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The Manhattan Project legacy : low level radioactive waste health effects, an epidemiological study

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ABSTRACT

Title of Thesis: The Manhattan Project Legacy: Low Level Radioactive Waste Health Effects: An Epidemiological Study

Lisa Fetterman Voyce, Master of Science, 1984

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An epidemiological survey was performed that included the area surrounding a former Department of Energy thorium processing and disposal facility. This facility processed monazite sands to obtain thorium under Federal Government contracts from 1941-1973.

New Jersey Department of Environmental Protection radiological surveys had shown elevated radiation levels at the site and in the vicinity of the plant. The area was divided into sections according to distance from the site and from Sheffield Brook, which is also contaminated. Questionnaires were mailed to 400 families, with 112 responses. These represent 362 people.

Statistical analysis of the accumulated data regarding lifestyle, occupation, reproductive history, cancer and other disease states was performed. No significant increase in cancer, miscarriage or any other disease included in the survey was found.

While not statistically significant, liver diseases other than cancer are more prevalent in all case groups. The reported jaundice rate is also higher.

The rate of birth defects is also greater for those living closer to the site. The leukemia rate is also increased.

An aggregation of disease incidence is apparent in the study area, and is of interest for further investigation.

THE MANHATTAN PROJECT LEGACY:
LOW LEVEL RADIOACTIVE WASTE HEALTH EFFECTS,
AN EPIDEMIOLOGICAL STUDY

by

LISA FETTERMAN VOYCE

Thesis submitted to the Faculty of the Graduate School of the New Jersey Institute of Technology in partial fulfillment of the requirements for the degree of

Master of Science

Environmental Engineering/Toxicology Option

1984

APPROVAL SHEET

Title of Thesis: The Manhattan Project Legacy:
Low Level Radioactive Waste Health Effects,
An Epidemiological Study

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I would like to thank my advisors, G. Reza Najem, M.D., Ph.D., and Richard Trattner, Ph.D.; Martin Feuerman and Oresta Ferrito for their assistance in this effort.

Also, my thanks and concern to the neighbors of W.R. Grace, to whom this paper is dedicated.

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INTRODUCTION

"In the past, disposal of this low level waste has been haphazard, at the very least. The locations of many disposal sites associated with the Manhattan Project are now no longer known." (21)

This study was initiated at the request of local residents, concerned about the health effects from living near this radioactive waste site.

A community based survey had indicated numerous cases of cancer in the area. The New Jersey Dept. of Health and Centers for Disease Control declined to investigate further and the Township Health Department did not have the resources to do so.

The levels of contamination off-site are very low. The wastes have been at the site for 40 years. But aerial surveys had shown elevated levels of radiation, and the people were very concerned.

"As of now, there is no clear evidence that these dumps pose a health hazard to humans. The dumps are, however, excellent samples of poor waste management practices." (21)

Whether our statistics bring peace of mind with no sign of significant increase in disease, or bad news that will force

further action, these people deserve the answer.

I. THE LEGACY: W. R. GRACE THORIUM FACILITY

A. BACKGROUND INFORMATION

1. Site Description

The site is located at 868 Black Oak Ridge Road (US Highway Route 202), in Wayne Township, Passaic County, New Jersey. The former processing plant and disposal area encompass approximately seven acres.

Currently, there are two buildings on the site; a two story brick structure and a one story wood warehouse or storage building. Until recently, the buildings were leased from W.R. Grace by Electro Nucleonics, Incorporated.

Fronting on Black Oak Ridge Road, at the Pompton Plains Crossroad intersection, the site is also within a half mile of Route 23. Disposal pits lie within 100 feet of the sidewalk. Commercial businesses, a nursing care facility, school bus maintenance yard, parochial high school and residential homes are adjacent to this site.

An open field behind the buildings serves as the burial site for the various processing wastes. A small sign stating "Radioactive Materials- Do Not Excavate" adorns the six foot

fence that surrounds the field. It is only in recent years that the fence was erected.

A drainage ditch runs at the northern and eastern borders of the site, and discharges into Sheffield Brook at the field's northeast corner. Sheffield Brook drains into the Pompton River via 600 feet of underground pipes at Pompton Plains Crossroad, reemerging behind homes across Black Oak Ridge Road.

Geologically, the area lies on bedrock of Brunswick shale. Estimated depth to bedrock is 70 feet. The Brunswick formation is a potable water source of some significance.

Sandy loam soils dominate in the area. The site has well drained soils, with a seasonal high water table of 1.5 to greater than six feet. Tests conducted by the NJDEP indicate that groundwater moves toward the surface. (51,52)

See area and site maps, Figures 1 and 2.

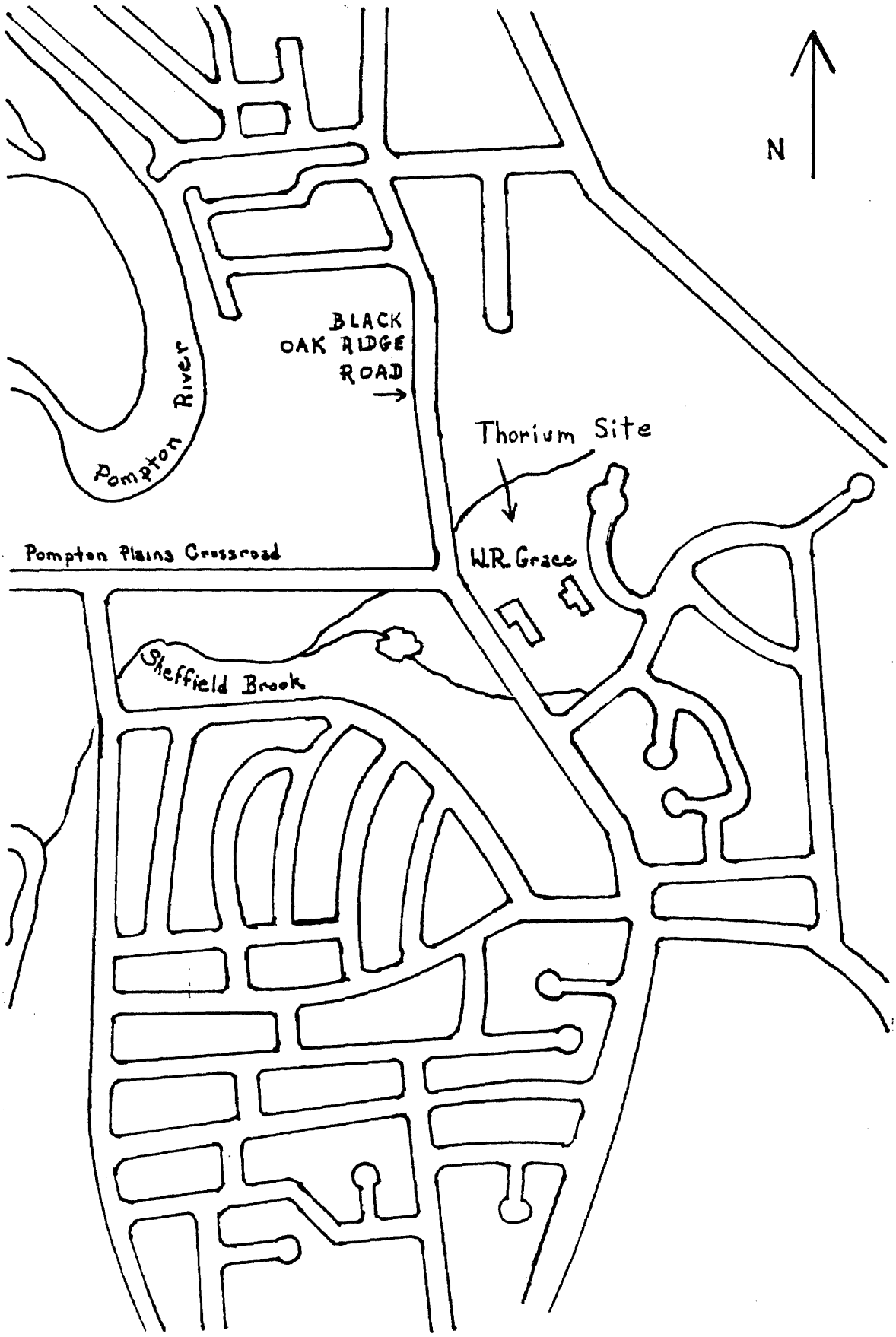
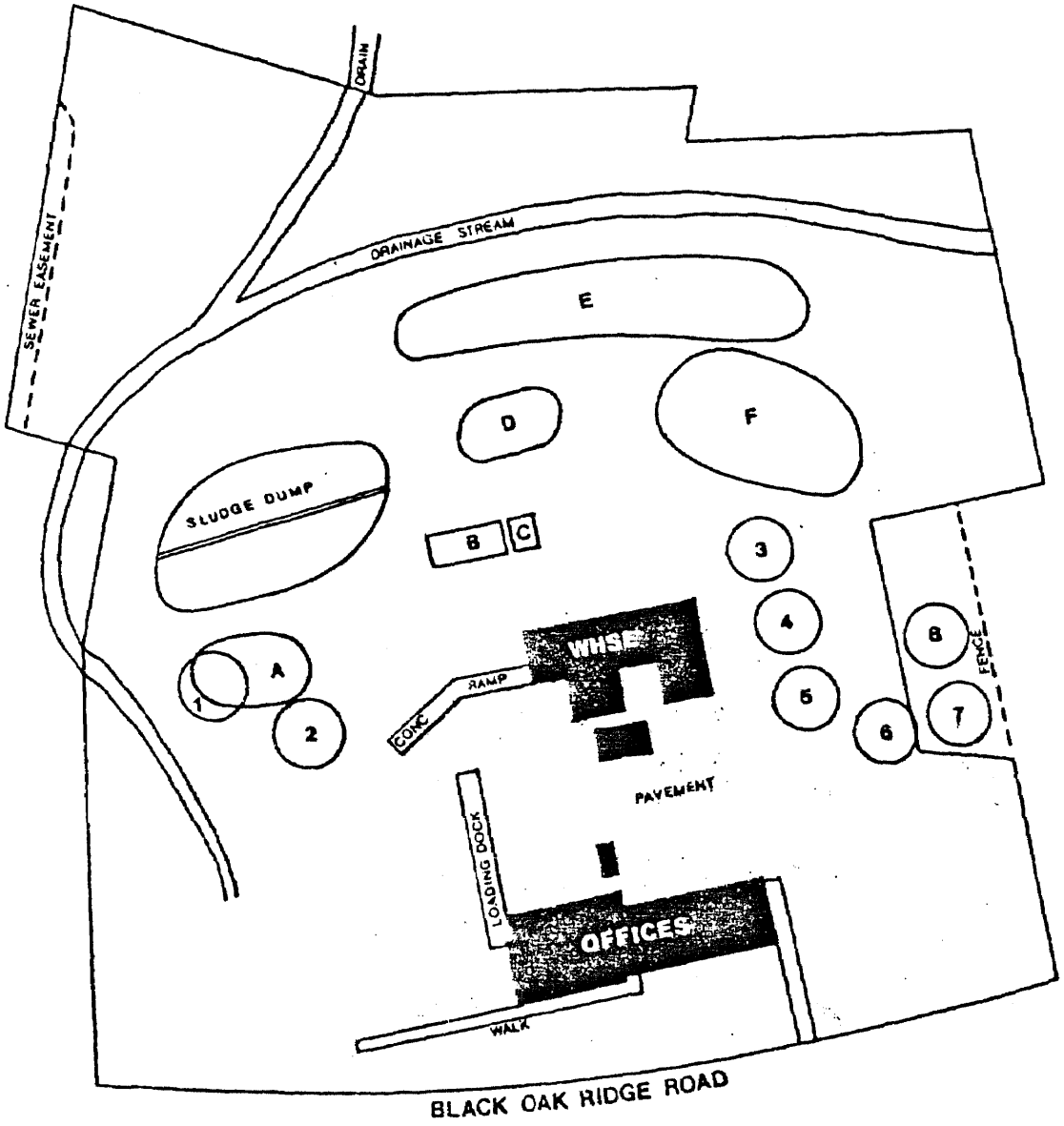

N
BLACK
OAK RIDGE
ROAD
Pompton River
Thorium Site
Pompton Plains Crossroad
W.R. Grace
Sheffield Brook

FIGURE 1



A=Reworked Sludges
B=Yttrium Concentrate
C=Thorium Hydroxide
D=Waste Treatment Disposal
E=Ore Tailings and Gangue
F=Yttrium and Silica Sludges

1-8 = Circular Holes Filled April-June 1974 with debris and contaminated equipment resulting from decontamination of buildings.

FIGURE 2 - Suspected Burial Locations on the W. R. Grace Property.

2. Site History

Processing Operations and Disposal of wastes

"Thorium was not produced in quantity in a reasonably pure form until required by the Atomic Energy Program." (13)

The radioactive waste left in Wayne is aging. Rare Earths, Inc. first processed monazite ore there in 1948. Their product was destined for Manhattan Project research. The Atomic Energy Commission (AEC) licensed the facility in 1954, when the AEC was established.

Purification of the monazite sands continued uninterrupted, and W.R. Grace began to manage the operation in 1956.

During its active years, the plant waste was dumped in backyard sludge piles. In addition to the rare earth wastes, acids and caustics used in the processing found their way to Sheffield brook.

The AEC inspectors complained to the operators about their waste disposal practices, but never took formal action to control the situation. (57)

Some of the wastes have been buried only in the last few years, after spending 20-30 years above ground, in the rain and

wind. Overburden on the buried material has been deemed insufficient.

Processing ceased in 1971, and the AEC licensed the site for storage in the same year.

Decommissioning

Decontamination of the processing site occurred in 1974. Material from the cleanup was also buried on-site, as shown in Figure 2.

The site was released for unrestricted use by the US Nuclear Regulatory Commission in 1975. A fire at the plant in 1977 destroyed most of the operating and burial records from 30 years of activity. Electro Nucleonics, Inc. began leasing the plant soon after that fire.

An aerial survey of the site, as part of an assessment of former Department of Energy facilities, showed elevated radiation levels at and near the site. Further radiological surveys in 1982 confirmed the increased nuclide levels.

Placed on the National Priority List for Superfund cleanup funds in 1983, the site is currently under study by Bechtel Intl., Inc., for the Dept. of Energy. Though on the Superfund list, Grace and other radioactive waste sites will not receive any of that money. Their special nature brings them under the jurisdiction of agencies other than the US Environmental Protection Agency or NJ Dept. of Environmental Protection.

3. RADIOLOGICAL SURVEYS

Radiological Survey of W.R. Grace Property

The discovery of contamination by aerial survey prompted closer study by the NJ Dept. of Environmental Protection, Division of Radiation Protection. The radiological survey of Grace and vicinity properties included:

* Gamma radiation measurement with scintillometers

* Radionuclide concentration readings in soil and sediment samples

* Measurement of radiation in water samples from the artesian well on site, drainage ditch and Sheffield Brook.

* radon gas (Rn 222) concentration in ambient air, and inside buildings , emanating from radium in the soil. (52)

Survey Summary

The site was divided into sections A-I, as indicated on Figure 3.

Ground Level Gamma Measurements

Region A encompasses the greater part of the open field behind and north of the warehouse. Readings of 40 1491 uR/hour were found there. The variation in measurements may be due to shallow overburden.

The highest readings are associated with a former waste treatment plant and burial areas for reworked sludges, thorium hydroxides and ore tailings.

Most of Region B, located north of and behind the warehouse, had radiation levels between 50—200 uR/hour. Decommissioning wastes, yttrium and silica sludges and carbonate cakes are buried there.

Along the drainage ditch, bordering Region B to the west, Region C is the resting place of ore tailings and sludges. East bank readings rose to 166 uR/hour. Higher west bank rates of up to 689 uR/hour indicate slumping of materials.

Region D, which includes the north and eastern boundaries of the Grace site, had little above background activity. No contamination was detected beyond the fence.

Rates of up to 850 uR/hour were found in region E, near the warehouse loading dock. Rates were lower near the brook. A former waste treatment plant and decommissioning wastes are located there.

The paved areas of the site showed rates usually less than 50uR/hour. A crack in the asphalt pushed rates to a maximum of 854 uR/hour. The underlying soil probably does not have lower activity, as indicated by this breach in cover.

The sidewalk in Region G was betwen background level and 30 uR/hour. The grassy area between the sidewalk and Black Oak Ridge Road showed rates of up to 301 uR/hour.

Region H rates were up to 238 uR/hour. Wastes from the decommissioning process are buried there.

The storage barn on adjacent Township property (the bus maintenance yard), may have served as a monazite ore storage area during plant operations. Levels measured 854 uR/hour at the barn entrance.

Measurements taken at one meter above ground level were highest in region A, with a maximum reading of 854 uR/hour. In all sections, higher one meter levels were associated with elevated ground level readings.

Indoor readings in the warehouse ranged from 12-89 uR/hour. An upper level lunchroom gave readings of 29 uR/hour.

The storage barn in Region I had its highest rates at cracks in the floor, with a range of 11-318 uR/hour.

Office and bus maintenance buildings on the Township property were at background levels. (52)

Soil Samples

Radium (Ra 226) and Thorium (Th 232) concentrations were determined by gamma spectroscopy. Delayed neutron counting was used for Uranium (238) concentration determinations.

Results showed no quantitative differences between thorium daughter products, indicating that they are in equilibrium, as were radium daughters.

Concentration of radium was normally lower than thorium by a magnitude.

Though lower than thorium, uranium concentrations were higher than radium by 2 to 100 times.

Highest Thorium concentration was found in region A near

the drainage ditch, 2008 +- 10 pCi/gram. Region I, on adjacent property, showed a reading of 1721 +- 17 pCi/gram.

Region I also had the highest soil radium concentration, 108 +- 3 pCi/gram.

The site of highest thorium concentration was also site of maximum amounts of uranium, in Section A.

Background levels of thorium range from 0.2 2.2 pCi/gram, radium 0.24- 1.36 and uranium 0.13-1.36. (52)

Water Samples

Surface water grab samples from Sheffield Brook and the drainage ditch were collected and analyzed.

All samples indicate no above background gamma activity. All meet NJDEP safe drinking water standards for radiation. (52)

Radon Sampling

Grab samples and 48 hour samples using activated carbon canisters were taken.

Indoor and ambient samples were mostly within state and NRC guidelines. The only exception is in the lunchroom, which exceeds those standards. (52)

Summary

The open field east of the warehouse has the highest gamma exposure rates. There is indication of shallow to non-existent overburden on the Grace site.

Soil samples show radionuclides from both thorium and uranium decay chains. Analysis of water samples showed alpha and gross beta activity, but no gamma activity.

Radon analysis indicates a calculated whole body dose equivalent to approximately 150 mrem/year for the highest measured concentration of 5.2 pCi/liter. Most samples of air were within background levels. (52)

Standards vs. Results

Federal and NJ regulations limit the general public radiation dose to 500 mrem/year. It is doubtful that any person would exceed that limit at Grace. Workers at the site could possibly receive up to 200 mrem/year.

Site use changes could increase the risk of exposure, as could manipulation of the materials buried there. Any cleanup efforts must consider this increased exposure risk. The site has been released for unrestricted use.

Proposed NRC regulations are more conservative, and the Grace site would exceed these modified limits. More than 60% of the property would not meet the limits of 10 uR/hour for external exposure rate and 5 pCi/gram above background levels for thorium.

Water analysis results are within standards.

Radon standards are exceeded in the lunchroom and inside the warehouse.

Decommissioning efforts did not effect the 200 uR/hour exposure rates planned. Overburden on the burial pits is

insufficient.

There is potential for groundwater contamination, though it has yet to occur. (52)

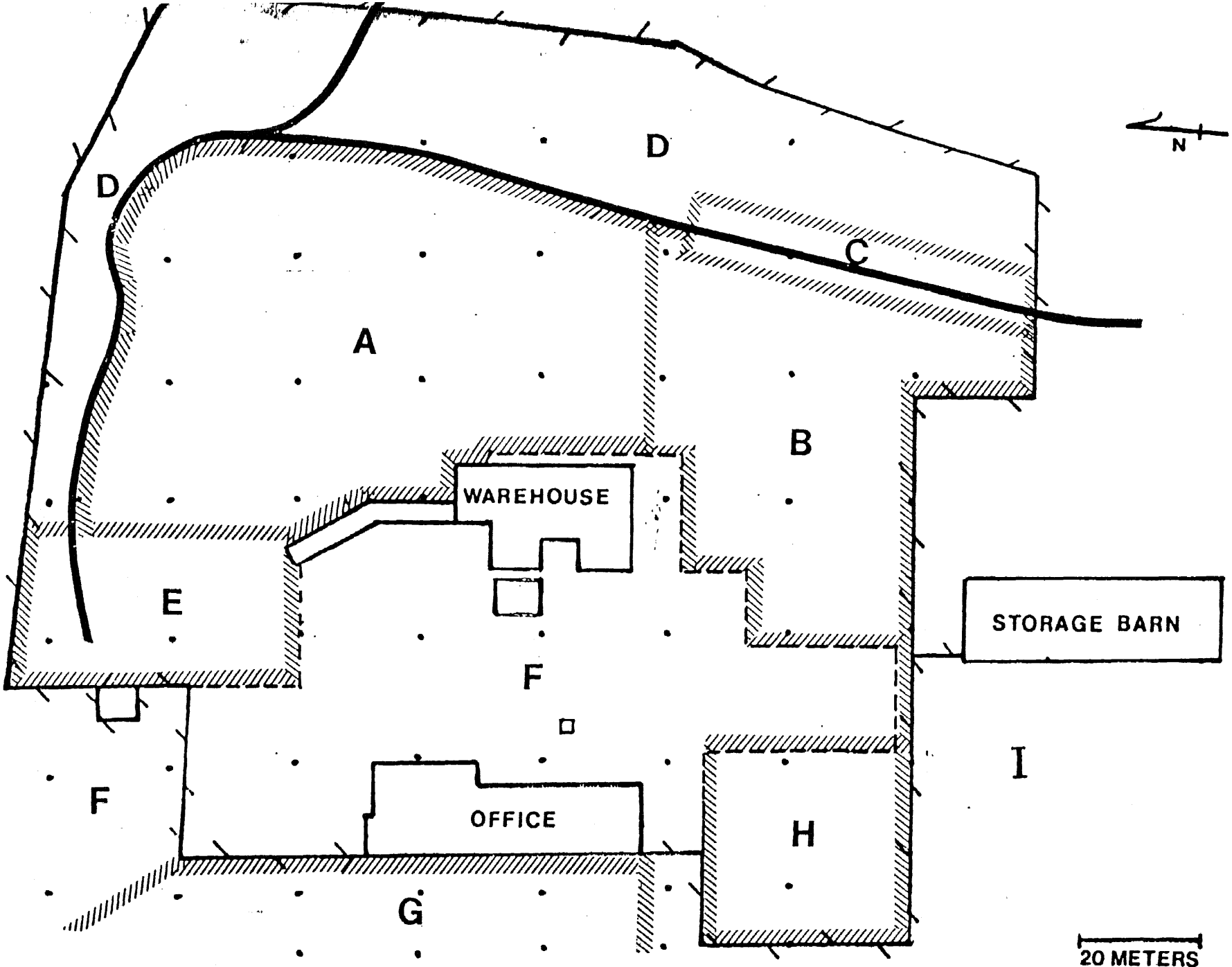


FIGURE 3- NJDEP LOCATION OF DESCRIPTIVE REGIONS

NJDEP Radiological Surevy of Sheffield Brook

Sheffield Brook drains the W.R. Grace site, and soon thereafter empties into the Pompton River. Between Grace and the river lie numerous homes that back on the brook, and a main water supply pipeline.

A radiological survey of the brook was performed in April and May of 1982. (51)

Surface Gamma Radiation

Highest ground level exposure rates were found on the north side of Sheffield Brook, east of the intersection of Deerfield and Farmingdale Roads. Maximum readings were 354 uR/hour east of Farmingdale and 151 uR/hour west of it.

Contamination appears to be confined to within 10 meters on either side of the brook. (51)

Soil and Sediment Samples

The thorium concentration was highest at a site east of Farmingdale Road. Berms on both sides of the brook showed 562 +- 5 pCi/gram, 5 and 10 meters from the banks. These berms are most likely dredging wastes from the brook itself.

Low lying wet areas north of the brook also had high thorium concentrations, 522 +- 7 and 549 +- 7 pCi/gram.

Radium 226 concentration reflect thorium findings, but are

much lower, with the highest concentration being 39.5 +- 8.2 pCi/gram.

Lower levels of all nuclides were found in the brook sediment. (51)

Water Analysis

Highest gross alpha and beta concentrations of 9.22 +- 2.49 pCi/gram and 8.41 +- Ø.99 pCi/gram were obtained from a sample at the confluence of Sheffield Brook and the Pompton River. (51)

Radon Air Sampling

All test results were within NJ natural background levels. (51)

B. THORIUM

1. Source of Thorium and Its Properties

A naturally occurring substance, thorium is found in alluvial monazite sands of India, Brazil, Ceylon, Scandinavia and Tasmania. United States sources include North and South Carolina coastal sands. (15)

Thorium content is approximately 10% in these monazite sands. Its atomic weight is 232.12, atomic number 90. The natural isotope is 232 Thorium. Thorium dioxide (THO2) is a dense, white, inert solid.

With a physical half life of 1.41 x 10(10) years, a whole body half-life of 5.7 x 10(4) days, and in bone 7.3 x 10(4) days, it radiates for some time. (10)

It tends to concentrate on bone surfaces. Natural decay processes produce 77% alpha radiation.

The daughter products of decay (including radon gas) are responsible for its principal biological effects. The electrically charged daughters attach to inert dusts and are released into the atmosphere. (10)

If breathed in, some of the dust can be deposited in the lung. Alpha emitters in the body can be very damaging, their

high levels of energy are expended in small areas.

Radioactive contamination differs from strictly chemical toxicity in that:

1. There are no methods available to "neutralize" radioactivity.

2. The materials remain active practically "forever" and must be contained.

3. Minute amounts can be very hazardous. Industrial hygiene standards illustrate the difference clearly. The standard for lead is 100 ug. Pb per cubic centimeter. For Radioactive lead (Pb 210), only 5 x 10(-6) ug. per cubic meter are allowed. (10)

The relative insolubility of thorium precludes its being incorporated into plants. Analysis of plant samples taken from the produce farm across the street from Grace showed no nuclide contamination.

Newly processed thorium has alpha and low energy gamma activity.

That declines to a minimum after three years, after which radon gas production grows until alpha and gamma activity peaks after 67 years.

Around the Year 2010, Grace will reach that peak from its earliest dumping activities.

2. Commercial Uses

Discovered in 1828 by J.J. Berzelius, thorium was of little practical use until 1885. It was then incorporated into the manufacture of incandescent gas mantles. Several thousand pounds a year are still used in that industry.

Thorium dioxide is useful as a high temperature ceramic material. It is also used in electronic tubes, photocells, vacuum systems and in gas purification. (10,25)

Aircraft engine and frame construction materials include thorium to strengthen light magnesium metals.

It has been estimated that the world's thorium reserves contain more energy than all the uranium, coal and oil combined. A thorium nuclear fuel cycle, in place of either uranium or plutonium, has been proposed. (25)

The Grace Processing plant began purifying the ores for Manhattan project research. It was continued for industrial applications of rare earths and thorium.

THORIUM PURIFICATION PROCESS

FROM MONAZITE SANDS TO CRUDE THORIUM FEED

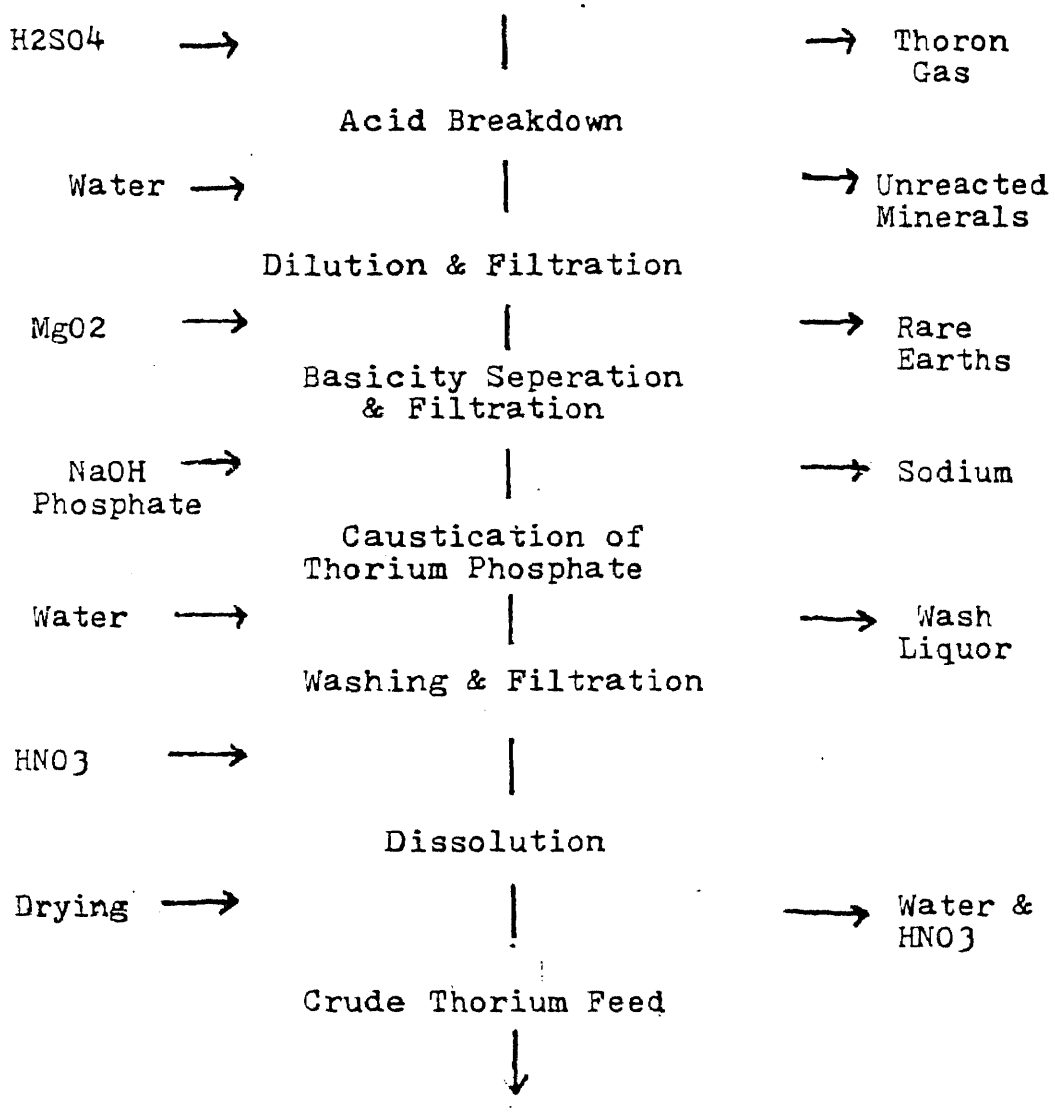


FIGURE 4

THORIUM PURIFICATION PROCESS

FROM CRUDE THORIUM FEED TO FINISHED PRODUCT

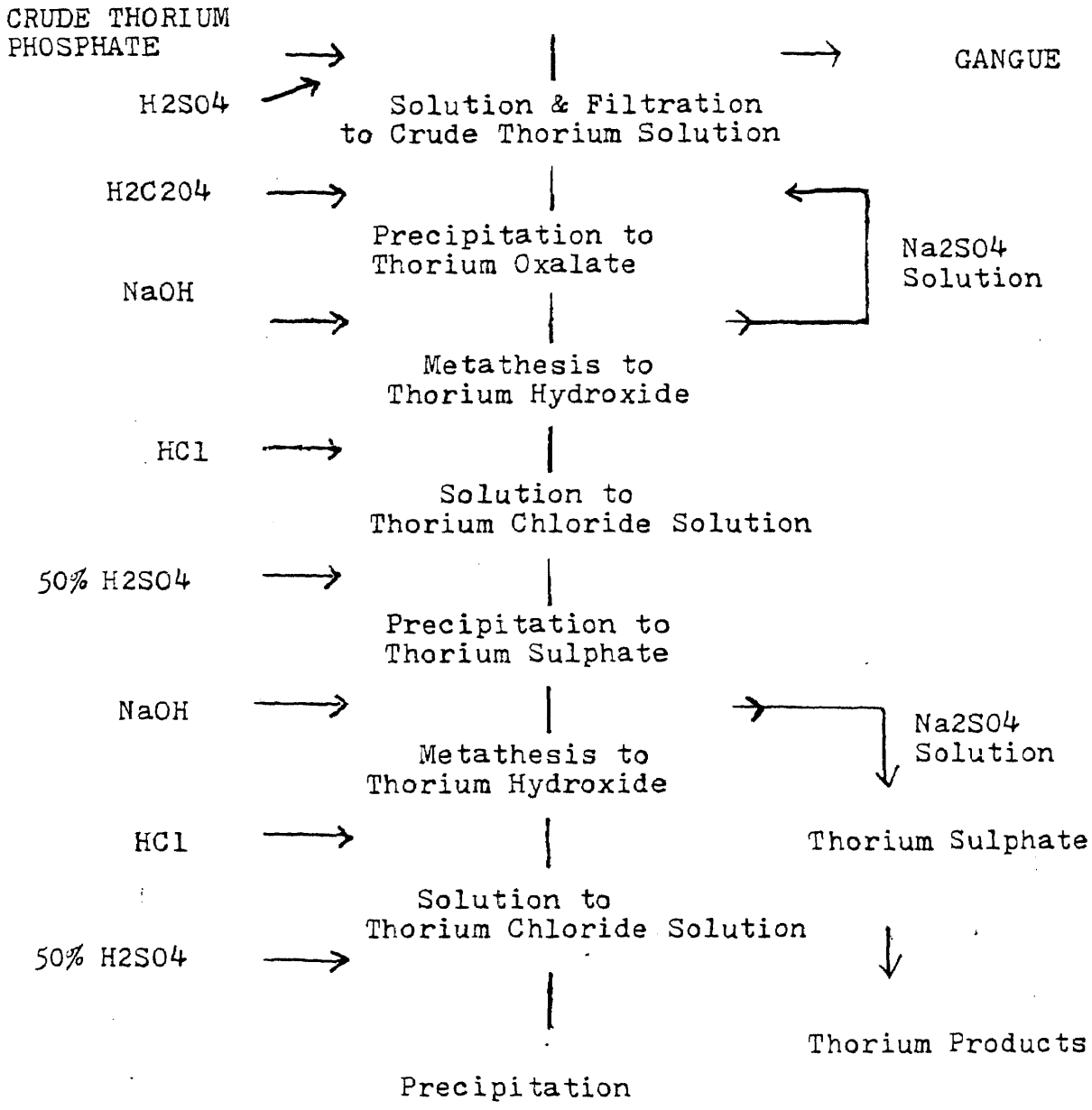


FIGURE 5

THORIUM DECAY SERIES

Isotope	Half-Life	Radiation Emitted
Th232	1.4 x10(10) years	Alpha & Gamma
Ra228	6.7 years	Beta
Ac228	6.13 hours	Beta & Gamma
Th228	1.9 years	Alpha & Gamma
Ra224	3.64 days	Alpha & Gamma
Rn220	55 seconds	Alpha & Gamma
Po216	0.16 seconds	Alpha
Pb212	10.6 hours	Beta
Bi212	60.5 minutes	Beta & Alpha
Po212	3.0 x10(-7) secs.	Alpha
Tl208	3.1 minutes	Beta & Gamma
Pb208	Stable	

Table 1 (10)

II. REVIEW OF LITERATURE

A. LOW LEVEL RADIATION HEALTH EFFECTS

Studies of low level radiation health effects have yet to rid this area of uncertainty and controversy. As man's use and abuse of radioactive materials grows, background levels get higher, and we are all exposed to levels that may be deleterious to health.

Major groups studied have included the Hiroshima and Nagasaki survivors, patients treated with radiation for ankylosing spondylitis, postpartum mastitis and tuberculosis; radiologists and radium dial painters. (29,31)

Some researchers have concluded that a threshold concept for radiation effects should be abandoned. Others have stated that radiation effects are so minor that it is impossible to distinguish no effect from the small increases they do cause. (46)

Even if it is assumed that low level radiation impacts human health, the dose response relationship is very much in question.

"The evidence is inconclusive on effects in the range of exposures allowed by current radiation standards." (42)

Sagan has said that the studies fail to reveal a threshold for low level (less than 100 rad) doses. The relatively small risks involved, long latency periods and difficulty in detecting radiogenic tumors are cited as reasons for this failure. (42)

Chromosome breaks, genetic effects, cancer induction and lifespan shortening are seen as having no threshold by webster. Fetal malformations can occur at 10 rads, white blood cell depression at 25 rads and fertility reduction at 100 rads. (48)

Radiogenic cataracts are seen as beginning at levels around 250 rads.

A study of Radium dial workers exposed an earlier age of onset for cataracts, and shortened latency period relative to radiation dose. (28)

The same workers are seen as having an increased number of deaths from all causes, including bone, blood, and other cancers.

Upton states that the risk of cancer in individuals exposed to low levels of radiation is comparable to the genetic risk they carry from their descendants.

> "With the passage of time and continuing study of delayed effects of ionizing radiation in man, two trends become evident... more tissues are susceptible to radiation induced neoplasia... and lower levels have been found to be associated with these effects." (26)

Blatz has said that statistical evidence indicates that even small doses of radiation can cause damage to living tissue. Factors of radiation biology include:

1. Changes in living cells on exposure
2. Possibly no threshold for damage
3. Greater response to alpha emitters (such as Thorium)
4. Some reversible effects
5. Incidence of epilation and erythema
6. Hematopoiesis defects
7. Genetic sex ratio shifts (4)

The International Atomic Energy Agency has said that leukemia, bone tumors, lung cancer, breast, thyroid and other malignancies can be caused by radiation. Their research has also found liver cancer associated with thorium radiodiagnostic materials. (16)

Beebe reports heritable mutations in many species of plants and animals. Birth defects from radiation include small head size and mental retardation. These effects were observed in the atomic bomb blast survivors' offspring. (31)

The Three Mile Island nuclear reactor accident in 1979 exposed the public to a maximum 83 mrads. Chromosomal damage can occur at one rad. And radiation effects are cumulative. (47)

Dobzhansky states that any increase in radiation will

increase the total number of mutations in exposed populations. "...These mutations will maim and murder for many generations after our present follies have been forgotten." (26)

The debate continues.

BIOLOGICAL EFFECTS OF IONIZING RADIATION

Exposure Range	Chronic Exposure	Acute Exposure
Less than 1 rem	No Observable Effects	No observable Effects
1-50 rems	chromosomal aberrations Increased leukemia and thyroid cancers	slight blood changes, fetal risks
50-100 rems	Doubling dose for spontaneous mutations	Mild radiation sickness possible
100-200 rems	Doubling dose for cancer	Vomiting,fatigue, Increase cancer risk
200-600 rems	Increased leukemia risk Excess lung cancers	Vomiting, loss of hair some deaths from infection and hemorrhage
600-1000 rems		Death within 2 months of 80-100% exposed

TABLE 2 (21)

PRINCIPAL ROUTES OF HUMAN EXPOSURE

TO RADIOACTIVE SUBSTANCES

Type Exposure	Environment to Man	Factors of Dose
Inhalation	Atmospheric radiation to inhalation	Rate & Duration of release,wind, precipitation
Direct Gamma	Airborne Release to surface deposition	Same as above
Direct Beta	Airborne Release to Skin deposition	Same as above
Ingestion	Gaseous Release to Crops,Livestock,Man	Above plus diet, season
	Liquid Release to water, ingestion bioconcentration, man	Same as Above

TABLE 3 (10)

B. Thorium and Thorotrast

"Thorium and uranium are toxic in the same way heavy metals such as lead and copper are, plus radioactive decay." (13)

Thorium, as an alpha emitter, must be internalized to do damage. This internal irradiation creates a hazard determined by the quantity available in the body, initial body retention (relative absorption and solubility), the fraction retained in the body, tissue radiosensitivity, the target organ and the size of that organ.

The material's biological half-life and energy of the radiation produced are also factors of hazard.

Internal emitters are more dangerous because they irradiate tissue continuously until they are eliminated, they have a very long biological half life, are not easily excreted and have intimate contact with body tissues. It is impossible to accurately assess the hazard in a living organism.

Bone and liver tissue are the main targets in thorium exposure. (10) The decay products have principal biological effect. Radon and thoron gas released by decay is electrically charged and attaches to dust particles. These dusts find their way into the lungs.

Once in the body, the alpha particle emmission can wreak havoc.

Workers in thorium processing are exposed to thorium dioxide, thorium tetrachloride and soluble thorium nitrate. The last is most toxic. (19)

The LD50 of the nitrate in a rat study was 68 mg/kg, and the tolerated dose was 48.6 mg/kg. (19)

Other animal studies indicate that thorium effects blood pressure. There was a sharp and persistent drop in arterial pressure after thorium dioxide injection. (19)

Bronchial lesions, perifocal pneumonia and sarcomas have occurred following intratracheal administration. There was a definite dose/response relationship. (19)

Clinically, thorium had applications in diagnostic radiology.

Used between 1930 and 1955, a colloidal suspension of radioactive thorium dioxide was injected into patients as an angiographic contrast agent. (44)

Called thorotrast, this agent was introduced into the bodies of 10,000 to 100,000 patients. Its use was discontinued due to the long term effects of energetic alpha emittance. (33)

It has been shown that 90% of the thorotrast injected is retained in the reticuloendothelial system throughout life.

A computer search for thorium related medical literature elicited information relating thorium to sinonasal cancer, osteosarcoma, hepatic angiosarcoma and myelogenous leukemia.

The clinical manifestation of these diseases arises many years after exposure. A 26 year mean latency period is noted in one study. (33)

Thorium deposits are found throughout the body of exposed individuals. The thorotrast is phagocytized by lymph cells and concentrates in the spleen, liver, bone marrow and lymph nodes.

Localized chronic effects of thorotrast include fibrous tissue growths, or granulomas. Fibrosis of the spleen and lymph nodes, and hepatic necrosis are diffuse long term effects. (33)

Thorium is found at tumor sites, indicating direct neoplastic effect.

Not only the alpha emittance, but thorium's chemical and physical properties may also cause these deleterious effects.

Elevated serum alkaline phosphatase levels are a possible indicator by which to screen former thorotrast patients. Higher serum levels are associated with liver tumors and osteosarcomas.

Cancer of the nose and paranasal sinus has been associated with both occupational radium exposure and thorotrast clinical exposure. Smoking and snuff taking were also associated with sinonasal cancers. (40)

After injection into the maxillary sinus during radiological testing, the thorium decays relaesing alpha, beta and gamma radiation. This activity reaches a peak after 15 years.

Numerous articles concerning thorotrast patients with late occurring hepatic angiosarcoma and myelogenous leukemia were found. The hepatic lesions caused by the radioactive material

are similar to those caused by vinyl chloride and arsenic. A sequence of exposure leading to hyperplasia and angiosarcoma is common. (29, 31, 35)

Incidence of bone cancer related to thorotrast has been low, but more cases are being reported in the literature. (33, 44)

Thorium concentrates in bone and remains there to radiate the immediate area.

It is possible that thorium induced bone tumors will have increasing incidence as years go by, due to the history of its clinical use and length of the latency period. (44)

C. Environmental Health Studies

Najem has completed research on the environmental variables associated with gastrointestinal and respiratory disease. (36, 37)

Toxic waste disposal sites are implicated in that work as a factor in increased incidence of disease, as well as are a high degree of urbanization and population density.

Age adjusted gastrointestinal cancer mortality rates were found to be higher than national rates in 2Ø of 21 NJ counties.

For males, esophageal cancer rates were higher. Both men and women had increased stomach cancer incidence.

Colon cancers were more prevalent in all groups except non-white males. All whites, male and female, had significantly higher incidence of rectal cancer than U.S. figures.

National rates of most respiratory malignancies are catching up with New Jersey. The observed number of laryngeal and lung cancers remain significantly higher for several NJ counties.

In response to reports of elevated radioactivity levels at the Grace site, a health survey was conducted by local residents.

Randy Freeman, R.N., lead the volunteer force that went door-to-door in the effected neighborhood, asking questions related to cancer, birth defects and other health problems.

Of 39 homes surveyed on Deerfield Road, which backs on Sheffield Brook, 13 cases of cancer were reported among former and current residents. The survey results are illustrated by Figure 6.

The questionnaire used in the survey is also included. (53)

The New Jersey Department of Health declined when asked to study the area. Analysis of Wayne Township statistics showed no increase in leukemia or thyroid cancer between 1962-1981.

The Nuclear Regulatory Commission estimated a total radiation dose of 2.2 rems over a 70 year period from the site. Increased risk of fatal cancers from 2.2 rems is 0.22 deaths per 1,000 total deaths, according to NRC reports.

The Centers for Disease Control, while stating that there was insufficient data from NRC reports on the site, stated that "inhalation of radioactive dust particles may be the greatest health risk posed by the dump."

There was enough uncertainty about the possible public health impact to warrant further investigation, especially since the site is under study prior to its cleanup.

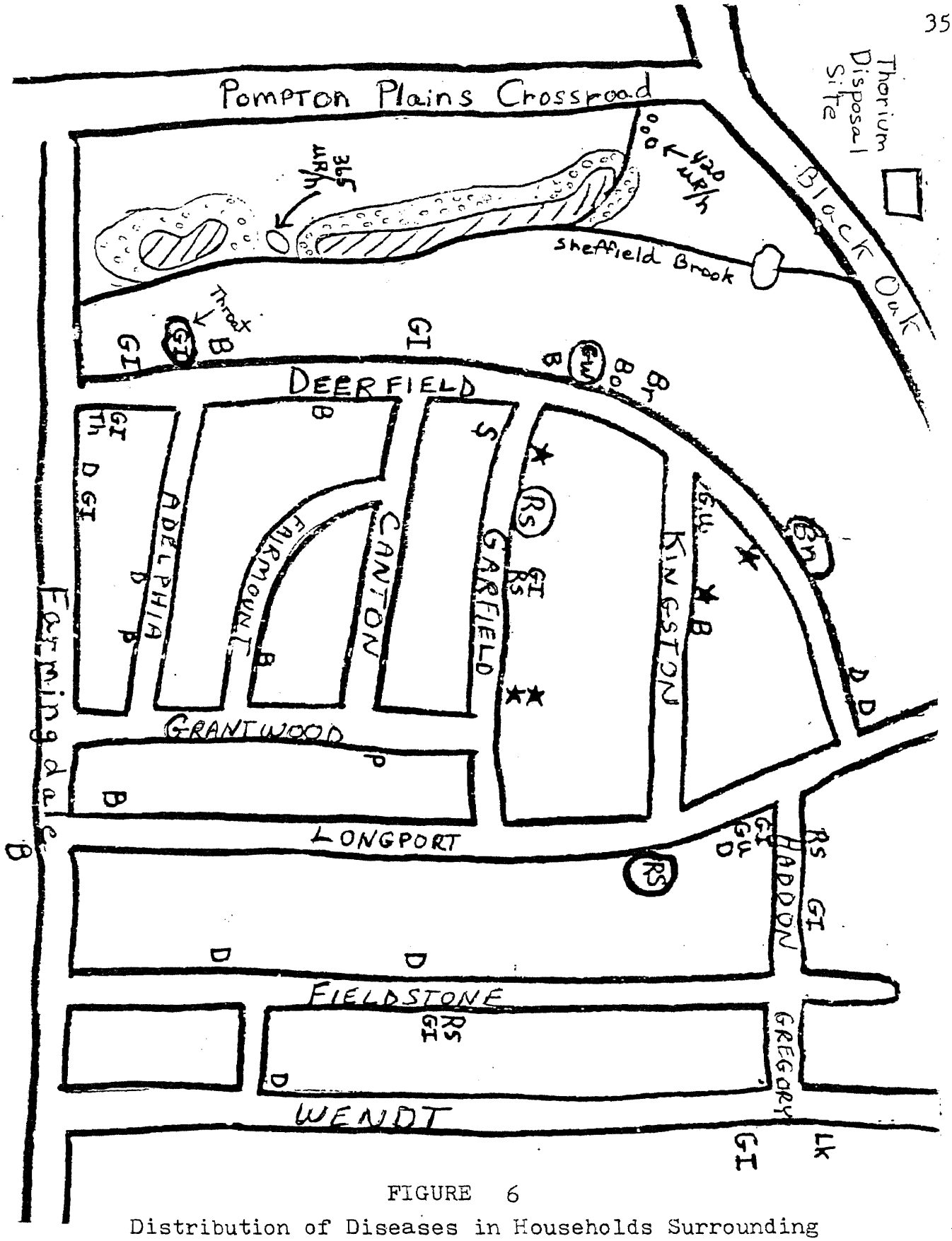


FIGURE 6

Distribution of Diseases in Households Surrounding Thorium Disposal Site; Freeman Study

KEY TO FREEMAN STUDY INCIDENCE MAP (FIGURE 7)

LK= Leukemia

D= Dog With Cancer

RS= Respiratory

GI= Gastrointestinal

GU= Genitourinary

Bo= Bone

B=Breast

L= Liver

Bn= Brain

P= Pancreas

Th= Thyroid

★ = Type Unknown

ANONYMOUS QUESTIONNAIRE FORM

Address: Name:(optional)

Size of Family_____ Any Pets _____

Length of current residency_____

Are there or have there been any household members who had cancer, leukemia, miscarriages or birth defects?_____

If so: (If answer is no, skip to last two questions)

Specific Medical Condition: (Be very specific)_____

_____

Date of Diagnosis_____Age at Diagnosis_____

Sex of Patient_____ Is/Was Patient a Smoker_____

Occupation of Patient (or of parents if patient is child)_____

Date of Death:(If appropriate)_____

Note: Attach additional sheets if more than one condition is reported.

Have there been any pets in the family who have suffered from cancer, leukemia, miscarriages, or birth defects?

Species (Dog or Cat)_____ Medical Condition_____

Do you know other people who have moved away who have suffered from or died from any of the above? Can you get information about these people?

FIGURE 7

III. RESEARCH METHODS AND PROCEDURES

A. Sample Selection

The Grace site is surrounded by homes and businesses. Using Township maps and working out from the site in an approximately concentric manner, 400 homes were included in the study. Some variations were made due to the nature of the area's development. A produce farm directly across the street, a parochial school and nursing home near the site were not included in our study.

Seven sections were delineated. Sections 1, 2, 4 and 5 are across Black Oak Ridge Road from the site, and border on Sheffield Brook and/or the Pompton River.

Sections 6 and 7 are uphill and behind the site, and are without any waterborne exposure. Further from the site is Section 3, an area lying near the river, but upstream from Sheffield Brook. See Figure 8.

The approximate boundaries of the study area are Farmingdale Road on the west, Audobon Parkway on the north, Ridgeview Terrace on the east and Wendt Lane on the south.

Acquiring the addresses of 400 families required working with the Wayne Planning Department, Township Engineering Office

and the Tax Assessor, located in the Municipal Complex on Valley Road.

Planning maps with block and lot numbers were coordinated with tax maps and books that list street address and owner's name.

A complete list of names and addresses was compiled and mapped out for future reference. Phone numbers were also obtained from the Passaic County directory.

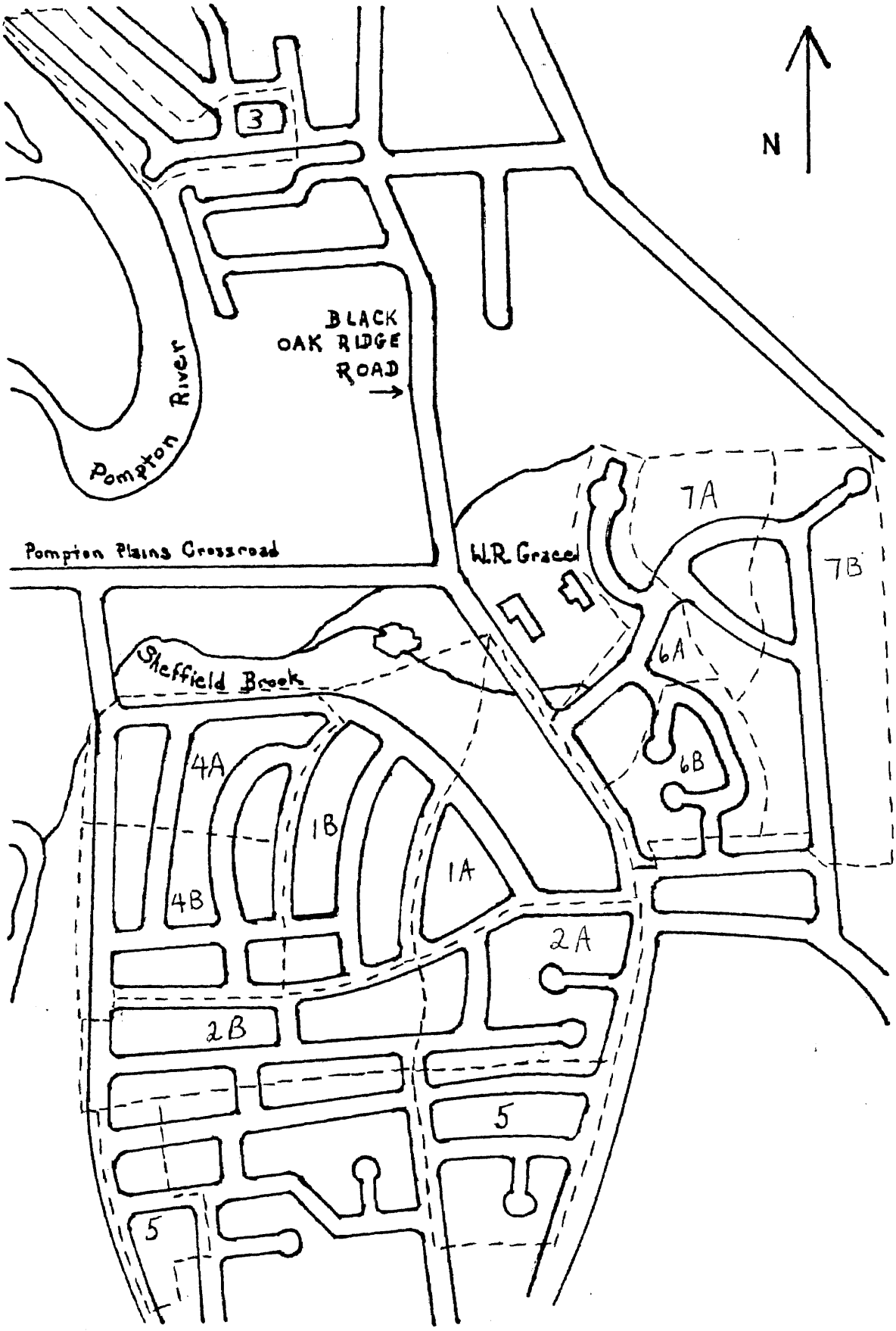


FIGURE 8- Dividing the Area into Sections (1-7) with Respect to the Source of Thorium Contamination

B. Questionnaire Development

Questions regarding vital statistics, reproductive and occupational history, lifestyle and disease were included. The respondents were asked to answer these questions for both themselves and their immediate families.

Special attention was paid to conditions that have been associated with radiation exposure and thorium clinical administration, such as hepatic cancer, leukemia, birth defects and miscarriage.

A complete questionnaire used in this survey is included in the appendix of this paper.

C. Statistical Analysis

The data obtained from the questionnaires was coded and analyzed using the Statistical Analysis System (SAS) and the New Jersey Educational Computer Network (ECN). (14, 50) Programming was done by Martin Feuerman of the UMDNJ Computer Services Department.

Statistical significance of the data differences between

"case" and "control" groups was measured using the chi square test.

IV. RESULTS

A. Survey Experience

"Radiation scare: from worried, to angry, to complacent."

Herald News 12/12/83

The press, in describing public reaction in Grand Junction, Colorado, accuratelt paints the attitude picture in Wayne.

Questionnaires were mailed in August 1983. The 400 families included in the study population received the 12 page survey form, asking about disease, reproductive history and lifestyle. (See questionnaire in appendix)

Response was mixed; some were concerned about their health, others more about their property values. The concern came out as questions about our legitimacy, about cleanup plans.Some residents asked, why the fuss? They weren't aware anything was there. We found new residents that had bought homes and were never told about the Grace site problems.

We received an elaborate map, showing prevailing winds and water flows in the area. Though the mapmaker lives one block from the site, he considered himself unexposed, as he lives on the "right side" of Grace.

The most disturbing letter was from a woman who had allegedly lost her husband to myelogenous leukemia. We could not authenticate her letter and she refused further contact. (49)

These were people who didn't answer the questionnaire, and therefore are not included in the statistical analysis.

By October we had received approximately 80 responses. Reminder letters were mailed, phone calls were made, and a total of 112 questionnaires were received. This represents 362 persons living near the site. See Table 4 for age and sex distribution of the study population.

The questionnaires were then organized according to the predetermined sections and coded for analysis.

B. Results of Data Analysis

The first group of sections for this study included Sections 1, 4, and 6 as the Cases and Sections 2, 7, 5, and 3 as Controls. These are the areas closest to Grace, irrespective of water or air, and those further away, respectively. See Tables 5 and 6 for results.

In an attempt to assess the effects of waterborne contamination, Sections 1 A-B, 3, and 4A are Cases, and Sections 2 A-B, 4B, 6 A-B, and 7 A-B are the Controls.

To measure the airborne contamination effects, Sections 1 A-B, 2 A-B, 6 A-B, and 7A were considered exposed to higher levels of radiation. Sections 4 A-B, 5, 3, and 7B were further away.

Examination of the statistics generated by this study indicates no significant differences in disease incidence between Case and Control populations.

In fact, many of the diseases included in the survey questions were slightly more prevalent in the population further from the Grace thorium site.

Liver disease other than cancer, and jaundice, were both more prevalent in all case groups. The rate of birth defects is greater for those living closer to the site. It should be noted that thorium targets liver and bone, and that the fetus is first to be affected by radiation. The leukemia rate is also increased, and blood changes will occur in exposed populations long before solid tumors arise.

In addition to disease and reproductive outcomes, the survey asked about smoking, dietary habits and alcohol consumption. Although there are more smokers in the Case sections, the difference is not significant. The same is true for alcohol. There is no difference in eating habits between the groups, in the number that eat red meats, are vegetarians, take vitamin supplements or eat certain ethnic foods. An equal proportion of local residents buy produce at the neighborhood farm stand.

Possible occupational exposures were assessed by asking for a complete work history, and including a check off list of occupations with possible confounding chemical exposures. There is no correlation between occupation and Case or Control groups. (See Tables 11-13)

The three Case/Control groups were delineated in an attempt to assess differences incurred by air or water contamination.

The Center for Disease Control has stated that radioactive dust may be the most serious route of exposure at this site.

This comparison of data by Cases and Controls shows a higher percentage of respiratory disease, skin disorders, diabetes, jaundice, leukemia and liver diseases in those closer to the site, regardless of air or water exposure. (Table 5-6) None of these differences are significant.

Miscarriage, premature births, pet cancers, lung, nasal, laryngeal, bone and other cancers were actually slightly lower in the group closer to Grace and the thorium. (Table 6)

For waterborne contamination, the percentage of birth defects, pet cancer, diabetes and jaundice was somewhat larger for those closer to Sheffield Brook and the river. Bone and other cancers were slightly more prevalent. (Table 7)

The rate of miscarriage, premature births, lung and nasal cancers and leukemia was lower for the exposed group. An almost significant difference in the rate of heart disease was found, but this too is lower in the Case group, 0 versus 9.4%. (Table 8)

The group closer as the wind blows (airborne exposure) showed an increased rate of birth defects, respiratory disease, nasal cancer and leukemia. The rate of premature births, skin disorders, heart disease, diabetes and other cancers was higher in the control group. (Tables 9-10)

Incidence of human and pet cancers, miscarriage and premature births is mapped on Figure 10. There is an aggregation of cases both near Ridgeview Terrace and between Deerfield and Longport Roads.

Distribution of cases of anemia, liver, heart and respiratory disease, and skin disorders is illustrated on Figure 11. Again, there is an accumulation of cases between Deerfield and Longport Roads.

The Age and Sex Distribution of 362 Study Participants

Table 4

AGE	MALE	FEMALE
0-12 months	1	1
1-5 years	7	10
6-10 years	12	5
11-20 years	33	43
21-29 years	22	22
30-39 years	27	29
40-49 years	25	28
50-59 years	25	28
60-69 years	19	18
70-79 years	3	3
80 & over	0	1
Total	176	186

*Note all respondents were white.

Variables Which are Greater Among

Cases than Controls

	Case	Control
	%(# cases)	%(# cases)
Respiratory Disease	16.7(10)	15.8(6)
Skin Disorders	17.2(11)	14.6(6)
Diabetes	6.2(3)	3.0(1)
Jaundice	4.7(3)	2.4(1)
Unexplained Fever	3.1(2)	2.3(1)
Leukemia	1.6(1)	0.0(0)
Other Liver Disease	4.6(3)	2.2(1)
Other Disease	10.9(7)	9.5(4)

TABLE 5

Variables Which are Lower Among

Cases than Controls

	Case	Control
	%(# cases)	%(# cases)
Miscarriage	21.2(14)	28.3(13)
Premature Births	7.6(5)	8.7(4)
Pet Cancer	7.9(5)	10.9(5)
Pet Pregnancy	0.0(0)	2.2(1)
Lung Cancer	1.7(1)	2.4(1)
Heart Disease	4.0(2)	6.5(2)
Bone Cancer	0.0(0)	2.4(1)
Nasal Cancer	0.0(0)	2.2(1)
Enlarged Liver	0.0(0)	2.2(1)
Internal Abdominal Bleeding	1.5(1)	2.2(1)
Anemia	8.1(5)	13.6(6)
Other Cancers	10.9(6)	13.5(5)

TABLE 6

Variables Which are Greater Among

Cases than Controls

	Case	Control
	%(# cases)	%(# cases)
Birth Defects	12.5(5)	8.Ø(4)
Pet Cancer	1Ø.3(4)	6.Ø(3)
Diabetes	6.7(2)	5.4(2)
Jaundice	4.8(2)	2.2(1)
Bone Cancer	2.4(1)	Ø.Ø(Ø)
Internal Abdominal Bleeding	2.4(1)	Ø.Ø(Ø)
Anemia	9.5(4)	8.9(4)
Other Cancer	14.7(5)	11.6(5)
Other Liver Disease	7.1(3)	2.Ø(1)
Other Diseases	9.5(4)	6.5(3)

TABLE 7

Variables Which are Lower Among

Cases than Controls

	Case	Control
	%(# cases)	%(# cases)
Miscarriage	21.4(9)	24.Ø(12)
Premature Births	4.8(2)	8.Ø(4)
Lung Cancer	Ø.Ø(Ø)	4.6(2)
Respiratory Disease	1Ø.5(4)	18.6(8)
Skin Disorders	13.2(5)	16.7(8)
Heart Disease	Ø.Ø(Ø)	9.4(3)
Unexplained Fever	2.4(1)	4.2(2)
Nasal Cancer	Ø.Ø(Ø)	2.1(1)
Leukemia	Ø.Ø(Ø)	2.1(1)

TABLE 8

Variables Which are Greater Among

Cases than Controls

	Case	Control
	%(# cases)	%(# cases)
Miscarriage	25.Ø(12)	23.4(15)
Birth Defects	13.Ø(6)	7.8(5)
Lung Cancer	2.3(1)	1.8(1)
Respiratory Disease	19.1(8)	14.3(8)
Jaundice	4.3(2)	3.4(2)
Nasal Cancer	2.2(1)	Ø.Ø(Ø)
Internal Abdominal Bleeding	2.1(1)	1.6(1)
Anemia	12.8(6)	8.5(5)
Leukemia	2.2(1)	Ø.Ø(Ø)
Other Disease	13.Ø(6)	8.3(5)
Other Liver Disease	6.3(3)	1.6(1)

TABLE 9

Variables Which are Lower Among

Cases than Controls

	Case	Control
	%(# cases)	%(# cases)
Premature Births	6.3(3)	9.4(6)
Pet Cancer	8.7(4)	9.5(6)
Pet Pregnancy	0.0(0)	1.6(1)
Laryngeal Cancer	0.0(0)	1.6(1)
Skin Disorders	11.1(5)	20.0(12)
Heart Disease	2.7(1)	6.8(3)
Diabetes	3.0(1)	6.3(3)
Unexplained Fever	2.1(1)	3.2(2)
Bone Cancer	0.0(0)	1.6(1)
Enlarged Liver	0.0(0)	1.6(1)
Other Cancer	10.5(4)	13.0(7)

TABLE 10

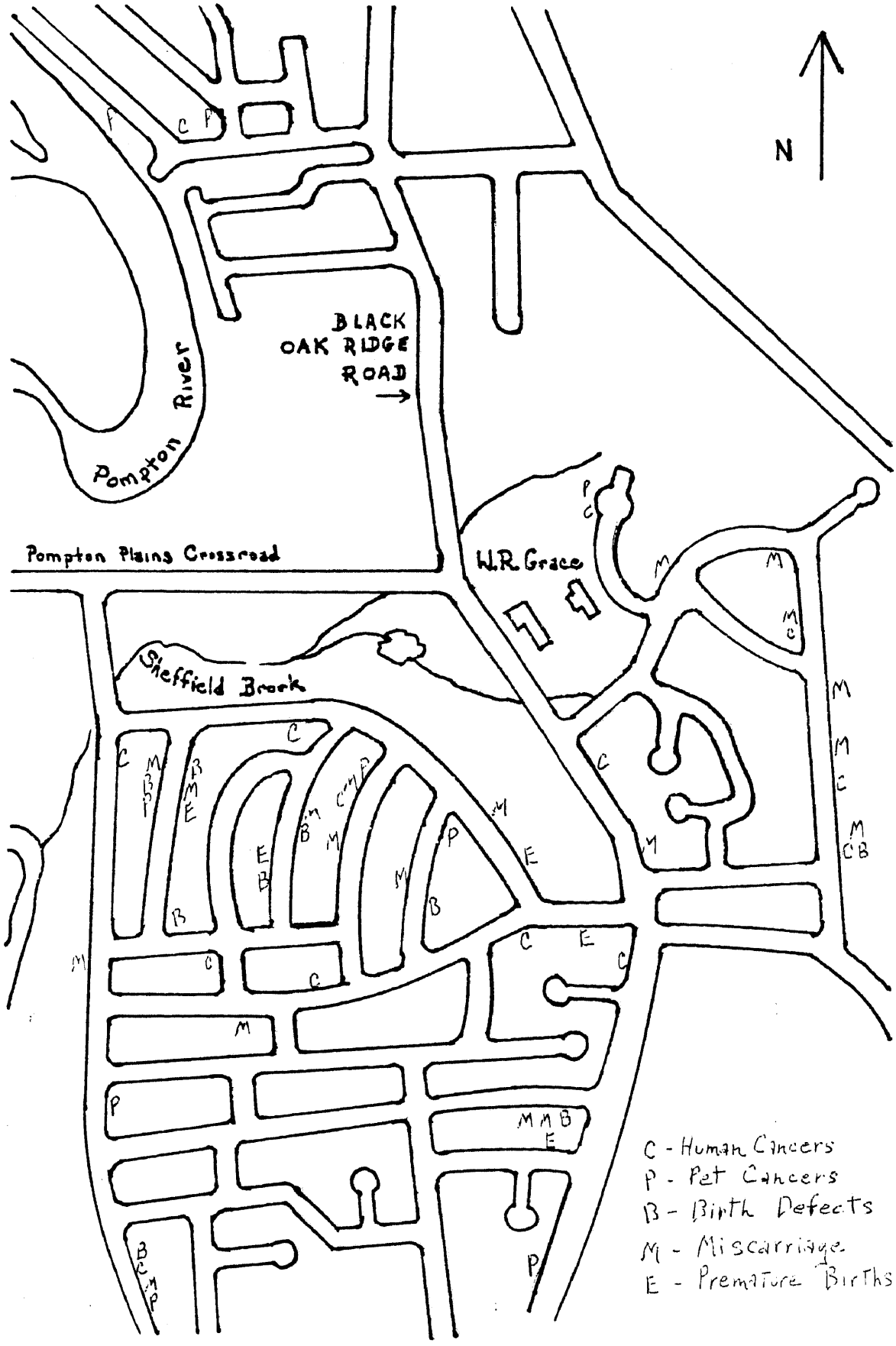

N
BLACK
OAK RIDGE
ROAD
Pompton River
Pompton Plains Crossroad
W.R. Grace
Sheffield Brook
C - Human Cancers
P - Pet Cancers
B - Birth Defects
M - Miscarriage
E - Premature Births

FIGURE 9

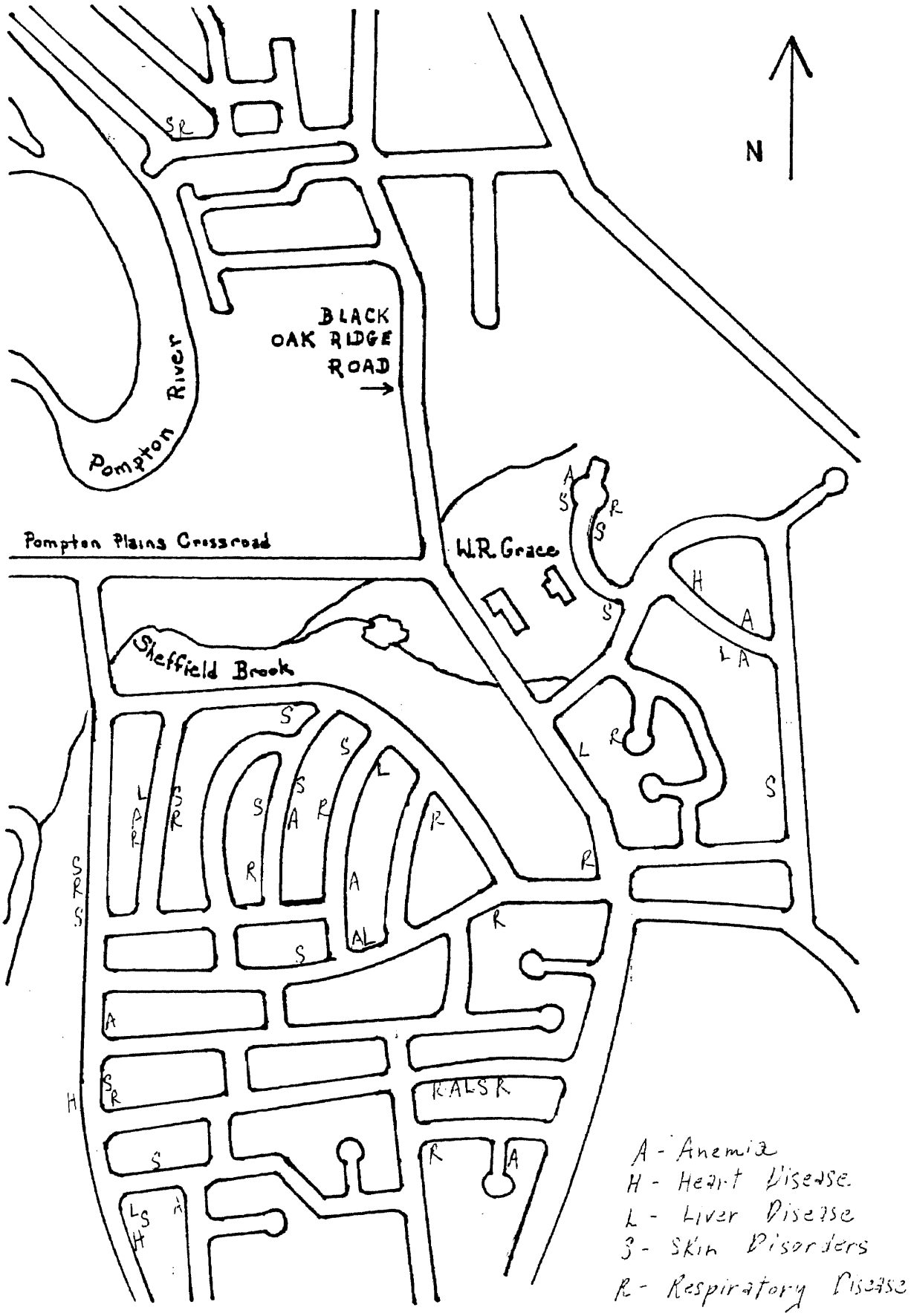

N
BLACK
OAK RIDGE
ROAD
Pompton River
Pompton Plains Crossroad
W.R. Grace
Sheffield Brook
A - Anemia
H - Heart Disease
L - Liver Disease
S - Skin Disorders
R - Respiratory Disease

FIGURE 10

ALCOHOL CONSUMPTION

CASE VS. CONTROL

	Yes	No
Case	11(17%)	55 (83%)
Control	5(11%)	40 (89%)

Table 11

SMOKING HABIT

CASE VS. CONTROL

	Yes	No
Case	42 (63%)	24 (36%)
Control	26 (57%)	20 (43%)

Table 12

OCCUPATIONS

CASE VS. CONTROL

	Case	Control
Homemaker	10 (15%)	5 (11%)
Professional	23 (35%)	23 (52%)
Skilled	17 (26%)	9 (20%)
Semi-Skilled	7 (11%)	2 (5%)
Unskilled	1 (2%)	0 (0%)
Retired	6 (9%)	4 (9%)
Other	2 (3%)	1 (2%)

Table 13

C. Discussion

For the neighbors of W. R. Grace, these survey results might be good news. However, many questions remain to be investigated further.

Because of the number and distribution of responses, this study may not have detected the effect of the low level radiation. The response rate was 27%, and many of those living closest to the site and waterways did not participate.

These persons are assumed to have the greatest exposure levels, and also were shown to have disease in the Freeman Study.

Because of the low risk of deleterious effect from very low level exposure, or the large number of those not responding, it is possible that we cannot detect minor increases of disease in a population as small as this neighborhood. (46) The long latency period of radiogenic cancer and the mobility of today's society make it even more difficult. (42)

The damage done by ionizing radiation, no matter how small the dose, has been shown to be cumulative. By increasing the background levels of radiation and then exposing ourselves to clinical or occupational doses, we add the risks together.

Minor changes in the blood and increased risk to the

fetus are the first effects to be detected at a dose of 1-50 rems. (21) There is some evidence of increased leukemia and birth defects in our Case groups.

This study detected a number of diseases clustered closer to the Grace site and Sheffield Brook. (Figures 10-11) These findings were not statistically significant at $p < .05$, but are of interest biologically. Future surveys of disease in the area are needed to detect cumulative radiation exposure effects with long latency periods.

The plant fire occurred in 1977, decommissioning of plant operating equipment in 1974. Site "cleanup" is slated for the next few years. These may be critical events in increasing exposure levels to the neighborhood, and surveillance for public health purposes is advisable.

V. PROTECTING AGAINST THE PAST

A. Site Cleanup

1. Bechtel Engineering Study for Grace Site Mitigation

Bechtel International, Inc., under contract to the U.S. Department of Energy, has developed cleanup options for the site. Cost estimates for Grace also include cleanup of the school bus maintenance yard next door, and a section of the Erie Lackawanna Railroad at Peck Avenue, Pompton Plains.

The options include:

1. Stabilization of waste on site using excavation, with reburial over a clay liner.

2. Removal of wastes at Grace and vicinity to a disposal site within New Jersey, within 100 miles.

3. Removal and transport of waste to a USDOE site in Oak Ridge, Tennessee, within 750 miles.

Their cost study assumes that disposal sites are open to receive these radioactive materials. At present, they are not.

Option I.

On-site stabilization would have to involve first

excavation and then deposition of these materials on a clay liner, in the same pits they have occupied all along, with additional graves for the off site wastes. Clay dikes would be erected above groundwater level to contain runoff. The hydrogeology of the site make these steps necessary, according to Bechtel.

Approximate cost is $19 Million, for 20,000 cubic yards of material that is on site and 16,000 cubic yards from the railroad tracks and bus yard.

Option II.

The cost for disinternment and transporting the wastes to an undetermined New Jersey disposal site is $21 million.

Option III.

To take the waste to Oak Ridge for disposal adds an additional $10 million, for a total of $31 million.

A cost study breakdown follows: (60)

BECHTEL COST STUDY BREAKDOWN

	Option1	Option2	Option3
Task description	On Site stabilization	Transport to NJ Site	Transport to TN Site
Engineering and Technical	8,456,000	7,498,000	7,748,000
Site Characterization	300,000	185,000	185,000
Site Preparation	580,000	452,000	452,000
Property Acquisition	415,000	N/A	N/A
Demolition	190,000	190,000	190,000
Water System	250,000	250,000	250,000
Earthwork,Yr 4	1,771,000	1,032,000	1,032,000
Earthwork,YR 5	870,000	570,000	570,000
Earthwork YR 6	1,218,000	605,000	605,000
Cap Covering	1,386,000	N/A	N/A

Disposal (36,000 CY)	N/A	6,583,00	14,904,000
Contingency	3,087,000	3,473,000	5,187,00
Total Cost	18,523,000	20,838,000	31,123,000

Table 11

2. Proposed Timetable for Mitigation

Bechtel Intl. has developed a timetable for cleanup of the site, assuming that funding will be available and a final decision will be made and accepted by involved parties.

During 1984 they plan to stop off-site migration of materials, and remove contaminated soil from the Township soccer field and school bus maintenance yard. These materials will go to the site for "interim storage".

Materials collected from Sheffield Brook will be moved on site in 1985-86. In the "future", all materials will be removed to a permanent disposal site. Dig it all up once, then dig it up again.

A total of 20,000 cubic yards of soil, rubble and other materials is to be removed. That equals 150,000 pounds.

In addition, the Pequannock train station and parts of Farmindale Road are to be decontaminated, and that soil moved to Grace also.

Robert Rudolph is the Project Manager for Bechtel, and Hirth Weidener Associates of Wayne is assisting in the cleanup. (60)

B. RECOMMENDATIONS

1. Analysis of Bechtel Options

"Waste relocation is costly in dollars and radiation exposure. It is only done when other methods leave unacceptable radiation levels." (55)

Bechtel's options for cleanup of the site and estimated costs to complete mitigation deserve analysis.

Two of their "options" are currently inoperable, as there is no other site to transport these wastes to.

A major health concern should be the effect of excavation on increasing radiation levels.

The radiological surveys done by NJDEP showed increased levels where overburden was shallow, and where there were cracks in the pavement. In addition, destruction of company records in the 1977 fire leaves the exact location of wastes on the site in question.

The CDC has indicated that the greatest health hazard presented by the Grace site is through inhalation of contaminated dust.

Yet all of Bechtel's options involve excavation of the site. And that means kicking up dust.

Serious consideration should be given to on site

containment, using alternative methods that do not require excavation.

Further contamination of Sheffield Brook can be reduced or eliminated by isolating the waterway from the radioactive soils.

Piping or rerouting of this brook could accomplish that goal.

Additional placement of soil as overburden would reduce the amounts of radon gas and gamma radiation being released into the environment. It would also contain the radioactive soil, eliminating a dust source.

The problem of groundwater contamination would require that a monitoring program be instituted.

With major water movement toward the surface, it is unlikely that a major infiltration will occur. After 40 years, no radiation has seeped into the groundwater system.

The concentration of wastes onto the site, by adding the 16,000 cubic yards of off-site soil on-site is feasible. Precautions must be taken to prevent dust generation (and these are expensive) during removal. The additional material should be stored in a retrievable manner.

The same options for non-excavating modes of mitigation should be studied, before any decision to move off site waste is made.

The materials that have found their way into Sheffield Brook must also be dealt with. Removal of bank soils and dredging of sediment may be possible and desirable. They too would end up at the Grace site for storage.

Another option would be to isolate the stream by limiting access with fencing. Soil contamination is limited to 5 10 meters from the brook. The water shows no elevated radiation levels. Such a localized problem can effectively be dealt with by simple methods.

As unappealing as these alternatives may be to the local government and residents, it may be that they are in their best interests.

Further technological developments may relieve the neighborhood of its radioactive burden. However, as long as there is no place to take the wastes, they should be contained effectively, on-site. The alternative is to allow the nuclides to migrate further while waiting for a disposal site that may be years in coming.

2. Health Surveillance

The results of this study are by no means conclusive. Acting like an "epidemic in slow motion", cancer and genetic defects take years, decades, to show their true force. The full effect of life near this and other Manhattan Project sites has yet to be determined.

A monitoring and surveillance program, if initiated, would do much to ascertain the true impact on exposed persons. It would also help protect the residents against increased levels should there be a breach of cover or excavation at the site.

With no place else to go, it is likely that the material will be contained on site.

Once that is accomplished, and even during any cleanup operations, a program of surveillance will act to ensure regulatory compliance and monitor the efficacy of containment measures. Public satisfaction with site management would be enhanced if they knew someone was watching.

In addition, some protection from future legal liability may result from a continuing program.

The site has been released for unrestricted use by the Nuclear Regulatory Commission. Monitoring of future land use is crucial to protect any future owners of the property, and its

neighbors.

In designing a program, the International Commission on radiation Protection (ICRP), suggests assessment of the following:

a. Type of facility and potential hazards

b. Activity, form and routes of nuclide release

c. Other possible nuclide sources

d. Natural environmenat behavior of the nuclide

e. Climate, site topography, hydrogeology and vegetative cover

f. Man-made features

g. Land use

h. Population distribution, both occupational and residential (27)

The "at risk" population must be determined by identifying hazardous nuclides and their routes of exposure.

At Grace, there are elevated levels of thorium, uranium and radon gas, being released into the atmosphere and water system on and near the site.

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LIST OF FIGURES

UNIVERSITY OF MEDICINE AND DENTISTRY OF NEW JERSEY

COLLEGE HOSPITAL

100 Bergen Street
Newark, New Jersey 07103

Dear Concerned Citizen:

Enclosed you will find a questionnaire that concerns itself with your health. It is being conducted because members of your community have requested information about the possible health impacts incurred by the radio-active wastes stored at the Grace site.

There are approximately 350 hazardous waste disposal sites in New Jersey. No scientific study of the health effects on local residents has ever been conducted.

That is why it is so important for you to complete and return the enclosed questionnaire. I assure you that your identity will be kept confidential.

The results of this investigation will assist in the decisions being made in clean-up of the Grace site. It may help assure that your family is protected from further exposure to radioactive materials buried there.

The Department of Environmental Engineering of N.J.I.T. and the Department of Preventive Medicine and Community Health of UMDNJ are sponsoring this research and we hope you will help us in helping your community.

If you have any questions regarding the enclosed questionnaire, please call Mrs. L. Voyce at 835-4489 or the undersigned at 456-4778.

Sincerely,

G. Reza Najem, M.D.
Professor
Dept of Preventive Medicine
and Community Health

Enc.

THORIUM STUDY QUESTIONNAIRE

CONSENT

I have been informed that representatives of UMDNJ/NJIT are conducting a study of environmental factors and their possible effects on human health. This study involves obtaining information from me about my residence, occupation and health, as well as some information about other possible exposures. My identification is strictly confidential and the information obtained from me will be used only for research purposes.

I will also provide information about my family's occupation and health.

I understand that it may be necessary to contact me again.

I agree to take part in this study and provide information understanding that:

1. All information will be kept confidential.

2. My participation is voluntary and I am free to discontinue participation at any time.

3. The data obtained will be used to determine whether environmental factors in this area may contribute to health problems. Any publication or use of this data will be in the form of statistics or anonymous quotations.

4. A summary of results of this study will be made available upon written request.

_____

Name (please print)

_____

Signature

_____

Date

Please return this questionnaire when completed in the provided self-addressed, stamped envelope. Thank you.

THORIUM STUDY

Card One

I.D. # [ ][ ][ ][ ] (1 2 3 4)

Card #01

Last Name [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] (5 6 7 8 9 10 11 12 13 14 15 16 17 18)

First Name [ ][ ][ ][ ][ ][ ][ ][ ] (19 20 21 22 23 24 25 26)

M.I. [ ] (27)

S.S.# [ ][ ][ ][ ][ ][ ][ ][ ][ ] (28 29 30 31 32 33 34 35 36)

Birthdate [ ][ ][ ][ ][ ][ ] (37 38 39 40 41 42)

Present Age [ ][ ] (43 44)

Birth Place

Sex: 1. male 2. female [ ] (45)

Race: 1. White 2. Black 3. Oriental 4. Other [ ] (46)

Marital Status: 1. single
2. married
3. separated
4. divorced
5. widowed
[ ] (47)

Please list name, relationship and age of any other persons residing with you:

What is your religion:

1. Catholic
2. Protestant
3. Jewish
4. Moslem
5. Other

Yourself [ ] (48)

Family [ ] (49)

Card One

How long have you resided at your present address? Years [ ] (50 51)

Where have you lived before? _____

For how long? _____

What is approximate total family income per year? [ ] (52)

1. Less than $15,000
2. $15,000 - $29,000
3. $30,000 - $44,000
4. $45,000 - $49,000
5. $50,000 - $54,000
6. $55,000 - $59,000
7. $60,000 or more

Card Two

I.D.# [ ][ ][ ][ ] 1 2 3 4

Card #02

Last Name

1. Do you or any member of your family eat red meat (steak, roast beef, pork, etc.) at least 3 times a week? (Place appropriate number beside yourself/ family).

   1. Yes 2. No

   Yourself [ ] 5

   Family [ ] 6

2. What kind of vitamin supplement do you or your family take?

   1. Vitamin A
   2. Vitamin E
   3. Vitamin C
   4. Vitamin B
   5. Multivitamin
   6. I don't take any vitamin supplements
   7. Other _____ Specify

   Yourself [ ] 7

   Family [ ] 8

3. Are you or other members of your family a vegetarian?

   1. Yes 2. No

   Yourself [ ] 9

   Family [ ] 10

4. Which of the following foods do you or your family eat at least 3 times per month?

   1. Sausage
   2. Bacon
   3. Ham
   4. Cold cuts
   5. Bologna
   6. Hot dogs
   7. None of the above

   Yourself [ ] 11

   Family [ ] 12

5. Do you eat any type of ethnic (or country) cooking predominately?

   1. Yes 2. No 3. Unsure [ ] 13

   What type _____

6. Do you grow your own vegetables? ___ 14

1. Yes 2. No

7. Do you buy produce from the local farms? ___ 15

1. Yes 2. No

8. What is your weight? ___ 16 17 18

What is your height (inches)? ___ 19 20

9. Have you ever smoked?

1. Yes 2. No

Yourself ___ 21

Family ___ 22

10. Do you smoke now?

1. Yes 2. No

Yourself ___ 23

Family ___ 24

11. If you do not smoke now, did you smoke in the past?

1. Yes 2. No

Yourself ___ 25

Family ___ 26

12. If you stopped smoking, how many years ago did you stop?

Yourself ___ 27 28

Family ___ 29 30

13. For how many years have you smoked?

Yourself ___ 31 32

Family ___ 33 34

14. What did you smoke?

1. Cigarette
2. Cigar
3. Pipe
4. All of the above

Yourself ___ 35

Family ___ 36

15. How many cigarettes did you smoke per day?

Yourself ___ 37 38

Family ___ 39 40

16. How many pipefuls did you smoke per day?

Yourself ___ 41 42

Family ___ 43 44

17. How many cigars did you smoke per day?

Yourself ___ 45 46

Family ___ 47 48

18. How many cups of coffee do you or your family drink every day?

1. over 5 cups
2. over 2 cups
3. one cup
4. I don't drink coffee

Yourself ___ 49 50

Family ___ 51 52

19. Do you or your family have over 3 alcoholic drinks per day? (3 ounces of gin, scotch, whiskey, 3 beers or 3 wines).

1. Yes 2. No

Yourself ___ 53

Family ___ 54

20. If not, did you drink alcohol in the past?

1. Yes 2. No

Yourself ___ 55

Family ___ 56

21. What types of alcohol do you drink?

1. beer
2. wine
3. hard liquor

Yourself ___ 57

Family ___ 58

22. How many oz. (or shots) per week?

1. 0 - 1
2. 2 - 4
3. 5 - 8
4. > 8

Yourself ___ 59

Family ___ 60

Card Three

I.D.# _____ (1 2 3 4)

Card #03

Last Name

1. What is your current job title? _____

2. Classify your present job into one of the following categories:

1. Homemaker
2. Professional
3. Skilled
4. Semi-skilled
5. Unskilled
6. Retired
7. Other

Yourself _____ (5)

Family _____ (6)

3. Have you ever worked in any of the following industries:

1. dye products
2. textiles
3. printing
4. rubber
5. plastics
6. pesticides
7. x-rays
8. power generation
9. vinyl chloride
10. arsenic
11. contact with fuel/soot
12. pharmaceuticals
13. radiopharmaceuticals

Yourself _____ (7 8)

Family _____ (9 10)

List all types and years of occuption held since age 16 or for the past 20 years. Make separate lists for all family members. (Use reverse side if needed).

Card Four

I.D.# [ ][ ][ ][ ]
1 2 3 4

Card #04

Last Name

1. Have any miscarriages (spontaneous abortions) occurred in your immediate family? If yes, what year did they occur?

   1. Yes 2. No [ ] 5

2. Have there been any premature births in your immediate family? If yes, what year did they occur?

   1. Yes 2. No [ ] 6

3. Have any children been born with a physical or mental deficiency (birth defects i.e. cleft lip, spina bifida, mental retardation) among members of your family?

   1. Yes 2. No [ ] 7

   If yes, what is the relationship to you? _____

4. Do you have any birth defects?

   1. Yes 2. No [ ] 8

5. Does anyone living with you have any birth defects?

   1. Yes 2. No [ ] 9

   If yes, please write their ages and relationship to you.

   _____

   _____

   _____

6. Do any of your following relatives have birth defects?

1.	Mother:	Yes	No	Unknown
2.	Father:	Yes	No	Unknown
3.	Grandfather:	Yes	No	Unknown
4.	Grandmother:	Yes	No	Unknown
5.	Children:	Yes	No	Unknown
6.	Brothers/Sisters:	Yes	No	Unknown

7. Have any family pets ever been diagnosed as having cancer?

   1. Yes 2. No ☐ 10

8. Have there been any difficulties with pregnancy or malformed offspring from a family pet?

   1. Yes 2. No ☐ 11

   If yes, please describe.

Card Five

I.D.# _____
1 2 3 4

Card #05

Last Name

1. Do you feel healthy?

1. Yes 2. No _____
5

2. Have you or any member of your family had any of the following diseases. (Please use the following numbers in the boxes in front of each disease).

1 = Self
2 = Other family residing with you
3 = Other relative (living or deceased)
4 = More than one of the above

6 [ ] Lung cancer
7 [ ] Laryngeal cancer
8 [ ] Respiratory diseases that lasted for more than 2 weeks
9 [ ] Skin disorders
10 [ ] Heart Disease
11 [ ] Diabetes
12 [ ] Liver cancer
13 [ ] Liver tumor (benign)
14 [ ] Jaundice
15 [ ] Cancer of the spleen
16 [ ] Unexplained fever for more than than 2 weeks
17 [ ] Cancer of the bone
18 [ ] Cancer of the nose
19 [ ] Large liver
20 [ ] Liver failure
21 [ ] Internal abdominal bleeding
22 [ ] Anemia
23 [ ] Leukemia
24 [ ] Cirrhosis
25 [ ] Any other cancer _____ specify
26 [ ] Any other liver disease _____ specify
27 [ ] Any other diseases that lasted for more than 1 month _____ specify

3. Are your parents living?

   1. Yes 2. No ☐ 28

4. What is your parents age?

   Present age if still living _____

   Age at death, if deceased _____

5. If your parents are deceased, what were the causes of death?

   _____

   _____

6. Have you ever been hospitalized more than 2 nights? ☐ 29

   1. Yes 2. No

   If yes, reason for hospitalization _____

   _____

7. Have you ever received radiation therapy?

   1. Yes 2. No Yourself ☐ 30 Family ☐ 31

   If yes, for what purpose? _____

8. Have you or any member of your family had any kind of disease that lasted for more than 1 month?

   1. Yes 2. No Yourself ☐ 32 Family ☐ 33

   If yes, please list the diseases that you or any member of your family had since living at your present address and write the duration of the illness and the year that you got the disease.

Yours	Others	Type of Disease	Duration	Year

9. Have you or any of your blood relatives had any cancer? ☐ 34

1. Yes 2. No

If yes, please specify the type of cancer and relationship to you.

_____

_____

THANK YOU VERY MUCH!

UNIVERSITY OF MEDICINE AND DENTISTRY OF NEW JERSEY
100 BERGEN STREET / NEWARK, NEW JERSEY 07103

MEMORANDUM

TO: The Neighbors of W.R. Grace DATE: 10/6/83

FROM: G. Reza Najem, M.D. and
Lisa Voyce, B.A.

A previous study of toxic waste disposal sites in New Jersey showed that there is an association between these dump sites and certain cancer mortality rates. Because of those findings, we are continuing our research by investigating the health problems that may or may not be associated with the W.R. Grace disposal site in Wayne.

We have yet to receive your completed health questionnaire. Without your help, we cannot complete this survey and find answers that may assist in assuring the future health of your family and neighbors. Many people have already answered the questionnaire; won't you please help us and your neighbors? If you have any concerns or questions, please call Dr. Najem at 456-4778, or Mrs. Voyce at 835-4489. If you need a new copy of the survey we will be happy to send you one. Thank you!

PATERSON NEWS 10/4/83

Your To

400 Wayne people aid MD's study on thorium

By DONNA SYLVESTER
Staff Writer

WAYNE — Four-hundred residents are participating in a medical study to learn what possible consequences a radioactive-thorium dumpsite in the Sixth Ward could have on their health.

"This is an area where not much work has been done, and people are very concerned about it," said Dr. G. Reza Najem, professor of preventive medicine and community health at the University of Medicine and Dentistry of New Jersey.

In an earlier study, Najem said he found some relationship between cancer in New Jersey and chemical toxic-waste dumps.

The thorium study expands this preliminary study, he said, focusing on a specific-disposal site.

He said, "thorium is a radioactive material more hazardous than most chemicals."

Three or four months ago, Najem began his study, distributing questionnaires to residents.

The 400 residents included in the study must respond to questions about cancer in the family, birth defects, premature childbirths, sterilization and more, Najem said.

He could not give a completion date for the study. The sooner people answer the surveys, the sooner the study will be completed, said Dr. Najem of the Newark-based college.

The research also questions residents who do not live in proximity to the dumpsite. These residents will be the control group, used in research for comparison.

"If there is any association between the site and health problems," Najem said, "then appropriate measures should be taken."

Councilman Gary Webb said some residents have mixed reactions to the health study.

Webb said he has heard both complaints and favorable responses to the study.

The council should have been informed of the research project so residents could be prepared, Webb said.

"Anything that we do with thorium, as far as trying to collect data, is going to be important," he said.

"We don't know to what extent people in that area have been affected," he added.

George Yasenchock, head of Concerned Citizens, said the township should have initiated its own health study. Concerned Citizens is a citizens watchdog group on the thorium issue.

Yasenchock also questioned whether the study would "prove anything," because agencies have said from the start, there are no immediate health problems related to the thorium site.

Webb argued an in-depth health survey was beyond the means of the town, but residents were offered the services of the Department of Health for cancer screening, he said.

W. R. Grace and Co. processed thorium on Black Oak Ridge Road from 1948 until 1971. Burial of the radioactive matter continued until 1974.

Testing reveals radiation at seven to nine times federal guidelines on the site and along nearby Sheffield Brook. Radiation also is found in some backyards along the brook.

NO MORE QUESTIONNAIRES, SURVEYS, COMMISSIONS. THORIUM IS A POISON, IT IS IN MY NEIGHBORHOOD, IT KILLS, IT SHOULD BE REMOVED IMMEDIATELY. IT HAS BEEN STUDIED TO DEATH.

IF YOU WANT TO DO SOMETHING SPECTACULAR, BRING BACK MY HUSBAND WHO SUFFERED FOR MONTHS, AND FOR WANT OF A BETTER DIAGNOSIS, DIED OF "ACUTE MYLEOGENOUS LEUKEMIA." THIS DIAGNOSIS WAS FINALLY ARRIVED AT--AT THE TIME OF DEATH--BY FOURTEEN MEDICAL EXPERTS, ALL OF WHOM ASSURED ME THAT "WHATEVER HE HAS WILL NOT KILL HIM." SO MUCH FOR THE MEDICAL PROFESSION.

WANT TO DO SOMETHING EVEN MORE SPECTACULAR? MOVE THIS STUFF OUT OF HERE BEFORE IT KILLS MY CHILDREN.

AND DON'T TELL ME THAT THE MEDICAL PROFESSION OR THE GOVERNMENT OR ANYONE ELSE IS STUDYING, ANALYZING, CONFERRING, OR OTHERWISE "PROTECTING" ME.

THE GRACE COMPANY DUMPED POISON IN THE GROUND 20 YEARS AGO. IT IS STILL THERE, AND PROBABLY SPREADING. GET IT OUT.

Mrs. [redacted]

Reference #49

Low Level Radioactive Waste is defined as radioactive waste which is not High-Level Waste, Transuranic Waste, Spent Nuclear Fuel, or Uranium Mill Tailings. It includes Everything from Slightly Contaminated Clothing, Paper, Plastics and Tools to Medical Equipment and Scintillation Fluid to the more Radioactive Sludges and Resins and Used Components from Reactors. Some Low Level Waste is Relatively Harmless; Some is Highly Radioactive and Hazardous.

Reference: United States Nuclear Regulatory Commission. Federal Low Level Radioactive Waste Policy Act of 1980.

New York State: Low Level Radioactive Waste Management Study.