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AN AERIAL RADIOLOGICAL SURVEY OF
**WAYNE TOWNSHIP,
NEW JERSEY**
AND SURROUNDING AREA

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AN AERIAL RADIOLOGICAL SURVEY OF
WAYNE TOWNSHIP, NEW JERSEY
AND SURROUNDING AREA

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1.0 SUMMARY OF RESULTS

An aerial radiological measuring system was used to survey the area surrounding the former W. R. Grace property located in Wayne Township, New Jersey, during the month of September 1982. This site formerly contained a facility to extract rare earths and thorium from monzanite sands. The survey was conducted for the U.S. Department of Energy's (DOE) Office of Operational Safety by the Department's Remote Sensing Laboratory, operated for the DOE by the Energy Measurements Group of EG&G.

The highest radiation exposure rates were measured over the site. Average radiation levels of 30 to 60 microrentgens per hour ($\mu\text{R}/\text{h}$), normalized to 3 feet above the ground, were inferred from the aerial data. Elevated radiation levels ranging from 20 to 30 $\mu\text{R}/\text{h}$ were also observed over a stream (Sheffield Brook) extending approximately 1/2 mile west of the site as well as over the quarry area located to the west of Pompton Lakes. The source of the elevated activity in each case was thorium.

Natural background radiation exposure rates measured by the airborne system within the survey area typically ranged from 6 to 10 $\mu\text{R}/\text{h}$ with an average value of approximately 8 $\mu\text{R}/\text{h}$.

2.0 INTRODUCTION

An aerial radiological survey was flown over a 5½-mile by 10-mile area surrounding the former W. R. Grace property located in Wayne Township, New Jersey. This survey was conducted for the Department of Energy's (DOE) Office of Operational Safety (OOS) by the Energy Measurements Group of EG&G. The OOS conducts radiological surveys at sites and facilities where nuclear operations were formerly conducted for the government.

An MBB BO-105 helicopter, equipped with aerial radiological detection systems, was used for the survey. The helicopter altitude above ground level was 300 feet with 300-foot line spacings. A previous survey covering an area of 3 miles by 4 miles surrounding this site was flown in May 1981 utilizing this system.¹ The purpose of the present survey was to expand the coverage to include all of Wayne Township.

Aerial radiological detection systems average the radiation levels produced by gamma-emitting radionuclides existing over an area of several acres. These detection systems are capable of determining specific radionuclides causing radiological anomalies. However, because of averaging, airborne systems, as compared to ground-based measurements, tend to underestimate the magnitude of localized sources. Details of the systems and procedures employed in obtaining and processing aerial radiation data are presented in References 2 and 3.

In aerial radiological surveys, the gamma ray energies, source concentrations, and relative distribution are measured by specialized instrumentation. The results are reported as radiation exposure rates

in $\mu\text{R/h}$ at 3 feet above the ground. The maximum annual radiation dose that could be absorbed through continuous exposure (24 hours a day for 365 days to a constant exposure rate), expressed in millirem per year (mrem/y) is approximated by multiplying the exposure rate in micro-roentgen per hour ($\mu\text{R/h}$) by 8.76*. These results apply to external radiation only and do not account for inhalation or ingestion of radioactive materials. The actual amount of radiation absorbed depends on the duration and circumstances of exposure.

3.0 BACKGROUND RADIATION

Background gamma radiation originates from naturally occurring radioactive elements present in the earth (terrestrial radiation) and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Variable concentrations of these nuclides produce estimated annual radiation doses ranging from 15 to 140 mrem/y (1.7-16 $\mu\text{R/h}$) at the surface of the earth in the United States. The higher background radiation dose levels (up to 140 mrem/y) are typically found in the western states, primarily in the Colorado Plateau area, and are a result of high uranium and thorium concentrations in surface minerals and increased cosmic radiation because of higher elevation.

The uranium decay chain includes radium-226 and its daughter, radon, which is a noble gas, i.e., it will not combine chemically with other elements. The radionuclide radon can both diffuse through the

$$* \frac{\mu\text{R}}{\text{h}} \times 24 \frac{\text{h}}{\text{day}} \times 365 \frac{\text{day}}{\text{y}} \times \frac{1}{1000} \frac{\text{mrem}}{\mu\text{R}} = \frac{\text{mrem}}{\text{y}} \quad \left(\text{using the approximate conversion from } \mu\text{R to mrem} \right)$$

soil and move through the air to other locations. Thus, the level of radiation contributed by this noble gas depends upon the meteorological conditions, mineral and moisture content and permeability of the soil, and other physical conditions existing at each location at any particular time. Airborne radon typically contributes from 1 to 10 percent of the natural background radiation levels.

Cosmic rays, the space component of the natural radiological background, interact in a complex manner with the elements of the earth's atmosphere and soil. These cosmic ray interactions produce additional background radiation dose rates which vary slightly with latitude and directly with altitude, increasing from 26 mrem/y (3 μ R/h) at sea level in Florida to 107 mrem/y (12 μ R/h) at 10,000 feet above sea level at some locations in Colorado. The cosmic ray dose rate in Denver, Colorado (1 mile above sea level), contributes about 50 mrem/y to the total background dose rate of about 125 mrem/y.

The aerial survey results include the terrestrial gamma radiation measured throughout the surveyed area and an estimated cosmic ray exposure rate, but the results do not include the contribution from airborne radon.

4.0 SURVEY BOUNDARIES

This survey covered an area of approximately 55 square miles including all of Wayne Township, New Jersey. The boundaries of the survey are shown in Figure 1.

5.0 SURVEY RESULTS

The results of this aerial survey are presented in Figure 1 as closed contour curves of total radiation exposure rates (isoration contours) overlaid on an aerial photograph of Wayne Township, New Jersey.

The results are reported in units of $\mu\text{R}/\text{h}$ at 3 feet above ground and include a cosmic ray contribution estimated at $3.7 \mu\text{R}/\text{h}$.

The highest radiation exposure rates were measured over the site. Average radiation levels ranging from 30 to 60 $\mu\text{R}/\text{h}$ were inferred from the aerial data. Elevated radiation levels ranging from 20 to 30 $\mu\text{R}/\text{h}$ were also observed over a stream (Sheffield Brook) extending approximately 1/2 mile west of the site and over the quarry area located to the west of Pompton Lakes.

A special data processing technique (details of which are given in References 2 and 3) was used to help identify areas containing thorium concentrations greater than that present in typical background soils. The results of this special analysis are also shown in Figure 1. The green area includes the site and the stream west of the site. The other areas, shown in yellow, appear to be the result of natural anomalies. Elevated exposure rates were associated with the excess thorium over the site, over the stream, and over the quarries north of the site. The other areas did not show elevated exposure rates, and appear to be due to slight perturbations in the relative amount of thorium within these areas compared to the rest of the survey area.

A similar technique was used to search for possible areas containing excess radium-226, normally associated with uranium ore and tailings. No positive indications were observed.

Natural background radiation exposure rates within the survey area typically ranged from 6 to 10 $\mu\text{R}/\text{h}$ with an average value for Wayne Township of approximately 8 $\mu\text{R}/\text{h}$.

6.0 COMPARISON WITH PREVIOUS SURVEYS

The results of the September 1982 survey compare quite well with the results of the May 1981 aerial survey except directly over the site and along the stream west of the site. The previous survey inferred exposure rate levels greater than 120 $\mu\text{R}/\text{h}$ over the site and maximum levels between 60 and 120 $\mu\text{R}/\text{h}$ along the stream. The present survey indicated levels between 30 and 60 $\mu\text{R}/\text{h}$ over the site and between 20 and 30 $\mu\text{R}/\text{h}$ along the stream. These differences result from the different survey altitudes flown in the two surveys (150 feet in 1981 versus 300 feet in 1982), and indicate that the source of the activity within the site and along the stream is highly localized. At the higher survey altitude the airborne system averages over a larger area and will infer a lower exposure rate for a localized source. Due to terrain limitations it was not possible to fly the large area survey lower than 300 feet.

A ground-based radiological survey was conducted April 26 to May 1, 1982 along the stream west of the site by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee.⁴ This survey indicated the presence of thorium contaminated soil and sediment along the stream. The survey findings also showed that the thorium contamination was generally limited to a narrow strip, approximately 30 feet maximum, on either side of the stream. Elevated radium-226 was also detected but at levels much lower (5 to 10%) than the thorium concentrations. Exposure rate levels measured 3 feet above ground were highly variable, ranging from 8 to 269 $\mu\text{R}/\text{h}$, with an average value along the stream of 50 $\mu\text{R}/\text{h}$. These results are consistent with those obtained from the aerial data after taking into consideration the large area averaging property of the airborne system.

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Figure 1. GAMMA EXPOSURE RATE CONTOURS DERIVED FROM AERIAL SURVEY DATA OBTAINED OVER WAYNE TOWNSHIP, NEW JERSEY AND THE SURROUNDING AREA.