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DNA 6030F

SAFETY EXPERIMENTS

NOVEMBER 1955 - MARCH 1958

United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

Prepared by the Defense Nuclear Agency as Executive Agency
for the Department of Defense

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Project 56	PASCAL B	SATURN
Project 57	PASCAL C	VENUS
Project 58	COULOMB A	URANUS
PLUMBBOB	COULOMB B	
PASCAL A	COULOMB C	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the 14 experiments with nuclear weapons to determine their susceptibility to fission due to accidents in storage and transportation. One of the tests (Project 57) was designed to develop effective monitoring and decontamination procedures in the event of non-nuclear detonation of a nuclear weapon. The tests were conducted during the following operational periods: in November 1955 and January 1956, during Operation PLUMBBOB from April 1957 to October 1957, and in December 1957 and February and March 1958. DOD participation was limited to members of AFSWC and the Weather Bureau, some Exercise Desert Rock VII and VIII

18. SUPPLEMENTARY NOTES (continued)

The Defense Nuclear Agency Action Officer, Lt. Col. H. L. Reese, USAF, under whom this work was done, wishes to acknowledge the research and editing contribution of numerous reviewers in the military services and other organizations, in addition to those writers listed in block 7.

20. ABSTRACT (continued)

personnel, and DOD civilian and military scientists and technicians working for the AEC weapons development laboratories.

PREFACE

From 1945 to 1962, the U.S. Government, through the Manhattan Engineer District and its successor agency, the Atomic Energy Commission (AEC), conducted 235 atmospheric nuclear weapons tests in the United States and in the Pacific and Atlantic Oceans. In all, an estimated 220,000 Department of Defense (DOD) participants, both military and civilian, were present at the tests. Of these, approximately 90,000 participated in the atmospheric nuclear weapons tests conducted at the Nevada Test Site (NTS),* northwest of Las Vegas, Nevada.

In 1977, 15 years after the last above-ground nuclear weapons test, the Center for Disease Control+ noted a possible leukemia cluster among a small group of soldiers present at Shot SMOKY, a test of Operation PLUMBBOB, the series of atmospheric nuclear weapons tests conducted in 1957. Since that initial report by the Center for Disease Control, the Veterans Administration has received a number of claims for medical benefits from former military personnel who believe their health may have been affected by their participation in the weapons testing program.

In late 1977, the DOD began a study to provide data to both the Center for Disease Control and the Veterans Administration on potential exposures to ionizing radiation among the military and civilian participants in the atmospheric nuclear tests. The DOD organized an effort to:

- Identify DOD participants in the atmospheric nuclear weapons tests

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*Known as the Nevada Proving Ground until 1955.

+The Center for Disease Control is part of the U.S. Department of Health and Human Services (formerly the U.S. Department of Health, Education, and Welfare).

- Determine the extent of the participants' exposure to ionizing radiation
- Provide public disclosure of information concerning participation by DOD personnel in the atmospheric nuclear weapons tests.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report on the 14 safety experiments conducted between November 1955 and March 1958 is based on the military and technical documents associated with these tests. Many of the documents pertaining specifically to DOD involvement in the 14 experiments were found in the Department of Energy Nevada Operations Office, the Los Alamos National Laboratory Records Center, and the Reynolds Electrical and Engineering Company Coordination and Information Center.

In some cases, the surviving historical documentation addresses test specifications and technical information, rather than the personnel data critical to the study undertaken by the Department of Defense. Moreover, the documents sometimes have inconsistencies, such as the number of DOD participants in a certain project at a given shot or their locations and assignments at a given time. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader.

For several of the activities discussed in this volume, the only documents available are the Desert Rock operation orders and the Air Force air mission summary reports. These sources detail the plans developed by DOD and AEC personnel; they do not necessarily describe operations as they were actually conducted at the NTS. Although some of the after-action documents summarize the activities conducted during the operation, they do not always supply information specific to each safety experiment. In the absence of such information, activities are described according to the way they were planned. Because accomplishment

of objectives required detailed planning and adherence to operation orders, plans and operation orders should provide a reasonably accurate account of personnel activities. The references indicate whether the description of activities is based on operation orders, air mission summary reports, or after-action reports. Data on the tests, such as meteorological conditions, are taken from DNA 1251-1, Compilation of Local Fallout Data from Test Detonations 1945-1962, Volume 1, except in instances where more specific information is available elsewhere.

PLUMBBOB Series, 1957 includes information on the six safety experiments discussed in chapter 3 of this report. Operation HARDTACK II addresses the activities of participants at the 17 safety experiments conducted during that operation.

The information in this report is supplemented by the Reference Manual: Background Materials for the CONUS Volumes. This manual summarizes information on the physical processes and characteristics of a nuclear detonation, radiation physics, radiation health concepts, exposure criteria, and measurement techniques. It also lists acronyms and a glossary of terms used in the DOD reports addressing test events in the continental United States.

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume.

AEC	Atomic Energy Commission
AFB	Air Force Base
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
BJY	BUSTER-JANGLE Y
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Incorporated
LASL	Los Alamos Scientific Laboratory
NTS	Nevada Test Site
REECo	Reynolds Electrical and Engineering Company
R/h	Roentgen per hour
UCRL	University of California Radiation Laboratory
USPHS	United States Public Health Service

CHAPTER 1

INTRODUCTION

The 14 detonations discussed in this volume were safety tests of nuclear weapons developed by the Los Alamos Scientific Laboratory (LASL)* and the University of California Radiation Laboratory (UCRL)** for inclusion in the nuclear arsenal. The safety experiment program began with PROJECT 56, four tests conducted in November 1955 and January 1956 following Operation TEAPOT. The program continued through Operation PLUMBBOB in 1957 and Operation HARDTACK II in 1958. Thirty-one safety experiments were performed during this three-year period. Operation HARDTACK II provides information on 17 of the experiments. This report discusses the other 14 safety experiments, conducted at the NTS between November 1955 and March 1958. Table 1-1 summarizes these 14 experiments, including dates of the detonations and their locations at the test site. Figure 1-1 displays a map of the NTS and indicates the approximate positions of each experiment.

Thirteen of the experiments discussed in this volume were conducted to determine the weapons' susceptibility to fission due to accidents in storage or transportation. Elements of the high-explosive portions of these devices were fired to simulate accidental detonation and to determine the potential for such firings to result in a significant nuclear yield. The test results were used to develop devices that could withstand shock, blast, fire, and accidents without initiating a nuclear chain reaction and producing a nuclear detonation.

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*Now the Los Alamos National Laboratory.

**Now the Lawrence Livermore National Laboratory.

Table 1-1: SUMMARY OF THE SAFETY EXPERIMENTS

Shot	PROJECT 56 EXPERIMENT 1	PROJECT 56 EXPERIMENT 2	PROJECT 56 EXPERIMENT 3	PROJECT 56 EXPERIMENT 4	PROJECT 57	COULOMB A	PASCAL A	SATURN	PASCAL B	COULOMB B	PASCAL C	COULOMB C	VENUS	URANUS
Sponsor	LASL	LASL	LASL	LASL	LASL	LASL	LASL	UCRL	LASL	LASL	LASL	LASL	UCRL	UCRL
Actual Date	11/01/55	11/03/55	11/05/55	01/18/56	04/24/57	07/01/57	07/26/57	08/09/57	08/27/57	09/06/57	12/06/57	12/09/57	02/22/58	03/14/58
Local Time	1410	1315	1155	1330	0627	1030	0100	1800	1535	1350	1215	1200	1700	1400
NTS Location	Area 11	Area 11	Area 11	Area 11	Area 13	Area 3	Area 3	Area 12	Area 3	Area 3	Area 3	Area 3	Area 12	Area 12
Type	Surface	Surface	Surface	Surface	Surface	Surface	Shaft	Tunnel	Shaft	Surface	Shaft	Surface	Tunnel	Tunnel
Actual Yield (kilotons)	NMY*	NMY	NMY	Slight Nuclear Yield	NMY	NMY	Slight Nuclear Yield	NMY	NMY	0.3	Slight Nuclear Yield	0.5	Less Than One Ton	Less Than One Ton

*No measurable yield.

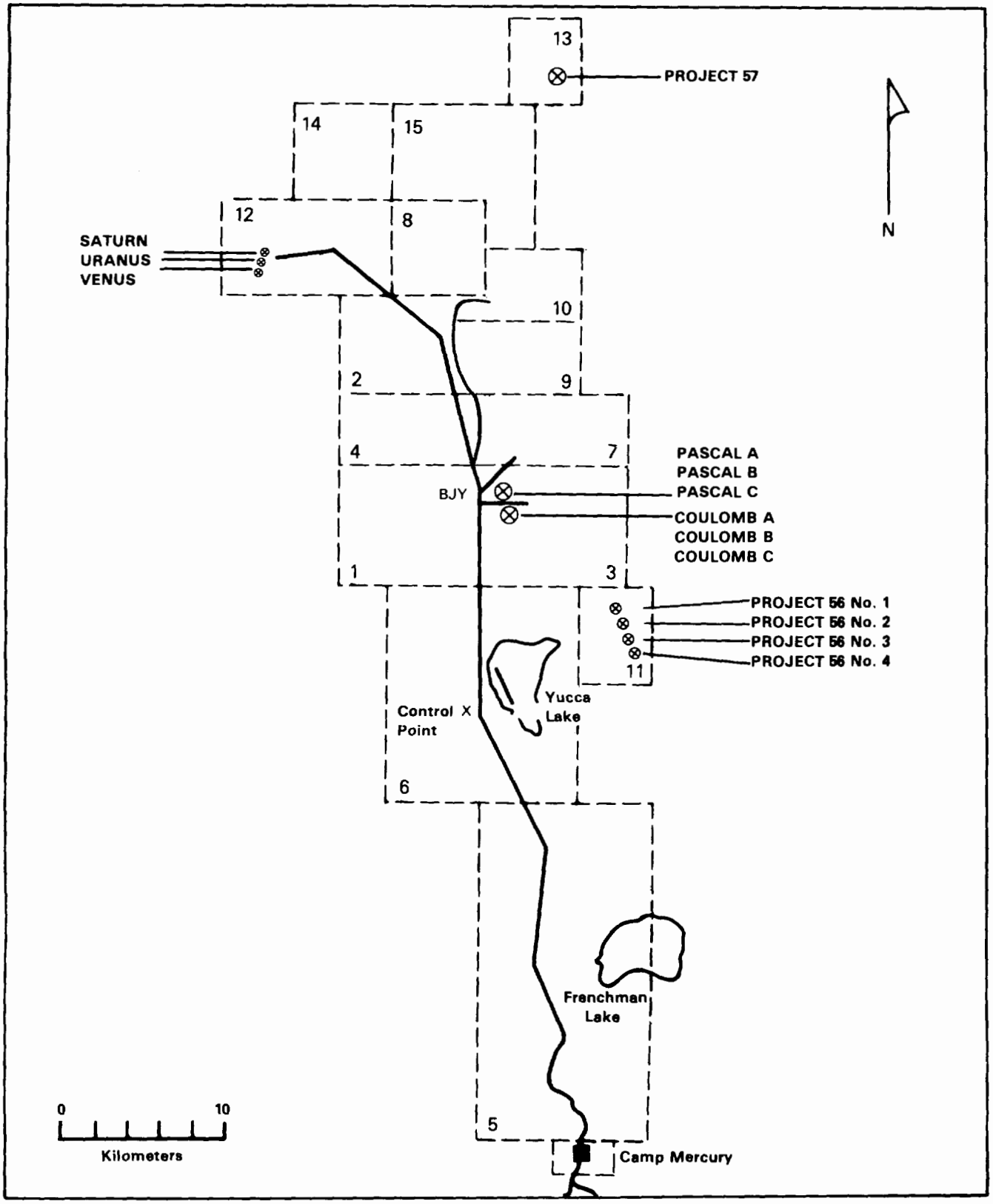

Figure 1-1: LOCATIONS OF THE SAFETY EXPERIMENTS WITHIN THE NEVADA TEST SITE

One of the experiments, PROJECT 57, was conducted to disperse a known quantity of alpha-emitting material over a defined area. The experiment was designed to develop effective monitoring and decontamination procedures and to study the biological effects of alpha radiation in the event of non-nuclear detonation of a nuclear weapon (18).*

LASL conducted the four PROJECT 56 experiments in Area 11 of the NTS in November 1955 and January 1956. Participants were LASL, Sandia Corporation, and Reynolds Electrical and Engineering Company (REECo) employees. AEC contractors and U.S. Public Health Service (USPHS) personnel performed radiological monitoring outside the NTS boundaries and in all areas of the NTS except Area 11 (3-5).

The six PLUMBBOB experiments were conducted in April, July, August, and September of 1957, while the PLUMBBOB nuclear weapons testing series was in progress. Five of the devices were detonated by LASL, and one by UCRL. Most of the personnel directly involved in the six PLUMBBOB safety experiments were employees of LASL; UCRL; Sandia; Edgerton, Germeshausen, and Grier, Incorporated (EG&G); or REECo. Employees of these AEC contractors performed sampling and diagnostic projects and monitored the areas for radiation (9; 37).

The four safety experiments of PROJECT 58 were conducted in December 1957 and February and March 1958, after Operation PLUMBBOB was concluded. The two experiments in December 1957 were tests of LASL devices. A group of LASL, EG&G, Sandia, and REECo employees placed and recovered samples and other equipment

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*All sources cited in the text are listed alphabetically and numbered in the Reference List, appended to this volume. The number given in the text is the number of the source document in the Reference List.

in Area 3 and recorded the radiological conditions resulting from the tests. UCRL tested two devices in February and March 1958. UCRL, EG&G, and REECo employees participated in these tests (7; 8). Except for the onsite monitoring for PROJECT 56, the REECo Radiological Safety Division provided the radiological safety support for the safety experiments.

The participation of DOD personnel during these 14 safety experiments is difficult to determine. Some of the workers at the nuclear weapons development laboratories, LASL and UCRL, were civilian or military DOD personnel. The largest identified group of DOD personnel directly involved in any of the 14 safety experiments consisted of eight Air Force Special Weapons Center (AFSWC) personnel and two participants from the 50th Chemical Service Platoon, who performed field work for one of the programs during PROJECT 57, the alpha-dispersion experiment conducted at the beginning of Operation PLUMBBOB. Other DOD participation included Project 50.3 and 50.8 personnel and AFSWC personnel involved in cloud sampling for COULOMB A and COULOMB B and cloud tracking for PASCAL C and COULOMB C (11; 12; 18; 20; 21).

CHAPTER 2

PROJECT 56 SAFETY EXPERIMENTS

The Los Alamos Scientific Laboratory conducted four safety experiments at the Nevada Test Site during late 1955 and January 1956. These four tests, known collectively as PROJECT 56, were designed to determine the safety of newly developed nuclear weapons during transportation and storage. LASL developed these experiments in response to a DOD request that the weapons be tested for safety prior to inclusion in the nuclear arsenal.

LASL had originally planned for the four experiments to be part of Operation TEAPOT (1955). The TEAPOT schedule, however, could not accommodate the events, and plans were subsequently made to conduct the four safety experiments as a separate operation after TEAPOT, during the fall of 1955.

The four safety experiments were all conducted in Area 11 of the NTS, approximately six kilometers* east of Yucca Lake. As indicated in figure 2-1, the four detonation points were on a line running south-southeast to north-northwest. For each experiment, LASL technicians and scientists set up instrumentation to study neutron production during the test (3; 16).

A field control point was established in a trailer in Area 11, two to three kilometers from each ground zero. A blockhouse near the field control point served as headquarters for the Test Director's representatives of the Plans and Operations Section and the Construction, Communication, and Signal Section. The

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*Throughout this report, surface distances are given in metric units. The metric conversion factors include: 1 meter = 3.28 feet; 1 meter = 1.09 yards; 1 kilometer = 0.62 miles.

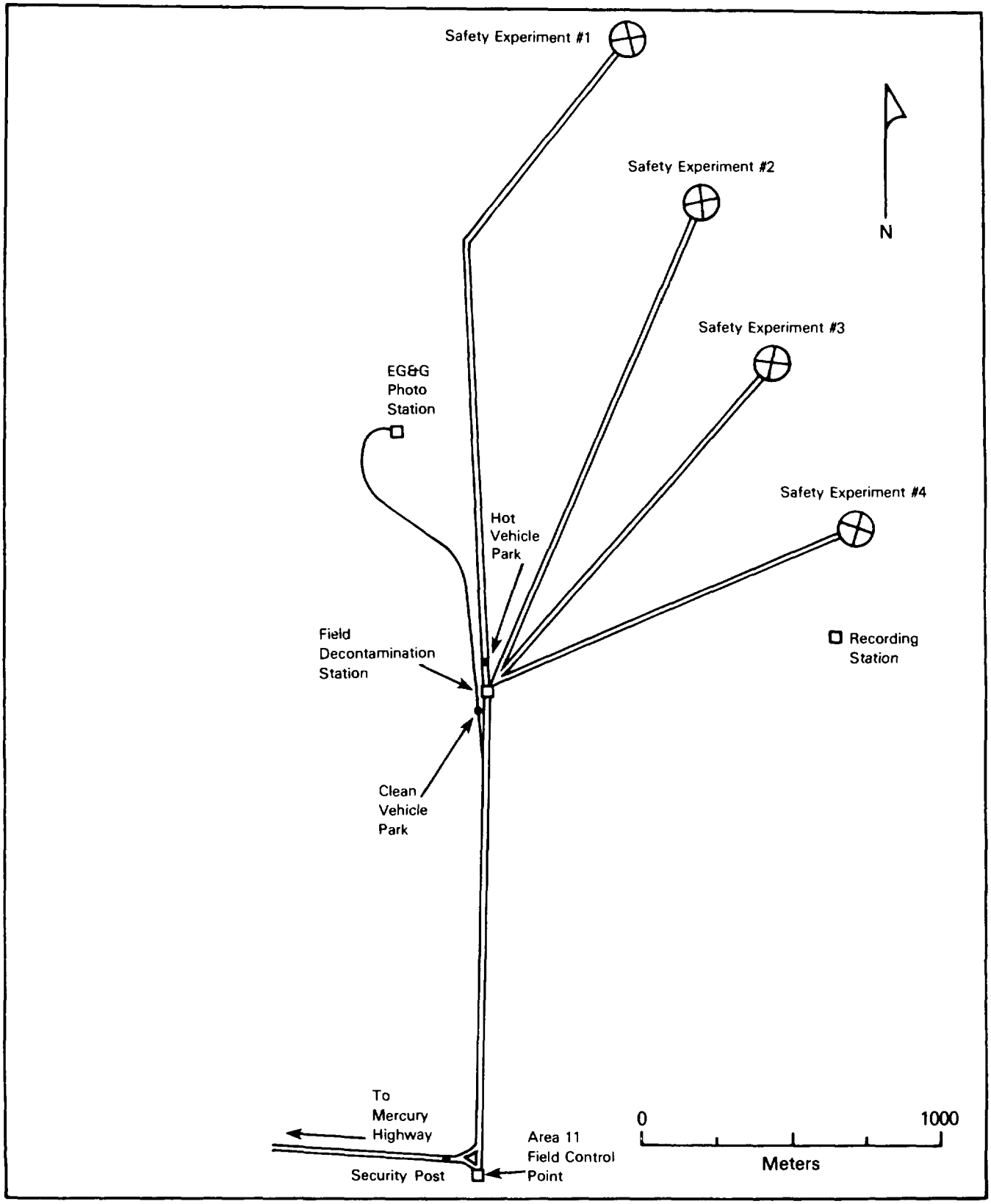

Figure 2-1: LOCATIONS OF PROJECT 56 GROUND ZEROS AND FIELD INSTALLATIONS

Yucca Lake airstrip building was used as a counting lab by a group of LASL scientists performing neutron threshold detector experiments for each of the four tests. LASL personnel developed film badges in the trailers at the Yucca Pass main control point. Sandia and LASL employees also used these trailers for documentary photography activities (3; 16).

Three devices were detonated on 1, 3, and 5 November 1955. The third device produced questionable results, prompting cancellation of the detonation of the fourth device. Instead, plans were made to test a device similar to the third device to make more definitive measurements. This fourth test was scheduled for 14 January 1956.

Most of the information available for PROJECT 56 pertains to all four of the safety experiments and is organized into the following two general sections, which describe participation and radiological safety for PROJECT 56. The final four sections include data unique to each safety experiment.

2.1 PARTICIPATION AT PROJECT 56

Participants in this operation were (23):

- LASL and Sandia Corporation employees performing experiments, onsite radiological safety monitoring, and administrative tasks
- AEC contractors and the USPHS performing offsite radiological safety monitoring and providing onsite support services
- Air Weather Service personnel supplying meteorological information.

Fifty-seven LASL and Sandia personnel, of whom at least six were military or civilian DOD personnel, were scheduled as

participants, technical representatives, and alternates for PROJECT 56. Of these personnel (3; 4):

- One was the Test Director.
- One was the Test Director's representative for the LASL Plans and Operations Section and also an officer in the armed services.
- One was the Test Director's representative for the LASL Construction, Communication, and Signal Section.
- Three were LASL personnel who conducted neutron threshold detector experiments.
- Six were onsite radiological safety monitors.

The remaining LASL and Sandia personnel probably had administrative, construction, or communications duties or tasks related to other aspects of the experiments.

The offsite radiological safety personnel were from the AEC Las Vegas Branch Office, including assigned USPHS personnel, and from REECo, the AEC operations contractor. A pilot from CARCO, a contracted air service, also participated. Of the individuals involved in offsite activities, only one assigned to the counting and collection group and one air sample attendant at Indian Springs AFB were DOD personnel (5; 34).

Six Air Force personnel from the 6th Weather Squadron (Mobile), Air Weather Service, Tinker Air Force Base, Oklahoma, were at the NTS during PROJECT 56, assessing meteorological data for weather prediction. They arrived at Indian Springs AFB on 22 October and returned to Tinker AFB on 8 November 1955. Before each scheduled event, the Test Director conferred with the Air Weather Service personnel on expected weather conditions.

2.2 RADIOLOGICAL SAFETY AT PROJECT 56

LASL conducted radiological safety activities for this operation both within and outside the NTS. AEC contractors and assigned USPHS personnel conducted these operations. The onsite group was responsible for keeping individuals other than designated project personnel outside of the test area and for monitoring areas that project personnel were required to enter. The offsite program was designed to measure and record the extent of airborne and surface radioactive contamination (5; 34).

The six onsite radiological safety monitors established an area out to approximately 800 meters surrounding the four detonation points. This area was considered contaminated, and the number of personnel who entered the area following the first detonation on 1 November was kept to a minimum (5; 34).

The main duties of offsite radiological safety personnel were to (5; 34):

- Place and exchange approximately 300 fallout trays and film badges at various intervals in designated areas within a 30-kilometer radius of the detonation points
- Place and exchange air sampling equipment at eight NTS stations and ten stations outside the NTS up to 160 kilometers from the detonation points
- Collect, count, and record all fallout trays, film badges, and sampling equipment
- Assist onsite when required
- Make area reconnaissance and cloud-height measurements after each test
- Monitor roads and work areas after each detonation.

Two pickup trucks and one radio-operator trailer with five monitors were on standby at Camp Mercury during each shot period. These men were to be dispatched for monitoring to the closest populated community in the expected fallout path if any of the safety tests produced a significant nuclear yield (5).

2.3 PROJECT 56, EXPERIMENT 1

Safety Experiment Number 1 was conducted on 1 November 1955 at 1410 hours in Area 11 of the NTS, UTM coordinates 924934.* Alpha-emitting surface contamination extended in all directions approximately 20 meters from the detonation point. When the LASL test group pulled the neutron instrumentation cables from the detonation area to 365 meters from ground zero, the alpha readings on the samples were 200 to 3,500 counts per minute. No beta or gamma radiation resulted from this test (19; 26).

2.4 PROJECT 56, EXPERIMENT 2

Safety Experiment Number 2 was conducted on 3 November 1955 at 1315 hours in Area 11 of the NTS, UTM coordinates 926930. Alpha surface levels around the detonation point were above 2,000,000 counts per minute. The instrumentation cable, when pulled approximately 365 meters from ground zero, measured 10,000 to above 20,000 counts per minute of alpha activity. No beta or gamma radiation resulted from this experiment (19; 26).

2.5 PROJECT 56, EXPERIMENT 3

Safety Experiment Number 3 was detonated on 5 November at 1155 hours in Area 11 of the NTS, UTM coordinates 928925. One hour after the test, monitors found readings of 0.12 roentgen per hour (R/h) at ground zero and less than 0.001 R/h approximately 30 meters away. Alpha surface contamination levels at ground zero were approximately 200,000 counts per minute (19; 26).

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*Universal Transverse Mercator (UTM) coordinates are used in this report. The first three digits refer to a point on an east-west axis, and the second three refer to a point on a north-south axis. The point so designated is the southwest corner of an area 100 meters square.

2.6 PROJECT 56, EXPERIMENT 4

Safety Experiment Number 4 was scheduled for 14 January 1956 but, because of adverse weather, the test was delayed until 18 January. When detonated on 18 January at 1330 hours in Area 11 of the NTS, UTM coordinates 930920, it produced a very slight nuclear yield (19).

The Test Director's representative for Plans and Operations and representatives from the LASL radiological safety group and the three LASL groups conducting experiments met before the test on 13 January to plan experiment recovery operations. There were three types of experimental data to recover (27):

- Film records in a bunker 910 meters from ground zero from the time measurement of a neutron production experiment
- Radiological and chemical samples
- Samples from the neutron threshold detector experiment, attached to a cable that surrounded the test device.

The film records and radiological and chemical samples did not need to be retrieved immediately after the detonation. Thus, the groups recovering these records and samples could wait until monitors measured the radiation intensities in the test area. The neutron samples, however, had to be recovered soon after the detonation because of the short half-lives of some of the nuclides produced (27).

On 18 January, before the detonation, the six-man neutron sample recovery group, accompanied by one radiological safety monitor, and another group of at least two monitors suited up in anticontamination clothing at the field control point. Immediately after the detonation, these two groups left the field control point in two uncontaminated vehicles, proceeded to the field decontamination station, transferred to contaminated

vehicles, and drove into the test area. The party of at least two monitors went to a point 360 meters from ground zero, where they measured radiation intensities. They then proceeded closer toward ground zero measuring radiation intensities. The sample recovery group drove to 460 meters from ground zero, where a tractor with the neutron instrumentation cable attached had been started 30 minutes before the test and left idling. The tractor driver then left the group. He was to drive from the 460-meter point to a point 820 meters from ground zero, pulling the 460-meter cable to a point 360 meters from ground zero where the recovery group would be waiting. The rest of the sample recovery team then moved from their position 460 meters from ground zero to the 360-meter point, where the initial monitoring team was beginning its survey (27).

The radiation level at the 360-meter point was low until the tractor driver pulled the sample end of the instrumentation cable into the area. Two different instruments then detected gamma radiation of 20 to 30 R/h. The radiological safety monitor with the recovery team did not inform the other team members of these readings, but radioed the information to the radiological safety center at the field decontamination station. Another monitor with another radiac instrument was immediately sent from the radiological safety center to the 360-meter point to recheck the reading. One survey monitor drove toward ground zero, where he found readings of 50 R/h approximately 30 meters from ground zero. The monitor returned to the position of the neutron recovery team to radio his readings to the radiological safety center (27).

Meanwhile, four personnel from the recovery group removed the neutron detection samples from the cable, drove back to the tractor at the 820-meter point, picked up the tractor driver, and went to the decontamination station. Two members of the recovery team, who did not have a radiac instrument, drove toward ground

zero to look for neutron detectors that had dropped from the cable. They found none and returned to the 460-meter point. The radiological safety monitors then moved everyone out of the test area. The total time the recovery group was in the area within 360 meters of ground zero was about 12 minutes (27).

Four personnel at Experiment 4 received exposures greater than the 3.9 roentgen exposure limit. The readings were 28, 18.5, 13.7, and 4.3 roentgens (27). These readings may have resulted from the participants' having handled the hot instrumentation cable.

The isointensity contour lines in figure 2-2 reflect readings at approximately one hour after the detonation. These readings are much lower than the ones taken during the recovery of the neutron detectors (19).

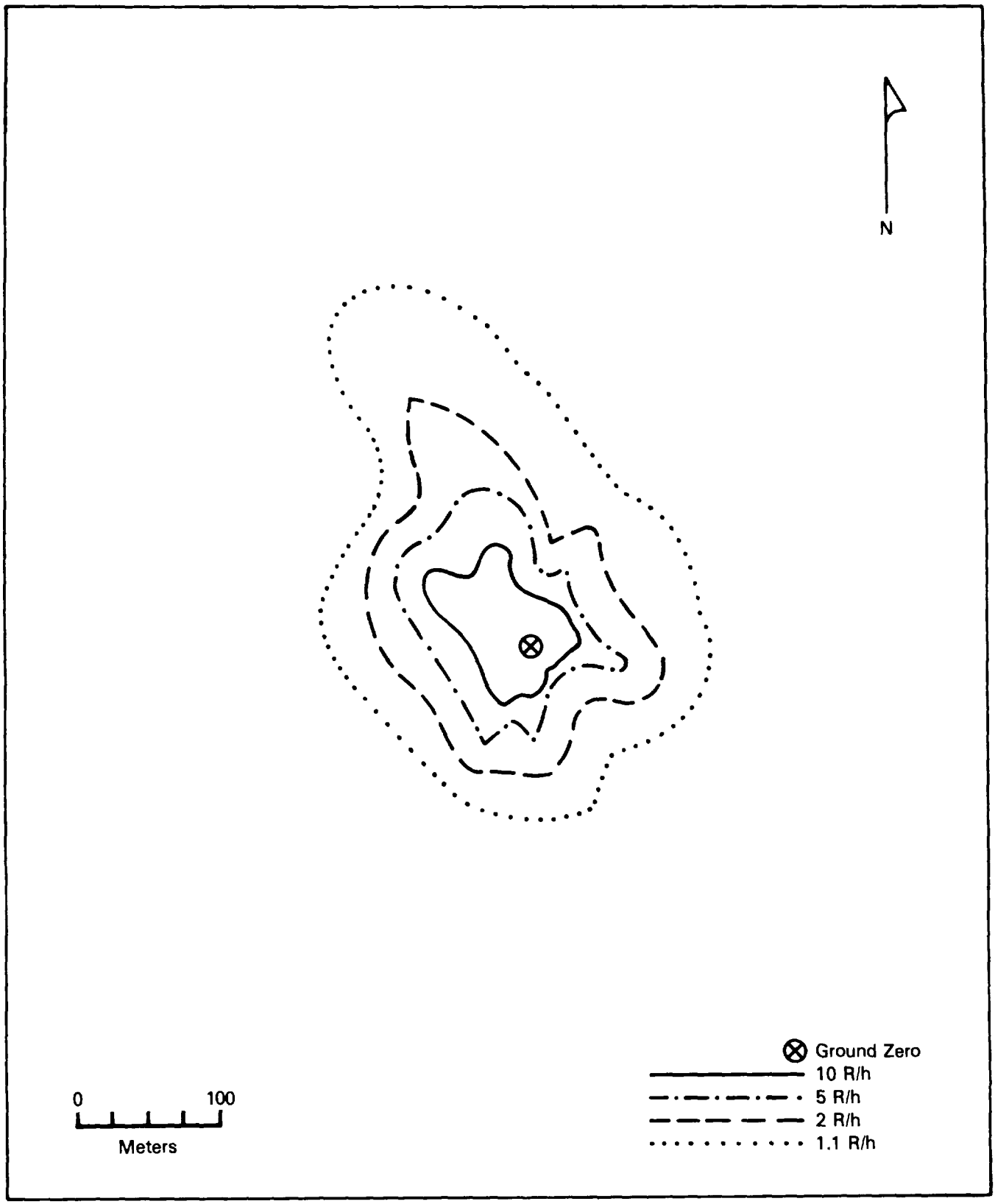

Figure 2-2: GAMMA INTENSITY CONTOURS FOR EXPERIMENT NUMBER FOUR OF PROJECT 56 AT 1255 HOURS

CHAPTER 3

THE PLUMBBOB SAFETY EXPERIMENTS

The six safety experiments associated with Operation PLUMBBOB began with PROJECT 57, conducted by a special task group of civilian and military personnel on 24 April 1957, and concluded with COULOMB B on 6 September 1957. The experiments were (19; 37):

Test	Date
PROJECT 57	24 April 1957
COULOMB A	1 July 1957
PASCAL A	26 July 1957
SATURN	9 August 1957
PASCAL B	27 August 1957
COULOMB B	6 September 1957

Although these experiments were considered part of Operation PLUMBBOB, they were actually separate experiments that took place during the series. The scheduling of these experiments took advantage of logistical support available for the operation.

Except for PROJECT 57, all of these experiments were conducted for the same purpose: to determine the weapons' susceptibility to fission due to accidents in storage and transportation. Elements of the conventional high-explosive portions of the devices were fired to simulate accident situations and to determine whether significant nuclear yields would result. PROJECT 57 was conducted to spread alpha-emitting material (plutonium) in a defined area to study biological effects of alpha radiation and to test monitoring and decontamination procedures (18).

The Los Alamos Scientific Laboratory conducted experiments COULOMB A, PASCAL A, PASCAL B, and COULOMB B in Area 3, north of Yucca Lake.* LASL and the Sandia Corporation conducted PROJECT 57 in Area 13, in the northeastern corner of the Nevada Test Site. The University of California Radiation Laboratory conducted SATURN in a tunnel in Rainier Mesa within Area 12, the northwest portion of the NTS (19; 37).

PROJECT 57 and COULOMB A and B were surface bursts. PASCAL A and B were fired in unstemmed shafts, and SATURN was fired inside a sealed tunnel. PASCAL A vented some radioactive debris, but debris from PASCAL B and SATURN was contained underground (19; 37).

Scientists and technicians from LASL and UCRL conducted most of the activities at the safety experiments. Some participants may have been DOD civilian or military personnel working with the AEC nuclear weapons development laboratories. Other DOD personnel assigned to the safety experiments included (1; 9; 18; 22; 24; 25):

- AFSWC personnel who conducted activities in conjunction with PROJECT 57 and who conducted cloud sampling, cloud tracking, and terrain surveys at the safety experiments
- Personnel from the 50th Chemical Service Platoon, who assisted in radiological monitoring during PROJECT 57
- Air Weather Service personnel of the Weather Prediction and Fallout Prediction Units
- Construction and signal personnel assigned to set up ground zero structures, instrumentation, and communications
- Desert Rock personnel assigned to technical service and operational training projects that may have been conducted during three of the tests.

*These four safety experiments were conducted in Yucca Flat, which is about 4,000 feet above mean sea level.

3.1 PROJECT 57

PROJECT 57, sponsored by Sandia Corporation, was detonated on 24 April 1957 at 0627 hours in Area 13. The experiment was actually a series of tests designed to develop effective decontamination procedures and to study the potential biological hazards occurring after the non-nuclear detonation of a nuclear weapon. Such an event would disperse alpha-emitting material (primarily plutonium) in the immediate area of the incident (18).

Alpha particles do not penetrate clothing or the outer layer of skin. However, alpha-emitting material is hazardous when inhaled or ingested. The radiological safety procedures established for PROJECT 57 were based on the expectation that alpha contamination levels would be high. Consequently, the following procedures were mandatory (22):

- Wearing full anticontamination clothing
- Taping shut all openings in clothing
- Wearing full-face respirators with high-efficiency filters.

3.1.1 Scientific Programs

The four programs conducted to study the biological effects of alpha contamination and to test alpha monitoring and decontamination procedures were (22):

- Program 71, Particulate Physics
- Program 72, Biomedical Field Study of Plutonium Inhalation
- Program 73, Plutonium Monitoring and Decontamination
- Program 74, Surface Alpha Monitoring.

Test Group 57, consisting of scientists from civilian laboratories and AFSWC, conducted these programs. Other DOD personnel provided radiological monitoring, veterinarian, and administrative support to the test group (18; 22).

Program 71, Particulate Physics, was designed to:

- Measure plutonium levels in the air and on the ground as a function of time after the detonation
- Develop a fallout model for the type of nuclear device detonated so that it could be used for any wind pattern
- Study the size, shape, and distribution of the fallout particulate
- Compare fractionation characteristics of plutonium fallout with uranium fallout.

To obtain data, personnel used air samplers, soil samples, balloon-borne precipitators, and photography. The program resulted in the construction of iso-concentration contours of alpha contamination (22).

Program 72, Biomedical Field Study of Plutonium Inhalation, was developed to study:

- The environmental short-term and chronic rates and the persistence of plutonium debris resulting from a burst without nuclear yield
- The rate of environmental decay of plutonium in selected areas.

Program personnel, including DOD veterinarians, exposed a small group of dogs to the PROJECT 57 cloud to examine the effects of acute exposure. They also placed 70 to 80 dogs in the contaminated area to study the effects of chronic exposure. Field crews wore full-face supplied-air masks. As the study continued, air concentrations of plutonium decreased, and field personnel were permitted to wear full-face filter-equipped masks. As plutonium concentration levels decreased further, restrictions were again reduced, based on radiological sampling of the area, and personnel were permitted to wear half-mask respirators with high-efficiency filters. These half-mask respirators were considered acceptable protection in areas with plutonium dispersion levels of less than 100 micrograms per square meter (22).

Program 73, Plutonium Monitoring and Decontamination, was to determine techniques for removing plutonium from large land surface areas, from large concrete and asphalt pads, and from construction materials, such as wood, brick, stucco, concrete, aluminum, and steel. Personnel studied various decontamination methods, including washing, vacuuming and steam cleaning, leaching with water, plowing, and fixation with subsequent removal of contaminated soil. They also examined techniques for monitoring air, surface, and soil contamination. Operations began two hours after the detonation on 24 April 1957 and continued until 25 May 1957 (22; 37).

Eight AFSWC participants and two 50th Chemical Service Platoon personnel, all of whom wore full-face filter respirators, conducted the field work. AFSWC was interested in this program because non-nuclear detonation of a weapon can occur during operational activities, such as an aircraft crash or an accidental jettison of a nuclear device. In such instances, the high-explosive charges in the device might explode on impact, dispersing plutonium over the surrounding area (18; 22).

Program 74, Surface Alpha Monitoring, was designed to correlate alpha monitoring data from sticky pan collectors in Area 13 with field survey data from concrete slabs positioned next to the pan collectors. The study also included soil and brush measurements.

3.1.2 Radiological Safety

REECo, the AEC support contractor, provided radiological safety support to all test personnel. REECo activities included (22; 37):

- Clearing the test area of grazing cattle

- Assisting Sandia Corporation personnel in placing and setting timers and batteries at 46 impactor stations
- Manning a temporary personnel decontamination building beside the access road into the test area
- Providing 389 sets of full anticontamination clothing and respirators at the decontamination building
- Monitoring the test area
- Manning a mobile rest station for workers in some of the contaminated areas.

Working from 20 days before to two days after the detonation, REECo personnel also placed and recovered approximately 15,000 fallout trays in an area measuring 13 by 21 kilometers. REECo and Sandia Corporation personnel collected the trays after the detonation (22; 37).

Thirty minutes after the detonation, a team of three REECo monitors performed a beta and gamma survey of the area around ground zero. An alpha survey crew, consisting of five Program 74 personnel, began surveying the test area about four hours and 30 minutes after the detonation. They spent about two hours in this activity (37).

Figure 3-1 shows the contours based on the initial alpha survey. Resurveys of Area 13 were conducted throughout the rest of Operation PLUMBBOB, as detectable surface radioactivity decreased through weathering and settling (19).

REECo personnel at the decontamination building used portable alpha survey instruments to monitor all personnel leaving the contaminated area. Personnel were decontaminated when alpha levels on the skin exceeded 100 counts per minute. REECo personnel also monitored respiratory devices, considered contaminated when readings exceeded 100 counts per minute. Vehicles and equipment were decontaminated if levels read over

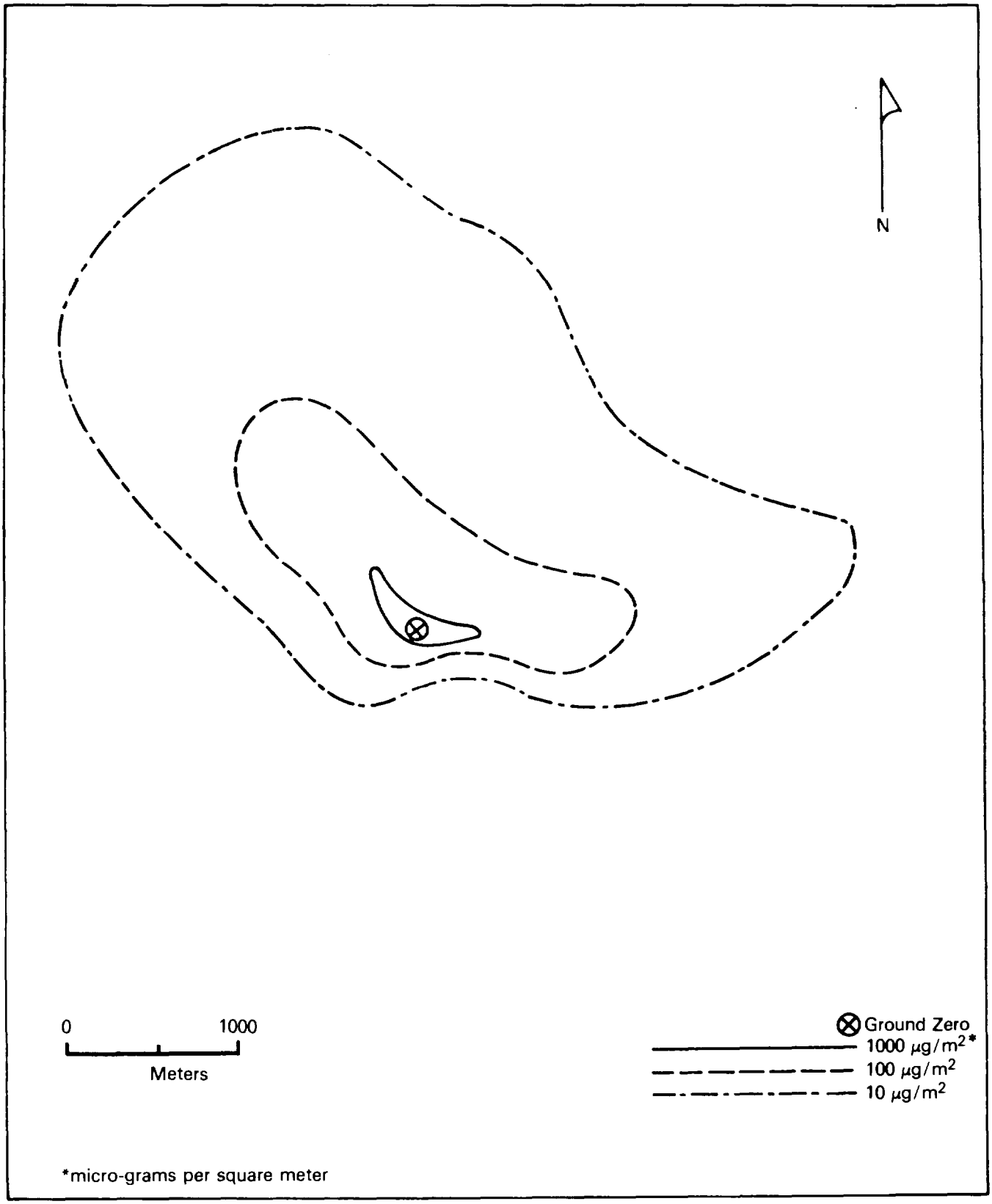

Figure 3-1: SURVEY FOR ALPHA CONTAMINATION PRODUCED BY PROJECT 57, 24 APRIL 1957

500 counts per minute. In all cases, the probe counting area was 55 square centimeters (37).

After being monitored, personnel removed their anticontamination clothing and placed it in receptacles. Decontamination personnel then took nasal swabs (389 from April 24 to April 30). All of the swabs were negative except for that of one individual who removed his respirator in the vicinity of ground zero. Urine samples from this individual indicated "no significant internal exposure" (37). In addition to the nasal swabs, urine samples were taken from participants leaving the test area. The samples were then packaged and shipped offsite for analysis. Negative results were reported for the 73 urine samples obtained from participating groups. After the urine samples and nasal swabs were taken, personnel showered, entered the clean area, and dressed in their personal clothing (37).

3.2 COULOMB A

COULOMB A, sponsored by LASL, was detonated on the surface in Area 3, UTM coordinates 867997, at 1030 hours on 1 July 1957. The top of the cloud resulting from COULOMB A rose to a height of 1,000 feet* (19; 37). DOD participation at this experiment was limited to (9; 22):

- Army Artillery Board personnel testing optical instruments for Project 50.8, Detection of Atomic Bursts and Radioactive Fallout
- Air Force personnel who participated in Project 53.7, Indirect Bomb Damage Assessment, in cloud sampling for LASL Project 11.2, Radiochemistry Sampling, and in sample return activities.

*Vertical distances are given in feet. Altitudes are measured from mean sea level, while heights are measured from ground surface.

3.2.1 Operations

Project 50.8, Detection of Atomic Bursts and Radioactive Fallout, was an Exercise Desert Rock project conducted at most of the PLUMBBOB events. Project personnel operated radar equipment at two stations on a mountain 13 kilometers northwest of ground zero at UTM coordinates 749052 and 752048 and one station 13 kilometers southeast of ground zero at UTM coordinates 902873. The Army Artillery Board worked only with the optical instruments used in the project (9; 22).

Project 53.7, Indirect Bomb Damage Assessment, was conducted by the Wright Air Development Center. AFSWC provided support by carrying damage assessment equipment in an F-89D. At the time of detonation, the aircraft was flying at an altitude of 35,000 feet and at a heading of 360 degrees (9).

After COULOMB A was detonated, one L-20 sampler control aircraft climbed to an altitude of 5,000 feet and orbited in a right-hand pattern five nautical miles north of ground zero. Two F-84 sampler aircraft, each with a crew of two, followed the directional advice of the sampler control aircraft, collected cloud samples, and then returned to Indian Springs AFB. The samples were removed from the aircraft, and both the aircraft and crew members were routinely decontaminated after the flight. Two courier aircraft, a C-47 and an L-20, then transported the samples to LASL for analysis (11).

3.2.2 Radiological Safety

All personnel involved in COULOMB A operations wore film badges. Additionally, the Logistics Branch of the Radiological Safety Division issued full anticontamination clothing and respirators to 66 project personnel who reentered the test area on shot-day and the day after. The Plotting and Briefing Branch issued area access permits to six parties. Procedures for

monitoring and decontaminating personnel and equipment were consistent with the Operation PLUMBBOB procedures then in effect (37).

Monitoring activities involved the use of helicopter and initial ground surveys and of roving monitors to control access to radiation areas. The helicopter survey, scheduled to be conducted by two monitors and two AFSWC pilots, was canceled after the ground survey indicated little gamma radiation in the test area (37).

The four monitors of the initial survey party began their survey one minute after the detonation. They determined that the gamma radiation level at ground zero was 0.002 R/h. An alpha survey within a 45-meter radius of ground zero showed 15,000 counts per minute per 55 square centimeters. Resurveys were conducted periodically but are not shown in PLUMBBOB documentation because gamma levels were relatively insignificant (37).

3.3 PASCAL A

PASCAL A, sponsored by LASL, was detonated inside a 500-foot deep, unstemmed shaft in Area 3 at 0100 hours on 26 July 1957 (35). DOD participation in this safety test was limited to Project 50.8, Detection of Atomic Bursts and Radioactive Fallout. Because the test unexpectedly produced a nuclear detonation, AFSWC personnel provided support in the form of a precautionary airlift evacuation of the area. Two aircraft were involved in this operation (13; 22; 37).

3.3.1 Operations

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the Army Artillery Board. The objective was to evaluate the capability of Army equipment

to determine the location, height of burst, and yield of a nuclear detonation. The only Project 50.8 activity known to have been performed involved sound-ranging equipment placed nine kilometers south of ground zero at UTM coordinates 860915. The command post was 11 kilometers southwest of ground zero at UTM coordinates 768944 (8; 22).

3.3.2 Radiological Safety

Because the test produced a nuclear detonation, the Test Director's radiological safety officer ordered the forward area evacuated at 0111 hours, 11 minutes after the detonation. The initial radiation survey was delayed until after 0500 hours, when the evacuation was complete. Monitors made a limited beta and gamma survey of the shot area and adjacent areas, including Mercury Highway from the Control Point to the BUSTER-JANGLE Y (BJY), at a mid-time of 0620 hours. No alpha survey was made at that time because of moist conditions, which caused the alpha counters to function erratically. Monitors placed barricades around the site to prevent entry into Area 3. Two monitors completed the alpha survey of the area at 0930 hours (37).

Figure 3-2 presents a copy of the isointensity contour map generated from a gamma survey of the shot area at a mid-time of 0929. Alpha readings were roughly proportional to gamma readings. Monitors also conducted resurveys later on 26 July 1957, and on 27, 28, 29, and 31 July, and on 2 August 1957 (37).

According to the Onsite Radiological Safety Report, the Personnel Dosimetry Branch of the Radiological Safety Division issued 884 film badges and 240 pocket dosimeters to personnel on 26 July 1957. The Logistics Branch, however, issued anticontamination clothing to only 23 personnel, who were briefed for entry into the test area. Following the test, about 75 personnel and 25 vehicles were decontaminated (37).

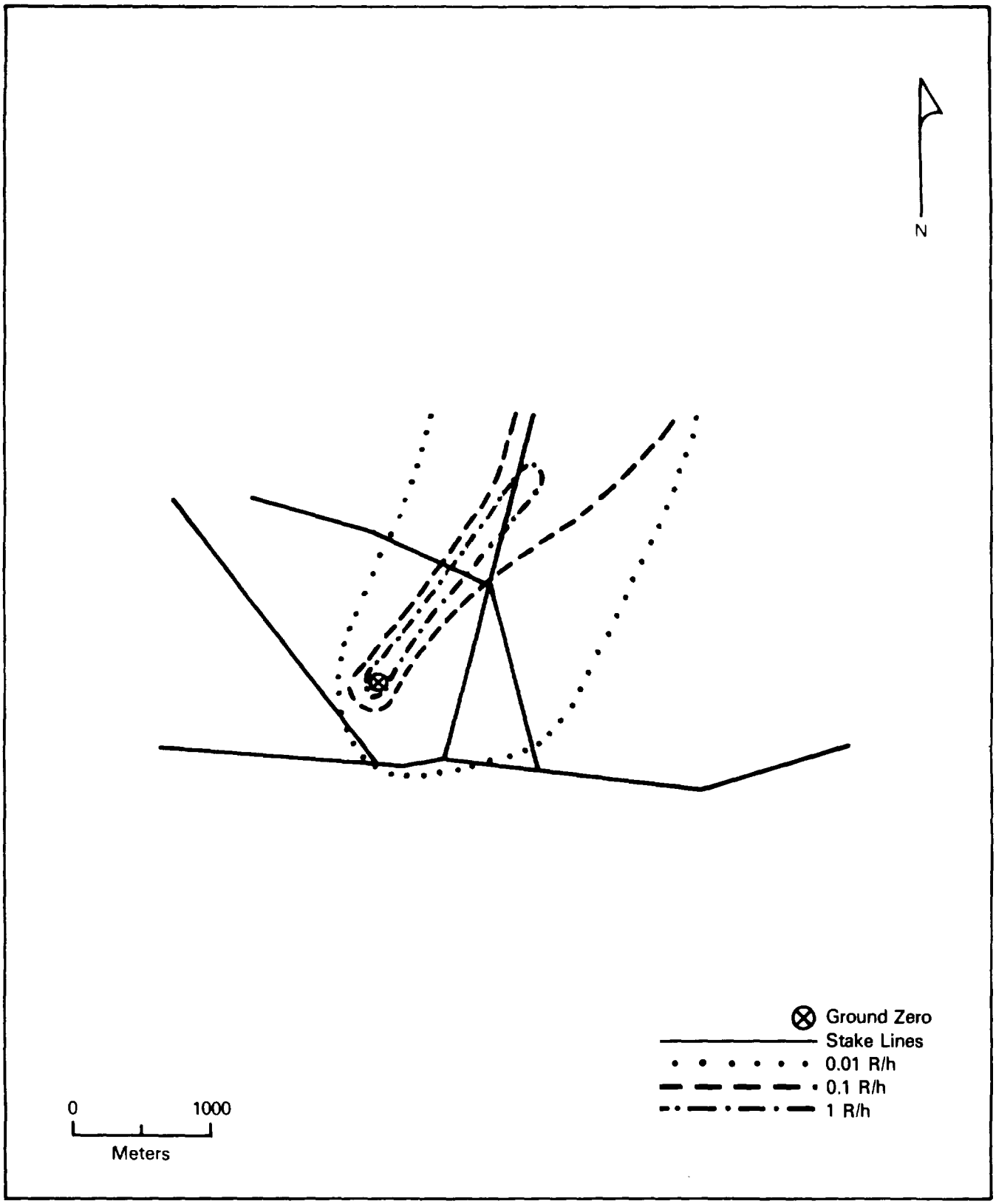

Figure 3-2: SURVEY FOR PASCAL A, 26 JULY 1957, MID-TIME 0929

3.4 SATURN

SATURN was a UCRL device detonated 28 feet below ground surface inside a tunnel in Area 12, UTM coordinates 711165, at 1800 hours on 9 August 1957. DOD participation was limited to Project 50.3, Evaluation of Medium Range Detonation and Cloud Tracking Systems (19; 24; 37).

3.4.1 Operations

Project 50.3, Evaluation of Medium Range Detonation and Cloud Tracking Systems, was conducted by the Army Signal Corps Laboratory, Fort Monmouth, New Jersey. The project had two purposes: to test the capabilities of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds and to examine Army fallout prediction methods. Radar units were 34 kilometers southeast of ground zero near Yucca Lake at UTM coordinates 893872. The 865th Aircraft Control and Warning Squadron operated an AN/FPS-6 radar unit at Angel's Peak, 48 kilometers from Yucca Lake. A fallout prediction unit operated from a van next to the weather station at Camp Mercury (15; 17; 24).

3.4.2 Radiological Safety

Five minutes after the detonation, three monitors surveyed the test area. These monitors, wearing film badges, anticontamination clothing, and respirators, surveyed the tunnel entrance and surrounding area for both alpha and beta-gamma radiation. They found no radiation above background levels during this survey, which was completed at 1900 hours. Because the tunnel had completely contained the detonation, no isointensity contour map was plotted. Monitors resurveyed the test area on 10 August 1957 at 0600 hours and again found no radiation intensities above background levels. No personnel or equipment were decontaminated (37).

3.5 PASCAL B

PASCAL B was a LASL device fired inside a 500-foot deep, unstemmed shaft in Area 3 at 1535 hours on 27 August 1957 (35). Because PASCAL A had been a partial nuclear detonation, it was thought that PASCAL B might also result in a nuclear reaction. Thus, a cloud-sampling mission was planned for PASCAL B involving an L-20 sampler control aircraft and two F-84 samplers. PASCAL B had a partial nuclear yield, which caused the shot to vent and contaminate the area. However, the cloud-sampling mission was not conducted, and the sampling aircraft returned to Indian Springs AFB (14; 19; 37).

Five minutes after the detonation, four monitors performed the initial survey for both alpha and beta-gamma radiation. The survey results indicated only background levels of beta-gamma radiation and a maximum of 300 counts per minute of alpha activity at one location. Monitors posted alpha radiation warning signs around the area. Because of the low levels of radioactivity encountered, no isointensity contour map was developed, and no resurveys were conducted (37).

The Personnel Dosimetry Branch of the Radiological Safety Division issued 25 film badges and 25 pocket dosimeters to participants at PASCAL B. The Logistics Branch issued anti-contamination clothing and respirators to 18 personnel (37).

3.6 COULOMB B

COULOMB B, a LASL device, was detonated three feet above the surface in Area 3 at 1350 hours on 6 September 1957. The safety test resulted in a nuclear yield of 0.3 kiloton. The top of the COULOMB B cloud rose to 18,000 feet. Fallout drifted west from ground zero and was surveyed offsite as far as the vicinity of Death Valley, California. DOD participation in this experiment consisted of AFSWC activities, discussed below (12; 19; 37).

3.6.1 Operations

One L-20 sampler control and two F-84 sampler aircraft were scheduled for participation. Because the cloud had a greater intensity and height than had been anticipated, two additional F-84 aircraft participated in cloud sampling. The L-20, with an estimated crew of two, reported to Camp Mercury, and the F-84s, each probably with one pilot, reported to Indian Springs AFB (12).

After the sampling mission had been completed, two C-47 aircraft, each with an estimated crew of four, delivered the samples to LASL for analysis. One aircraft began its flight on shot-day two hours after the detonation. The other C-47 began its mission at 1100 hours on the next day (12).

An L-20 aircraft conducted a security sweep of the test area. This aircraft, which had an estimated crew of two, reported to Camp Mercury (12).

One B-25 aircraft conducted a cloud-tracking mission. This aircraft, probably with a crew of five, flew at an altitude of 15,000 feet. Its reporting point was Indian Springs AFB (12).

3.6.2 Radiological Safety

Because COULOMB B had some nuclear yield, the Test Director alerted the General Monitoring Branch of the Radiological Safety Division to explore possible evacuation routes and to prepare for an immediate survey. Five minutes after the detonation, two monitors surveyed Mercury Highway from the Control Point north to determine the maximum intensity along that route. At the same time, two monitors were dispatched east from the BJY to the Federal Civil Defense Agency road on the east side of Yucca Flat, then south behind Area 3, and southwest back to Mercury Highway. This route was found free of radiation. Along Mercury Highway,

1.4 kilometers south of the BJY, the intensity reached 1 R/h 30 minutes after the detonation (37).

Monitors conducted the initial ground survey of the test area at a mid-time of 1344 hours and found no alpha activity above background levels outside the 1 R/h isointensity line shown in figure 3-3. Monitors resurveyed the area later that day and on 7, 8, and 9 September 1957 (37).

The Personnel Dosimetry Branch of the Radiological Safety Division issued ten film badges and 20 pocket dosimeters to COULOMB B participants. The Logistics Branch issued anti-contamination clothing and respirators to 36 personnel, who were briefed for entry into the test area (37).

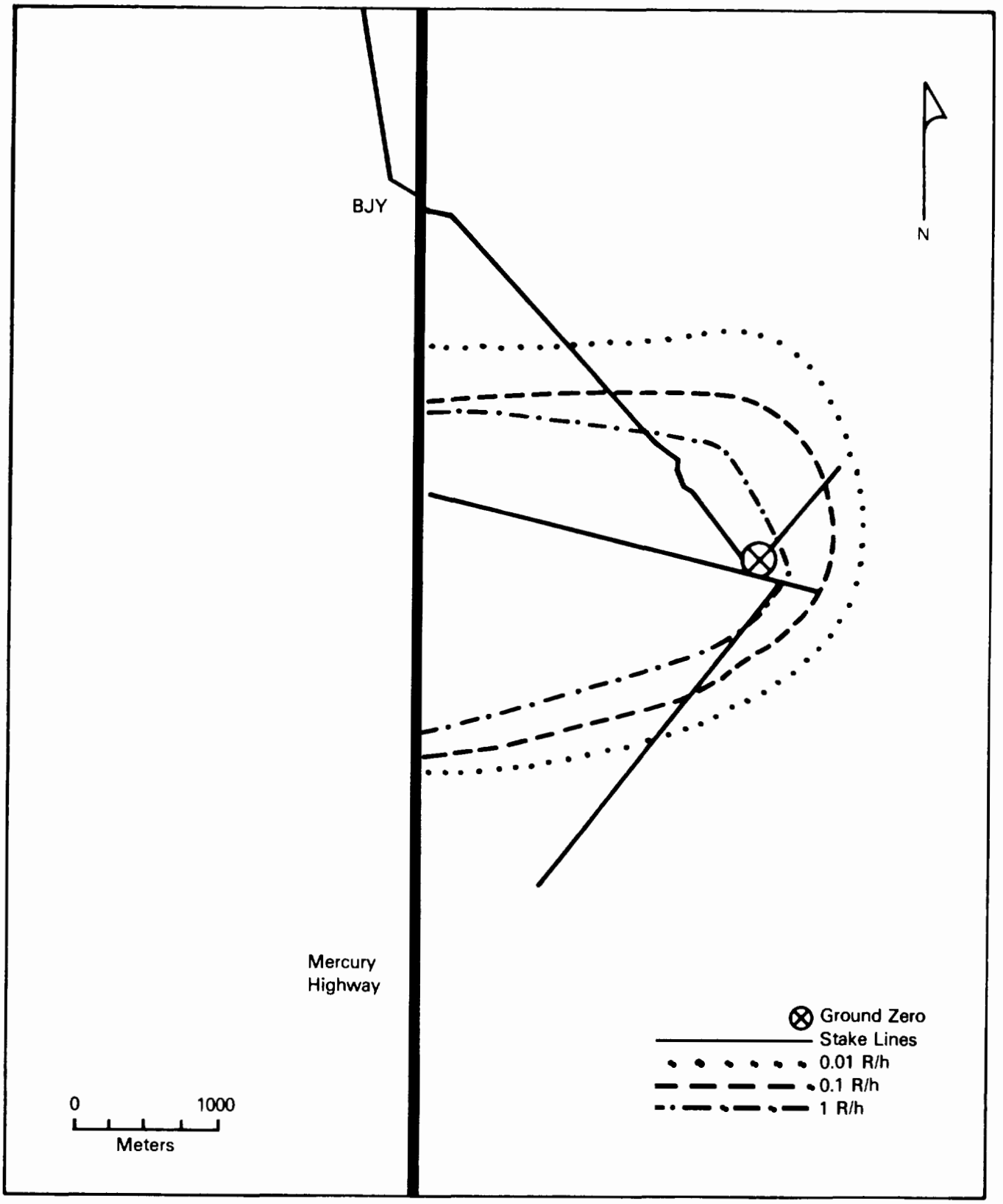

Figure 3-3: INITIAL SURVEY FOR COULOMB B, 6 SEPTEMBER 1957, MID-TIME 1344

CHAPTER 4

PROJECT 58 SAFETY EXPERIMENTS

The four safety experiments of PROJECT 58 were conducted during two separate periods. The Los Alamos Scientific Laboratory safety-tested two devices on 6 and 9 December 1957. These tests were similar to safety experiments conducted during Operation PLUMBBOB. The University of California Radiation Laboratory safety-tested two devices on 22 February and 14 March 1958. These types of devices were being tested for inclusion in operational nuclear tests. The four safety experiments were (7; 8):

- PASCAL C, a sub-surface test in an unstemmed shaft in Area 3 on 6 December 1957
- COULOMB C, a surface test in Area 3 on 9 December 1957
- VENUS, a sealed-tunnel test in Area 12 on 22 February 1958
- URANUS, a sealed-tunnel test in Area 12 on 14 March 1958.

The operational period for the two LASL tests, PASCAL C and COULOMB C, was effective from 17 November 1957 to approximately one week after COULOMB C was conducted. No Department of Defense, civil effects, or observer programs were approved for this operation. The radiological safety criteria at the NTS remained as in PLUMBBOB: a maximum of 3 roentgens of whole-body gamma radiation within any consecutive 13-week period and 5 roentgens within a year (7).

Before the operational period for these two LASL tests, REECo cleared the debris from the two locations in Area 3 where

PASCAL C and COULOMB C were to be conducted and prepared dormitories at Camp Mercury for (6; 33):

- 44 LASL personnel, scheduled to arrive on 5 December
- Five EG&G personnel, to arrive on 5 December
- 31 Sandia Corporation personnel, to arrive on 14 December.

Of these 80 persons, a few were probably DOD military and civilian scientists and technicians working at these three agencies. Other participants in these two safety experiments included (6; 10; 28; 33; 36):

- REECo employees performing engineering and construction, camp management, medical aid, safety and fire protection, supply and warehousing, communications, transportation, and radiological safety
- One LASL employee predicting and making post-test analyses of cloud height and fallout
- 15 meteorologists at Mercury and Yucca Flat and seven meteorologists at Tonopah, Beatty, and Shoshone from the U.S. Weather Bureau Las Vegas Research Station
- One CARCO pilot operating a twin-engine Bonanza for security sweeps and other aircraft support, as necessary
- AFSWC aircrews performing cloud tracking.

The operational period for the two UCRL safety experiments, VENUS and URANUS, began on 9 February 1958. No DOD, civil effects, or observer programs were scheduled for this operation. Participants included UCRL, EG&G, and Sandia Corporation scientists and technicians and REECo radiological safety monitors (8; 19; 31).

4.1 PASCAL C

PASCAL C, developed by LASL, was detonated at 1215 hours on 6 December 1957. The device had been placed 250 feet below the surface in an unstemmed shaft in Area 3 (35). LASL had scheduled the detonation for 1200 hours on 6 December. At 1030 hours, the Fallout Prediction Unit had given a favorable forecast for the firing at 1200 hours. However, because of information obtained from balloons released into the air about five kilometers south of the test position at 1115 hours, LASL decided to delay the test for 15 minutes to allow winds from the south to strengthen (28).

The surface winds were calm at the time of the test. The detonation broke the ground surface, and the resulting cloud rose to about 7,000 feet above mean sea level (about 3,000 feet above ground level) and drifted east (18; 28).

4.1.1 Operations

Participants in PASCAL C included five parties, probably from LASL, performing recovery operations on 6 and 7 December and the crew of one L-20 aircraft conducting cloud tracking. One party of two persons entered the test area on 6 December, and four parties totaling 22 persons entered the area on 7 December. They probably collected films and samples from the ground zero area for analysis (21; 30).

An initial airspace closure, within which aircraft other than those associated with the NTS were not allowed, was established in a 60-nautical-mile radius from the Control Point and up to an altitude of 10,000 feet beginning at 1130 hours. Based on the results of the cloud-tracking mission performed by an L-20 aircraft, this closure was lifted at 1235 hours except for a sector from 40 degrees to 160 degrees northeast to south-southeast (21).

4.1.2 Radiological Safety

Thirty minutes after the test, monitors left the barricade at the intersection of Mercury Highway and the Area 3 access road to conduct an initial survey of the test area and adjacent locations. Figure 4-1 shows a copy of the isointensity map developed from this survey. Monitors resurveyed the test area at 1543 hours on 6 December and again on 7 and 8 December (30).

A check station was established at the intersection of Mercury Highway and the Area 3 access road on 6, 7, and 8 December. The Personnel Dosimetry Branch issued 133 film badges and 33 pocket dosimeters to participants, and the Logistics Branch provided anticontamination clothing to 172 personnel. The Plotting and Briefing Branch issued area access permits to the recovery parties. Seventeen vehicles were decontaminated at Control Point Building 6 during this time (30).

4.2 COULOMB C

COULOMB C, developed by LASL, was detonated on the surface in Area 3 of the NTS at 1200 hours on 9 December 1957 (19). The safety test had been scheduled for 1300 hours on 8 December 1957. However, the weather forecast on the morning of 8 December indicated that winds bearing southwest would cause possible fallout in the area of the Control Point. The test was rescheduled for 0800 hours on 9 December, following a more favorable weather forecast on the night of 8 December (28). Early in the morning of 9 December, however, the weather forecast again indicated that the winds had not yet veered northwest, as predicted, and the test was postponed until 1200 hours (28). The weather forecast was favorable at 1100 hours, and COULOMB C was fired at 1200 hours on 9 December.

The test produced a nuclear yield of 0.5 kiloton. The cloud top rose to an altitude of about 13,000 feet, and the cloud

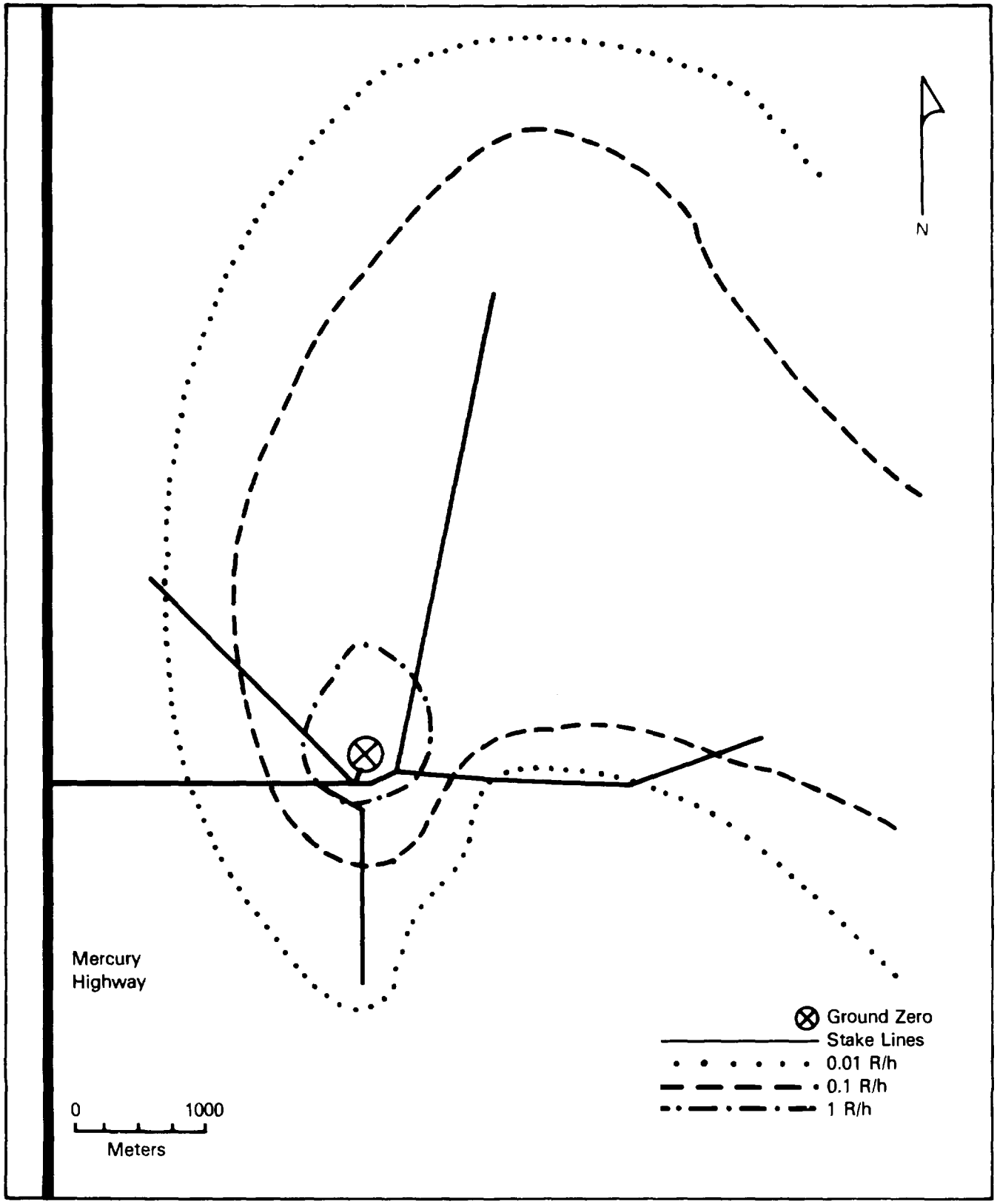

Figure 4-1: INITIAL SURVEY FOR PASCAL C, 6 DECEMBER 1957, MID-TIME 1338

headed almost directly west. According to reports from the crew in the B-25 that tracked the cloud, its leading edge was about 23 kilometers from ground zero at 1400 hours. Fallout on Jackass Flats, southwest of Yucca Flat, forced evacuation of personnel in that area (2; 20; 28).

4.2.1 Operations

Personnel participating in COULOMB C included a B-25 cloud-tracking crew and 25 parties conducting recovery operations. These parties, listed below, entered the test area on the day of the detonation and the three subsequent days (29):

Date	Number of Parties	Number of Personnel
9 December	3	9
10 December	11	34
11 December	9	33
12 December	2	25
	25	101

The participants were probably from LASL, EG&G, or Sandia Corporation and were recovering film and samples for analysis. Most likely, some of the individuals entered the area more than once during the four days.

The B-25, probably with a crew of five, tracked the cloud, noting the height, distance, and direction. The airspace within a distance of 60 nautical miles from the Control Point was closed from 1130 hours until 1245 hours, to an altitude of 22,000 feet. Half of the closure was lifted at 1245, from due north clockwise to due south. The remaining area was opened at 1400 hours (20).

4.2.2 Radiological Safety

Monitors began taking measurements along Mercury Highway at 1242 hours and encountered intensities greater than 10 R/h. The

initial survey of the test area began at about 1300 hours. Figure 4-2 presents a copy of the isointensity map generated from the initial survey. Resurveys of the test area were made on 10, 11, and 12 December. Figures 4-3 and 4-4 show the isointensity maps generated from the resurveys. A check station was established south of the intersection of Mercury Highway and the Area 3 access road. The check station was maintained through 12 December (29).

The Personnel Dosimetry Branch issued, received, and processed 219 film badges during the period of COULOMB C. The Logistics Branch provided 223 sets of anticontamination clothing and equipment. The Plotting and Briefing Branch issued access permits to 25 recovery parties on the day of the test and the subsequent three days. Seventy-two vehicles and 14 pieces of equipment were decontaminated during the four-day period (29).

The personnel evacuated from Jackass Flats were sent to Camp Mercury at 1430 hours. Their film badges indicated a maximum exposure of 0.12 roentgens. The worker who received this exposure had been in the area of highest intensity and was the last to leave the area (2; 29).

4.3 VENUS

VENUS was the first of two devices safety-tested by UCRL in early 1958. It was fired at 1700 hours on 22 February. The device was placed 100 feet below ground in Area 12 in a sealed tunnel in Rainier Mesa, the northwestern part of the Nevada Test Site (19).

UCRL personnel and one REECo monitor conducted the initial radiological survey on the day of the test. During the survey, a UCRL employee spot-monitored the access road leading to the tunnel portal. The REECo monitor followed the spot survey with a

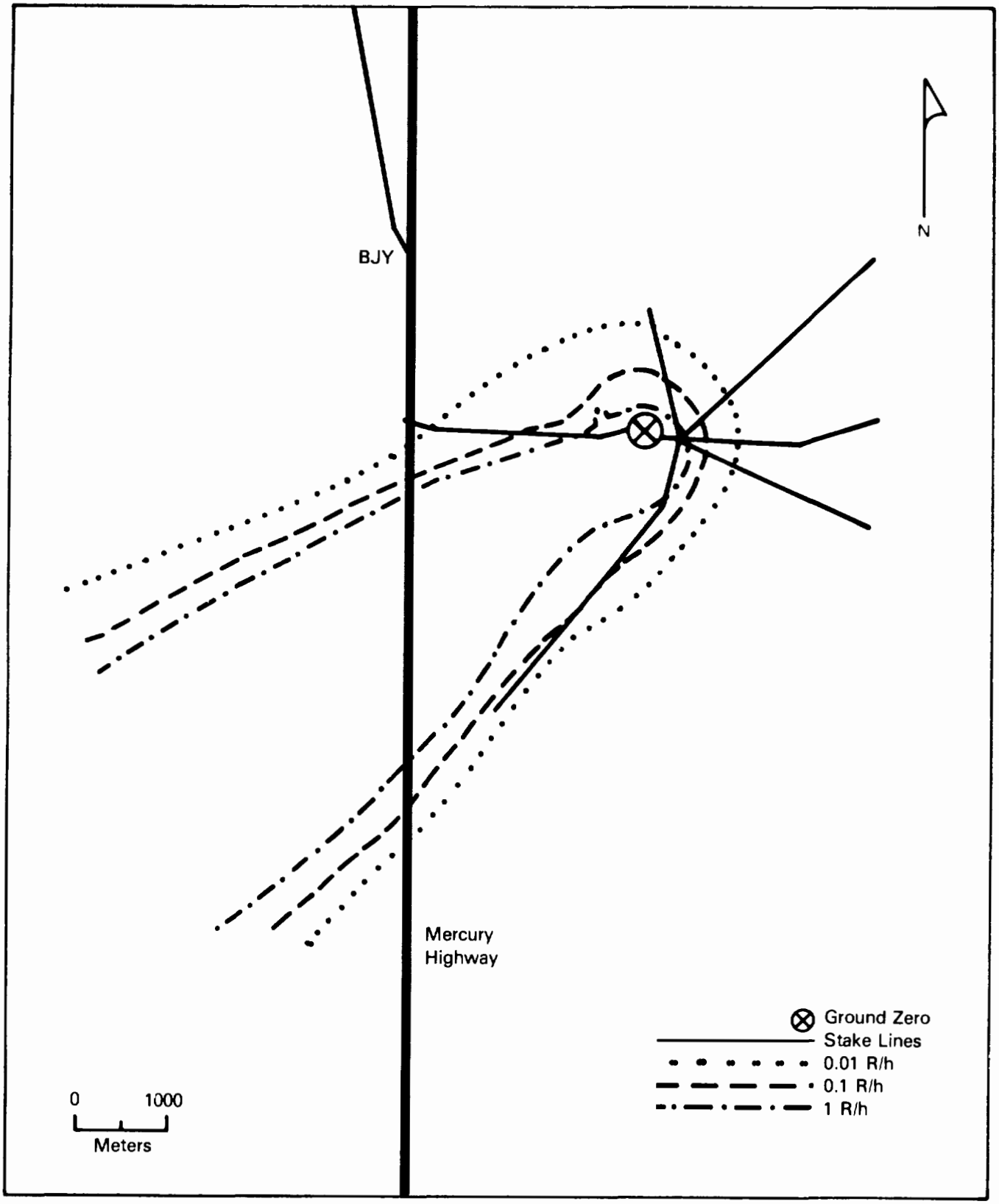

Figure 4-2: INITIAL SURVEY FOR COULOMB C, 9 DECEMBER 1957, MID-TIME 1341

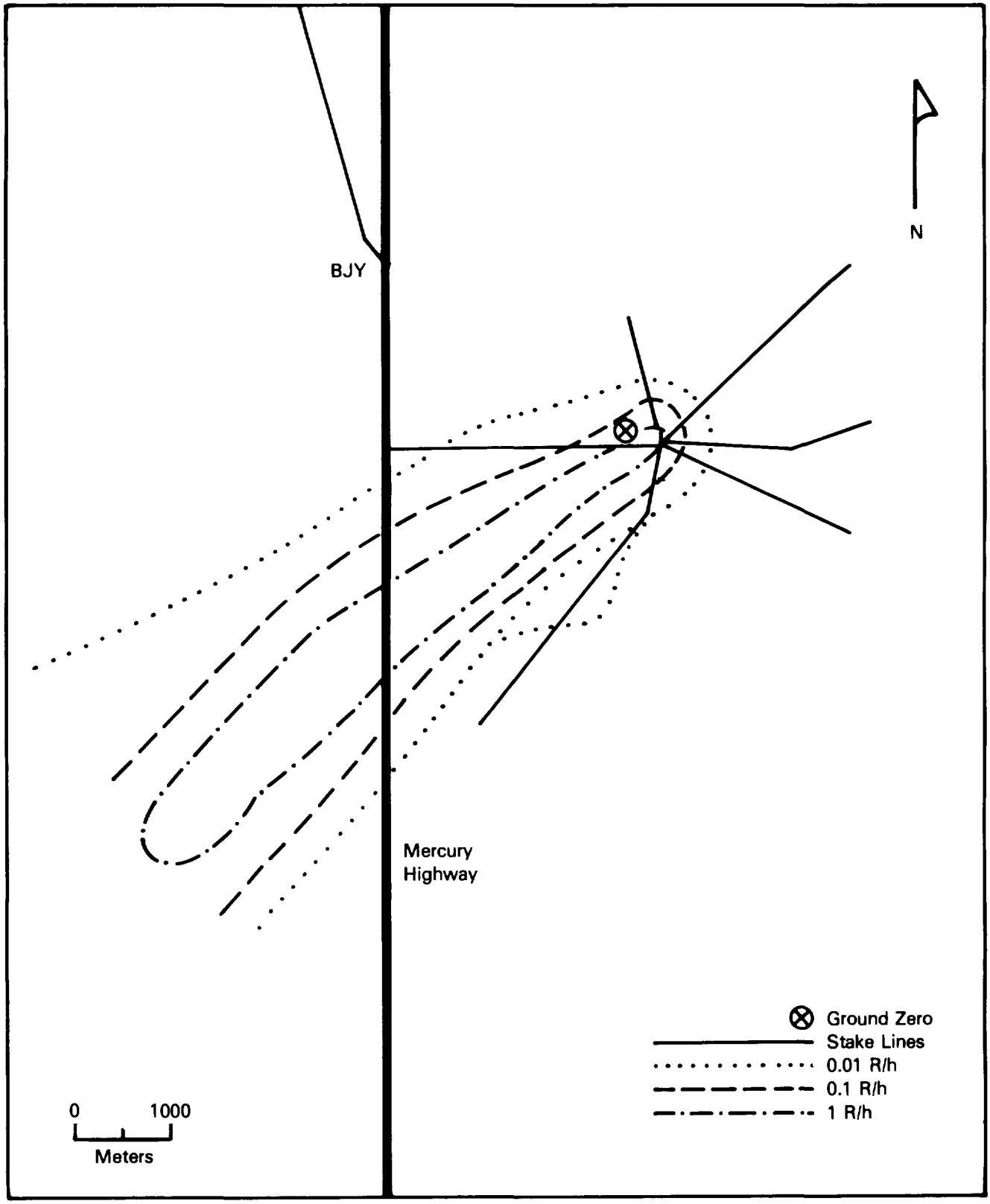

Figure 4-3: RESURVEY FOR COULOMB C, 10 DECEMBER 1957, MID-TIME 0945

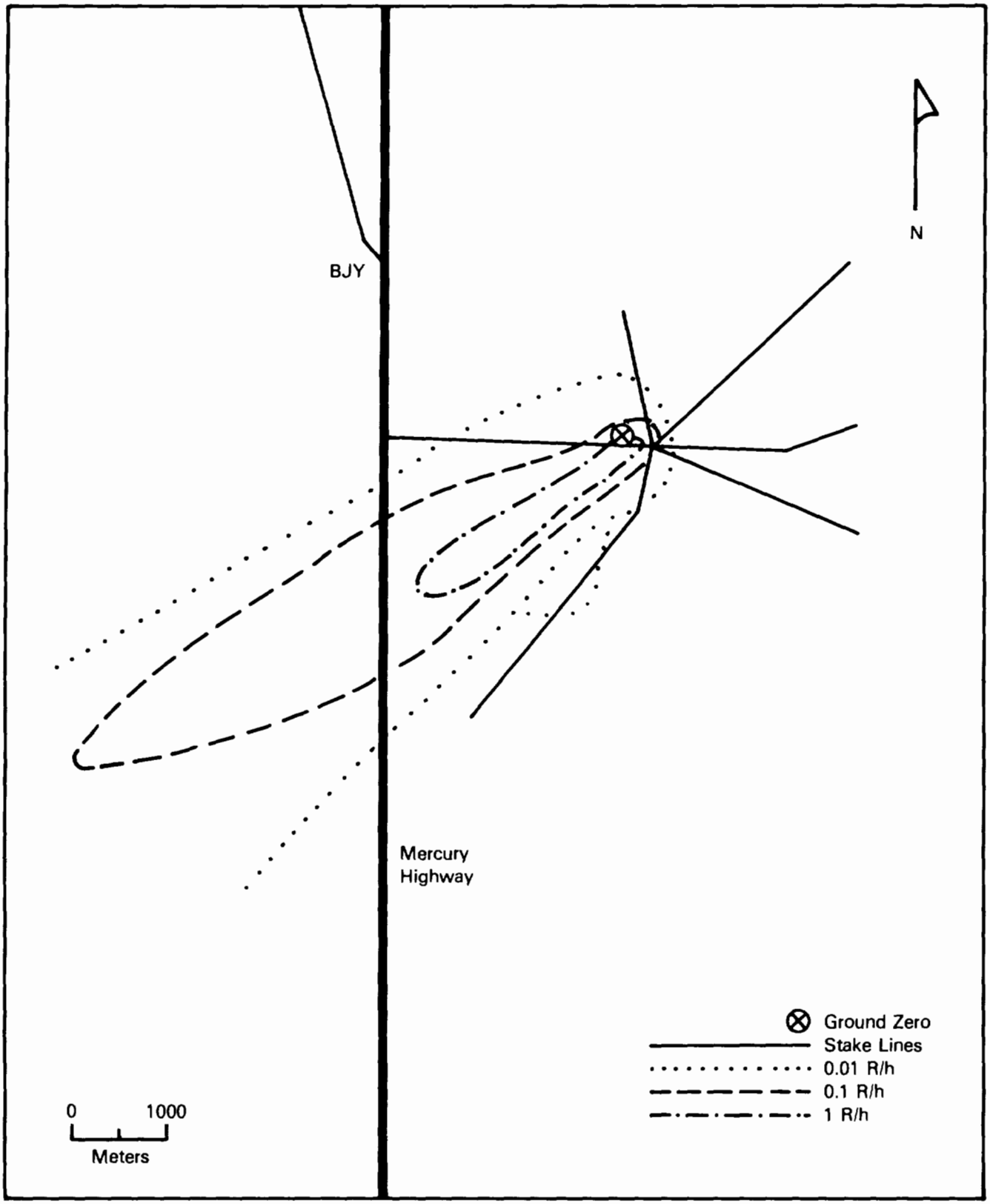

Figure 4-4: RESURVEY FOR COULOMB C, 11 DECEMBER 1957, MID-TIME 0915

more complete survey of the access road, the tunnel portal, and tunnel entrance area, finding no radiation above background levels (32).

On the following day, a recovery party of two UCRL personnel and two REECo radiological safety monitors entered the test area. The two monitors wore anticontamination clothing and respiratory equipment, but the UCRL employees did not. The lack of proper protection resulted in alpha contamination of the face and nasal passages of the UCRL personnel. Decontamination involved repeated washings and flushings. In addition, a series of body fluid samples were taken from the UCRL personnel (32).

Survey and recovery activities did not take place again until the latter half of June 1958. On 17, 23, and 24 June, nine personnel recovered electronic detector equipment from both the VENUS and URANUS tunnels. Three of the participants entered the tunnels, while the other six remained outside the entrance to assist the entrants and monitor and decontaminate them after the operation (32).

4.4 URANUS

URANUS, designed by UCRL, was detonated 114 feet below ground surface inside a sealed tunnel in Area 12 at 1400 hours on 14 March 1958. Six to nine inches of snow covered the ground, making accurate and detailed alpha readings impossible (19; 31).

Following the detonation, an initial survey party of 14 UCRL personnel and two REECo radiological safety monitors entered the test area. As they drove in, the group passed two vehicles, each occupied by one person, coming back from the test area. The survey party assumed that these two individuals were from the EG&G manned station within the test area. Of the 14 UCRL employees, only one wore anticontamination clothing and a

respirator. This participant and the two REECo monitors performed most of the initial monitoring. On the road 180 meters from the position of the test, the survey party detected 1,000 counts per minute of alpha activity per 55 square centimeters. The monitors recommended that the party turn back. Two personnel, however, continued toward the site. These persons found a rupture in the vent pipe and measured readings of 1 R/h gamma radiation and above 100,000 counts per minute alpha activity at the rupture (31).

On the following day, 15 March, two REECo monitors and five UCRL personnel, including a photographer, recovered the samples near the tunnel opening. The REECo monitors checked for radiation on the road to the sample station and at the station. They found readings between 400 and 1,000 counts per minute, with one bare spot reading 4,000 counts per minute. Two UCRL personnel removed samples, while one individual remained close by in case the two needed assistance. A fourth participant stayed at the 100 count-per-minute line to receive equipment as it was brought to that point. The photographer took pictures throughout the recovery operations. After the recovery, all personnel were monitored, and no external contamination was detected. The personnel proceeded to Control Point Building 2, where nasal swabs were taken from three participants, and film badges were exchanged. The results of the nasal swabs were negative (31).

REFERENCE LIST

The following list of references represents only those documents consulted in the safety experiments volume. When a DNA-WT is followed by an EX, the latest version has been cited.

The safety shots volume was prepared after the completion of the respective series volumes. Hence, many references in this listing do not appear in the respective series bibliographies.

AVAILABILITY INFORMATION

An availability statement has been included at the end of the reference citation for those readers who wish to read or obtain copies of source documents. Availability statements were correct at the time the bibliography was prepared. It is anticipated that many of the documents marked unavailable may become available during the declassification review process. The Coordination and Information Center (CIC) and the National Technical Information Service (NTIS) will be provided future DNA-WT documents bearing an EX after the report number.

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Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Docs Dept/D-103

Fond Du Lac Public Library
ATTN: Librn

Ft Hays State University
Ft Hays Kansas State College
ATTN: Librn

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

University of Hawaii at Monoa
ATTN: Dir of Libraries (Reg)

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

University of Idaho
ATTN: Dir of Libraries (Reg)
ATTN: Docs Sec

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

Illinois University at Urbana-Champaign
ATTN: P. Watson Docs Lib

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

Jersey City State College
ATTN: F. A. Irwin Library Periodicals
Doc Sec

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

University of Texas
ATTN: Lyndon B. Johnson School of Public
Affairs Library

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

University of Kentucky
ATTN: Gov Pub Dept
ATTN: Dir of Lib (Reg)

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

Los Angeles Public Library
ATTN: Serials Div U.S. Docs

Louisiana State University
ATTN: Gov Doc Dept
ATTN: Dir of Libraries (Reg)

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingnam

OTHER (Continued)

Manchester City Library
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Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
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Memphis & Shelby County Public Library & Information Center
ATTN: Librn

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
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University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
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Murray State University Library
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OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
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Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

University of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

University of New Mexico
ATTN: Dir of Libraries (Reg)

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Control Cultural Ed Ctr

State University of New York at Stony Brook
ATTN: Main Lib Docs Sec

State University of New York Col Memorial Lib
at Cortland
ATTN: Librn

State University of New York
ATTN: Lib Docs Sec

North Texas State University Library
ATTN: Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
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State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State
University
ATTN: Librn

University of North Carolina at Charlotte
ATTN: Atkins Lib Doc Dept

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
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University of North Dakota
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North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

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Northeast Missouri State University
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Northeastern Oklahoma State University
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Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
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Northwestern Michigan College
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Northwestern State University
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Northwestern State University Library
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Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
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University of Notre Dame
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Oakland Community College
ATTN: Librn

Oakland Public Library
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Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN: Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
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Oklahoma City University Library
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OTHER (Continued)

Oklahoma Department of Libraries
ATTN: U.S. Gov Docs

University of Oklahoma
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Old Dominion University
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Olivet College Library
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Omaha Public Library Clark Branch
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Onondaga County Public Library
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Oregon State Library
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University of Oregon
ATTN: Docs Sec

Ouachita Baptist University
ATTN: Librn

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN: Librn

Portland Public Library
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Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN: Librn

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN: Librn

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College Library
ATTN: Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
ATTN: Gov Pubs Ofc

University of Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
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OTHER (Continued)

Richland County Public Library
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Riverside Public Library
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University of Rochester Library
ATTN: Docs Sec

University of Rutgers Camden Library
ATTN: Librn

State University of Rutgers
ATTN: Librn

Rutgers University
ATTN: Dir of Libraries (Reg)

Rutgers University Law Library
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Salem College Library
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Samford University
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San Antonio Public Library
ATTN: Bus Science & Tech Dept

San Diego County Library
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San Diego Public Library
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San Diego State University Library
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San Francisco Public Library
ATTN: Gov Docs Dept

San Francisco State College
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San Jose State College Library
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San Luis Obispo City-County Library
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Savannah Public & Effingham Liberty Regional Library
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Scottsbluff Public Library
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Scranton Public Library
ATTN: Librn

Seattle Public Library
ATTN: Ref Docs Asst

OTHER (Continued)

Selby Public Library
ATTN: Librn

Shawnee Library System
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Shreve Memorial Library
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Silas Bronson Public Library
ATTN: Librn

Sioux City Public Library
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Skidmore College
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Slippery Rock State College Library
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South Carolina State Library
ATTN: Librn

University of South Carolina
ATTN: Librn

University of South Carolina
ATTN: Gov Docs

South Dakota School of Mines & Technical Library
ATTN: Librn

South Dakota State Library
ATTN: Fed Docs Dept

University of South Dakota
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South Florida University Library
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Southeast Missouri State University
ATTN: Librn

Southeastern Massachusetts University Library
ATTN: Docs Sec

University of Southern Alabama
ATTN: Librn

Southern California University Library
ATTN: Docs Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librn

Southern Illinois University
ATTN: Docs Ctr

Southern Methodist University
ATTN: Librn

University of Southern Mississippi
ATTN: Library

OTHER (Continued)

Southern Oregon College
ATTN: Library

Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN: Librn

St Louis Public Library
ATTN: Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN: Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
ATTN: Librn

State University of New York
ATTN: Librn

Stetson University
ATTN: Librn

University of Steubenville
ATTN: Librn

Stockton & San Joaquin Public Library
ATTN: Librn

Stockton State College Library
ATTN: Librn

OTHER (Continued)

Superior Public Library
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Swarthmore College Library
ATTN: Ref Dept

Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
ATTN: Librn

Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN: Librn

Tennessee Technological University
ATTN: Librn

University of Tennessee
ATTN: Dir of Libraries

College of Idaho
ATTN: Librn

Texas A & M University Library
ATTN: Librn

University of Texas at Arlington
ATTN: Library Docs

University of Texas at San Antonio
ATTN: Library

Texas Christian University
ATTN: Librn

Texas State Library
ATTN: U.S. Docs Sec

Texas Tech University Library
ATTN: Gov Docs Dept

Texas University at Austin
ATTN: Docs Coll

University of Toledo Library
ATTN: Librn

Toledo Public Library
ATTN: Social Science Dept

Torrance Civic Center Library
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Traverse City Public Library
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Trenton Free Public Library
ATTN: Librn

Trinity College Library
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Trinity University Library
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OTHER (Continued)

Tufts University Library
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University of Tulsa
ATTN: Librn

UCLA Research Library
ATTN: Pub Affairs Svc/U.S. Docs

Uniformed Services University of the Health Sciences
ATTN: LRC Library

University Libraries
ATTN: Dir of Lib

University of Maine at Oreno
ATTN: Librn

University of Northern Iowa
ATTN: Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN: Librn

University of Utah
ATTN: Special Collections

University of Utah
ATTN: Dir of Libraries
ATTN: Dept of Pharmacology

University of Richmond
ATTN: Library

Valencia Library
ATTN: Librn

Vanderbilt University Library
ATTN: Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Librn

Virginia Military Institute
ATTN: Librn

Virginia Polytechnic Institute Library
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Sec

University of Virginia
ATTN: Pub Docs

Volusia County Public Library
ATTN: Librn

OTHER (Continued)

Washington State Library
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Washington State University
ATTN: Lib Docs Sec

Washington University Libraries
ATTN: Dir of Lib

University of Washington
ATTN: Docs Div

Wayne State University Library
ATTN: Librn

Wayne State University Law Library
ATTN: Docs Dept

Weber State College Library
ATTN: Librn

Wesleyan University
ATTN: Docs Librn

West Chester State College
ATTN: Docs Dept

West Covina Library
ATTN: Librn

University of West Florida
ATTN: Librn

West Hills Community College
ATTN: Library

West Texas State University
ATTN: Library

West Virginia College of Grad Studies Library
ATTN: Librn

University of West Virginia
ATTN: Dir of Libraries (Reg)

Westerly Public Library
ATTN: Librn

Western Carolina University
ATTN: Librn

Western Illinois University Library
ATTN: Librn

Western Washington University
ATTN: Librn

Western Wyoming Community College Library
ATTN: Librn

Westmoreland City Community College
ATTN: Learning Resource Ctr

OTHER (Continued)

Whitman College
ATTN: Librn

Wichita State University Library
ATTN: Librn

William & Mary College
ATTN: Docs Dept

Emporia Kansas State College
ATTN: Gov Docs Div

William College Library
ATTN: Librn

Willimantic Public Library
ATTN: Librn

Winthrop College
ATTN: Docs Dept

University of Wisconsin at Whitewater
ATTN: Gov Docs Lib

University of Wisconsin at Milwaukee
ATTN: Lib Docs

University of Wisconsin at Oshkosh
ATTN: Librn

University of Wisconsin at Platteville
ATTN: Doc Unit Lib

University of Wisconsin at Stevens Point
ATTN: Docs Sec

University of Wisconsin
ATTN: Gov Pubs Dept

University of Wisconsin
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librn

Wright State University Library
ATTN: Gov Docs Librn

Wyoming State Library
ATTN: Librn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Librn

Yuma City County Library
ATTN: Librn

Simon Schwob Mem Lib, Columbus Col
ATTN: Librn

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