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AN AERIAL RADIOLOGICAL SURVEY OF THE UNITED STATES DEPARTMENT OF ENERGY'S

BATTELLE NUCLEAR SCIENCE FACILITY

WEST JEFFERSON, OHIO

DATE OF SURVEY: MAY 1977

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ABSTRACT

An aerial radiological survey to measure terrestrial gamma radiation was carried out over the United States Department of Energy's Battelle Nuclear Science Facility located in West Jefferson, Ohio. The facility is operated by the Battelle Memorial Institute.

Gamma ray data were collected over a 5.5 km^2 area centered on the Facility by flying east-west lines spaced 61 m apart. Processed data indicated that on-site radioactivity was primarily due to radionuclides currently being processed due to the "hot lab" operations. Off-site data showed the radioactivity to be due to naturally occurring background radiation consistent with variations due to geologic base terrain and land use of similar areas.

ACKNOWLEDGMENT

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1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains an aerial surveillance operation called the Aerial Measuring Systems (AMS),* which is operated for the DOE by EG&G This continuing nationwide program, started in 1958, involves surveys to monitor radiation levels in and around facilities producing, utilizing, or storing radioactive materials At the request of the DOE, or other federal and/or state agencies (such as the United States Nuclear Regulatory Commission), the AMS is deployed for various aerial survey operations

The AMS was utilized during the period 25-27 May 1977 to radiometrically survey a 5 5 km^2 land area centered on the Battelle Nuclear Science Facility on the northern edge of the town of West Jefferson, Ohio, 24 km west of Columbus, Ohio Bolton Field served as the survey base of operations

2.0 SITE DESCRIPTION

Battelle's Nuclear Science Facility was established in 1955 It is surrounded by farm lands and moderately vegetated areas The terrain is virtually flat

The hot laboratory is a research facility with capabilities including

(1) Power reactor fuel performance evaluation

(2) Pressure/vessel irradiation, surveillance, capsule examination, and evaluation

(3) Post-irradiation examination of nuclear materials and components

(4) Power reactor control rod and core component examinations

(5) Radiation source encapsulation

(6) Physical and mechanical property studies of irradiated materials and structure

(7) Plutonium handling and storing laboratory

In addition to the hot laboratory, the Facility has a retired research reactor and several other buildings that have non-nuclear functions

3.0 SURVEY METHOD

The aerial data were accumulated at an altitude of 45 m above the terrain along lines 3 2 km in length and spaced 61 m apart (Fig 1) Twenty-four such lines were flown using a Hughes H-500 helicopter (Fig 2) equipped with 20 NaI(Tl) scintillation detectors and associated instrumentation Spectral and gross count data were collected simultaneously along these lines with the Radiation and Environmental Data Acquisition and Recorder (REDAR) system

For airborne activity measurements, data were collected over flight lines 1 and 2 at two different altitudes In this case, a dual altitude method for computing the airborne radon was used [1]

Systems and procedures utilized are discussed briefly here They are described in considerable detail elsewhere [2]

4.0 DATA PROCESSING METHODS AND RESULTS

4.1 Aerial Data

The REDAR system accumulates 300 channel gamma ray spectral data over 3 sec time intervals and stores them on magnetic tape Data from five single channels, whose limits can be set to include any portion of the 300 channel spectrum, are accumulated by the REDAR every 0 2 seconds Spectral data of both types are processed according to various algorithms that combine different portions of the spectrum to accentuate nuclides of interest The Radiation and Environmental Data Analyzer and Computer (REDAC) system (Fig 3) combines radiation data and aircraft position data to produce plots of selected letter symbols that correspond to radiation levels measured along the flight path, scaled to a photograph or map

Routines are available in the REDAC to smooth count rate vs time data before it is letter classified The width of the smoothing function is generally chosen so that spatial resolution inherent in the detector/ground plane geometry is not degraded (Point sources of equal magnitude are considered resolved when separated by twice the flight altitude) Wider smoothing functions can be applied to increase sensitivity at the expense of spatial resolution

* *Formerly the Aerial Radiological Measuring System (ARMS)*

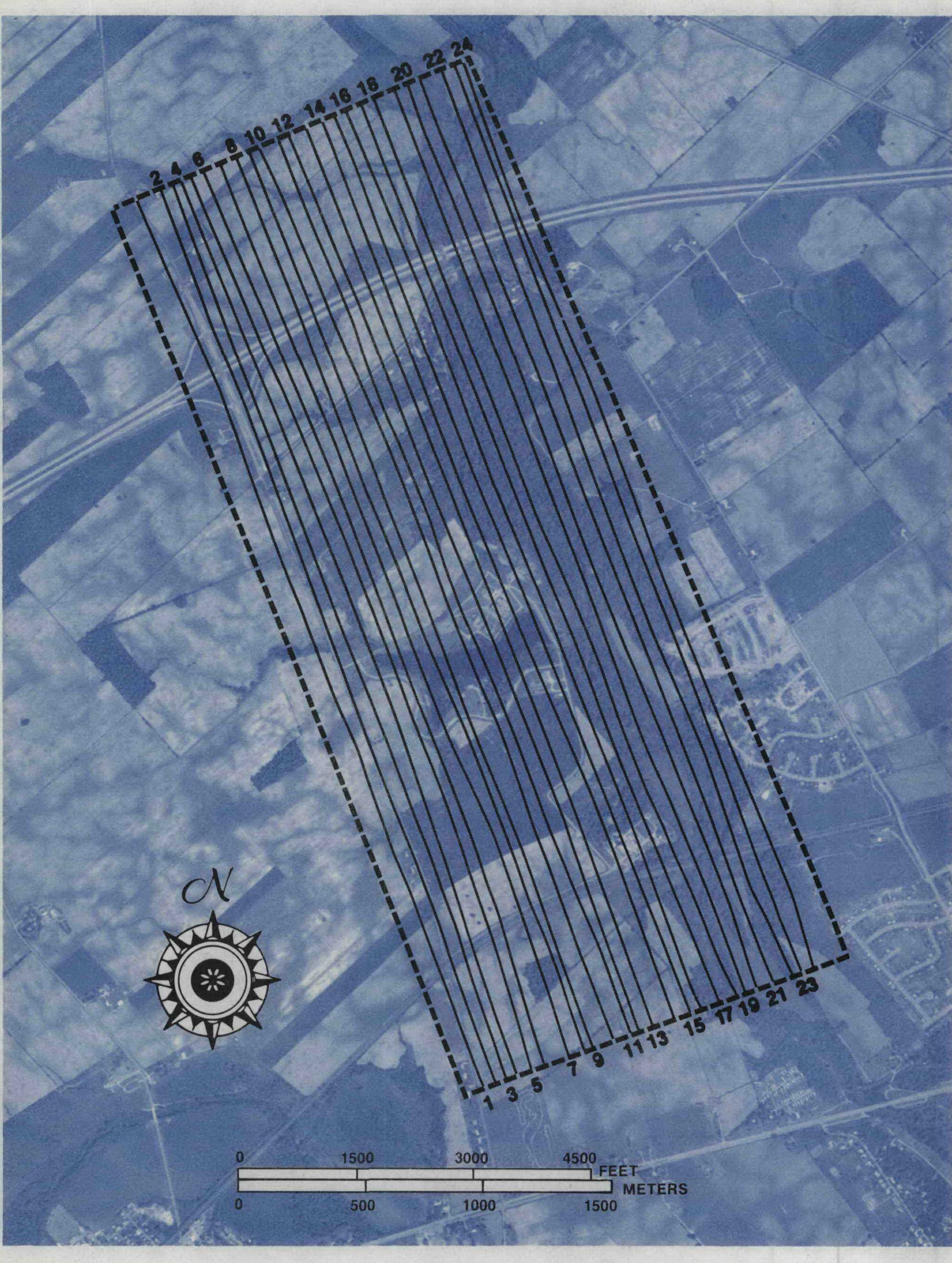

Figure 1. Flight lines superimposed on an aerial photo of the Battelle Nuclear Science Facility.

Figure 2. Hughes H-500 helicopter containing the REDAR system.

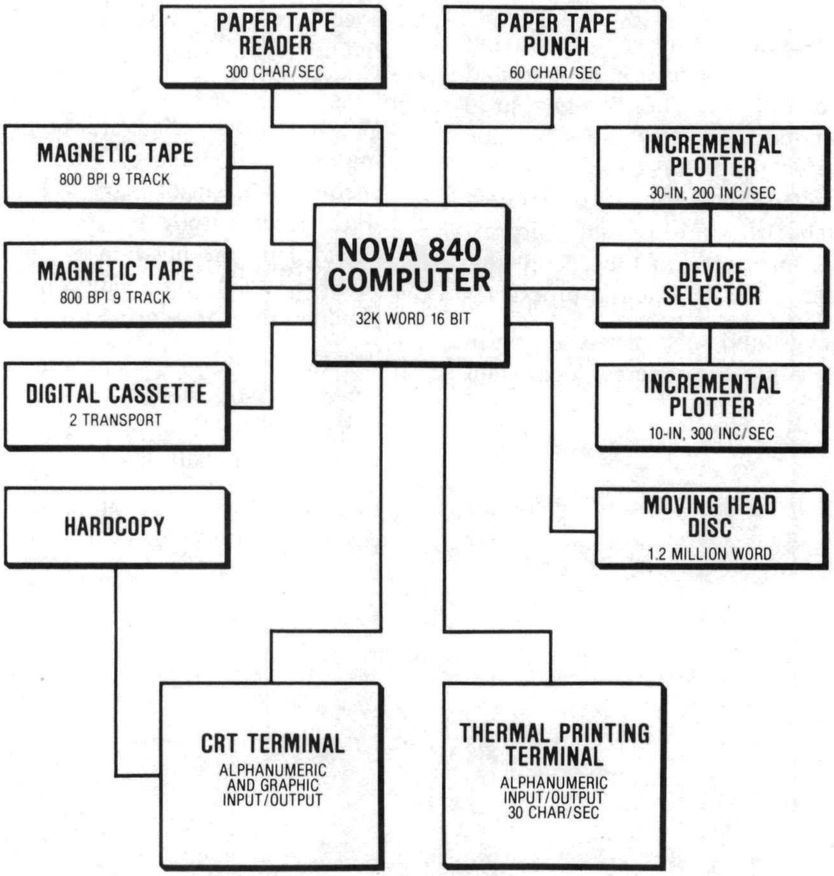

Figure 3. REDAC system block diagram.

Spatial resolution limitations of the processed data should constantly be borne in mind when interpreting aerially measured radiation isopleths constructed from the x-y plots of letter labels A point source on the ground will appear to be spread over an area whose lateral dimensions are comparable to twice the survey altitude Thus, aerial surveys will not compare well with ground surveys in areas that contain sources whose physical dimensions are small relative to flight altitude

4.2 Gross Count Isopleth

The isopleth shown in Fig 4 was derived from integral counts in the energy region between 0 05 MeV and 3 0 MeV No distinction is made between natural or man-made radionuclides that contribute to this region of the spectrum The detector system is calibrated for a particular mix of natural emitters in the soil in a particular area, and absolute levels will be in error where a different mix exists or where man-made contaminants contribute

The gross count radiation isopleth describes radiation from terrestrial sources, plus cosmic rays The factor that converts counting rate of terrestrial origin to 1 m level exposure rate is applied to the difference between the counting rate measured over the survey area and the counting rate due to non-terrestrial background (radon, aircraft, and cosmic) The non-terrestrial background is computed using the dual altitude method [1] The calculated cosmic ray exposure rate is then added to the terrestrial components to obtain a final isopleth Airborne radon and aircraft components are not represented in these isopleths, since they are removed in the subtraction process

A typical natural background spectrum is shown in Fig 5 Table 1 lists the gamma ray energies consistent with Fig 5

4.3 Sensitivity

Gamma ray detector detectability limits[1,2] for the AMS are dependent upon survey altitude, source geometry, gamma ray energy, background variations, detector angular response/field-of-view, and aircraft speed The level of detectability for the H-500 at 45 m altitude for unshielded point sources on the ground surface directly beneath the aircraft is estimated to be 0 4 mCi of ^{60}Co, and 0 8 mCi of ^{137}Cs Minimum detectable surface concentrations of these materials, spread out over an area larger than the field-of-view of the detector (at least 6362 m^2), are 0 08 μCi/m^2 of ^{137}Cs, and 0 003 μCi/m^2 of ^{60}Co * These correspond to an exposure rate value of approximately 1 μR/h at 1 m above the ground

5.0 DISCUSSION AND RESULTS

Data analysis revealed that the higher activity area was that centered over the Battelle reactor, as shown by Figs 4 and 5 The activity levels in all other parts of the survey area were those due to naturally occurring background radiation, consistent with variations due to geologic base terrain and land use of similar areas Table 1 lists those isotopes Background levels were mostly in the 9 0 to 13 5 μR/h range, with lower values occurring over heavy vegetation and water areas, and the higher values occurring over farm land and areas stripped of vegetation

Within the site perimeter, due to reactor operation, a maximum exposure value of 70 μR/h was encountered The primary contributors to this activity were generated by the hot laboratory activity, as revealed by the position of the maximum exposure rate (Fig 4) Normal plant operations resulted in the production of this level of activity

Activity in this area was sufficiently high to cause detector saturation and hence produce extreme spectral distortion No specific photopeaks were resolved as a result

Gross count exposure rate values stated here contain a cosmic value of 3 7 μR/h

* *Minimum detectable levels improve for distributions of larger lateral dimensions provided uncontaminated areas exist to establish zero reference levels*

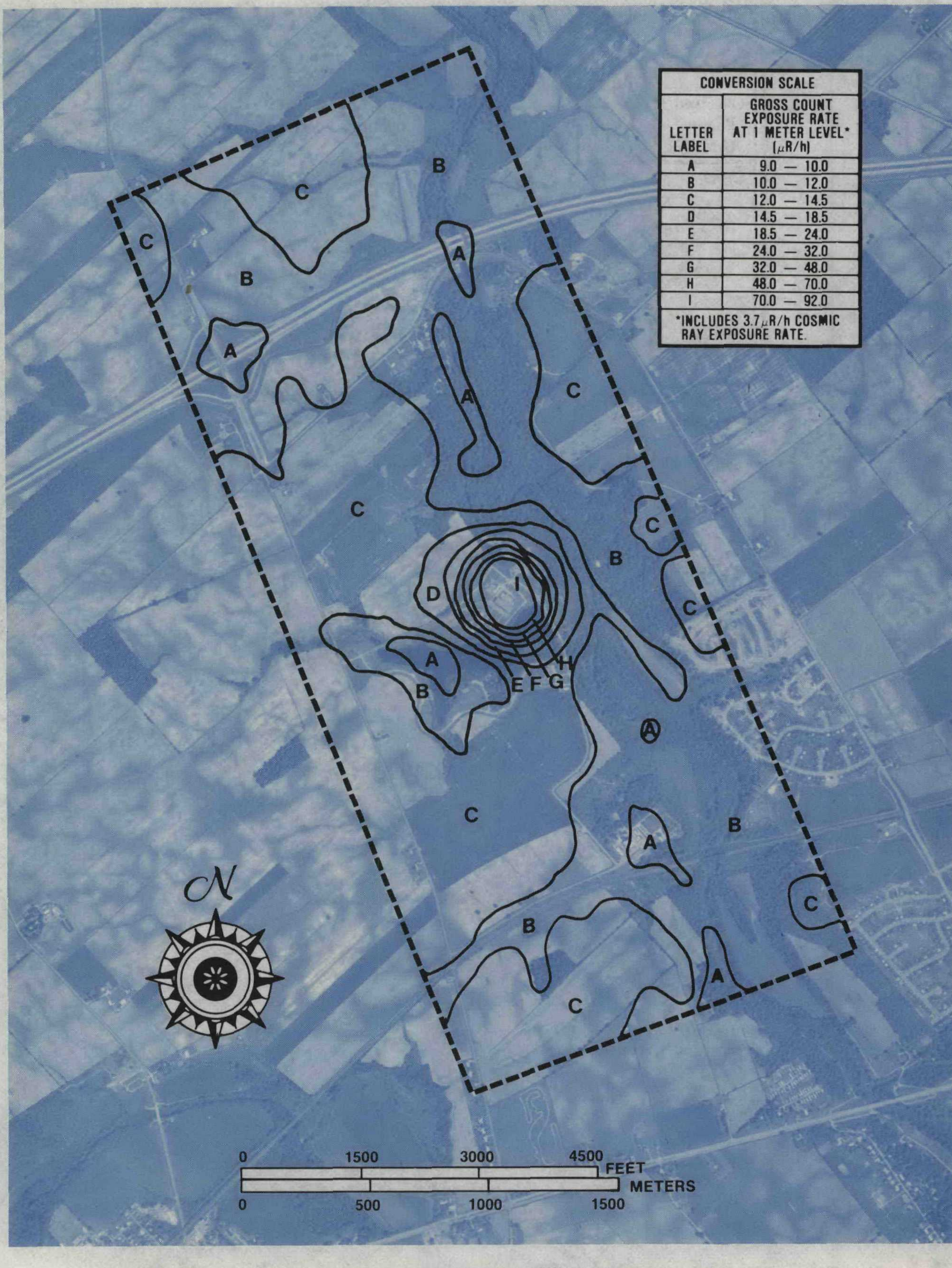

Figure 4. Exposure rate gross count isopleth.

Table 1. Gamma Ray Energies and Isotopes Consistent with Spectral Data

Observed Energy (MeV)	Radionuclides Consistent with Spectral Photopeaks		
	Fission Products	Activation Products	Background
0 35	....	....	$^{212,214}Pb$
0 61	....	....	^{214}Bi, ^{208}Tl
0 95	....	....	^{228}Ac
1 12	....	....	^{214}Bi
1 46	....	....	^{40}K
1 76	....	....	^{214}Bi
2 20	....	....	^{214}Bi
2 62	....	....	^{208}Tl

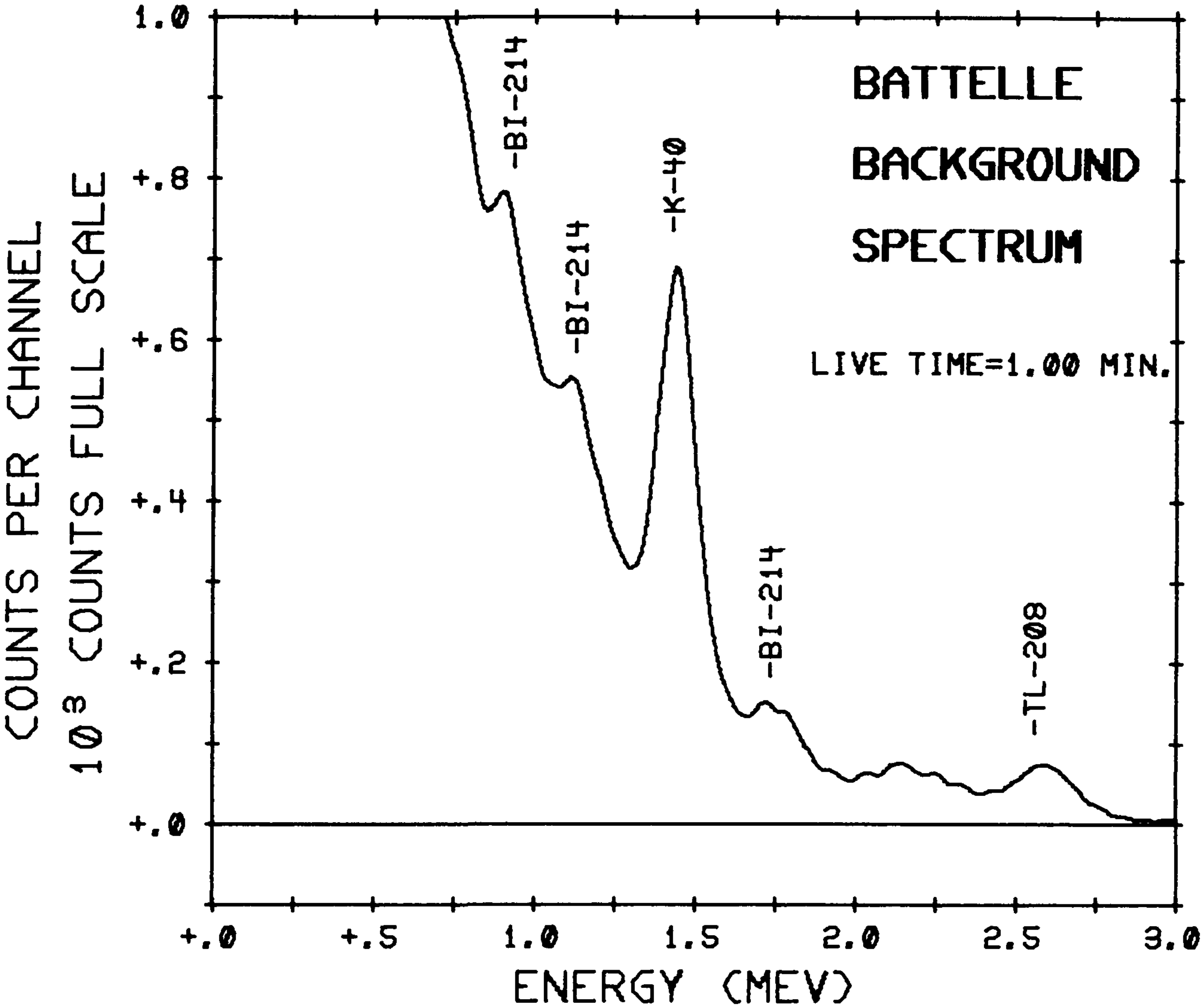

Figure 5. Typical gamma ray pulse-height spectrum collected over an area near the Facility perimeter

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2. Boyns, P. K., "The Aerial Radiological Measuring System (ARMS) Systems, Procedures and Sensitivity (1976)," Report No. EGG-1183-1691, EG&G, Las Vegas, NV, July 1976.

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