from ingestion of Ra^{226} and Pb^{210} in vegetation per year

soil concentration (pci/gm)	Ra-226			Pb-210	
	whole body	GI tract	kidney	liver	kidney
2,000	19	26	14	32	91
500	5	7	3	8	22
100	0.9	1	0.7	2	5
40	0.4	0.5	0.3	0.6	2

Soil Disturbance

Both adults and children may come into direct contact with highly contaminated soil if the ground is disturbed by common activities such as cultivation for gardens, landscaping such as reseeding lawns or planting shrubs, flowers, trees, etc. and repairing or adding drivew..., walkways, decks and porches. These are common activities and should be expected even when residents have been warned about "hot" spots. Near surface contamination may be brought to the surface during any digging activity, greatly raising the potential for exposure. To expect residents to permanently (or even over several years) refrain from all of the activities listed above is unrealistic. Direct contamination of hands and clothing with highly contaminated soil is quite possible during gardening, etc. and could lead to excess internal and external exposures as well as contamination inside homes.

Gamma Radiation

Residents are exposed to whole-body external gamma radiation from buried radium waste in their yards and under their homes. Twelve properties are known to have a combination of indoor and outdoor exposures that could lead to doses above 250 mrem per year. Calculations have been made only for houses with indoor radon problems so that more residents may have exposures above 250 mrem than given here. The estimates of exposure used in this assessment were made by EPA and are based on 75% percent occupancy at the average basement level and 25% at the average outdoor level. Outdoor gamma levels exceed 50 microR/hr on thirty-two properties. Exposure rates of 300 microR/hr are fairly common and levels as high as 400 to 500 microR/hr occur in limited areas. Residents may receive significant doses from these elevated gamma levels. Actual doses are difficult to calculate or predict because the size of the dose depends heavily on the living patterns of each resident. A summary of gamma exposure data is given in Table 6.

Table 6
Summary of Gamma Exposure Data

	Number of Houses			
	Glen Ridge	Montclair	West Orange	total
soil removal fully or partially completed	4	5	0	9
indoor gamma shielding complete	2	2	1	5
estimated average gamma exposure larger than 250 mrem per year	2	7	3	12
outside gamma levels above 50 microR/hr	9	18	5	32

The risk estimate used in this report, 2×10^{-4} deaths/rem, from the National Council on Radiation Protection[4], includes the deaths in future generations due to the genetic effects of radiation. The lifetime risks including genetic effects for various dose levels are provided in Table 7. The risk due to cancer in the current generation is 1/2 the total risk given in the table. Residents who receive 250 mrem/yr have an additional excess risk of dying from radiation induced cancer of 2.8×10^{-5} each year they live in their home. At 500 mrem/year the residents' risk rises by 5.5×10^{-5} each year.

Table 7
Lifetime risk of death from radiogenic cancer and genetic effects from external gamma exposure

annual whole-body gamma exposure	lifetime risk+ 70 year exposure	lifetime risk from one year exposure
200 mrem	3.0×10^{-3}	4.3×10^{-5}
500 mrem	7.5×10^{-3}	1.1×10^{-4}
1,000 mrem	1.5×10^{-2}	2.1×10^{-4}

+ref. 4

Radon

Houses that were designated as "A" or "B" homes were ventilated by EPA to reduce radon exposure to those residents quickly.[1] Homes designated as "C" homes were only recently ventilated so that the success of ventilation can not be evaluated yet in those residences. However, data are available to calculate an annual average radon concentration for A and B homes. The average results for 4 consecutive quarters are given in Table 8. The data in Table 8 indicate that eight homes have average radon levels on the first floor above 0.02 wl and 10 homes have levels above 0.02 in the basement. Whether a basement should be considered a living area depends on how the particular homeowner uses the basement now or may use it in the future. Even at radon daughter concentrations of 0.02 wl the excess lifetime risk is $1 - 4 \times 10^{-4}$ for each year of exposure. At a concentration of 0.05 wl the risk per year of exposure rises to $0.4 - 2 \times 10^{-3}$. One side effect of remedial actions dependent on ventilation in these homes is that in about 9 homes the radon levels on the first floor are now higher than levels in the basement. Ventilated houses will require periodic monitoring to ensure that ventilation systems are still functioning. In addition, the ventilation systems themselves will require continual maintenance.

Table 8

Lifetime risk of death from lung cancer based on radon levels averaged over 4 quarters after ventilation in homes originally designated as A or B

working level	number of houses in each range		lifetime risk per 1000* 70 yr. exposure	lifetime risk per 1000 one year exposure
	living area	basement		
0.01			7 - 30	0.10 - 0.43
	4	3		
0.02			13 - 50	0.19 - 0.71
	5	7		
0.05			30 - 120	0.43 - 1.7
	3	0		
0.10			60 - 210	0.86 - 3.0

*EPA risk estimates for lifetime radon exposure

Water Contamination

While water samples have been analyzed for Ra^{226}, adequate data are not available on background water concentrations of radium in New Jersey to determine if ground water systems have been contaminated. Appropriate background values should be obtained for comparison with water samples already taken.

Summary

It is important to note that each resident may accrue an excess risk through each route of exposure described, including ingestion of radium and other radioisotopes, contamination of clothes and homes from contact with the soil, whole body external radiation and indoor radon. Since the half-life of $radium^{226}$ is about 1600 years, the concentrations of radium in the soil and the associated risks will not decrease over the lifetime of the residents nor over the useful life of the homes. Under current conditions the radium contaminated soil cannot be contained in a way that will prevent significant exposures to residents. Children playing in contaminated areas of Montclair, Glen Ridge or West Orange may ingest soil contaminated with radium, lead, uranium and thorium. The excess risk of dying from bone cancer from ingesting soil ranges from $0.2 - 1.6 \times 10^{-3}$. Ingestion can also occur through food chains. Both adults and children may consume vegetables grown in contaminated areas with an associated lifetime risk of $2 - 11 \times 10^{-3}$ at soil concentrations of 100 pci/gm for radium and lead. In addition organs other than bone will also receive significant doses from the ingestion pathway including the whole-body, the gastrointestinal tract, kidneys, and liver. The exposure from direct soil contact during gardening or other activities is more difficult to estimate. However, highly contaminated soil exists very close to the soil surface where it can be easily disturbed during any type of digging increasing the probability and severity of exposure through ingestion or external radiation. In addition, residents could easily carry contaminated soil into their homes on shoes and clothing.

Residents are exposed directly by gamma radiation from contamination surrounding or underneath their homes. Some estimates of gamma doses have been made but actual doses will depend upon the particular resident and how much time they spend indoors or in particular areas of their property. Calculations indicate that residents in 12 homes currently may receive over 250 mrem per year. The excess lifetime risk of dying from cancer for these residents from external gamma exposure is 2.0×10^{-3}. (If the genetic component of the risk is included the excess risk rises to 3.8×10^{-3}.)

While ventilation equipment was installed in many homes to lower indoor radon concentrations, 8 houses originally classified as tier A or B have average indoor levels above 0.02 wl with 3 above 0.05 wl. For lifetime exposure at 0.02 wl, the risk of dying from lung cancer ranges from $1 - 5 \times 10^{-2}$. Because of the large risk associated with radon, even at the recommended remedial action level, indoor radon concentrations should be lowered as much as possible below 0.02 wl.

While indoor radon poses the largest single risk to most residents, other exposure pathways cannot be ignored and must be addressed in plans to remediate Montclair, Glen Ridge and West Orange. Each year residents continue to live on contaminated areas their excess risk of dying due to radiation induced cancer increases significantly. This ongoing exposure adds to the risk these residents have already accrued while living in these homes. The annual excess risk to a significant number of residents clearly exceeds the 10^{-6} to 10^{-5} range. While it may not always be possible to lower the risks from environmental contaminants to below 10^{-5} or 10^{-6} (such as with indoor radon), the levels of risk to these residents from radioactively contaminated soil warrant expedient action to substantially lower the risk to current and future residents. Actions to lower exposure that depend upon permanent changes in behavior or on mechanical and barrier type systems that may be easily destroyed by residents during common home repairs or additions are not desirable means of lowering exposure and may be ineffective over long periods of time.

Appendix

Table A

ratios of radionuclides in core samples (some isotopes were not measured and values are estimated by CDM)

isotope	ratio
U^{238}	1
U^{234}	1
Th^{232}	10
Th^{230}	10
Ra^{226}	10
Pb^{210}	10

Table B
Ingestion in microcuries for Ra^{226}, Pb^{210}, Th^{232} and Th^{230} over five years by children

soil concentration pci/gm	5 year ingestion
100	0.03 - 0.33
40	0.013 - 0.13
2,000+	0.013 - 0.13

+ 7 day/yr exposure

Table C
Ratios of dose to organs and whole body to bone doses (dose X/dose bone)

organ	Ra^{226}+D	Pb^{210}+D
whole body	0.73	0.036
bone	1.0	1.0
kidney	0.53	0.80
GI-LLI	1.1	-
liver	-	0.29

(Brodsky)

References

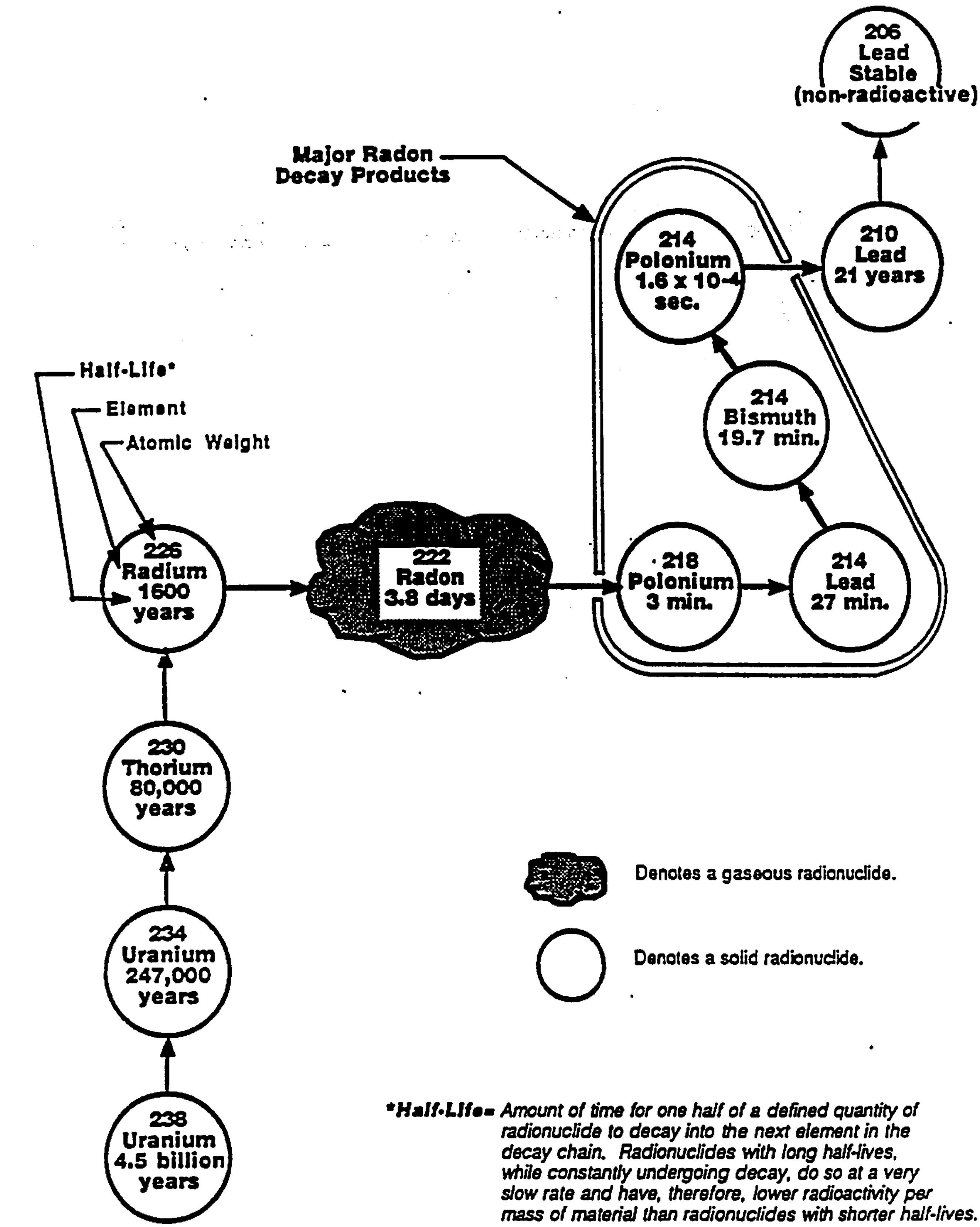
[1] Centers for Disease Control. Public Health Advisory for Montclair and Glen Ridge, New Jersey, December 6, 1983.

[2] Brodsky Allen, ed. Handbook of Radiation Measurement and Protection, vol 2. Biological and Mathemantical Information. CRC Press, Boca Raton, 1982.

[3] Binder Sue, David Sokal, David Maughan. Estimating Soil Ingestion: The use of tracer elements in estimating the amount of soil ingested by young children. In Press: Archives of Environmental Health.

[4] National Council on Radiation Protection and Measurements. Exposures from the Uranium Series with Emphasis on Radon and its Daughters, report no. 77, Bethesda. 1984.

[5] Committee on the Biological Effects of Ionizing Radiations. The effects on Populations of Exposure to Low Levels of Ionizing Radiation. National Academy Press, Washington DC, 1980.



***Half-Life=** *Amount of time for one half of a defined quantity of radionuclide to decay into the next element in the decay chain. Radionuclides with long half-lives, while constantly undergoing decay, do so at a very slow rate and have, therefore, lower radioactivity per mass of material than radionuclides with shorter half-lives.*

CDM

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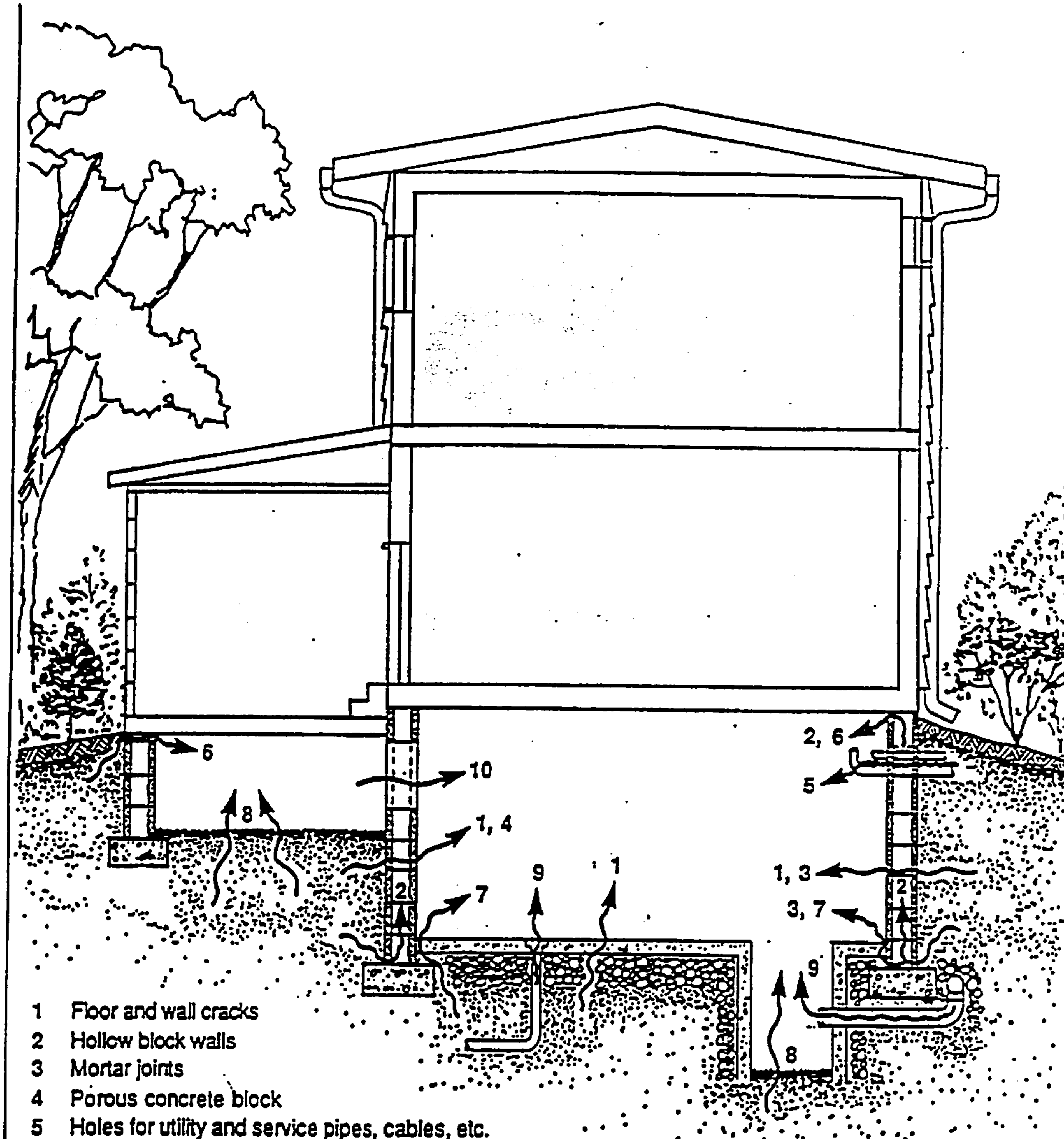
Major Radionuclides in the Uranium-238 Chain

Montclair/West Orange and Glen Ridge Radium Sites



1 Floor and wall cracks
2 Hollow block walls
3 Mortar joints
4 Porous concrete block
5 Holes for utility and service pipes, cables, etc.
6 Sill plate and header joist gaps
7 Slab - footing joints
8 Exposed soil
9 Drains, sumps and weeping(drain) tiles
10 Crawl spaces

Not to Scale

Adapted from "Radon Reduction Techniques for Detached Houses; Technical Guidance," USEPA

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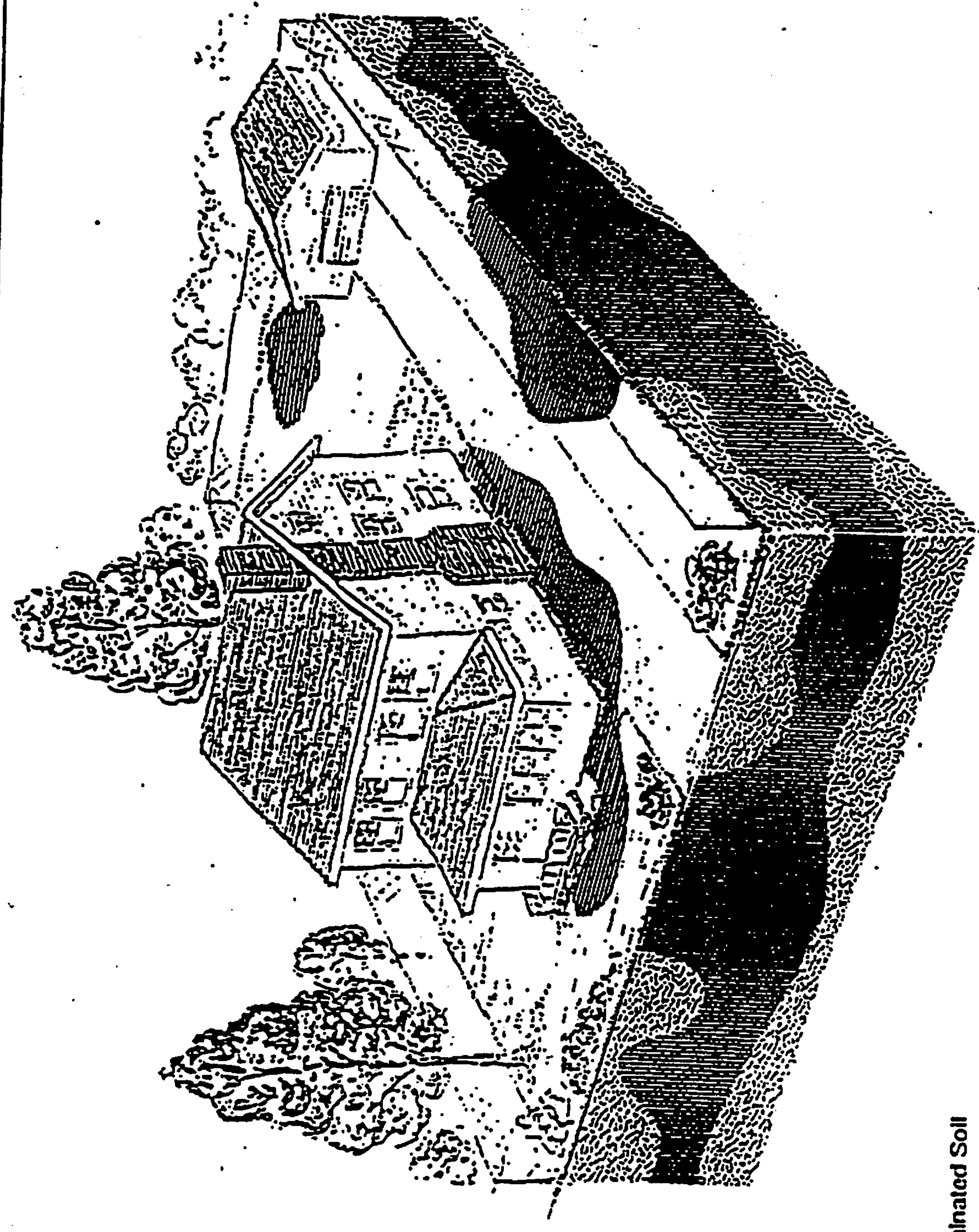
Typical Radon Entry Routes

Montclair/West Orange and Glen Ridge Radium Sites



Radium Contaminated Soil

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Property with Extensive Contamination within the Core Area

Montclair / West Orange and Glen Ridge Radium Sites