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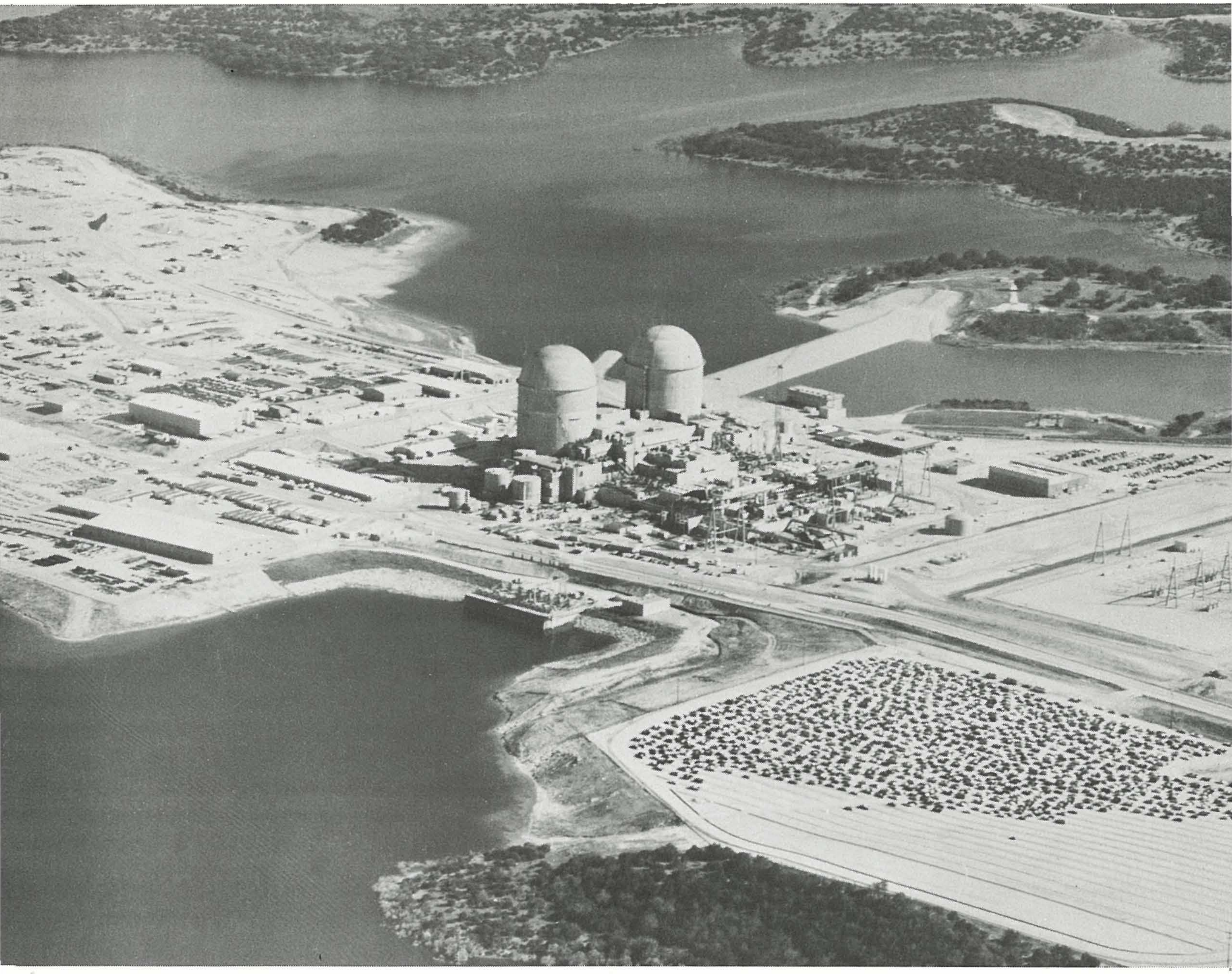

AN AERIAL RADIOLOGICAL SURVEY OF THE

COMANCHE PEAK STEAM ELECTRIC STATION

AND SURROUNDING AREA

GLEN ROSE, TEXAS

DATE OF SURVEY: MARCH 1982

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This Document is UNCLASSIFIED

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Classification Officer

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ABSTRACT

An aerial radiological survey was performed from 1 to 9 March 1982 over a 260-square-kilometer area centered on the Comanche Peak Steam Electric Station located in Somervell County, Texas. The survey was conducted by the Energy Measurements Group of EG&G for the U.S. Nuclear Regulatory Commission. All gamma ray data were collected by flying parallel lines spaced 152 meters (500 feet) apart at an altitude of 91 meters (300 feet) above ground level. Count rates obtained from the aerial platform were converted to total exposure rates at 1 meter above the ground and are presented in the form of an isoradiation contour map. The observed exposure rates ranged from 6 to 12 microroentgens per hour (μR/h), with the average background ranging from 6 to 8 μR/h. These values include an estimated cosmic ray contribution of 3.8 μR/h. The exposure rates obtained from ground-based measurements taken in typical background locations within the survey area displayed positive agreement with the aerial data.

CONTENTS

1.0 INTRODUCTION

An aerial radiological survey of the Comanche Peak Steam Electric Station (SES), located in Somervell County, Texas, was conducted at the request of the Nuclear Regulatory Commission from 1 to 9 March 1982. The survey was performed by the United States Department of Energy's Remote Sensing Laboratory, operated for the DOE by the Energy Measurements Group of EG&G. This survey was part of a continuing nationwide program, initiated in 1958, which involves the monitoring and documentation of radiation levels, at a given point in time, in and around facilities producing, utilizing, and/or storing radioactive materials. The purposes of the Comanche Peak SES survey were to: (1) map the distribution of all gamma-emitting radionuclides visible at the earth's surface, (2) determine the typical range of natural background radiation exposure rates, and (3) identify any anomalous areas above the typical natural background range.

It is customary to report survey results as radiation exposure rates in microroentgens per hour (μR/h) extrapolated to 1 meter above ground level. The maximum annual radiation exposure (24 hours per day for 365 days) caused by external irradiation is related only to duration of exposure, so the total dose can be expressed in millirem per year (mrem/y) by multiplying the reported exposure rate in μR/h by 8.76. However, this dose rate relates only to external sources of radiation and does not reflect contributions from inhalation, ingestion, or any other internal source (body burden) of radioactive material. Therefore, the actual amount of radiation tissue absorbs depends on circumstances as well as duration of exposure.

The present survey also includes a series of ground-based measurements. The ground-based measurements, performed at five locations identified as exhibiting only natural background radiation, were used to corroborate the aerial results.

2.0 SURVEY PROCEDURES AND EQUIPMENT

2.1 Site Description

The Comanche Peak SES is located approximately 7 kilometers north of Glen Rose, Texas, near the northern boundary of Somervell County along the banks of the Squaw Creek Reservoir. The Comanche Peak SES is owned by the Texas Utilities Company System, Texas Municipal Power Agency, Brazos Electric Power Cooperative, Inc., and the Tex-La Electric Cooperative of Texas, Inc., and operated by Texas Utilities Generating Company (TUGCO). The station was in a pre-operational status at the time of the survey. The two 1,150 megawatt (electric) pressurized water reactors are scheduled to come into operation by the mid-1980's.

2.2 Survey Plan

The base of operations during this survey was Panther Aviation located at Cleburne Municipal Airport, Cleburne, Texas. All survey activities were coordinated from this base. Microwave transponder units were located several kilometers east of the survey area.

Topographic maps were used to define the area to be investigated. The survey area covered 260 square kilometers centered on the Comanche Peak Steam Electric Station. Data acquisition flights were conducted using a helicopter, with each flight approximately two and one-half hours in duration. All flights were made during daylight hours, weather permitting. The data acquisition flight lines were flown in a predetermined pattern of parallel lines. The flight lines were flown in a northwest/southeast direction at a nominal altitude of 91 meters with a line spacing of 152 meters.

In addition to aerial data acquisition, five ground-based measurement locations were selected at random in typical background areas of the survey. Both pressurized ionization chamber measurements and soil samples were taken at each location. These ground-based measurements were made in an effort to verify the total external exposure rates measured by the airborne detection system in background areas. The soil samples were later subjected to gamma ray spectral analyses to determine the isotopic composition.

2.3 Survey Equipment

The detectors and electronic systems which accumulate and record the data are described briefly here. A more detailed description can be found in References 1 and 2 and Appendices A and B of Reference 3.

A Messerschmitt-Bolkow-Blohm (MBB) BO-105 helicopter (Figure 1) was utilized as the survey platform to collect and record data. The helicopter was manned by a pilot and an equipment operator/navigator. The aircraft carried a lightweight, fourth-generation version of the Radiation and Environmental Data Acquisition and Recorder (REDAR IV) system. In addition, two pods—each containing ten 12.7-centimeter diameter by 5.1-centimeter thick sodium iodide (thallium activated), NaI(Tl), detectors—were mounted on the helicopter, one on each side.

Figure 1. *MBB BO-105 HELICOPTER*

The gamma ray signals from each of the 20 detectors were calibrated with a ^{22}Na source. These signals were then summed and routed through an analog-to-digital converter so that the calibration peaks appeared in preselected channels of the REDAR IV's multichannel analyzer. Gamma ray count rates and energy spectral data were accumulated in 1-second intervals and recorded on magnetic tape.

In addition to spectral data, non-spectral data were also recorded on magnetic tape. The non-spectral data consisted of aircraft position, altitude, time of day, temperature, pressure, and special labels for data reduction purposes.

Both gamma ray spectral data and non-spectral data were acquired in 1-second intervals and recorded every 4 seconds on four-track cassette tape recorders. The REDAR IV system has two tape recorders, each capable of recording approximately 1 hour of data. At the end of each tape, the system automatically switches to the other recorder.

The helicopter position was established by two systems: a microwave ranging system (MRS) and a radar altimeter. The MRS master station, mounted in the helicopter, interrogated two remote transceivers located on hilltops overlooking the Comanche Peak SES, several kilometers east of the survey area. By measuring the round-trip propagation time between the master and remote stations, the master computed the distance to each. The distances were recorded on magnetic tape each second. In subsequent computer processing these distances were converted to position coordinates.

The radar altimeter similarly measured the time lag for the return of a pulsed signal aimed at the ground surface and converted this delay to aircraft altitude. These data were also recorded on magnetic tape so that any variation in gamma ray signal strength caused by altitude fluctuations could be accurately compensated.

Gamma ray analyses on the soil samples were performed with a low-background, lithium-drifted germanium [Ge(Li)] detector. A sodium iodide annulus detector was used in anticoincidence with the Ge(Li) detector to suppress Compton background. Gamma counts were analyzed on a 1024-channel analyzer and plotted for inspection. The equipment and techniques used for sample preparation and analysis are described in Reference 4.

2.4 Data Processing Equipment

The data recorded on magnetic tape during the survey were processed with the Radiation and Environmental Data Analyzer and Computer (REDAC) system. This system consisted of a minicomputer mounted in a mobile data processing laboratory. An extensive inventory of software routines and supporting equipment was available for detailed data analysis.

Some of the data was processed during the actual survey period to assure complete coverage and data acquisition integrity, and to provide preliminary results as soon as possible. The data processing equipment and analysis procedures are described in detail in Reference 1.

3.0 NATURAL BACKGROUND RADIATION

Natural background radiation originates from radioactive elements present in the earth (terrestrial radiation) and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma radiation originates primarily from the uranium and thorium decay chains, and radioactive potassium. Local concentrations of these nuclides produce radiation levels typically ranging from 1 to 20 μR/h at the surface of the earth. The higher levels within the United States are normally found in the western states, primarily on the Colorado Plateau, as a result of higher uranium and thorium concentrations in surface minerals.

The thorium and uranium decay chains include radon, a radioactive, chemically inert gas, that diffuses through the soil and into the atmosphere. The rate of diffusion depends on the mineral composition and permeability of the soil. Atmospheric distribution of radon also depends on meteorological conditions within a given area at a particular time. Therefore, it is normal to see variations in the level of airborne radon with time at any given location. Typically, radon contributes from 1 to 10% of the natural external background radiation exposure.

Cosmic rays, the space component, interact in a complex manner with the elements of the earth's atmosphere and soil. These interactions produce an additional natural source of ionizing radiation. Radiation levels caused by cosmic rays vary with elevation (altitude) and slightly with geomagnetic latitude. Typical values range from 3.3 μR/h at sea level in Florida to 12 μR/h at an altitude of 3 km (10,000 ft) in Colorado (Reference 5).

4.0 DISCUSSION OF RESULTS

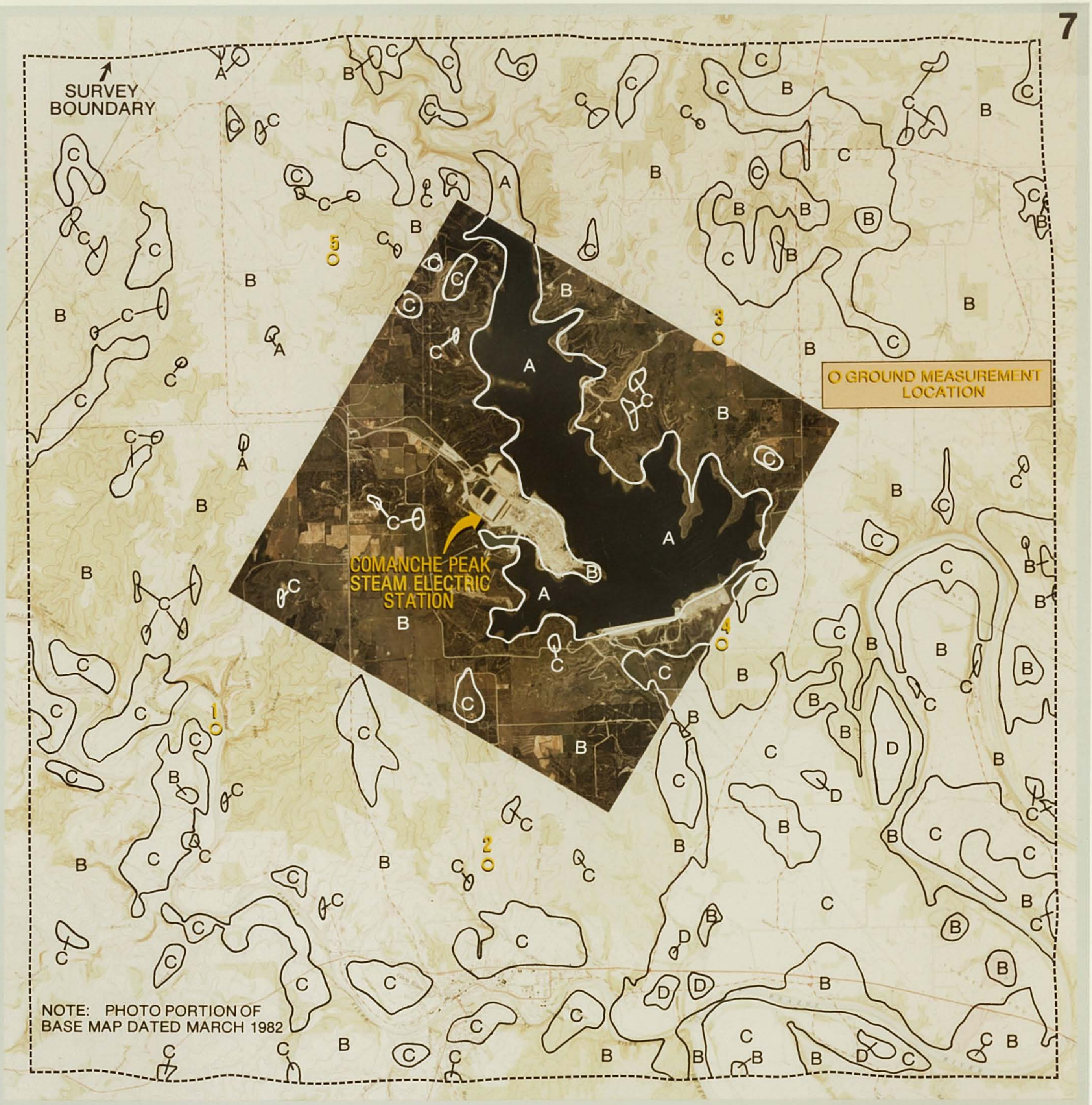
For this survey, the data analyses were directed toward producing three specific results: (1) a total gamma radiation exposure rate contour map of the survey area, (2) gamma ray spectra characterizing the overall radiation profile of the site, and (3) identification of anomalies above the typical background.

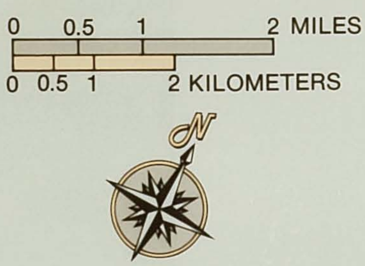
Exposure rate contours were constructed from gross count rate numbers, which refer to integral count rates in that portion of the gamma ray energy spectrum between 0.04 and 3.0 MeV. Letter labels were used to identify discrete count rate intervals. Exposure rate isoradiation contours were then constructed by plotting the radiation data as a function of position after the positional information had been properly scaled to the particular map base used. Before plotting the gross count rate data, the non-terrestrial contributions to the detector system were extracted. These included aircraft background, cosmic radiation, and airborne radon daughter contributions. Terrestrial exposure rate values, in microroentgens per hour (μR/h) at the 1 meter level, were calculated from the gross count rates using the conversion factor of 750 counts per second equals 1 μR/h at 1 meter above ground level. A cosmic ray contribution of 3.8 μR/h was then added to the aerial data to obtain the total external exposure rate values given in Figure 2.

Aerial radiological detection systems average existing radiation levels, produced by gamma-emitting radionuclides, over an area of several hectares. When comparing aerial survey results with ground-based measurements, it is important to note that 1 second of aerial survey data covers an area several thousand times larger than that measured by a survey instrument 1 meter above ground level and several million times larger than a single soil sample. For large areas with slowly varying activity, such as typical natural background radiation, the agreement between ground-based measurements and those inferred from aerial data is generally quite good.

4.1 Aerial Survey Results

A total external exposure rate isoradiation contour map for the 260-square-kilometer survey area surrounding the Comanche Peak Steam Electric Station is shown in Figure 2. The total external exposure rates (terrestrial plus cosmic) observed over the entire survey area ranged from 6 to 12 μR/h normalized to 1 meter above ground level. The average background exposure rate over the land area was approximately 6 to 8 μR/h. These values include a cosmic ray contribution of 3.8 μR/h. All gamma rays detected within the survey area were from naturally occurring radioisotopes. Lower radiation levels were evident over Squaw Creek Reservoir and along the Brazos River. A few small areas in the south-southeast corner of the survey area along the river indicated higher





CONVERSION SCALE

LETTER LABEL	TOTAL EXTERNAL EXPOSURE RATE (μR/h) AT 1 METER*
A	< 6
B	6 - 8
C	8 - 10
D	10 - 12

* Exposure rates are inferred from gross count rate measurements at an altitude of 91 meters averaged over the detector field-of-view and extrapolated to 1 meter above ground level. A cosmic contribution of 3.8 μR/h is also included.

Figure 2. *TOTAL EXTERNAL EXPOSURE RATE CONTOURS DERIVED FROM AERIAL SURVEY DATA OBTAINED IN MARCH 1982 OVER THE COMANCHE PEAK STEAM ELECTRIC STATION, SOMERVELL COUNTY, TEXAS AND SURROUNDING AREA. Ground-based measurement locations are also indicated.*

than the average background range (10 to 12 μR/h). (It is not unusual to find elevated natural radiation levels of this magnitude.) A gamma ray pulse-height spectrum typical of natural terrestrial background detected in the survey area is shown in Figure 3.

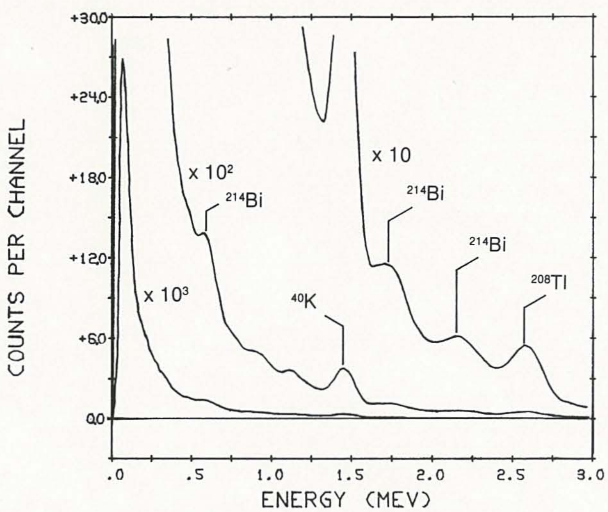


Figure 3. *TYPICAL BACKGROUND GAMMA RAY SPECTRUM OF THE AREA SURROUNDING THE COMANCHE PEAK SES, SOMERVELL COUNTY, TEXAS*

4.2 Ground-Based Measurement Results

Ground-based measurements were conducted at five locations identified in Figure 2. Each ground-based measurement was comprised of both total exposure rate measurements, obtained with a Reuter-Stokes (Model RSS-111) pressurized ion chamber, and radionuclide analyses performed on a group of soil samples.

The total external exposure rates measured by both ground-based and aerial techniques are compared in Table 1 for each measurement location. The soil analyses and aerial measurements both include a 3.8 μR/h cosmic ray contribution.

The results of the ground-based measurements generally corroborate the aerial measurements. Discrepancies between the ground-based and aerial results are of the magnitude expected because of area averaging and uncertainties involved in estimating the airborne radon contribution.

Results of the radionuclide assay for each sample location are presented in Table 2. Only the principal constituents are included. The values reported are averages of the 8 to 10 samples obtained at each location.

Table 1. Total External Exposure Rate Comparisons for the Comanche Peak SES Survey

Site Number	Soil Moisture (%)	Total External Exposure Rate (μR/h at 1 meter)		
		Ground-Based Measurements		
		Ion Chamber	Soil Analysis Estimate[1]	Aerial Measurements[1]
1	10.5	8.7	7.2	6 - 8
2	13.1	7.6	7.6	6 - 8
3	18.7	9.3	10.2	6 - 8
4	16.9	7.9	8.6	6 - 8
5	11.3	6.7	5.3	6 - 8

[1] Includes a cosmic ray contribution of 3.8 μR/h.

Table 2. Major Radioactive Soil Constituents

Site Number	U-238 (ppm)	Th-232 (ppm)	Cs-137 (pCi/g)	K-40 (pCi/g)
1	1.74±5%	4.43±5%	0.11±8%	5.1±8%
2	1.52	5.46	0.27	6.1
3	2.50	8.80	0.63	11.2
4	1.86	6.51	0.89	8.8
5	0.69	1.76	0.24	3.0

APPENDIX A

SURVEY PARAMETERS

Location:	Comanche Peak Steam Electric Station, Glen Rose, Texas
Survey Coverage:	260 km^2
Survey Date:	1 to 9 March 1982
Project Scientist:	H. A. Berry
Survey Altitude:	91 meters (300 ft.)
Line Spacing:	152 meters (500 ft.)
Lines Surveyed:	106
Detector Array:	Twenty 12.7-cm diameter by 5.1-cm thick NaI(Tl) detectors: (Cd band shield)
Acquisition System:	REDAR IV
Aircraft:	MBB BO-105 Helicopter
Data Processing:	Gross Counts Window: 0.04 to 3.00 MeV Conversion Factor: 750 cps per μR/h Cosmic Ray Contribution: 3.8 μR/h

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