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EG&G SURVEY REPORT
NRC-8302
MARCH 1983

AN AERIAL RADIOLOGICAL SURVEY OF THE

# E. R. SQUIBB & SONS, INC. FACILITY

AND SURROUNDING AREA

NEW BRUNSWICK, NEW JERSEY

DATE OF SURVEY: APRIL 1982

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Classification Officer

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## ABSTRACT

An aerial radiological survey was conducted over the E. R. Squibb and Sons, Inc. facility and surrounding area in New Brunswick, New Jersey. The survey, conducted from 14 to 19 April 1982, covered a 50-square-kilometer area centered on the facility. Radiological data were collected by flying at an altitude of 91 meters (300 feet) along lines oriented east-west and spaced 91 meters apart. Count rates obtained from the aerial platform were converted to exposure rates at 1 meter above ground level.

Over most of the survey area, the resulting exposure rates due to natural background radiation were between 8 and 10 microroentgens per hour ($\mu$R/h). The average exposure rate in the northwest corner of the survey area ranged slightly higher (10 to 12 $\mu$R/h). These results were in close agreement with ground measurements made at the same time as the aerial survey.

Elevated exposure rates, up to 100 $\mu$R/h, were measured directly over the facility. Gamma ray energy spectra characteristic of selenium-75 and molybdenum-99 were obtained directly over the facility site. The presence of these radioisotopes is consistent with site operations. Off-site anomalies were detected in two locations within the survey area. Iodine-131 was present at the warehouse of a common carrier located approximately 3.5 kilometers east of the Squibb facility. Gamma ray energy spectra characteristic of that radioisotope were obtained while flying over the facility. The other anomalous location was approximately 2.5 kilometers northwest of the Squibb facility. There, slightly elevated concentrations of naturally occurring uranium—in equilibrium with its daughter products—were detected.

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## 1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains the Remote Sensing Laboratory (RSL) in Las Vegas, Nevada and an extension facility in Washington, D.C. The RSL is operated for the DOE by the Energy Measurements Group of EG&G. A major function of the RSL is to manage an aerial surveillance program called the Aerial Measuring System (AMS).

Since its inception in 1958, the AMS has continued a nationwide effort to document baseline radiological conditions surrounding energy-related sites of interest, including nuclear power plants, manufacturing and processing plants, and research laboratories employing nuclear materials.[1] The AMS is deployed for various aerial survey operations at the request of federal or state agencies, and by direction of the DOE.

The aerial radiological survey over the E.R. Squibb and Sons, Inc. facility and surrounding area, New Brunswick, New Jersey, was requested by the U.S. Nuclear Regulatory Commission. Various radionuclides are handled at the site; radiopharmaceuticals are manufactured and tested. The purpose of the survey was to characterize the area's background radiation due to natural and man-made sources.

## 2.0 BACKGROUND RADIATION

Natural background radiation originates from radioactive elements present in the earth (i.e., the terrestrial component), airborne radon, and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma radiation originates primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Annual doses from the terrestrial component of background radiation are as low as 15 to 35 millirems (mrem) (less than 5 microroentgens per hour, $\mu$R/h) for the Atlantic and Gulf Coastal Plains and as high as 75 to 140 mrem (9 to 16 $\mu$R/h) on the Colorado Plateau.[2]

One member of both the uranium and thorium decay chains is radon, a noble gas. This radioisotope can diffuse through the soil and travel through the air to other locations. The level of airborne radiation at any specific location, due to radon and its daughter products, depends on a variety of factors, including meteorology, mineral content of the soil and soil permeability. Typically, airborne radiation contributes between 1 and 10 percent of the natural background levels.

Cosmic rays interact with the elements of the earth's atmosphere and soil to produce an additional natural source of gamma radiation. The intensity of this radiation source depends on the altitude and, to a lesser extent, on the geomagnetic latitude. In general, the cosmic ray contribution to the natural background radiation is largest at high altitudes and high latitudes. Annual doses in the United States due to cosmic rays range from about 29 mrem (3.3 $\mu$R/h) in Florida to about twice that in Wyoming.

External radiation may also be received from radioactive elements in building materials. Naturally occurring radioactive materials can be concentrated in a particular location due to building or road construction. In structures made of stone, concrete or brick, the radiation dose is generally higher than in nearby wooden buildings. Thus, radiation doses due to background sources are highly variable and depend upon a number of factors.

## 3.0 SURVEY SITE DESCRIPTION

The AMS was utilized during the period 14 to 19 April 1982 to characterize the background radiation in the area surrounding the Squibb facility by surveying a 50-square-kilometer area centered on the facility. The facility is located along U.S. Route 1 in New Brunswick, New Jersey, approximately 1.6 kilometers south of the Raritan River.

Routine facility operations were underway during the survey period. These operations include the shipping and receiving of radioactive materials and movement of these materials on-site. Therefore, radiation levels measured directly over the facility will differ from those reported here depending on the on-site operations at the time of measurement.

The aerial survey was conducted shortly after the snow from an early spring storm had melted. Up to 15 cm of snow covered the ground throughout the survey area prior to the start of the survey. All visible signs of the snow cover had vanished approximately 3 days before any measurements were made; however, an unusually high soil moisture content for this area may have been present.

## 4.0 SURVEY PROCEDURES AND EQUIPMENT

### 4.1 Aerial Measurements

Measurements of the total count rate and energy spectrum of gamma radiation were made along 75 flight lines spaced 91 meters (300 feet) apart and oriented in an east-west direction. The instrumentation and equipment used for this survey are described briefly here. A thorough description of AMS systems and procedures can be found in previous reports.[1,3] Twenty thallium-activated sodium iodide [NaI(T*l*)] crystals mounted on a Messerschmitt-Bolkow-Blohm (MBB) BO-105 helicopter (Figure 1) detected gamma rays while flying at an altitude of 91 meters (300 feet) above ground level at a ground speed of 36 meters per second (70 knots). Each NaI(T*l*) crystal was 12.5 cm in diameter and 5 cm thick.

**Figure 1.** *MBB BO-105 HELICOPTER WITH DETECTOR PODS*

Scintillation pulses from each crystal were converted to voltage pulses in a photomultiplier tube assembly. These pulses were summed and input to the Radiation and Environmental Data Acquisition and Recorder (REDAR) system on board the aircraft. The REDAR system was composed of several microprocessor-based subsystems. The control subsystem collected and formatted gamma ray spectral data, gross count data (gamma ray activity integrated over the energy range 0.04 to 3.0 MeV), aircraft position data, and system live time information. Records containing four 1-second data points for these parameters were stored on magnetic tape every 4 seconds. This tape subsystem consisted of a microprocessor and a dual cartridge digital recorder. Radiological data, along with selected operational parameters, were displayed on board the helicopter by the display subsystem. Two cathode ray tubes were available for viewing these data in real time.

The helicopter position was established with two systems: a microwave ranging system and a radar altimeter. The microwave ranging system consisted of two remotely-located transponders and an on-board interrogator. The on-board interrogator used the transit time of a microwave pulse to obtain the distance from the aircraft to each remote unit. The radar altimeter similarly measured the time lag of the return of a pulsed signal and converted this to aircraft altitude above ground level. Position and altitude information were also processed in real time by the steering microprocessor. These data provided steering indications to the pilot for flying the predetermined flight lines at the desired altitude.

Magnetic tapes with recorder data from the aerial radiological survey were processed after each flight with the Radiation and Environmental Data Analyzer and Computer (REDAC) system. This computerized data analysis system was built into a 5-ton step van. The interior of this van is shown in Figure 2. The REDAC system consisted primarily of a Data General NOVA 840 computer and peripherals. An extensive inventory of software routines was available for data processing.

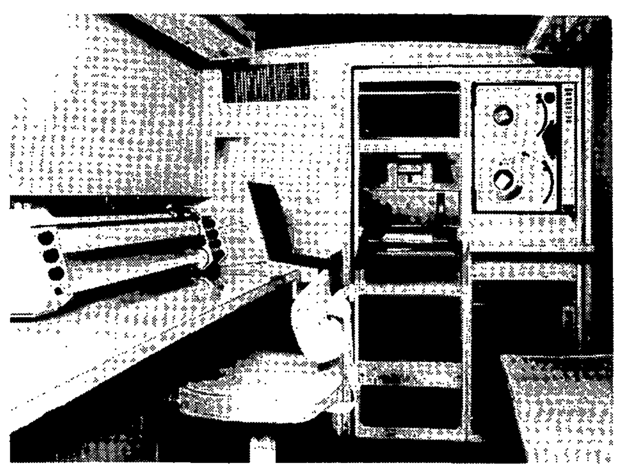


**Figure 2.** *INTERIOR OF THE MOBILE COMPUTER LABORATORY*

### 4.2 Ground-Based Measurements

Soil samples were collected and exposure rate values were measured at four locations within the survey area. Ground sampling was done during the same time period the aerial survey was conducted. The soil samples were analyzed and results tabulated for this report at EG&G's Santa Barbara Laboratory. Systems and procedures for soil sample data collection and analysis are outlined in a separate publication.[4] The ground sampling sites for this survey are shown in Figure 3.

## 5.0 ANALYSIS AND RESULTS

Exposure rates at 1 meter above the ground level were derived from the gross count rates measured at survey altitude. Contributions to these data from non-terrestrial sources (i.e., cosmic rays, airborne radon and aircraft background) were removed by subtracting the count rate measured over the Raritan Bay from the measurements made over the survey area. The "water line" measurements were assumed to be free of contributions from gamma ray emitters on the ground. This subtraction resulted in net counting rates due to terrestrial sources of gamma rays.

The resulting net count rates were converted to exposure rates at 1 meter above the ground level by applying a conversion factor of 740 counts per second per $\mu$R/h. This factor was derived from many measurements made over areas with known concentrations of naturally occurring gamma ray emitters and is strictly applicable only to areas with similar compositions. An estimated cosmic ray contribution of 4 $\mu$R/h was then added to the calculated exposure rates. An exposure rate contour map of the area surrounding the Squibb facility is shown in Figure 3.

The average exposure rates over most of the survey area were between 8 and 10 $\mu$R/h. Slightly higher exposure rates (10 to 12 $\mu$R/h) were observed in the northwest corner of the survey area. A gamma ray energy spectrum typical of the natural background radiation present within the survey boundaries is shown in Figure 4. The peaks in the spectrum occur at energies corresponding to gamma rays emitted by naturally occurring material.

Elevated exposure rates, up to 100 $\mu$R/h, were measured directly over the Squibb facility. The concentric contour lines over two locations on the site are characteristic of localized sources of radiation. Gamma ray energy spectra measured over these locations are shown in Figures 5 and 6. The spectrum in Figure 5 indicates that selenium-75 was present, with a peak exposure rate in the 12 to 20 $\mu$R/h range. Molybdenum-99 was identified from the spectrum shown in Figure 6. This spectrum was measured where exposure rates ranged up to 100 $\mu$R/h. Both selenium-75 and molybdenum-99 are handled at the facility; the locations defined by the contour lines are consistent with facility operations.*[5]

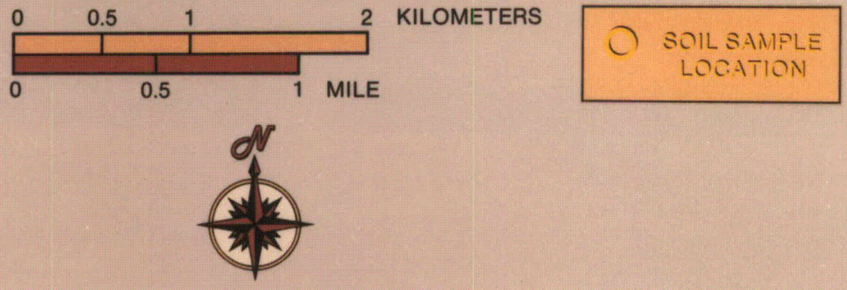
In addition to the analysis of the gross counting rates, the aerial data were processed utilizing a computer code more sensitive to gamma rays emitted from man-made radioactive materials.[3] Most of the man-made radioisotopes of interest emit gamma rays of energies less than 1.40 MeV. Therefore, spectral data with enhanced activity in a low-energy "window" (0.04 to 1.40 MeV) relative to that in a high-energy "window" (1.40 to 3.00 MeV) indicate the possible presence of man-made radioisotopes.

The two locations of elevated exposure rates on the facility site were confirmed by this analysis. In addition, two other locations within the survey boundaries were identified. The gamma ray energy spectrum shown in Figure 7 was measured over a location approximately 3.5 kilometers east of the Squibb facility (see Figure 3). The peaks observed in this spectrum occur at energies characteristic of iodine-131. This man-made anomaly occurred directly over a warehouse belonging to Sky Cab, Inc. Radioactive sources from Squibb are routinely shipped to local airports by Sky Cab.[6] Radiation levels and the gamma ray spectra over this location will change depending on the specific sources awaiting shipment.**

The other anomaly identified by the "man-made" analysis occurred approximately 2.5 kilometers northwest of the Squibb facility (see Figure 3). No "man-made" radioisotope was detected at this location, but the mixture of naturally occurring radioisotopes there was different than that found

*The flight lines directly over the facility were flown between 2:00 p.m. and 4:00 p.m. on Thursday, 15 April 1982. The radiation levels measured over the facility will vary depending on current site operations.

**The flight lines directly over the Sky Cab facility were flown between 2:00 p.m. and 4:00 p.m. on Thursday, 15 April 1982. At that time, packages containing iodine-131 were present at the facility. The total activity present was less than 200 millicuries. Measurements made at the Sky Cab building by the USNRC, when no packages of radioactive material were present, revealed that radiation levels did not exceed 6 $\mu$R/h.[6]


**CONVERSION SCALE**

| LETTER LABEL | EXPOSURE RATE AT 1 METER ABOVE GROUND LEVEL ($\mu$R/h)* |
|---|---|
| A | <8 |
| B | 8 - 10 |
| C | 10 - 12 |
| D | 12 - 20 |
| E | 20 - 50 |
| F | 50 - 100 |

*Inferred from aerial data obtained at an altitude of 91 meters above ground level. The exposure rates include a contribution of 4 $\mu$R/h from cosmic rays but do not include any contribution from airborne radon.

**Figure 3.** *EXPOSURE RATE CONTOUR MAP SUPERIMPOSED ON AN AERIAL PHOTOGRAPH OF THE AREA SURROUNDING THE E.R. SQUIBB FACILITY IN NEW BRUNSWICK, NEW JERSEY. The locations of the ground sampling sites are also shown.*

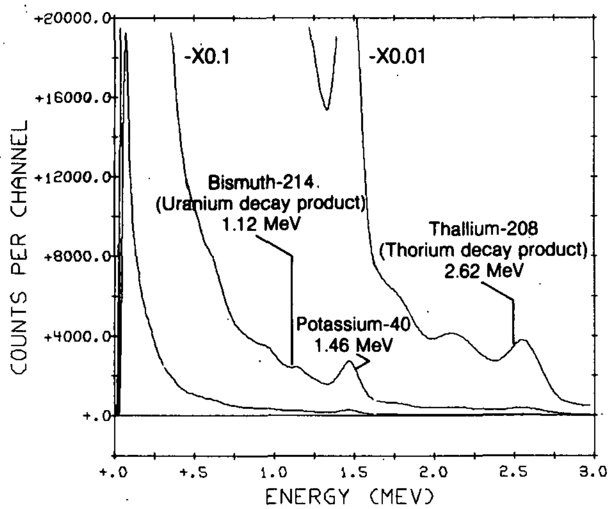



**Figure 4.** *GAMMA RAY ENERGY SPECTRUM TYPICAL OF THE NATURAL BACKGROUND RADIATION IN THE VICINITY OF THE E.R. SQUIBB FACILITY*

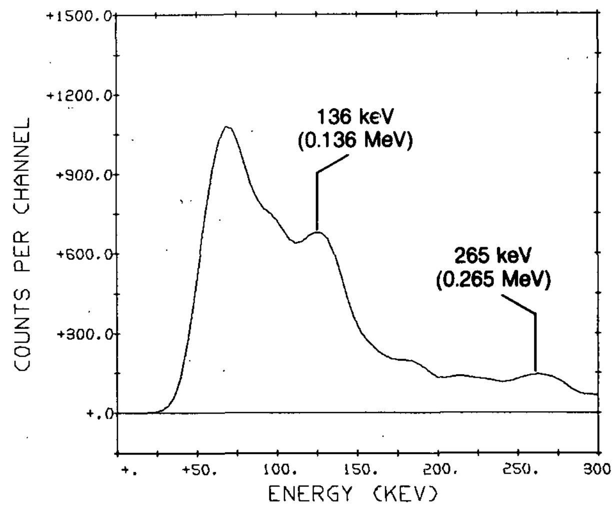



**Figure 5.** *BACKGROUND-SUBTRACTED GAMMA RAY ENERGY SPECTRUM OBTAINED FROM THE D-LEVEL CONTOUR OVER THE E.R. SQUIBB FACILITY. The peaks in the spectrum at 0.136 MeV and 0.265 MeV indicate the presence of selenium-75.*

in the remainder of the survey area. The gamma ray energy spectrum from this location revealed that the anomaly was due to a slightly elevated concentration of naturally occurring uranium in equilibrium with its daughter products. Exposure rates inferred from the aerial data measured there were within the overall range typical of background radiation found within the survey boundary.*

Results of the ground measurements are given in Table 1 along with the corresponding results from the aerial survey. Comparison of the results in the table demonstrates the close agreement between these measurement techniques. Also shown in the table are the measured values of soil moisture. The reported exposure rates include the effects of the relatively high soil moisture present during the survey. These effects influence the results from all measurement techniques as reported; any decrease in soil moisture would result in a corresponding increase in exposure rates. It is estimated that the exposure rates measured under dry conditions would increase by less than 15 percent.[7]

Many factors influence the different measurement techniques. For example, each aerial measurement represents an average exposure rate over a much broader area than that represented by a ground measurement. Therefore, exposure rates inferred from aerial measurements made directly over localized sources of radiation underestimate the peak values that would be measured at 1 meter above ground level. No localized sources were detected at or near the four ground sampling locations. However, the peak values reported directly over the Squibb facility probably represent—due to this averaging effect—an underestimate of the peak values present at the time of the aerial measurement.

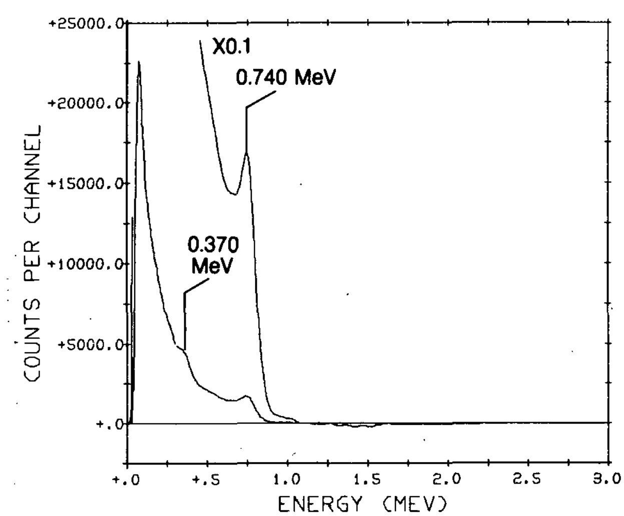



**Figure 6.** *BACKGROUND-SUBTRACTED GAMMA RAY ENERGY SPECTRUM OBTAINED FROM THE F-LEVEL CONTOUR OVER THE E.R. SQUIBB FACILITY. Molybdenum-99 was identified as the radioisotope giving rise to the elevated exposure rates.*

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*Ground-based follow-up measurements made by the USNRC indicated that exposure rates at 1 meter above the ground ranged up to 16 $\mu$R/h at this location.[6]

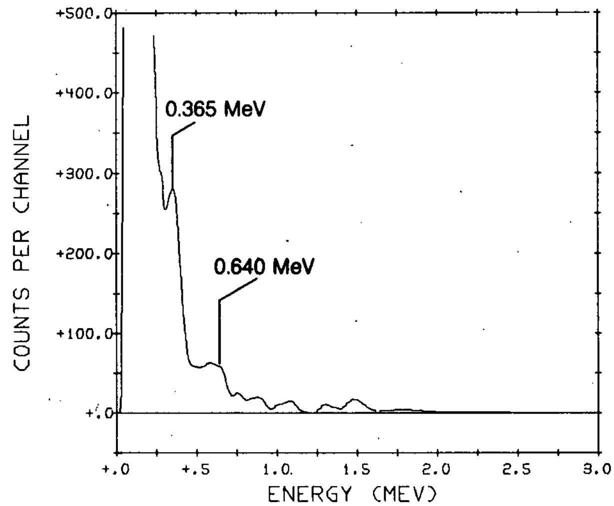


**Figure 7.** *BACKGROUND-SUBTRACTED GAMMA RAY ENERGY SPECTRUM MEASURED OVER THE SKY CAB, INC. FACILITY. The peaks in the spectrum at 0.365 MeV and 0.640 MeV indicate that iodine-131 was present when the helicopter flew over this location.*

**Table 1. Comparison of Ground and Aerial Measurement Results**

| Ground Sampling Location[1] | Soil Moisture (%) | Exposure Rate ($\mu$R/h) at 1 Meter Above Ground Level | | |
|---|---|---|---|---|
| | | Soil Sample Analysis[2,3] | Ion Chamber[4] | Aerial Data[3] |
| 1 | 26 | 9.8 | 8.8 | 8 - 10 |
| 2 | 11 | 9.3 | 9.2 | 8 - 10 |
| 3 | 24 | 11.8 | 12.3 | 10 - 12 |
| 4 | 18 | 9.8 | 9.8 | 8 - 10 |

[1] See Figure 3.

[2] These values include a correction for soil moisture (Reference 7).

[3] Includes a cosmic contribution of 4.0 $\mu$R/h.

[4] Reuter Stokes Model RSS-111, Serial No. R574.

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# E.R. SQUIBB AND SONS, INC.

NEW BRUNSWICK, NEW JERSEY

AERIAL RADIOLOGICAL SURVEY APRIL 1982


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