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RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE PALISADES PLANT SOUTH HAVEN, MICHIGAN DATE OF SURVEY: 29 JULY 1970

Approved for Publication

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ABSTRACT

The Aerial Radiological Measuring System (ARMS) was used to survey the area surrounding the Palisades Plant during July 1970.

A high-sensitivity detection system collected gamma-ray spectral and gross-count data. The data were then computer processed into a map of a 300 square mile area showing isoexposure contours three feet above the ground. Exposure rates and isotopes identified are consistent with normal terrestrial background radiation.

ACKNOWLEDGMENTS

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CONTENTS

1. INTRODUCTION

1.1 Identification of Surveyed Plant and Area

The Aerial Radiological Measuring System (ARMS) (Ref. 1) operated by EG&G, Inc., Las Vegas, Nevada, for the U. S. Atomic Energy Commission was used to survey an extensive area surrounding the Palisades Plant, Unit 1, during July 1970. The Palisades Plant, operated by the Consumers' Power Company of Michigan, is located near South Haven, Michigan. The size of the survey area was 300 square miles.

1.2 ARMS Program

The present survey was made as part of a continuing nationwide ARMS program started in 1958 to monitor radiation levels surrounding facilities producing or utilizing radioactive materials. This is the first such survey performed in the Palisades area since the station began operation in 1971.

The detection system on board the aircraft collects gamma-ray gross-count and spectral data on each flight line of the survey. The gamma radiation and aircraft position information are processed by a computer into an isoexposure contour map of the area surveyed.

1.3 ARMS Equipment and Procedures

The ARMS aircraft and its on-board radiation detection equipment were used in the survey. Since the ARMS equipment and procedures have been discussed in detail elsewhere (Ref. 1), they will only be described briefly here.

The ARMS surveys are flown in a Beechcraft Twin Bonanza at an altitude of 300 to 500 feet above ground level at a ground speed of about 140 knots (235 ft/sec). The ground position of the aircraft and its altitude above terrain are measured and recorded every other second by a radar navigation computer system. The position and altitude measurements are accurate to $\pm$ 350 ft and $\pm$ 5 ft, respectively.

A typical flight pattern consists of a series of parallel lines spaced one nautical mile (6080 feet) apart, covering all of the land area within a twelve and one-half nautical mile radius of the facility.

At an altitude of 500 feet, the field of view of the detectors is approximately 1/4 mile wide for a mean gamma energy of naturally occurring isotopes.

The aerial radiation measurements are of two distinct types, made simultaneously: (1) gross gamma count (intensity) measurements and (2) gamma spectral measurements. The detector system consists of an array of fourteen 4 x 4 in. NaI (Tℓ) scintillation crystals, each coupled to its own photomultiplier assembly. The detector system output is directed both to the gross gamma count computing system and to the multichannel spectrum analyzer. The data collecting system is shown in Figure 1.

The gross gamma count system consists of an amplifier-discriminator-computer unit that counts and records the total number of gamma-rays of energy greater than 50 keV that are detected during a 1-second time interval. The gross gamma count rate (number of gamma-rays detected per second) is digitally recorded along with aircraft position and altitude every other second. Aircraft position data are supplied by a track navigational computer and doppler radar. Altitude above terrain is measured with a radar altimeter. As a backup and complement to the digital recording of the gross-count data, a record is made on a continuous strip chart of both gross gamma count rate and radar altitude as a function of distance. Typical gross-count rates for natural background are several thousand per second.

Whereas the gross gamma count data specify the intensity of radiation as a function of position, the gamma spectral data are useful in identifying particular radioactive isotopes. A pulse-height analyzer automatically sorts detected gamma-rays according to energy, thereby generating a number per unit-energy versus energy spectrum. Although gamma rays occur only at well known discrete energies characteristic of the emitting species, air scattering tends to smear the detected distribution. Nevertheless, the characteristic peaks that permit isotope identification are readily observable. In wide area surveys the typical acquisition time for a gamma-ray spectrum is several minutes; thus, the spectrum represents the average radiological properties of a tract several miles in length. However, if an area of interest is indicated by an increase in the gross gamma count rate, spectral data acquisition times of only a few seconds are used to isolate the area spatially. If further investigation is warranted, a ground

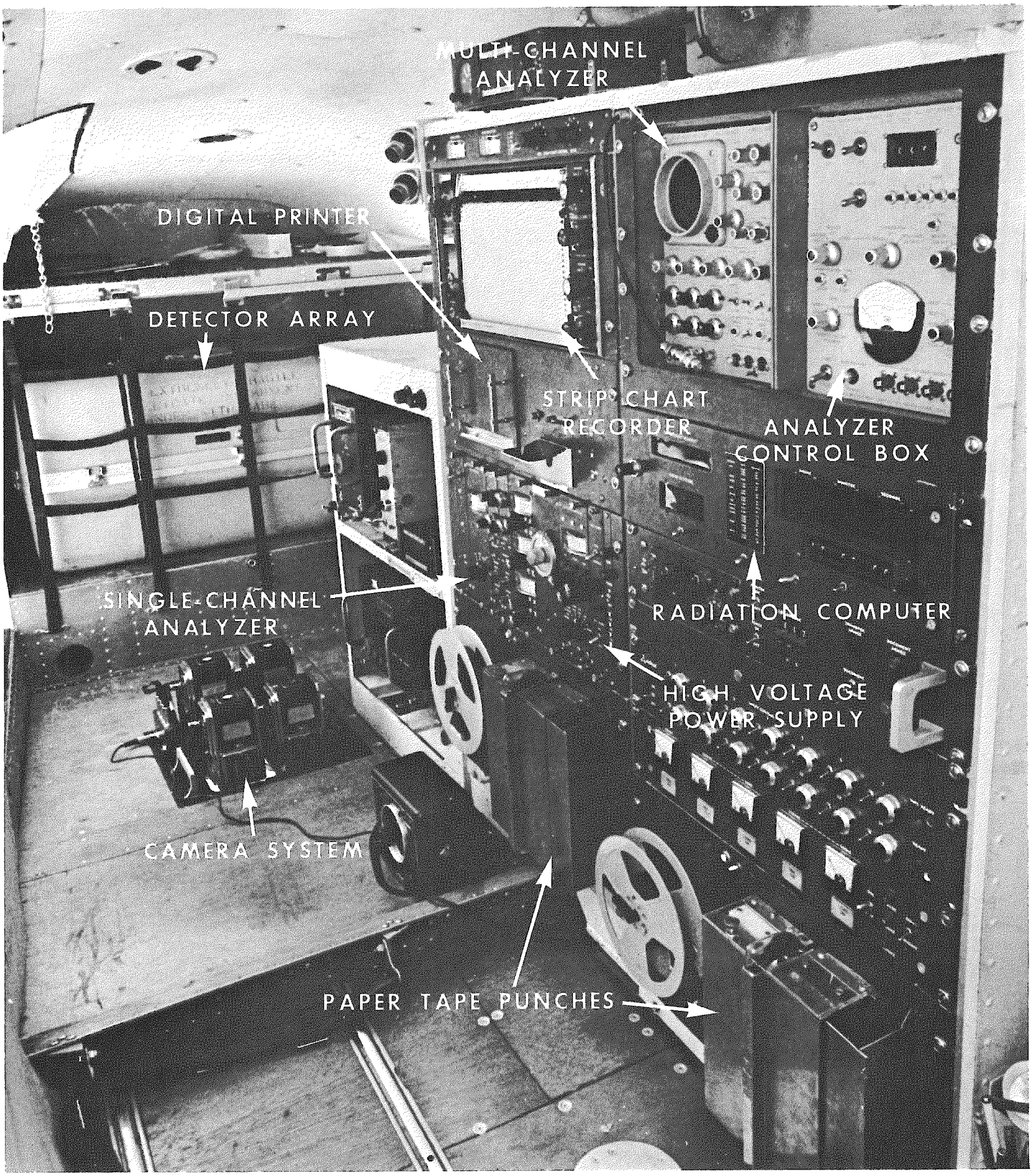

FIGURE 1. View of the interior of the Aerial Radiological Measuring System (ARMS) aircraft showing detector package and electronic data collection system.

mobile unit with equipment similar to that in the aircraft is available to provide greater spatial and energy resolution.

In addition to the equipment just described, the ARMS aircraft also carries an air sampling and analysis system for the measurement of airborne radioactivity.

1.4 Reduction and Presentation of Data

The raw data from the gross gamma count and the gamma spectral measurements are permanently recorded on paper tape, which is computer processed and analyzed to characterize the radiological properties of the area surveyed. Using an altitude-dependent conversion factor obtained from prior calibration measurements, the raw gross-count rate is converted to exposure rate (μR/hr) at three feet above ground.

The exposure rate conversion factor was obtained from repeated flights 200 to 1000 feet above terrain containing known distributions of natural isotopes. Such conversion factors have proved valid over distributed fission product fields, with a variation of less than 25%. In practice, variations of 2 μR/hr or greater can be reliably observed in repeated flights over the same area.

2. REACTOR AND SITE CHARACTERISTICS

2.1 Reactor Characteristics

The Palisades Unit 1 Reactor is located in Van Buren County, Michigan, six miles south of South Haven.

The principal nuclear contractor is Combustion Engineering, Inc. The facility is operated by the Consumers' Power Company of Michigan.

Table 1 gives the specifications of the reactor facility at the time of the survey.

TABLE 1. Reactor facility specifications.

Reactor Unit	Reactor Type	Start-Up Date	Power Levels (Megawatts)		Status
			Electrical	Thermal	
1	Presurized water	1971	700	2,212	Pre-operational

2.2 Site Area Characteristics

In general the terrain in the survey area is flat cultivated farmland with numerous small lakes and streams. The Palisades Plant is located on the shore of Lake Michigan, which bounds the area on the west.

Table 2 lists the towns in the survey area with significant populations, by distance and direction from the reactor site (1970 census figures -- Ref. 2).

TABLE 2. Population distribution within the Palisades Plant area.

Town	Direction from Power Station	Population		
		Distance from Station (Miles)		
		0 - 5	5 - 10	10 - 15
Bangor	E			2,050
Coloma	S		1,814	
Hartford	SE			2,508
Lake Michigan Beach	S		2,101	
South Haven	NNE		6,471	
Watervliet	SSE		2,059	
Totals			12,445	4,558
Grand Total				17,003

3. SURVEY PLAN

3.1 Specification of Flight Lines

The flight pattern for the Palisades Plant survey consisted of 23 flight lines approximately 3 to 12 nautical miles long and spaced one nautical mile apart. The flight lines were oriented in an east-west direction. Radiation data together with aircraft position and meteorological information were collected along each flight line.

3.2 Coordination with Local Authorities

ARMS survey missions are conducted under special waiver from the Federal Aviation Administration. The survey plan was discussed with the appropriate General Aviation District Office, and public announcements were published in the local newspapers prior to the survey operation in accordance with the FAA waiver for low-level flights.

The base of operations for the survey mission was Rockford, Illinois.

4. RADIOLOGICAL SURVEY

4.1 Survey Missions

The aerial survey of the Palisades Reactor area was conducted on 29 July 1970. This survey required a total flying time of six hours.

Gross-count and spectral data were simultaneously collected at an altitude of 300 feet. Spectra were accumulated over a 2 to 7 minute interval during which the aircraft traveled approximately 3 to 12 miles; consequently, one spectrum per line was collected.

4.2 Gross-Count Data

As a first step in the analysis of the gross-count data, the background due to nonterrestrial radiation was subtracted. This background consists of cosmic-ray, aircraft, and airborne radioactivity contributions (Ref. 3). After correction for background, the data were normalized to a standard air mass. The resultant net-count data were then converted to exposure rate in microroentgens per hour (μR/hr) at the 3-foot level above the ground. The cosmic-ray exposure rate was then added back to the terrestrial exposure rate. Finally, the composite exposure rate data, together with aircraft position information, were processed into an isoexposure contour map for overlay on U. S. Geological Survey topographic maps of the survey area.

An isoexposure map of the Palisades Plant area is enclosed (in pocket, back cover). The data shown on the map include a cosmic radiation contribution of 2 to 4 μR/hr. Spatial resolution of the exposure rate data is determined by the field of view of the detector system, which is about 1/4 mile.

4.3 Spectral Data

Spectral data were recorded from about 0.03 to 3.0 MeV. The recording system was calibrated prior to takeoff with an yttrium-88 source, which emits two prominent gamma-rays of 0.898 and 1.836 MeV. The gain for each crystal in the 14-crystal detector array was set independently.

A spectrum typical of those taken during the survey is shown in Figure 2. Table 3 lists the prominent gamma-ray energies and associated

source isotopes identified in the spectrum. Differences in shape between spectra taken over different portions of the survey area are minor, and the isotopes identified in all spectra are the same. Only isotopes consistent with normal terrestrial background are apparent.

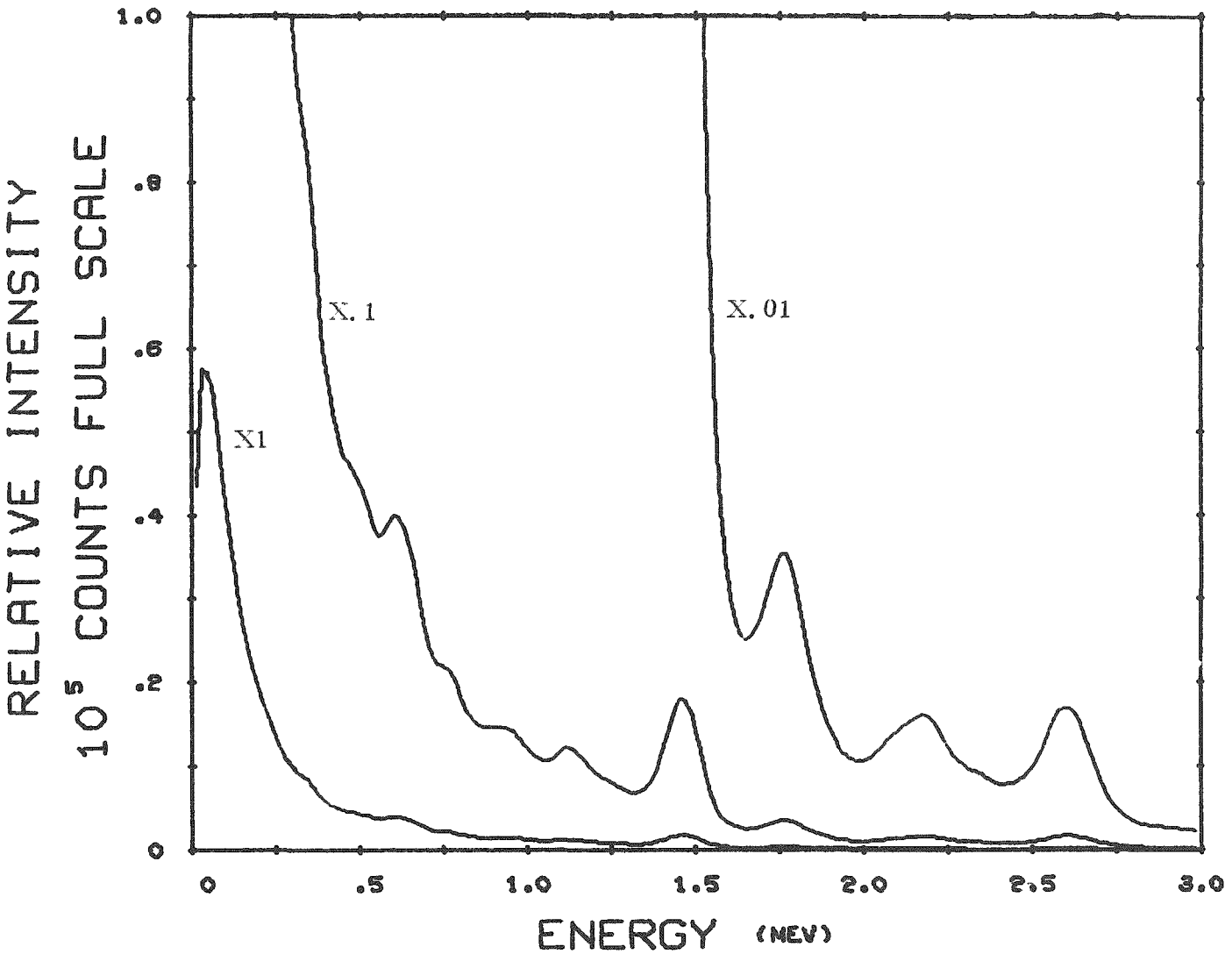

FIGURE 2. Typical pulse height spectrum for survey area.

TABLE 3. Gamma-ray energies and isotopes consistent with spectral data of Figure 2.

Observed Energy (MeV)	Radionuclides Consistent With Spectral Photopeaks		
	Fission Products	Activation Products	Terrestrial Background
0.35	. . . . .	. . . .	Pb-214
0.61	. . . . .	. . . .	Bi-214
0.78	. . . . .	. . . .	Bi-214
0.94	. . . . .	. . . .	Bi-214
1.12	. . . . .	. . . .	Bi-214
1.46	. . . . .	. . . .	K-40
1.76	. . . . .	. . . .	Bi-214
2.20	. . . . .	. . . .	Bi-214
2.62	. . . . .	. . . .	Tℓ-208

5. SUMMARY AND CONCLUSIONS

Since the Palisades Reactor had not commenced operating at the time of the survey, the aerial survey measured terrestrial background radiation. Exposure rates and isotopes observed are consistent with normal terrestrial background.

The 3-foot level exposure rates mapped during the survey were mostly in the 4 to 8 uR/hr range.

REFERENCES

1. "Aerial Radiological Measuring Systems (ARMS) - Systems and Procedures Employed Through FY71." AEC Report No. ARMS-71.6, in preparation.

2. 1970 Census of Population, Advance Report PC(VI)-24, U. S. Dept. of Commerce, Bureau of Census, January 1971.

3. Burson, Z. G., Boyns, P. K., and Fritzsche, A. E., "Technical Procedures for Characterizing the Terrestrial Gamma Radiation Environment by Aerial Surveys," EG&G/LVAO Report No. 1183-1559, 1972.

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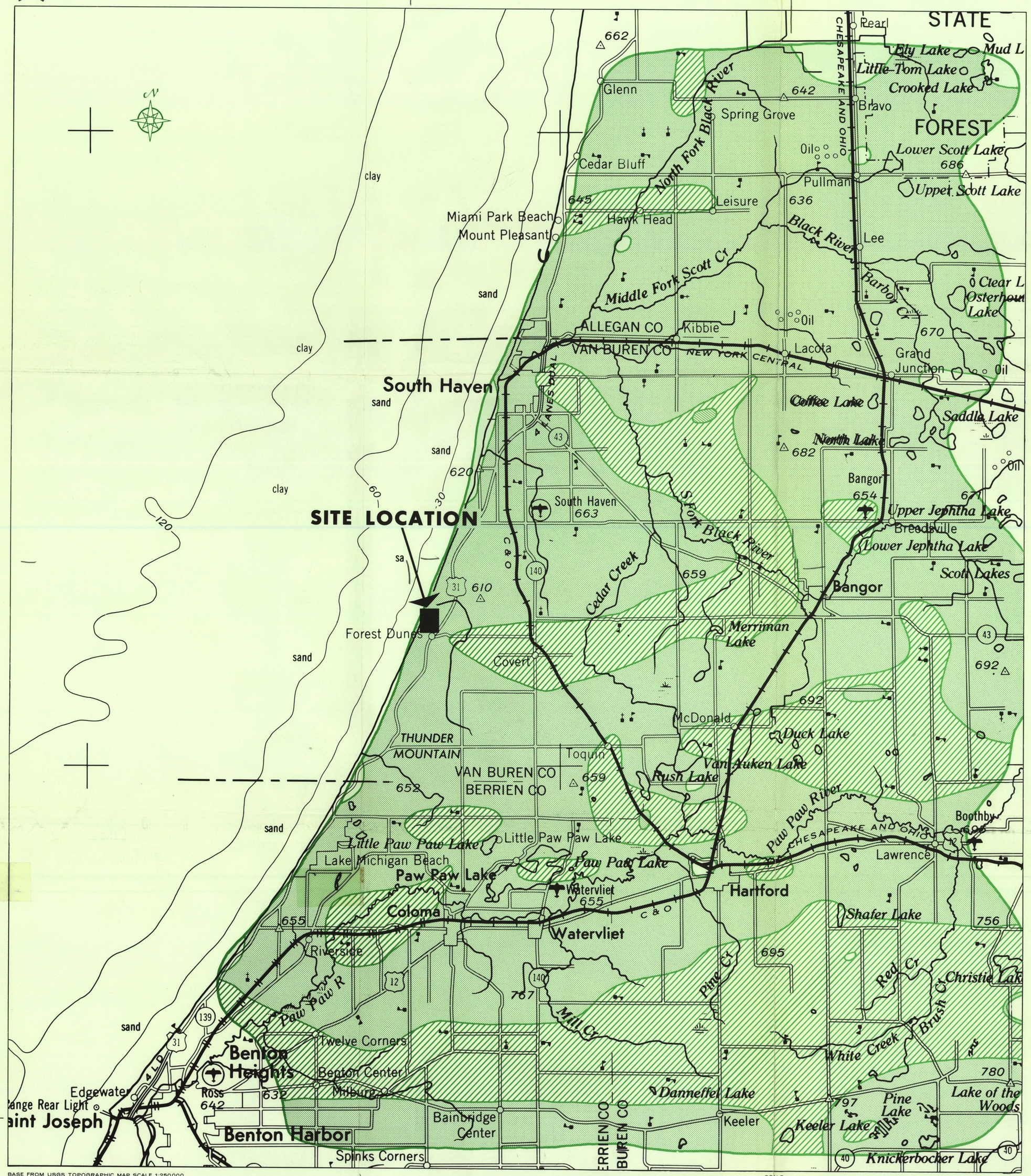


BASE FROM USGS TOPOGRAPHIC MAP SCALE 1:250,000

SCALE 0 5 10 MILES

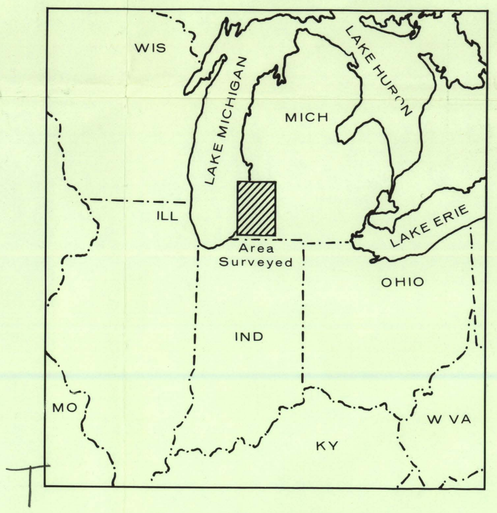
EXPOSURE RATE CONTOURS
PALISADES NUCLEAR POWER PLANT
MICHIGAN, JULY 1970

Printed in U.S.A.

LEGEND

2-4 μR/hr | 4-6 μR/hr | 6-8 μR/hr | 8-10 μR/hr

CONTOUR INTERVALS SHOWN ARE IN μR/hr AT THE 3-FOOT LEVEL



INDEX MAP

THIS SURVEY WAS MADE FOR THE USAEC WITH THE AERIAL RADIOLOGICAL MEASURING SYSTEM (ARMS).*

THE MEASUREMENTS WERE MADE USING AN ARRAY OF SCINTILLATION DETECTORS, MOUNTED IN AN AIRCRAFT, FLOWN IN A CAREFULLY CONTROLLED PATTERN AT A 300-FOOT ALTITUDE.

DATE OF THIS SURVEY: JULY 1970

SURVEY REPORT: ARMS 70.6.8 (PALISADES)

*(SEE REPORT: ARMS 71.6, ARMS SYSTEMS AND PROCEDURES THROUGH FY71.)