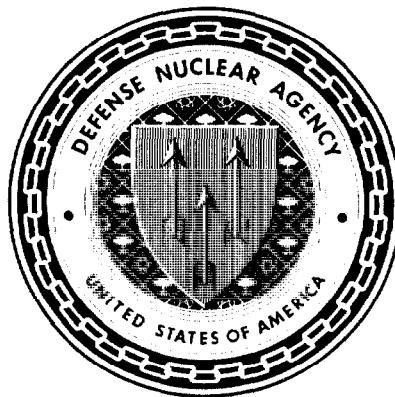


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DNA 6026F

OPERATION HARDTACK II 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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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the activities of an estimated 1,000 DOD personnel, both military and civilian, in Operation HARDTACK II, a nuclear testing series conducted in Nevada from 12 September to 30 October 1958. The series consisted of 37 events: 19 weapons tests and 18 safety experiments. DOD activities included scientific test participation, staff support, and air support. Radiological safety procedures were established and implemented to minimize individual radiation exposures.		

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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.

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Fact Sheet



Defense Nuclear Agency
Public Affairs Office
Washington, D. C. 20305

Subject: Operation HARDTACK II

Operation HARDTACK II was a series of nuclear weapons tests conducted at the Nevada Test Site (NTS) from 12 September through 30 October 1958. The operation consisted of 19 nuclear weapons tests and 18 safety experiments. The nuclear weapons tests were conducted to evaluate the yield and efficiency of newly developed nuclear devices. The safety experiments were designed to determine the stability of nuclear devices during transportation and storage. Operation HARDTACK II involved an estimated 1,000 Department of Defense (DOD) participants in scientific test activities, air support, and administrative staff support.

HARDTACK II was the continental phase of Operation HARDTACK. It followed Operation HARDTACK I, the nuclear test series conducted in the Pacific Ocean from April to August 1958. The Atomic Energy Commission (AEC), in conjunction with Field Command, Armed Forces Special Weapons Project (AFSWP), the Office of Civil and Defense Mobilization (OCDM), and other Government agencies, was involved in the planning for HARDTACK II. In August 1958, the President of the United States approved the AEC request to conduct the operation. HARDTACK II was the last series before the United States adopted a nuclear test moratorium, which had been originally intended to last one year but continued until 1961. HARDTACK II was designed to:

- Test nuclear devices for possible inclusion in the defense arsenal
- Test safety characteristics of nuclear devices
- Improve containment techniques for underground detonations.

Department of Defense Involvement

DOD participants were involved in three activities:

- Administrative staff support
- Test group activities
- Air and ground support, including radiological safety monitoring.

1

DOD personnel assisted the AEC Test Manager in planning, coordinating, and executing the programs and activities associated with HARDTACK II. They oversaw the technical and military objectives of the series for the DOD.

The following five test groups conducted scientific experiments to evaluate effects characteristics of the nuclear devices:

- DOD Effects Test Group, AFSWP
- Los Alamos Scientific Laboratory (LASL) Test Group
- University of California Radiation Laboratory (UCRL) Test Group
- Civil Effects Test Group (CETG)
- Office of Civil and Defense Mobilization (OCDM) Test Group.

The largest number of DOD participants took part in 11 projects conducted by the DOD Effects Test Group. Information gained from the projects was used in developing delivery systems for nuclear devices and in determining the military requirements for future nuclear device designs. At least one DOD Effects Test Group project was conducted at all the nuclear weapons tests except Shot BLANCA, the last weapons test of the series. One project was also conducted at four of the safety experiments: MARS, HIDALGO, NEPTUNE, and VESTA. Two of the nuclear weapons events, HAMILTON and HUMBOLDT, were effects tests cosponsored by the DOD and UCRL, an AEC weapons development laboratory. All 11 DOD Effects Test Group projects were performed at HAMILTON, and five were conducted at HUMBOLDT. For the DOD projects conducted only at these two shots, personnel placed thermal and radiation measuring instruments and soil samples in foxholes, in armored personnel carriers, and along cables between five and 730 meters from ground zero to determine the radiation and thermal effects produced by low-yield nuclear detonations. Participants also placed pigs and mice in the foxholes and armored personnel carriers to obtain data on biological effects of blast, heat, light, and radiation from nuclear detonations. Many of the experiments had to be retrieved soon after the detonations, while others could be collected later, when radiation intensities had decreased.

The DOD Effects Test Group projects involved personnel from the following service laboratories and agencies:

- Ballistic Research Laboratories
- Chemical Warfare Laboratories
- Chemical Corps Training Command

- Army Chemical Center
- Army Artillery Board
- Engineer Research and Development Laboratories
- Signal Research and Development Laboratories
- Walter Reed Army Institute of Research
- Headquarters, Continental Army Command
- Air Force Special Weapons Center
- Air Force Cambridge Research Laboratories.

The LASL and UCRL Test Groups conducted experiments to obtain information on diagnostic and effects characteristics of the devices developed and sponsored by each laboratory. LASL sponsored nine nuclear weapons events and nine safety experiments. UCRL sponsored ten nuclear weapons events, including two sponsored with DOD, and nine safety experiments. DOD involvement in LASL and UCRL Test Group projects included cloud-sampling missions conducted by Air Force Special Weapons Center (AFSWC) personnel. One AFSWC unit, the 4926th Test Squadron, flew aircraft through the clouds at 16 of the nuclear weapons events and 12 of the safety experiments to collect particulate samples of the clouds. The samples aided the laboratories in determining the yield and efficiency of each nuclear device.

The CETG and OCDM Test Group conducted projects to determine potential effects of blast, heat, radiation, and fallout on civilian populations and structures. Although some DOD personnel were assigned to the agencies and laboratories conducting the projects, there was no documented DOD participation at these projects.

DOD personnel participated in air support activities for the Test Manager and the test groups at HARDTACK II. AFSWC, located at Kirtland Air Force Base (AFB), New Mexico, provided air support to the Test Manager. AFSWC conducted cloud-sampling missions for the UCRL and LASL Test Groups and cloud-tracking missions, sample courier missions, aerial terrain surveys, and other air support, as requested by the Test Manager.

The 4950th Test Group (Nuclear) was the principal AFSWC unit involved in HARDTACK II. The 4950th consisted of four squadrons, three of which participated in the operation. The 4926th Test Squadron (Sampling) and the 4952nd Support Squadron (Test) were located at Kirtland AFB. The 4935th Air Base Squadron was the permanent unit at Indian Springs AFB, 30 kilometers east of Camp Mercury, and was central to the mission of that base. Other Air Force units involved in Operation HARDTACK II included the 4900th Air Base Group from Kirtland AFB, elements of the 20th Helicopter Squadron of the Tactical Air Command (TAC), and the 865th Air

Control and Warning Squadron of the Air Defense Command. Peak strength of these air support units during Operation HARDTACK II was 412 personnel.

Summaries of HARDTACK II Nuclear Weapons Events

The 19 HARDTACK II nuclear weapons events were conducted in Areas 3, 5, 7, 9, and 12 of the NTS. There were ten balloon, four underground, and five tower detonations. The accompanying table presents information on the nuclear weapons events, and the accompanying figure indicates their locations. Eleven of the 19 tests had yields under one kiloton. Some of these, including HAMILTON, HUMBOLDT, and EVANS, resulted in yields lower than expected. Shot BLANCA produced the largest yield.

BLANCA was detonated on 30 October 1958 in a tunnel 987 feet underground, with a 22-kiloton yield. Some radiation vented into the atmosphere producing a cloud that reached 7,700 feet above the ground and drifted southwest. DOD participation was limited to cloud-sampling, cloud-tracking, photography, and observer missions conducted by AFSWC.

Shots HAMILTON and HUMBOLDT were the two DOD effects tests and had the largest number of DOD participants. Shot HAMILTON was detonated on 15 October 1958 on a 50-foot wooden tower. The device produced a lower-than-expected yield of 0.0012 kiloton. Before the detonation, personnel set up instrumentation for 11 DOD Effects Test Group projects. Many of the projects required that instruments be placed as close as 4.5 meters to the shot tower. One project was conducted 160 kilometers from the NTS. For six of the projects, the same personnel both placed and retrieved the instruments. This reduced the number of personnel required to enter the shot area after the detonation. In addition to the DOD Effects Test Group projects, AFSWC conducted cloud-sampling, cloud-tracking, sample courier, and terrain survey missions. Nine aircraft with 26 AFSWC aircrew personnel conducted these missions.

Shot HUMBOLDT, the second DOD effects test, was conducted on 29 October 1958 at 0645. The device, detonated on a 25-foot wooden tower, had a yield of 0.0078 kiloton. Personnel placed instruments between nine meters and two kilometers from ground zero for all five DOD Effects Test Group projects. For three of the projects, personnel worked together to place and retrieve experiments, as they did at Shot HAMILTON. Cloud-sampling, cloud-tracking, and sample courier missions were conducted after the detonation. One aircraft participated in each of the missions. The missions engaged ten AFSWC aircrew personnel.

Summaries of HARDTACK II Safety Experiments

The 18 remaining detonations in HARDTACK II were safety experiments conducted to determine the stability of newly

developed nuclear weapons during transportation and storage. Elements of the conventional high explosive portions of these devices were fired to simulate accidental damage and to determine the potential for such partial firings to result in nuclear yield. Data gained from the tests were used to develop devices that could withstand shock, blast, fire, and other accidents and produce nuclear yields of less than four pounds.

The HARDTACK II safety experiments were conducted in Areas 3, 7, 8, 9, and 12 of the NTS. The shots consisted of six shaft, three tunnel, one balloon, five tower, and three surface detonations. The safety experiments ranged in yield from Shot NEPTUNE, which had a yield of 0.115 kiloton, to Shots SAN JUAN, OBERON, and GANYMEDE, which had no measurable yield. The accompanying table presents data on the safety experiments, and the accompanying figure shows their locations. DOD participation in the safety experiments was limited to one DOD Effects Test Group project conducted at four safety experiments, cloud sampling conducted at 12 events, cloud tracking at 11 events, sample courier missions after seven safety experiments, and one aerial photography mission and one observer mission during the final safety test, TITANIA.

Radiation Safety Standards and Procedures

The Nevada Test Site Organization (NTSO) and AFSWC developed radiological safety procedures to minimize exposure of individuals to ionizing radiation while they accomplished their missions at HARDTACK II. The AEC recommended a gamma plus neutron exposure limit of 3 rem (roentgen equivalent man) per calendar quarter or a total exposure of 5 rem per year for DOD participants at the operation. This was the accepted occupational limit for gamma exposure recommended by the National Committee on Radiation Protection and Measurements. AFSWC personnel who conducted cloud-sampling missions at HARDTACK II were permitted to receive up to 10 rem during the series, and those individuals who participated in cloud sampling at both HARDTACK I and HARDTACK II were permitted to receive 15 rem during the series.

The radiological safety procedures at HARDTACK II were essentially the same as those used for Operation PLUMBBOB, the series of tests conducted at the NTS in 1957. Personnel from the Radiological Safety Division of the Reynolds Electrical and Engineering Company (REECo) conducted all onsite radiological safety activities and functions, including:

- Personnel dosimetry--issuing, exchanging, and developing film badges for participants and determining gamma radiation exposures recorded on film badges
- Clothing and equipment--providing anticontamination clothing and respiratory equipment

- Monitoring--providing radiological survey equipment, performing radiological surveys, and controlling access to all radiation areas
- Decontamination--detecting and removing contamination on personnel, vehicles, and equipment.

Personnel from the 4950th Test Group provided radiological safety for AFSWC participants at Indian Springs AFB and Kirtland AFB. These responsibilities included monitoring and decontaminating personnel and aircraft.

Radiation Exposures at HARDTACK II

HARDTACK II participants wore film badges as a requirement for access to the NTS, and dosimetry records were maintained for participants. Dosimetry data are available for 210 Air Force, 69 Army, and 12 Navy personnel. In addition, 962 DOD scientific personnel, contractors, and observers have been identified. Dosimetry data are presented in the final table of this Fact Sheet, "Summary of Dosimetry for Operation HARDTACK II as of December 1982."

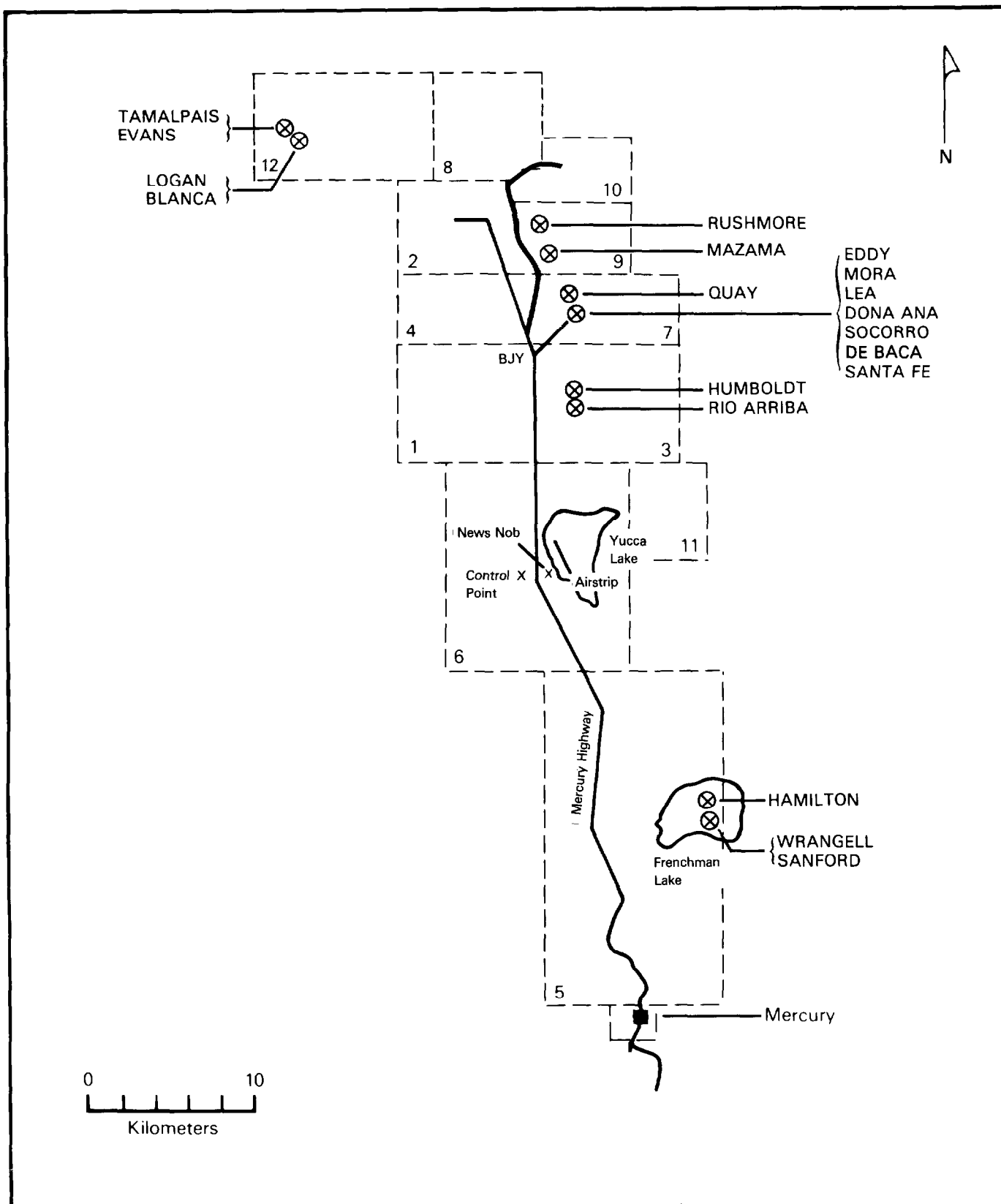
Sixteen participants had exposures greater than 3 rem. However, only nine of these 16 participants were subject to the 3 rem limit on gamma exposures which applied to most of the HARDTACK II participants. The other seven personnel who had exposures exceeding 3 rem were authorized to receive 15 rem per calendar year; none of these seven exceeded the 15 rem limit.

SUMMARY OF OPERATION HARDTACK II NUCLEAR WEAPONS TESTS, 1958

SHOT	EDDY	MORA	TAMALPAIS	QUAY	LEA	HAMILTON	LOGAN	DONA ANA	RIO ARRIBA	SOCORRO	WRANGELL	RUSHMORE	SANFORD	DE BACA	EVANS	MAZAMA	HUMBOLDT	SANTA FE	BLANCA
Sponsor	LASL	LASL	UCRL	LASL	LASL	DOD/ UCRL	UCRL	LASL	LASL	LASL	UCRL	UCRL	UCRL	LASL	UCRL	UCRL	DOD/ UCRL	LASL	UCRL
Planned Date	19 Sept	28 Sept	8 Oct	10 Oct	13 Oct	15 Oct	15 Oct	16 Oct	18 Oct	21 Oct	20 Oct	19 Oct	23 Oct	26 Oct	24 Oct	27 Oct	29 Oct	29 Oct	29 Oct
Actual Date	19 Sept	29 Sept	8 Oct	10 Oct	13 Oct	15 Oct	15 Oct	16 Oct	18 Oct	22 Oct	22 Oct	22 Oct	26 Oct	26 Oct	29 Oct	29 Oct	29 Oct	30 Oct	30 Oct
Local Time*	0700	0605	1400	0630	0520	0800	2200	0620	0625	0530	0850	1540	0220	0800	1600	0320	0645	1900	0700
NTS Location	Area 7	Area 7	Area 12	Area 7	Area 7	Area 5	Area 12	Area 7	Area 3	Area 7	Area 5	Area 9	Area 5	Area 7	Area 12	Area 9	Area 3	Area 7	Area 12
UTM Coordinates	867047	867047	709167	867057	867047	952732	709154	867047	867996	867047	956728	852100	856728	867047	706167	857091	867004	867047	704157
Type	Balloon	Balloon	Tunnel	Tower	Balloon	Tower	Tunnel	Balloon	Tower	Balloon	Balloon	Balloon	Balloon	Balloon	Tunnel	Tower	Tower	Balloon	Tunnel
Height of Burst (feet)	500	1,500	- 407	100	1,500	50	- 932	450	72.5	1,450	1,500	500	1,500	1,500	- 852	50	25	1,500	- 987
Yield (kilotons)	0.083	2	0.072	0.079	1.4	0.0012	5	0.037	0.090	6	0.115	0.188	4.9	2.2	0.055	NMY†	0.0078	1.3	22

* Pacific Daylight Time for Shot EDDY; Pacific Standard Time for all other shots.

† No measurable yield



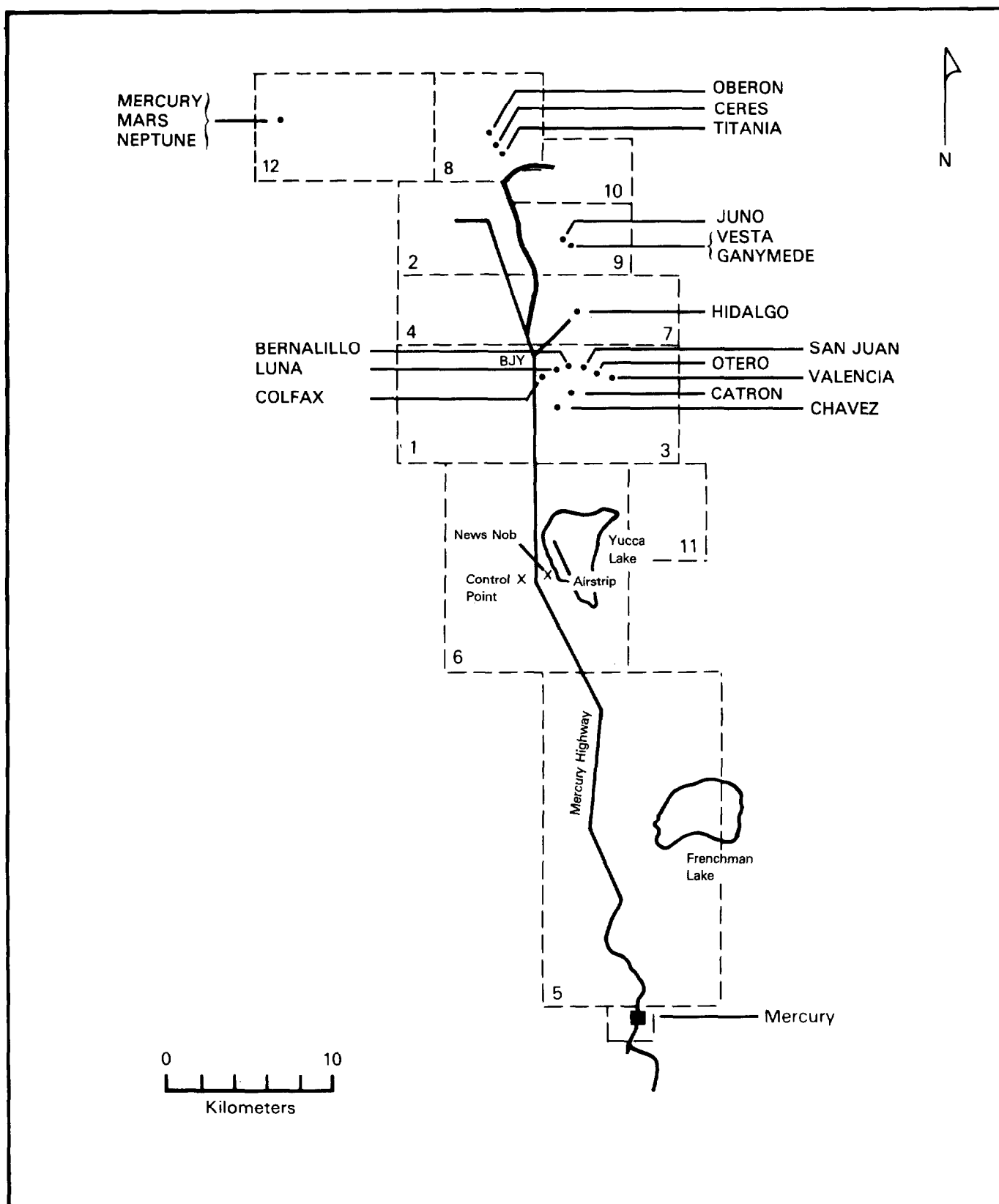
**LOCATIONS OF HARDTACK II NUCLEAR WEAPONS EVENTS
WITHIN THE NEVADA TEST SITE**

SUMMARY OF OPERATION HARDTACK II SAFETY EXPERIMENTS, 1958

SHOT	OTERO	BERNALILLO	LUNA	MERCURY	VALENCIA	MARS	HIDALGO	COLFAX	NEPTUNE	VESTA	SAN JUAN	OBERON	CATRON	JUNO	CERES	CHAVEZ	GANYMEDE	TITANIA
Sponsor	LASL	LASL	LASL	UCRL	LASL	UCRL	LASL	LASL	UCRL	UCRL	LASL	UCRL	LASL	UCRL	UCRL	LASL	UCRL	UCRL
Planned Date	11 Sept	17 Sept	21 Sept	23 Sept	26 Sept	27 Sept	3 Oct	5 Oct	14 Oct	17 Oct	20 Oct	22 Oct	24 Oct	23 Oct	25 Oct	27 Oct	29 Oct	30 Oct
Actual Date	12 Sept	17 Sept	21 Sept	23 Sept	26 Sept	28 Sept	5 Oct	5 Oct	14 Oct	17 Oct	20 Oct	22 Oct	24 Oct	24 Oct	26 Oct	27 Oct	30 Oct	30 Oct
Local Time*	1300	1230	1200	1500	1300	1700	0610	0815	1000	1500	0630	1230	0700	0801	2000	0630	0300	1234
NTS Location	Area 3	Area 3	Area 3	Area 12	Area 3	Area 12	Area 7	Area 3	Area 12	Area 9	Area 3	Area 8	Area 3	Area 9	Area 8	Area 3	Area 9	Area 8
UTM Coordinates	861007	859006	859005	709164	859006	709163	868048	859005	710164	857087	861008	826154	866999	855088	826152	862001	846090	826148
Type	Shaft	Shaft	Shaft	Tunnel	Shaft	Tunnel	Balloon	Shaft	Tunnel	Surface	Shaft	Tower	Tower	Surface	Tower	Tower	Surface	Tower
Height of Burst (feet)	- 480	- 456	- 484	- 183	- 484	- 140	377	- 350	- 110	0	- 234	25	72.5	0	25	52.5	0	25
Yield (kilotons)	0.038	0.015	0.0015	Slight	0.002	0.013	0.077	0.0055	0.115	0.024	NMY [†]	NMY	0.021	0.0017	0.0007	0.0006	NMY	0.0002

* Pacific Daylight Time for Shots OTERO through MARS; Pacific Standard Time for the remaining shots.

† No measurable yield



**LOCATIONS OF HARDTACK II SAFETY EXPERIMENTS
WITHIN THE NEVADA TEST SITE**

SUMMARY OF DOSIMETRY FOR OPERATION HARDTACK II AS OF DECEMBER 1982

Service	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Gamma Exposure (rem)					Number of Personnel with Zero Gamma Exposure*	Average Gamma Exposure (rem)	Maximum Gamma Exposure (rem)
			<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0 +			
Army	78	70	38	28	1	2	1	23	0.763	10.9
Navy	14	12	9	2	1	0	0	6	0.181	1.6
Air Force	319	210	107	69	27	5	2	86	0.509	7.7
Scientific Personnel, Contractors, and Observers	962	962	776	159	21	2	4	216	0.139	10.0
Total	1,373	1,254	930	258	50	9	7	331	0.281	

* The number of individuals in this column is also represented in the <0.1 Gamma Exposure column.

PREFACE

From 1945 to 1962, the United States Government, through the Manhattan Engineer District and its successor agency, the Atomic Energy Commission (AEC), conducted 235 atmospheric nuclear weapons tests at sites 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 were at 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 Centers 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 Centers 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 Centers 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 and other nuclear tests

*The Centers for Disease Control are 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 and other nuclear tests.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report on Operation HARDTACK II is based on the scientific and technical documents associated with the atmospheric nuclear weapons tests conducted at the NTS in 1958. Many of the documents pertaining specifically to DOD involvement in the operation were found in the Defense Nuclear Agency Technical Library, the Office of Air Force History, the Archives of the Department of Energy Nevada Operations Office, and the Los Alamos Scientific Laboratory Records 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, these documents sometimes have inconsistencies in vital facts, such as the number of DOD participants in a certain project at a given shot or their locations and assignments at a given time. These inconsistencies usually occur between two or more documents but occasionally appear within the same document. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader.

In addition to these inconsistencies in information, the documents describing test organization projects do not always present project titles and agencies consistently. To make this information as uniform as possible, this volume uses weapons test report titles for each project. Information concerning the planned and actual dates and yields of test detonations may also vary among documents. All such information presented in this report is taken from the Department of Energy, Announced United

States Nuclear Tests, July 1945 through December 1981 (NVO-209, Rev. 2). Other data on the tests, such as meteorological conditions and nuclear cloud dimensions, 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.

For several of the test organization projects discussed in this volume, the only available documents are the Schedule of Events from the Deputy Test Manager's "Operation Order 1-58." This source details the plans developed by DOD and AEC personnel prior to Operation HARDTACK II; it does not describe the projects as conducted at the NTS. It is not known if all the projects addressed in the planning documents and discussed in this volume were conducted exactly as planned. Although some of the after-action documents summarize the projects performed during Operation HARDTACK II, they do not always supply shot-specific information. In the absence of shot-specific after-action reports, projects are described according to the way they were planned. The references indicate whether the description of activities is based on the schedule of events, operation orders, or after-action reports.

ORGANIZATION OF THIS VOLUME

This volume proceeds from the general to the specific. Chapters 1 and 2 include introductory material on Operation HARDTACK II and on the AEC's Nevada Test Site Organization (NTSO). The next two chapters address radiological protection, with chapter 3 summarizing radiological safety criteria and procedures and chapter 4 presenting data on the results of the radiological protection program. Chapter 5 gives separate discussions of each of the 19 nuclear weapons events, as does chapter 6 for each of the 18 safety experiments.

The information in this report is supplemented by the Reference Manual: Background Materials for the CONUS Volumes. This volume summarizes information on radiation physics, radiation health concepts, exposure criteria, and measurement techniques. It also has a list of 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
CETG	Civil Effects Test Group
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Inc.
LASL	Los Alamos Scientific Laboratory
NTS	Nevada Test Site
NTSO	Nevada Test Site Organization
OCDM	Office of Civil and Defense Mobilization
PDT	Pacific Daylight Time
PST	Pacific Standard Time
REEC _o	Reynolds Electrical and Engineering Company
rem	roentgen equivalent man
R/h	Roentgen per hour
TAC	Tactical Air Command
UCRL	University of California Radiation Laboratory
USPHS	United States Public Health Service
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Operation HARDTACK II, a series of nuclear tests conducted in Nevada, consisted of 37 events: 19 nuclear weapons detonations and 18 safety experiments. The series, conducted from 12 September through 30 October 1958, involved about 2,500 Department of Defense personnel participating in scientific test activities, air support, and staff support to the Nevada Test Site Organization. The operation was intended to develop and test nuclear weapons for possible inclusion in the defense arsenal.

This volume summarizes information on organizations, procedures, and activities involving DOD personnel in Operation HARDTACK II. In addition, it discusses DOD participation in each of the 37 shots. The information helps demonstrate the relationships among specific shots, as well as the relationship of the series to previous and subsequent testing operations in the Pacific and Atlantic Oceans and at the Nevada Test Site. This chapter introduces Operation HARDTACK II with a description of the:

- Historical background and establishment of the series
- Nevada Test Site
- 19 nuclear weapons events and 18 safety experiments
- DOD participation at this test series.

This background information provides a basis for understanding the nature and extent of DOD participation in specific shots, discussed in chapters 5 and 6.

1.1 HISTORICAL BACKGROUND AND THE ESTABLISHMENT OF OPERATION HARDTACK II

The development of a nuclear weapon became a high priority for the United States at the onset of World War II. As the war effort intensified, and as reports circulated concerning German nuclear weapons research, the United States and Great Britain began collaborating in 1942 on a project to construct a nuclear weapon before the Germans did (42).^{*} The U.S. Army Corps of Engineers supervised the effort, code-named the Manhattan Project. On 16 July 1945, the Manhattan Project successfully detonated TRINITY, the first nuclear device ever tested. One month later, the U.S. detonated a nuclear bomb over Hiroshima and then another over Nagasaki, thereby bringing an end to World War II.

In 1945, the U.S. had a monopoly on nuclear weapons. Although postwar American research plans included peaceful uses of the atom, a major part of American nuclear research continued to emphasize weapons development because the U.S. expected the Soviet Union to develop nuclear weapons. In the years immediately following the war, the U.S. conducted two series of nuclear weapons tests in the Pacific: Operation CROSSROADS in 1946 and Operation SANDSTONE in 1948.

During the early 1950s, the U.S. reevaluated its military defense policy. In 1949, the Soviet Union had detonated its first nuclear device, well ahead of American projections. One year later, the U.S. committed ground forces to the Korean peninsula. To reduce the necessity of a large standing army and to minimize the likelihood of a surprise Soviet attack, the U.S. developed a nuclear arsenal capable of inflicting massive destruction on critical targets in the Soviet Union. Research

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

continued on strategic nuclear weapons for arming international ballistic missiles and USAF Strategic Air command aircraft. The U.S. also explored the potential of smaller nuclear devices for tactical battlefield use (62).

The U.S. formulated a defense policy during the 1950s that rested largely on its ability to deter attack and general war by threatening nuclear retaliation upon a major aggressor. The U.S. accordingly conducted an extensive nuclear weapons development program. From 1951 to 1957, the AEC and DOD conducted 11 nuclear weapons test series. Five of the series were in the Pacific: GREENHOUSE (1951), IVY (1952), CASTLE (1954), WIGWAM (1955), and REDWING (1956). Six of the series were within the continental U.S.: RANGER (1951), BUSTER-JANGLE (1951), TUMBLER-SNAPPER (1952), UPSHOT-KNOTHOLE (1953), TEAPOT (1955), and PLUMBBOB (1957). During Operation IVY, the U.S. tested the first thermonuclear device, Shot MIKE, which had a yield of 10.4 megatons (35; 57).

Concern about nuclear proliferation existed throughout the 1950s. A movement toward limiting or banning atmospheric nuclear tests gained momentum in 1954, when fallout from Shot BRAVO of Operation CASTLE contaminated and exposed natives of the Marshall Islands and the crew of a Japanese fishing boat. Pressure on the nuclear powers to reach an agreement on limiting testing resulted in the U.S. Government's proposal for an international conference to study the problems of monitoring a test ban. At this conference, held in Geneva, the U.S. unilaterally announced a test moratorium to begin on 1 November 1958, declaring a cessation in nuclear testing if the Soviet Union also refrained (32).

Because the testing and improvement of various nuclear weapons was crucial to American defense policy, a number of tests needed to be conducted before the moratorium began (28). Between

28 April and 18 August 1958, 35 nuclear weapons tests were conducted at the Pacific Proving Ground as part of Operation HARDTACK Phase I. On 28 August 1958, after the Geneva Conferences, the President approved an accelerated series of nuclear tests code-named Operation MILLRACE to be completed at the NTS before the start of the moratorium (28).

On 29 August 1958, by AEC directive, the name of the continental test series was changed from MILLRACE to Operation HARDTACK Phase II. This accelerated series was to consist of 32 shots, including six nuclear weapons tests and eight safety experiments originally scheduled for Operation MILLRACE. As the operation progressed, six additional shots were added to the schedule, making a total of 38 devices to be tested. One of the weapons-related events, a 1,500-foot balloon shot called ADAMS, was scheduled for detonation on 31 October. The device was lowered and disarmed after midnight, however, because it had been determined that extensive overpressure damage to the nearby town of Indian Springs would have resulted from the detonation (28; 35; 49).

The objectives of Operation HARDTACK II were to:

- Test nuclear devices for possible inclusion in the defense arsenal
- Test safety characteristics of nuclear devices
- Improve containment techniques for underground detonations.

DOD participation at HARDTACK II was relatively small compared with previous nuclear weapons testing series because of the weapons development emphasis of the program and because of DOD involvement in HARDTACK I. The primary DOD participation at HARDTACK II was planned for Shots HAMILTON and HUMBOLDT. Participation by other Federal agencies with interest in the weapons test program was greatly curtailed because of the accelerated test schedule of HARDTACK II (5; 28; 49).

1.2 THE NEVADA TEST SITE

The NTS, originally established as the Nevada Proving Ground by the AEC in December 1950, is located in the southeastern part of Nevada, 100 kilometers* northwest of Las Vegas, as shown in figure 1-1.

The NTS, depicted in figures 1-2 and 1-3, is an area of high desert and mountain terrain in Nye County. On its eastern, northern, and western boundaries, the NTS adjoins the Nellis Air Force Range, of which it was originally a part. The NTS has been the location for most of the nuclear tests conducted within the continental U.S. from 1951 to the present.

The HARDTACK II nuclear weapons tests and safety experiments were conducted in three areas of the NTS: Rainier Mesa, Yucca Flat, and Frenchman Flat. Rainier Mesa, in the northwest section of the NTS, is an area of rugged mountainous terrain. Yucca Flat, in the north-central part of the NTS, is a 320-square-kilometer desert valley surrounded by mountains. Frenchman Flat, which includes a 22-square-kilometer dry-lake basin, is in the southeastern part of the NTS. Yucca Flat and Frenchman Flat are linked by Mercury Highway, which extends north and south through Yucca Pass. Yucca Pass is the site of the Control Point and News Nob, a major observation area. The Control Point, which consists of several permanent buildings, is on the west side of Yucca Pass. Power and timing cables led from the control building to each test area in Yucca Flat and Frenchman Flat. The HARDTACK II shots were detonated from Building 1 at the Control Point. The Control Point was also the location of decontamination facilities for personnel and vehicles returning from the Yucca Flat and

*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; and 1 kilometer = 0.62 mile. Altitudes and other vertical distances are given in feet.

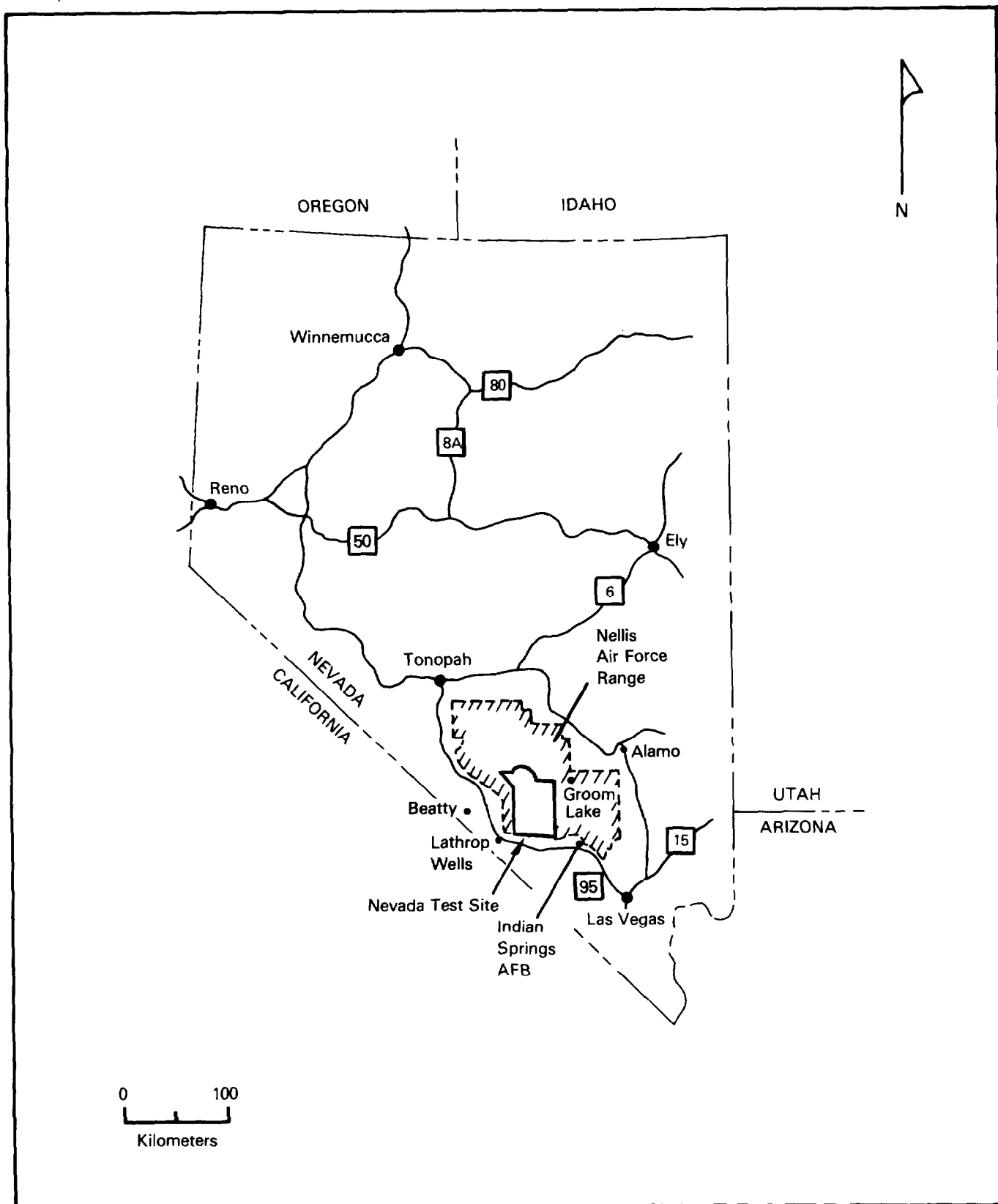
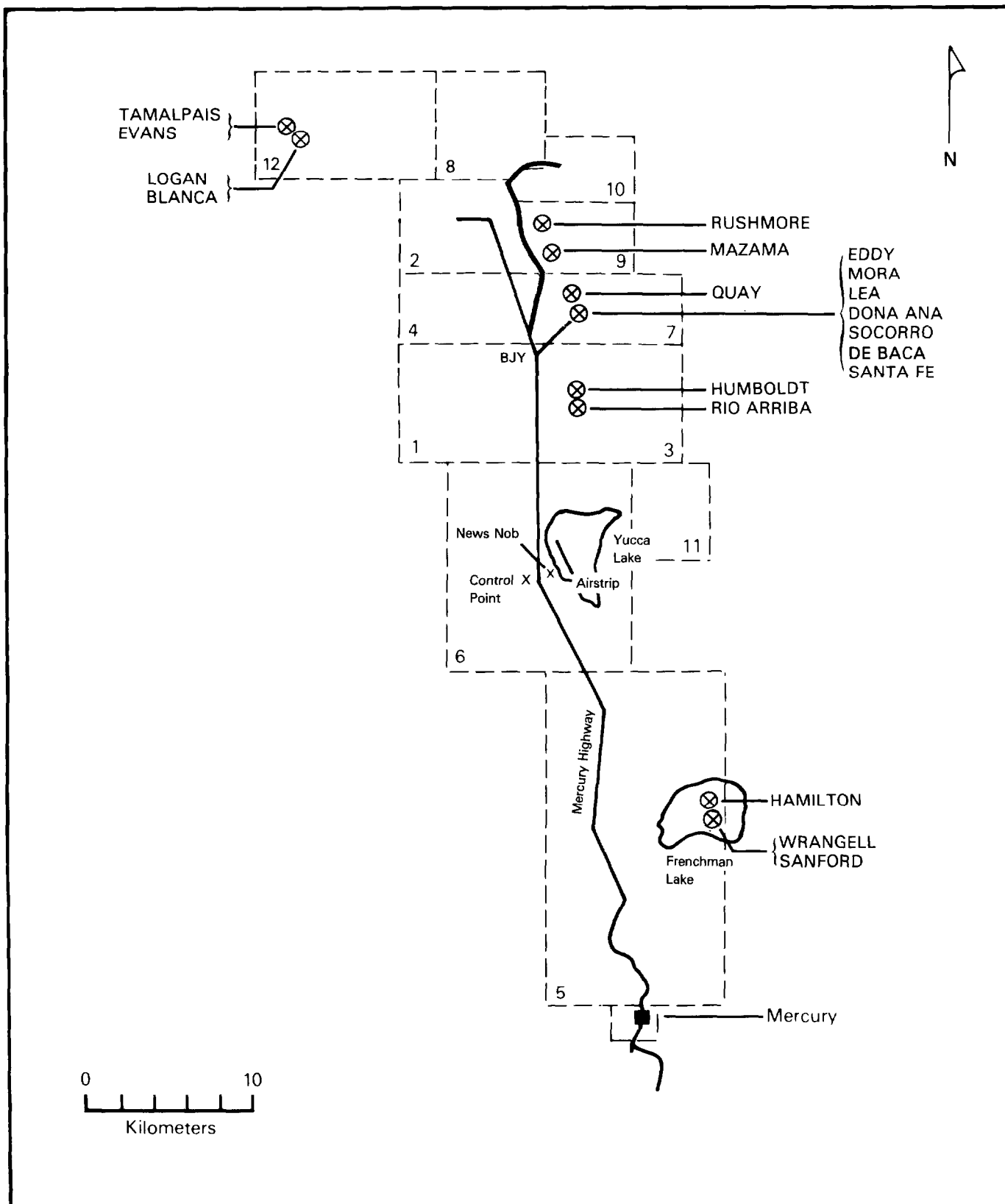


Figure 1-1: LOCATION OF NEVADA TEST SITE



**Figure 1-2: LOCATIONS OF HARDTACK II NUCLEAR WEAPONS EVENTS
WITHIN THE NEVADA TEST SITE**

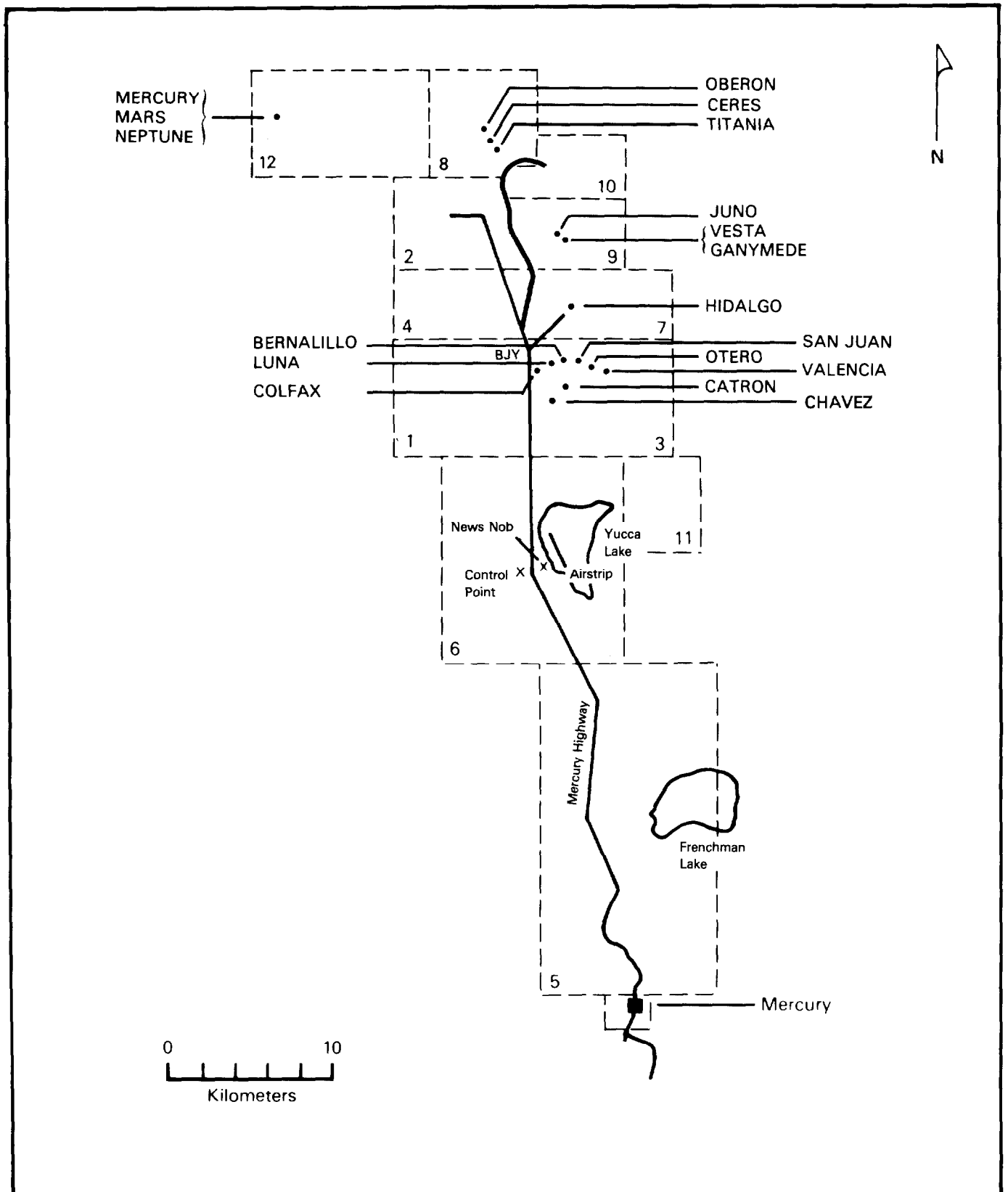


Figure 1-3: LOCATIONS OF HARDTACK II SAFETY EXPERIMENTS WITHIN THE NEVADA TEST SITE

Frenchman Flat testing areas. The Air Operations Center, which controlled all aircraft conducting test support missions over the NTS, was also located at the Control Point.

Mercury, situated on the southern boundary of the NTS, was the base of HARDTACK II management operations, the Nevada Test Site Organization. Mercury provided office and living quarters, as well as laboratory facilities and warehouses, for personnel participating in various test activities (28).

Indian Springs Air Force Base (AFB) is located 30 kilometers east of Camp Mercury. This base served as the principal staging and decontamination area for Air Force aircraft participating in HARDTACK II (39; 40).

1.3 SUMMARY OF OPERATION HARDTACK II EVENTS

During the planning for Operation HARDTACK II, the AEC directed the DOD and the two AEC nuclear weapons development laboratories, the Los Alamos Scientific Laboratory (LASL) and the University of California Radiation Laboratory (UCRL), to indicate experimental areas that could be pursued. Based on the responses, the AEC scheduled the 37 events listed in tables 1-1 and 1-2.* The first HARDTACK II detonation was a safety experiment, OTERO, conducted on 12 September. Inclement weather and technical difficulties caused some minor delays in subsequent tests. However, because of the accelerated testing timetable, as many as four detonations were held on one day, and all 37 tests were conducted within a 49-day period (5; 28).

*Universal Transverse Mercator (UTM) coordinates are used in tables 1-1 and 1-2 and elsewhere in this report. The first three digits refer to a point on an east-west axis, and the second three digits refer to a point on a north-south axis. The point so designated is the southwest corner of an area 100 meters square.

Table 1-1: SUMMARY OF OPERATION HARDTACK II NUCLEAR WEAPONS TESTS, 1958

SHOT	EDDY	MORA	TAMALPAIS	QUAY	LEA	HAMILTON	LOGAN	DONA ANA	RIO ARRIBA	SOCORRO	WRANGELL	RUSHMORE	SANFORD	DE BACA	EVANS	MAZAMA	HUMBOLDT	SANTA FE	BLANCA
Sponsor	LASL	LASL	UCRL	LASL	LASL	DOD/ UCRL	UCRL	LASL	LASL	LASL	UCRL	UCRL	UCRL	LASL	UCRL	UCRL	DOD/ UCRL	LASL	UCRL
Planned Date	19 Sept	28 Sept	8 Oct	10 Oct	13 Oct	15 Oct	15 Oct	16 Oct	18 Oct	21 Oct	20 Oct	19 Oct	23 Oct	26 Oct	24 Oct	27 Oct	29 Oct	29 Oct	29 Oct
Actual Date	19 Sept	29 Sept	8 Oct	10 Oct	13 Oct	15 Oct	15 Oct	16 Oct	18 Oct	22 Oct	22 Oct	22 Oct	26 Oct	26 Oct	29 Oct	29 Oct	29 Oct	30 Oct	30 Oct
Local Time*	0700	0605	1400	0630	0520	0800	2200	0620	0625	0530	0850	1540	0220	0800	1600	0320	0645	1900	0700
NTS Location	Area 7	Area 7	Area 12	Area 7	Area 7	Area 5	Area 12	Area 7	Area 3	Area 7	Area 5	Area 9	Area 5	Area 7	Area 12	Area 9	Area 3	Area 7	Area 12
UTM Coordinates	867047	867047	709167	867057	867047	952732	709154	867047	867996	867047	956728	852100	856728	867047	706167	857091	867004	867047	704157
Type	Balloon	Balloon	Tunnel	Tower	Balloon	Tower	Tunnel	Balloon	Tower	Balloon	Balloon	Balloon	Balloon	Balloon	Tunnel	Tower	Tower	Balloon	Tunnel
Height of Burst (feet)	500	1,500	- 407	100	1,500	50	- 932	450	72.5	1,450	1,500	500	1,500	1,500	- 852	50	25	1,500	- 987
Yield (kilotons)	0.083	2	0.072	0.079	1.4	0.0012	5	0.037	0.090	6	0.115	0.188	4.9	2.2	0.055	NMY†	0.0078	1.3	22

* Pacific Daylight Time for Shot EDDY; Pacific Standard Time for all other shots.

† No measurable yield

Table 1-2: SUMMARY OF OPERATION HARDTACK II SAFETY EXPERIMENTS, 1958

SHOT	OTERO	BERNALILLO	LUNA	MERCURY	VALENCIA	MARS	HIDALGO	COLFAX	NEPTUNE	VESTA	SAN JUAN	OBERON	CATRON	JUNO	CERES	CHAVEZ	GANYMEDE	TITANIA
Sponsor	LASL	LASL	LASL	UCRL	LASL	UCRL	LASL	LASL	UCRL	UCRL	LASL	UCRL	LASL	UCRL	UCRL	LASL	UCRL	UCRL
Planned Date	11 Sept	17 Sept	21 Sept	23 Sept	26 Sept	27 Sept	3 Oct	5 Oct	14 Oct	17 Oct	20 Oct	22 Oct	24 Oct	23 Oct	25 Oct	27 Oct	29 Oct	30 Oct
Actual Date	12 Sept	17 Sept	21 Sept	23 Sept	26 Sept	28 Sept	5 Oct	5 Oct	14 Oct	17 Oct	20 Oct	22 Oct	24 Oct	24 Oct	26 Oct	27 Oct	30 Oct	30 Oct
Local Time*	1300	1230	1200	1500	1300	1700	0610	0815	1000	1500	0630	1230	0700	0801	2000	0630	0300	1234
NTS Location	Area 3	Area 3	Area 3	Area 12	Area 3	Area 12	Area 7	Area 3	Area 12	Area 9	Area 3	Area 8	Area 3	Area 9	Area 8	Area 3	Area 9	Area 8
UTM Coordinates	861007	859006	859005	709164	859006	709163	868048	859005	710164	857087	861008	826154	866999	855088	826152	862001	846090	826148
Type	Shaft	Shaft	Shaft	Tunnel	Shaft	Tunnel	Balloon	Shaft	Tunnel	Surface	Shaft	Tower	Tower	Surface	Tower	Tower	Surface	Tower
Height of Burst (feet)	- 480	- 456	- 484	- 183	- 484	- 140	377	- 350	- 110	0	- 234	25	72.5	0	25	52.5	0	25
Yield (kilotons)	0.038	0.015	0.0015	Slight	0.002	0.013	0.077	0.0055	0.115	0.024	NMY. [†]	NMY	0.021	0.0017	0.0007	0.0006	NMY	0.0002

* Pacific Daylight Time for Shots OTERO through MARS; Pacific Standard Time for the remaining shots.

† No measurable yield

The 19 HARDTACK II nuclear weapons development tests were conducted in Area 5, which included Frenchman Flat, in Areas 3, 7, and 9 of Yucca Flat, and in Area 12, which included part of the Rainier Mesa. There were ten balloon, four underground, and five tower detonations. The detonations ranged in yield from Shot BLANCA with 22 kilotons to Shot MAZAMA with no measurable yield. Shots HAMILTON and HUMBOLDT involved the largest numbers of DOD project participants.

The 18 remaining HARDTACK II detonations were safety experiments conducted to determine the stability of newly developed nuclear weapons during transportation and storage. Elements of the high explosive portions of these devices were fired to simulate accidental damage and to determine the potential for such partial firings to result in a nuclear yield. Data gained from the tests were used to develop devices that could withstand accidents without sustaining a nuclear chain reaction and producing a nuclear detonation of four pounds yield or more. The 18 safety experiments were conducted in Areas 3, 7, 8, 9, and 12. The shots consisted of six shaft, three tunnel, one balloon, five tower, and three surface detonations. The safety experiments ranged in yield from three shots that had no measurable yield to one detonation with a yield of 0.115 kiloton (5; 28; 41).

1.4 DEPARTMENT OF DEFENSE PARTICIPATION AT OPERATION HARDTACK II

Estimates are that about 1,000 DOD personnel took part in Operation HARDTACK II. Fewer than 50 percent participated in test group activities. Of these participants, the majority were active in the DOD Effects Test Group, discussed below. The remaining DOD personnel were part of the administrative staff of the Nevada Test Site Organization, were assigned to the NTSO radiological safety organization, or were involved in Air Force Special Weapons Center (AFSWC) activities.

1.4.1 Nevada Test Site Organization Activities

The Atomic Energy Commission, through the NTSO, was responsible for planning, coordinating, and executing the activities associated with Operation HARDTACK II. DOD personnel assisted AEC personnel in these tasks. These DOD participants, whose duties are discussed in chapter 2, were responsible for overseeing the technical and military objectives of the series for the DOD.

DOD personnel took part in projects conducted by the DOD Effects Test Group, directed by Field Command, Armed Forces Special Weapons Project. The DOD used these projects to:

- Develop the delivery systems for employing nuclear weapons
- Design military equipment able to withstand the effects of a nuclear detonation
- Determine the military requirements for future nuclear weapons designs.

The DOD Effects Test Group experiments were divided into three categories:

- Basic measurements of the output characteristics of nuclear devices, such as blast, thermal, and radiation measurements
- Tests to determine blast and thermal effects on structures, equipment, and material
- Tests of instruments developed to increase the reliability of basic measurements of the characteristic outputs of a nuclear device.

Table 1-3 lists the DOD Effects Test Group programs and the projects that were part of the programs. Programs 3, 5, and 7 were not conducted at HARDTACK II but were performed in the oceanic phase, HARDTACK I.

Table 1-3: DOD EFFECTS TEST GROUP PROGRAMS INDICATING PARTICIPATION BY SHOT

Shot Program	EDDY	MORA	TAMALPAIS	QUAY	LEA	HAMILTON	LOGAN	DONA ANA	RIO ARRIBA	SOCORRO	WRANGELL	RUSHMORE	SANFORD	DE BACA	EVANS	MAZAMA	HUMBOLDT	SANTA FE	BLANCA
Program 1 Blast Measurements	1.7	1.7		1.7	1.7	1.7				1.7		1.7			1.7		1.7		
Program 2 Nuclear Radiation and Effects						2.12a 2.12b 2.12c 2.12d 2.13											2.12a 2.12b		
Program 4 Biomedical Effects						4.2 4.3											4.2		
Program 6 Tests of Service Equipment and Materials		6.14 6.15*	6.15	6.14 6.15	6.14 6.15	6.14 6.15	6.15	6.14 6.15	6.14 6.15	6.14 6.15	6.14 6.15								
Program 8 Thermal Radiation and Effects				8.8		8.8			8.8	8.8	8.8	8.8	8.8	8.8		8.8	8.8	8.8	

*This project was also conducted at the following safety experiments: MARS, HIDALGO, NEPTUNE, and VESTA.

In addition to conducting five programs at HARDTACK II, the DOD Effects Test Group coordinated the participation of a detachment from the 1352nd Motion Picture Squadron, Lookout Mountain Air Force Station. The detachment, consisting of a project officer and six cameramen, photographed various test events, including weapons assembly, several of the detonations, and Project 4.2 activities.

Four other test groups conducted projects at Operation HARDTACK II:

- Los Alamos Scientific Laboratory Test Group
- University of California Radiation Laboratory Test Group
- Civil Effects Test Group (CETG)
- Office of Civil and Defense Mobilization (OCDM)* Test Group.

The LASL and UCRL Test Groups, with scientists from LASL, UCRL, the Sandia Corporation, and Edgerton, Germeshausen, and Grier, Incorporated (EG&G), performed diagnostic tests of the nuclear devices. The CETG and the OCDM Test Group conducted projects to assess the effects of nuclear detonations on shelters, products, and food supplies and to evaluate civil effects emergency preparedness plans.

1.4.2 Air Force Special Weapons Center Support Missions

The Air Force Special Weapons Center played an operational and support role in many of the scientific and diagnostic projects conducted at the NTS during Operation HARDTACK II. Based at Kirtland AFB in Albuquerque, New Mexico, AFSWC used

*Prior to 1 July 1958, OCDM was known as the Federal Civil Defense Administration (FCDA).

Indian Springs AFB in Nevada as its principal staging area. AFSWC provided the aircraft and personnel required for cloud-sampling missions, sample courier missions, cloud-tracking missions, aerial surveys, weather-reconnaissance missions, and other air support as requested by the NTSO. The 4950th Test Group (Nuclear) was the principal AFSWC unit involved in HARDTACK II. The 4950th consisted of four organizations, three of which participated in the operation. The 4926th Test Squadron (Sampling) and the 4952nd Support Squadron (Test) were located at Kirtland AFB. The 4935th Air Base Squadron was the permanent unit at Indian Springs AFB and was central to the mission of that base. Other Air Force units involved in Operation HARDTACK II included the 4900th Air Base Group from Kirtland AFB, elements of the 20th Helicopter Squadron of the Tactical Air Command (TAC), and the 865th Air Control and Warning Squadron of the Air Defense Command. Tables 1-4 and 1-5 summarize AFSWC participation in support missions during HARDTACK II (39; 40).

The 4950th Test Group (Nuclear) planned the air operations for HARDTACK II and provided personnel for the Air Support Group of the Test Manager's staff. These personnel, who were from other AFSWC and Air Force units, arrived at the NTS from extended temporary duty in the Pacific Proving Ground and were rotated with other personnel between the NTS and Kirtland AFB (39; 40).

The Air Operations Center, located at the Control Point in Yucca Pass, maintained operational control over all nuclear test aircraft flying in the area of the NTS during the operation. The Air Operations Center operated daily and was responsible for clearance of aircraft into the NTS and for coordinating cloud-sampling and cloud-tracking information during each nuclear test (39; 40).

The 4926th Test Squadron (Sampling), the principal mission unit of the 4950th Test Group (Nuclear), gathered radioactive

Table 1-4: AFSWC SUPPORT FOR THE HARDTACK II NUCLEAR WEAPONS DETONATIONS

Shot	EDDY	MORA	TAMALPAIS	QUAY	LEA	HAMILTON	LOGAN	DONA ANA	RIO ARRIBA	SOCORRO	WRANGELL	RUSHMORE	SANFORD	DE BACA	EVANS	MAZAMA	HUMBOLDT	SANTA FE	BLANCA
Cloud Sampling	•	•		•	•	•		•	•	•	•	•	•	•		•	•	•	•
Sample Courier	•	•		•	•	•		•	•	•	•	•	•	•		•	•	•	
Cloud Tracking	•	•		•	•	•		•	•	•	•	•		•	•	•	•	•	•
Aerial Survey		•		•		•													
Flare Drop							•												
Aerial Photography															•				•
Radio Relay		•																	
Observer																			•

Table 1-5: AFSWC SUPPORT FOR THE HARDTACK II SAFETY EXPERIMENTS

Shot	OTERO	BERNALILLO	LUNA	MERCURY	VALENCIA	MARS	COLFAX	HIDALGO	NEPTUNE	VESTA	SAN JUAN	OBERON	CATRON	JUNO	CERES	CHAVEZ	GANYMEDE	TITANIA
Cloud Sampling	•	•	•		•		•	•		•		•	•	•		•		•
Cloud Tracking			•		•		•	•	•	•		•	•	•		•		•
Sample Courier			•		•		•	•					•	•		•		
Aerial Photography																		•
Observer																		•

samples from nuclear clouds for laboratory analysis. The 4926th provided the aircraft, usually B-57s, and personnel to conduct cloud sampling for the LASL and UCRL Test Groups. The Sample Recovery Section of the 4926th Test Squadron was a ground support unit that removed samples from the sampling aircraft. In addition to cloud sampling, the 4926th Test Squadron operated two T-33 aircraft for high-altitude cloud tracking. These aircraft were loaned to the 4926th by the 4900th Air Base Group. The 4926th Test Squadron was based at Kirtland AFB; it staged, however, from Indian Springs AFB and maintained a forward element of personnel to fulfill operational requirements for Operation HARDTACK II. Major maintenance was performed at Kirtland AFB (39; 40).

The 4952nd Support Squadron, also based at Kirtland AFB, provided augmentation personnel to the 4950th Test Group (Nuclear) and to the 4935th Air Base Squadron throughout Operation HARDTACK II (39; 40).

The 4935th Air Base Squadron, based at Indian Springs AFB, provided regular airbase functions to all personnel at Indian Springs AFB in support of the nuclear testing (39; 40).

The 4900th Air Base Group, based at Kirtland AFB, provided transport services for test personnel between Kirtland AFB and Indian Springs AFB and performed sample courier missions to LASL and UCRL, low-level cloud-tracking missions, and other support services for the NTSO, as requested (39; 40).

The 20th Helicopter Squadron from the Tactical Air Command furnished H-21 helicopters for use in support missions. The H-21 helicopters staged from Indian Springs AFB and areas within the NTS (39; 40).

Elements of the 865th Air Control and Warning Squadron of the Air Defense Command, located on Angel's Peak about 35 kilometers southeast of Indian Springs AFB, provided support for the Air Support Group as an auxiliary Air Operations Center. This support was needed because much of the 4950th Test Group aircraft and control equipment was enroute from the Pacific Proving Ground during Operation HARDTACK II. The Auxiliary Air Operations Center at Angel's Peak was manned on shot-days from one hour before the first aircraft left until the last mission aircraft landed. The center provided continuous flight communications for cloud-tracking and cloud-sampling aircraft and pinpointed positions for these aircraft at specified times (39; 40).

The personnel strength of these units for NTS operations during the HARDTACK II operational period was as follows (40):

<u>Unit</u>	<u>Peak</u>	<u>Average</u>
4950th	18	11
4926th	49	37
4952nd	67	53
4935th	251	251
Other	<u>27</u>	<u>21</u>
	412	373

Cloud Sampling

An important objective of Operation HARDTACK II was obtaining samples of fission products from the nuclear detonations so that the yields and efficiencies of the nuclear devices could be determined.

LASL and UCRL required particulate samples for analysis as part of their scientific programs. The 4926th Test Squadron (Sampling) collected these samples by using specially modified wing-tip tanks on B-57B aircraft. Valves controlled by the pilot

could be opened to allow an airstream to pass through the wing-tip tank. The airstream, containing radioactive particulates from the cloud, would strike against a filter paper held by a grid within the tip-tank. An ion chamber located in the wing-tip tank and connected to a meter in the cockpit indicated to the pilot the size and quantity of the sample collected.

Sampling aircraft were equipped with various types of radiological instruments that provided data on the exposures of the crew during flight. In addition, the crews of sampling aircraft were required to wear film badges.

Approximately 30 minutes before a detonation, a B-57B sampler control aircraft took off from Indian Springs AFB. It orbited about 30 kilometers south of ground zero until the detonation. The sampler control aircraft was manned by a pilot and a scientific advisor from either LASL or UCRL, depending on the sponsor of the detonation (34; 39; 40; 56).

After the detonation, the B-57B sampler control aircraft followed and observed the formation and dissipation of the cloud. During this time, the scientific advisor evaluated the cloud structure and determined the areas from which sampler aircraft would collect particulate samples.

Acting on advice from the scientific advisor, the Air Operations Center alerted the B-57B sampling aircraft for takeoff. The Air Operations Centers at Yucca Pass and Angel's Peak maintained radar surveillance of these aircraft, which they vectored to the approximate location of the sample control aircraft. There, the sampling aircraft were placed within range of a low-frequency homing device installed on the sampler control aircraft.

As each sampling aircraft rendezvoused with the B-57B sampler control aircraft, it was placed under the control of the scientific advisor, and final cloud penetration information was relayed from the sampler control aircraft to the sampling aircraft. The scientific advisor directed sampling aircraft to make one or more penetrations of the cloud at varying altitudes and locations to gather particulate cloud debris (34; 39; 40; 56).

After the sampling mission was completed, the sampling aircraft were returned to the control of the Air Operations Centers and directed to Indian Springs AFB. Upon landing, pilots shut down the engines. They kept the canopies closed and latched, however, until ground personnel removed the samples from the aircraft. The crew remained within the enclosed cockpits and on full oxygen during the removal of the samples. The sample removal team used long-handled tools to take the sample filter papers from each wing pod and place them in shielded containers.

After the samples were removed and stored, the crews shut down their oxygen supplies and opened their canopies. They stepped from the cockpit onto a platform on a forklift so they would not touch the contaminated outer surfaces of the aircraft. They were taken in pickup trucks to the decontamination station at Indian Springs AFB. The trucks then returned to the aircraft, where they were loaded with the samples, which were transported to the waiting courier aircraft for delivery to LASL or UCRL for analysis.

Sample Courier Missions

The purpose of AFSWC courier service, provided by the 4900th Air Base Group, was to deliver samples and data from HARDTACK II research projects to LASL and UCRL facilities. The samples and data were to be delivered two to three hours after each detonation (39; 40).

Courier aircraft were usually brought to Indian Springs AFB on the day before a detonation. The sample return coordinator then briefed the aircrews. Following the detonation, the samples from the cloud-sampling mission and from ground projects were packaged and loaded aboard the courier aircraft. The radiation intensities of the samples were monitored, and an isolation area was established around the package. Courier aircrews, who were required to wear film badges, flew the samples to LASL representatives at Kirtland AFB for subsequent transport to LASL or to UCRL representatives at Alameda Naval Air Station, California, for subsequent transport to UCRL. Twenty-two courier missions, using C-47 and B-25 aircraft, were conducted during HARDTACK II.

Cloud Tracking

The objective of cloud tracking, conducted at 28 HARDTACK II events, was to record the path of the cloud and monitor its radiation intensity in order to expedite civil airway closure, if required (39; 40). Radiological safety personnel on board the aircraft, which followed the path of the cloud, monitored and reported radiation intensities to the Test Manager to confirm or alter existing air closures.

C-47, L-20, and B-25 aircraft assigned to Indian Springs AFB or provided by Kirtland AFB flew low-altitude cloud-tracking missions. T-33 aircraft from the 4926th Test Squadron (Sampling) conducted high-altitude cloud tracking.

Standard cloud-tracking missions began with the departure of cloud-tracking aircraft from Indian Springs AFB immediately after the detonation. The aircraft entered the NTS area and established contact with the Air Operations Center. At the direction of the Air Operations Center, they began cloud tracking. Cloud tracking usually began immediately after cloud-sampling aircraft had left the area (39).

After the Air Operations Center had cleared the cloud trackers to proceed, they intercepted the cloud, approaching the visible portion until they encountered a radiation intensity of 0.005 R/h. At that time, the aircraft turned out from the cloud as sharply as possible. By repeating this procedure throughout the mission, the cloud trackers determined the progression and extent of the cloud. They tracked the cloud either until it dissipated or until the Test Manager directed them to stop. The aircraft then returned to Indian Springs AFB or Kirtland AFB (39; 40).

Aerial Surveys and Security Sweeps

Several support aircraft made low-altitude radiological surveys of the terrain in and around the NTS to determine when recovery parties could safely enter the shot area after each detonation and to determine the safety of personnel in the area surrounding the NTS. The 4935th Air Base Squadron operated several types of aircraft for aerial surveys, including three H-21 helicopters from the TAC 20th Helicopter Squadron. After a detonation, H-21s left the Control Point area and conducted low-altitude surveys of the test area to determine radiological conditions at critical recovery locations. The Test Manager determined the departure of these aircraft. Radiological safety monitors from Reynolds Electrical and Engineering Company (REECo), an AEC contractor, briefed pilots, directed flight patterns, made radiation measurements, and decontaminated the helicopters as necessary. Constant radio contact with the Air Operations Center was mandatory during these missions.

Security sweeps included a preshot flight around the shot area several hours before a scheduled nuclear test. One of two L-20 aircraft with a pilot and a security officer usually conducted the flight. The aircraft flew at low altitudes around the boundaries of the test area before the detonation to make sure no unauthorized personnel were approaching the cleared test area (39; 40).

During HARDTACK II, 44 helicopter missions and 92 L-20 missions were completed in direct support of the nuclear events. These missions included radiological surveys of the terrain after a detonation and security sweeps of the NTS before each detonation (39; 40).

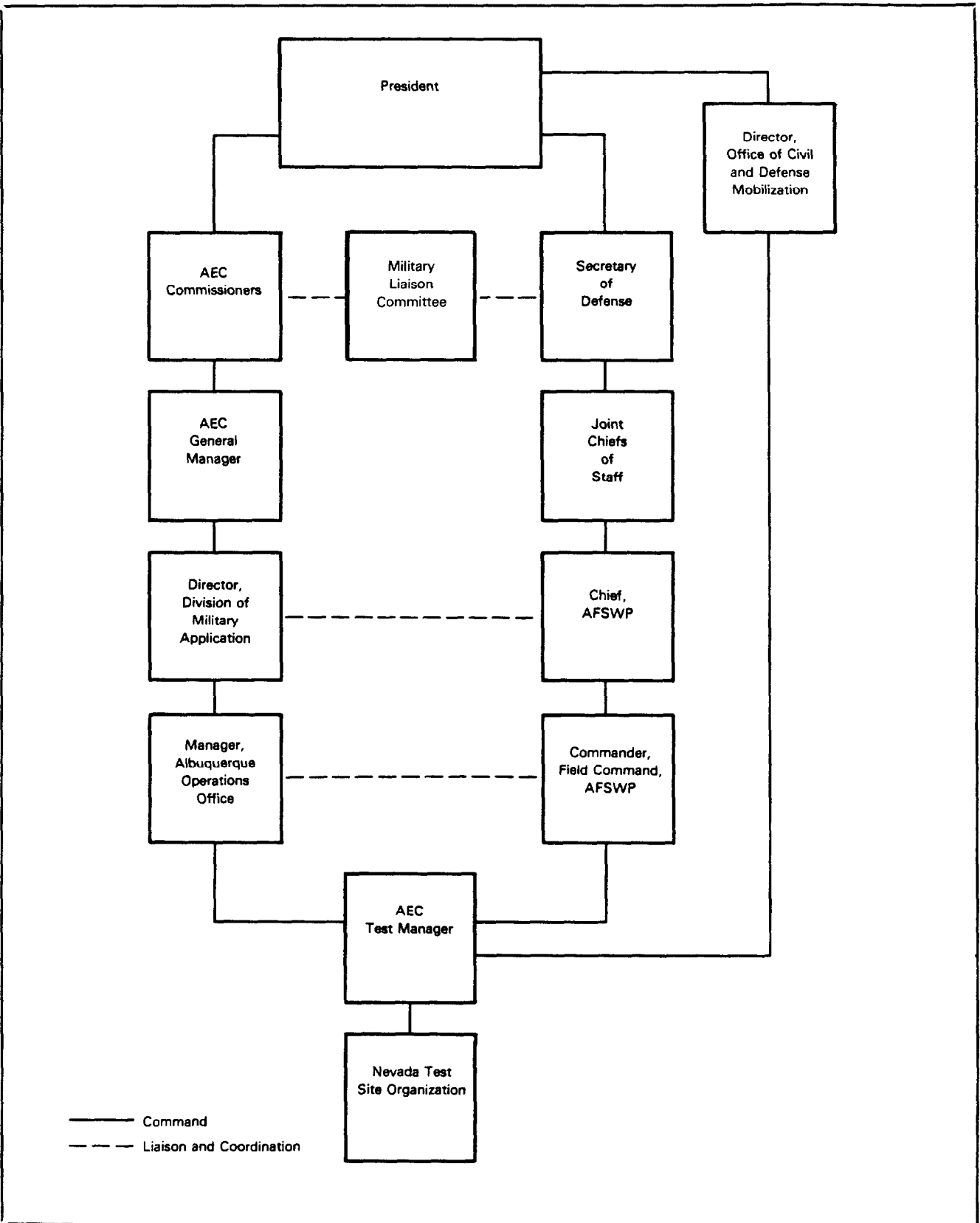
CHAPTER 2

FUNCTIONS OF THE NEVADA TEST SITE ORGANIZATION DURING OPERATION HARDTACK II

The Nevada Test Site Organization was responsible for planning and managing Operation HARDTACK II. The chief Government agencies represented in the NTSO were the Atomic Energy Commission, the Department of Defense, and the Office of Civil and Defense Mobilization. Other participants at HARDTACK II included Federal agencies involved in support work, research laboratories, and private firms under contract to the Government. DOD personnel participated in the activities of many of these organizations.

The Director of the AEC Division of Military Application supervised nuclear test operations from AEC headquarters in Washington, D.C. He delegated responsibility for test preparations at the Nevada Test Site to the Manager of the Albuquerque Operations Office. This responsibility included appointing the officials in charge of the nuclear test series and supervising the various test activities. Figure 2-1 shows the lines of authority from the President through the AEC and the DOD to the test organization (1; 2; 28).

The principal DOD agency for coordinating the nuclear test requirements of the military services was the Armed Forces Special Weapons Project, created in January 1947 by a Memorandum Order signed by the Secretaries of War and the Navy. At the operational level during nuclear testing series, the relationship of the AEC with AFSWP was formalized in a memorandum signed by representatives of both the AEC and Field Command, AFSWP. The memorandum, dated 16 February 1953, stated that in matters relating to military participation at the NTS the Test Manager



**Figure 2-1: NEVADA TEST SITE ORGANIZATION STRUCTURE
WITHIN THE FEDERAL GOVERNMENT**

(the senior AEC official) was responsible to the Commander, Field Command, AFSWP. In matters not relating to military participation, the Test Manager reported to the AEC Director of the Division of Military Application. A letter from the AEC to the Assistant of the Secretary of Defense for Atomic Energy confirmed this agreement (38; 54; 63).

Pursuant to an act of Congress, an Executive Order established the Office of Civil and Defense Mobilization on 1 July 1958, by consolidating the Federal Civil Defense Administration with the Office of Defense Mobilization. The purpose of OCDM involvement at HARDTACK II was to obtain technical and scientific information on the effects of nuclear weapons to help the Federal Government plan protective measures for civilians in case of a nuclear war.

2.1 THE NEVADA TEST SITE ORGANIZATION

On 23 July 1958, the President approved the conduct of the fall 1958 test series, originally designated Operation MILLRACE. On the same day, the AEC Division of Military Application issued a directive establishing the NTSO. On 7 August 1958, the AEC Albuquerque Operations Office appointed the senior AEC official for the NTSO, the Test Manager (28).

The Division of Military Application based the organizational plan of NTSO on that of its predecessor at Operation PLUMBBOB, the Nevada Test Organization. It reorganized communication channels, however, because Desert Rock exercises were not conducted during HARDTACK II, as they had been during Operation PLUMBBOB. The most important changes made in developing the NTSO were (28):

- Abolishing the Test Director's office and organization
- Consolidating all coordinating functions under the Test Manager.

2.1.1 Test Manager's Organization

The Test Manager was responsible for the overall direction of Operation HARDTACK II. This responsibility included scheduling the shots, coordinating the agencies involved in the weapons effects projects, and supervising the staff units that performed support functions for the test participants.

A large and diversified organization supported the Test Manager in fulfilling his duties. This organization, shown in figure 2-2, consisted of civilian and military personnel from the AEC, DOD, and Government contractors. The Test Manager was assisted by a Deputy Test Manager and a Deputy Test Manager for Military Matters, who was an AFSWP officer in charge of all DOD activities. DOD participation was chiefly confined to the DOD Effects Test Group, the Air Support Group, and the DOD Support Group (28).

The NTS Planning Board advised the Test Manager in matters relating to the overall planning for weapons tests. The board recommended the basic test schedule, the areas for the proposed shots, the support requirements for operations, and the assignment of tasks to the appropriate support organizations. The board members were drawn from Field Command, AFSWP, and from three contractor laboratories: the Los Alamos Scientific Laboratory, the University of California Radiation Laboratory, and the Sandia Corporation (28).

The Advisory Panel advised the Test Manager on the feasibility of proceeding with a scheduled nuclear event. The 27 members of the panel, who were chosen from the AEC, the DOD, the weapons development laboratories, the U.S. Public Health Service (USPHS), and the National Institutes of Health, were acquainted with AEC test policy and the scientific and technical information necessary to evaluate operating conditions (28).

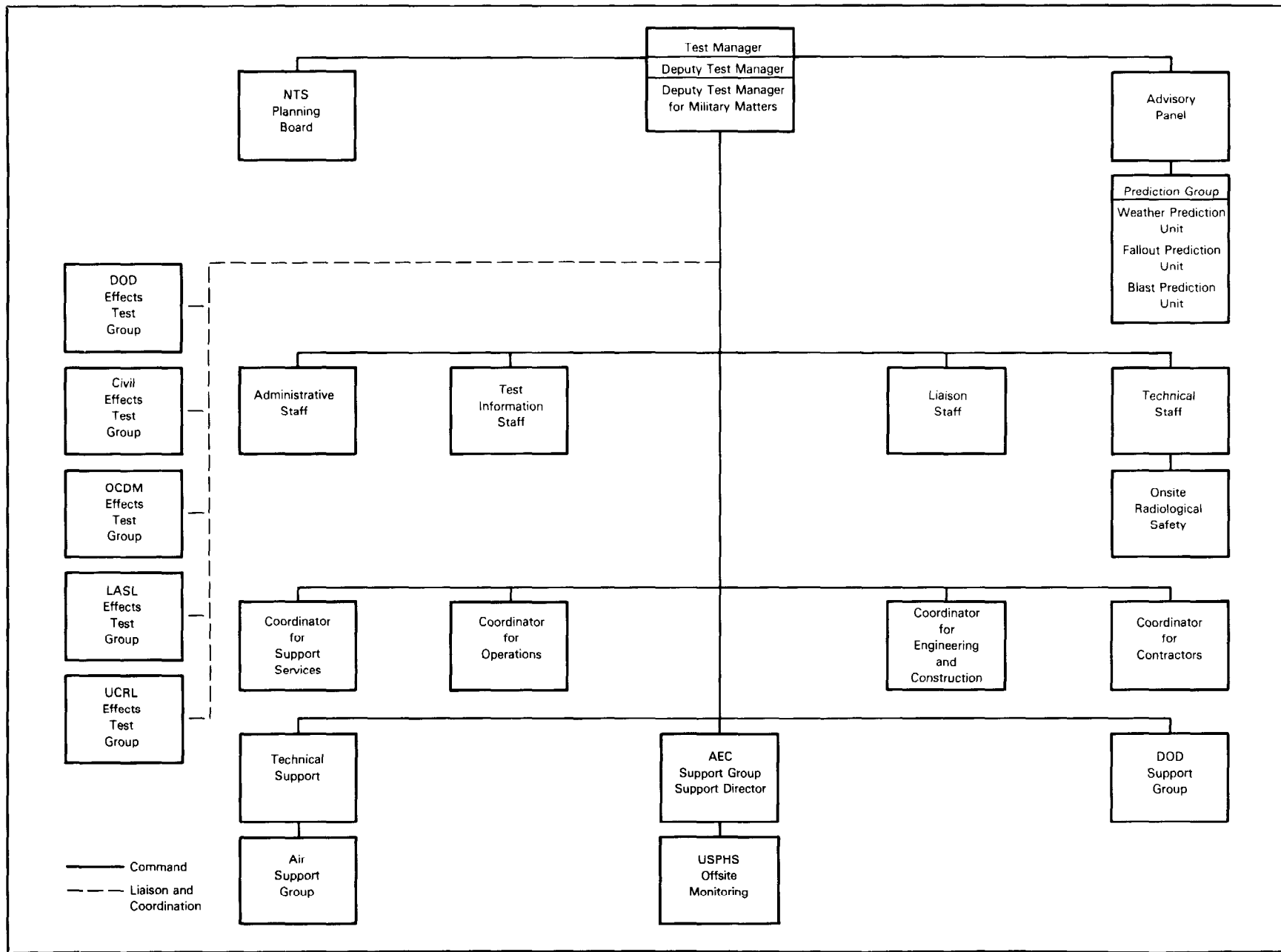


Figure 2-2: NEVADA TEST SITE ORGANIZATION

The Advisory Panel relied on the Prediction Group to assess operating conditions. The Prediction Group was divided into three units (28):

- Weather Prediction
- Fallout Prediction
- Blast Prediction.

The Weather Prediction Unit consisted of 34 meteorologists, aides, technicians, and clerks. Twenty-six of these personnel were from the U.S. Weather Bureau. The remaining eight were employees of REECo. The Weather Prediction Unit was located at the Camp Mercury Weather Station and had one onsite observation station at Yucca Flat and six observation stations at Tonopah, China Lake, Beatty, and Alamo, Nevada; St. George, Utah; and Shoshone, California (28).

The Fallout Prediction Unit, located at Camp Mercury, was staffed by the U.S. Weather Bureau. During the first half of Operation HARDTACK II, one Sandia Corporation employee was assigned to the Fallout Prediction Unit, and one man from OCDM worked for the unit for about three weeks. The Fallout Prediction Unit estimated the extent and path of fallout by comparing expected weather conditions, expected yield, and topographical conditions with actual fallout patterns from earlier shots (28).

The Blast Prediction Unit, staffed by the Sandia Corporation, was located at Camp Mercury. Personnel established manned microbarograph stations at the Control Point, Las Vegas, and Boulder City, Nevada; Bishop and Inyokern, California; and St. George, Utah. Two mobile stations functioned at various locations dependent upon operational and weather conditions (28).

Four staffs assisted the Test Manager (28):

- Administrative
- Test Information
- Liaison
- Technical.

The Administrative Staff consisted of AEC personnel, primarily from the Albuquerque Operations Office. It handled clerical and administrative matters for the Test Manager's Organization (28).

The Test Information Staff, with AEC, DOD, and OCDM employees, coordinated the activities of the NTSO Office of Test Information. The office informed the public of activities at the NTS and processed media personnel for entry into the NTS to observe certain nuclear detonations (28).

The Liaison Staff, composed of personnel from the AEC Division of Military Application and Division of Biology and Medicine, maintained contact with Federal agencies, Government contractors, weapons development laboratories, and the NTSO.

The Technical Staff, consisting of AEC and contractor personnel, was primarily responsible for the safety of HARDTACK II participants. This included onsite radiological safety, which was the direct responsibility of the Deputy Test Manager. The Technical Staff also maintained contact with the Civil Aeronautics Administration to ensure that commercial and private aircraft were rerouted away from radioactive clouds outside the NTS during detonation periods (28).

The Test Manager had assistance from contractors and Government agencies that provided technical support for

HARDTACK II. The main organizations involved in this type of support were (28):

- Edgerton, Germeshausen, and Grier, Incorporated
- Sandia Corporation
- Los Alamos Scientific Laboratory
- University of California Radiation Laboratory
- U.S. Weather Bureau
- U.S. Geological Survey
- U.S. Coast and Geodetic Survey
- U.S. Public Health Service
- Air Force Special Weapons Center
- Reynolds Electrical and Engineering Company.

The only DOD agency among the above organizations was AFSWC, which supervised the HARDTACK II Air Support Group. AFSWC was formed in 1949 to provide air support to the DOD, the AEC, and Government contractors in nuclear testing programs. During HARDTACK II, AFSWC provided many of the aircraft and personnel required for cloud-sampling, sample courier, and cloud-tracking missions, aerial surveys, and weather reconnaissance missions. The principal AFSWC unit for HARDTACK II was the 4950th Test Group (Nuclear), based at Kirtland AFB (28; 40).

The Test Manager appointed coordinators for support services, operations, engineering and construction, and contractors. The coordinators drew their staffs from the AEC and from a number of contractors, including REEC Co, Holmes and Narver, and the Sandia Corporation (28).

The AEC Support Group, administered by the AEC Support Director, provided logistical support for the AEC and its contractors. Most of the support activities were conducted by contractors or Government agencies under the AEC, as shown below (28):

- Visitor's Bureau: AEC, REEC Co
- Transportation: REEC Co

- Communications: AEC; REEC; Holmes and Narver, Incorporated
- Engineering and Construction: REEC, Holmes and Narver, Incorporated
- Security: Federal Services, Incorporated
- Offsite Radiological Safety: USPHS
- Camp Mercury Management: AEC, REEC.

The DOD Support Group consisted of four officers and 37 enlisted men. The DOD Support Director and his staff from Field Command, AFSWP, were responsible for (28):

- DOD Security
- DOD Visitor's Bureau
- DOD Public Information Office
- DOD Motor Pool
- DOD Dispensary
- DOD Administration and Finance.

2.1.2 The Effects Test Groups

The effects test groups, listed in figure 2-2 and discussed in chapter 1, were responsible for planning and implementing the scientific, technical, and diagnostic programs which were the principal reason for conducting HARDTACK II. To allow the AEC, the DOD, and the weapons development laboratories greater flexibility in developing and conducting their programs, the Division of Military Application organized the effects test groups outside the administrative structure of the Test Manager's Organization. The Test Manager, however, retained ultimate control over these groups (28).

CHAPTER 3

RADIATION PROTECTION AT OPERATION HARDTACK II

In addition to the thermal and blast effects associated with a conventional explosive device, a nuclear detonation also produces ionizing radiation. To protect HARDTACK II participants from unnecessary exposure to ionizing radiation, the Nevada Test Site Organization and the Air Force Special Weapons Center developed radiological safety procedures. These procedures included (28; 49):

- Orientation and training: preparing radiation monitors for their work and familiarizing other participants with radiological safety procedures
- Personnel dosimetry: issuing, exchanging, developing, and evaluating gamma and neutron exposures recorded on film badges
- Use of protective equipment: providing anti-contamination equipment, including clothing and respiratory protection
- Monitoring: performing radiological surveys and controlling access to radiation areas
- Decontamination: monitoring, containing, removing, and disposing of contamination on personnel, vehicles, and equipment.

The AEC defined permissible radiation exposure levels and instructed the Test Manager to implement overall procedures for the NTSO, which included the Department of Defense Effects Test Group, the test groups of the AEC nuclear weapons development laboratories, the Civil Effects Test Group, the Office of Civil and Defense Mobilization Test Group, and AFSWC. The radiological procedures used by the NTSO and AFSWC at HARDTACK II were essentially the same as those used for Operation PLUMBBOB, the 1957 nuclear weapons testing series (28).

Sections 3.1 and 3.2 discuss the radiological safety activities during Operation HARDTACK II. Each section addresses maximum permissible levels of exposure, the structure of the radiological safety organizations, and the procedures used by each organization to control individual exposures to ionizing radiation.

3.1 RADIATION PROTECTION FOR THE NEVADA TEST SITE ORGANIZATION

The Test Manager was responsible for the radiological safety of all NTSO personnel involved in onsite and offsite activities during Operation HARDTACK II. Operational control of onsite radiological safety was delegated to the Deputy Test Manager, while offsite radiological safety was the responsibility of the Support Director. The Radiological Safety Division of REECO conducted onsite radiological activities. REECO also provided support to AFSWC at the NTS and Indian Springs AFB. Personnel from the USPHS conducted all offsite radiological monitoring, under the direction of the offsite Radiological Safety Officer. The NTSO radiological safety program worked within guidelines recommended by the AEC Division of Biology and Medicine and accepted by the Test Manager. Individual exposures were limited to 3 rem of gamma and neutron radiation per quarter calendar year and not more than 5 rem annually. This was essentially the same as the accepted occupational exposure limit recommended by the National Committee on Radiation Protection and Measurements (28).

The operational responsibilities of the NTSO onsite Radiological Safety Division were to (49):

- Provide guidance and training in radiological procedures and situations to participants
- Provide radiac equipment and maintenance services onsite and offsite
- Maintain dosimetry and records service for all organizations participating in the operation onsite and offsite

- Conduct radiological surveys and plot isointensity maps
- Provide monitors to projects without certified monitors
- Conduct personnel and vehicle decontamination.

3.1.1 Organization and Responsibilities

The Test Manager was responsible for all radiological safety during Operation HARDTACK II. During periods of testing, the Deputy Test Manager assumed responsibility for radiological safety in the shot areas. He was assisted by the Radiological Safety Officer, who coordinated the support activities of the REEC Co Radiological Safety Division. Division personnel provided all onsite radiological safety support (28).

During periods when there was no testing, the Support Director was responsible for onsite radiological safety. He was also responsible for the offsite monitoring program conducted by USPHS personnel. The Support Director was assisted by a Radiological Safety Officer appointed by the AEC to coordinate USPHS activities during offsite monitoring. The Radiological Safety Division, operated by REEC Co, also provided some support for the offsite program. Figure 3-1 shows a chart of the NTSO radiological safety organization (28; 47).

3.1.2 Onsite Operations

The Radiological Safety Division had four branches during Operation HARDTACK II: Weapons Test, Laboratory, Instrument Maintenance, and Reactor. AFSWP monitoring personnel assigned to the Weapons Test Branch augmented the REEC Co radiological safety personnel. Members of these branches were responsible for all

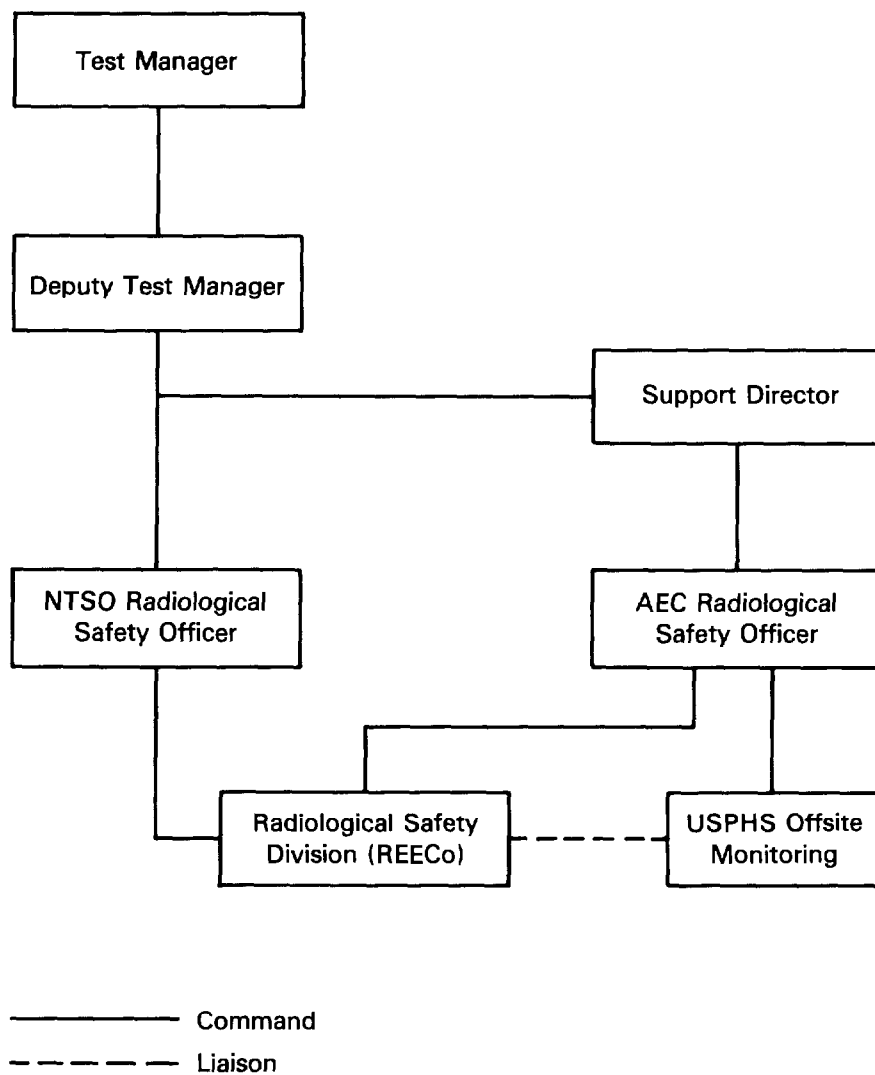


Figure 3-1: THE NTSO RADIOLOGICAL SAFETY ORGANIZATION

onsite radiological safety activities and functions.

Specifically, the Radiological Safety Division provided (49):

- Instructions for radiological safety monitors and participants
- Film badges and exposure records to determine the exposure of participants onsite and offsite to gamma and neutron radiation
- Radiation protection instruments, equipment, and clothing to personnel entering onsite and offsite radiation areas
- Monitoring of radiation areas and control of personnel access into these areas
- Isointensity contour maps of the shot areas and radiation information to personnel entering the areas
- Decontamination of personnel, vehicles, and equipment.

Figure 3-2 shows radiological safety procedures followed for personnel entering radiation areas. The following sections describe the procedures.

Instruction

Before HARDTACK II began, the Radiological Safety Division conducted 40-hour basic radiation monitoring courses for the radiological safety monitors. The courses consisted of lectures in basic mathematics, basic nuclear physics, nuclear weapons effects, biological effects of radiation, and maximum permissible exposures, as well as demonstrations in radiation detection and measurement and in radiological safety procedures. After completion of the course, each monitor participated in three to six weeks of training with a senior monitor. This training continued during HARDTACK II. During the operation, the training section briefed official visitors on radiation effects and radiological safety. The section also gave occasional lectures to participating organizations (49).

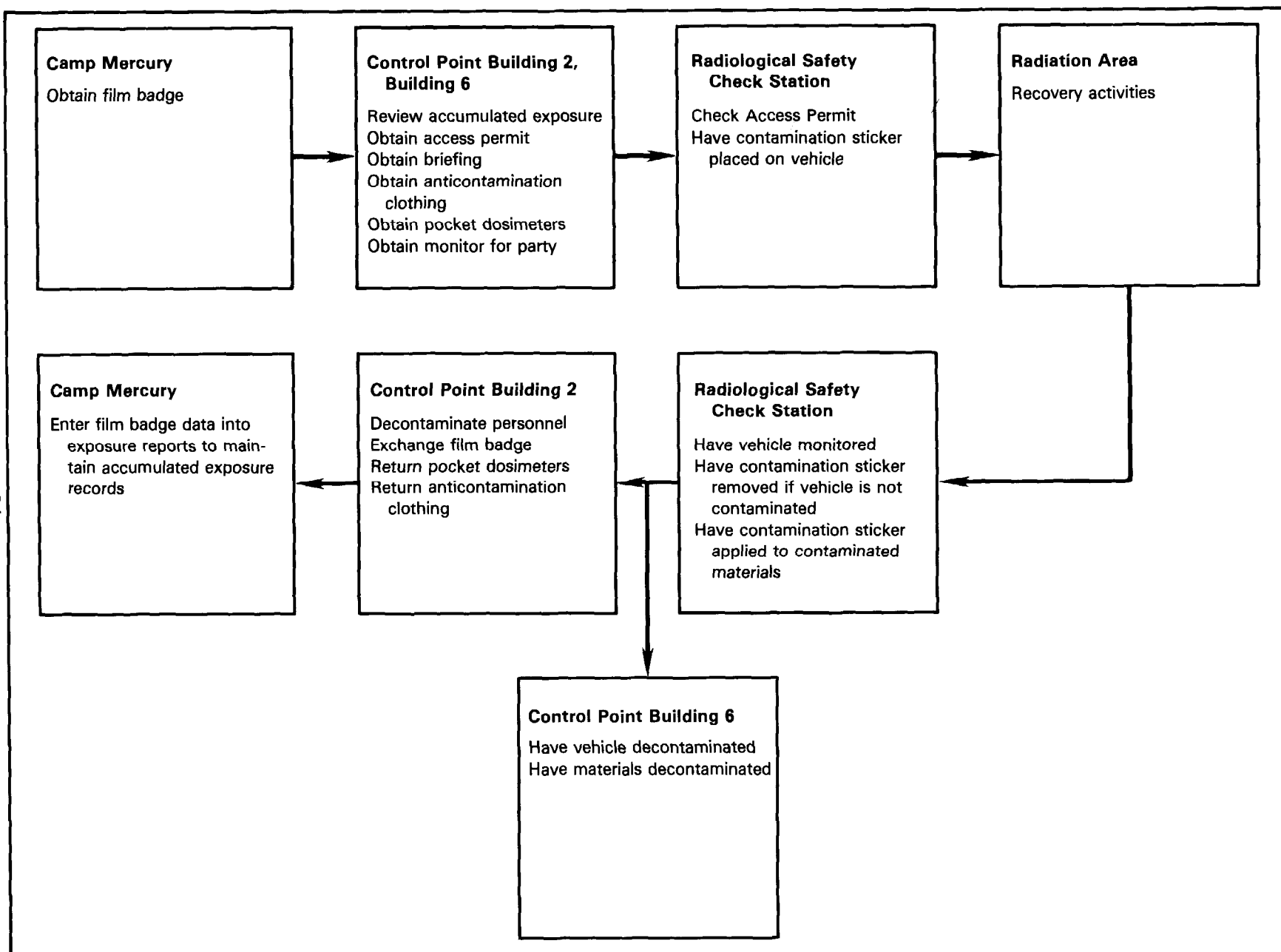


Figure 3-2: PROCEDURE FOLLOWED BY PERSONNEL ENTERING AND LEAVING RADIATION AREAS

Dosimetry and Records

Personnel from the Radiological Safety Division provided dosimetry service and maintained exposure records for NTSO personnel, both civilian and military. The procedure was to issue a film badge to each individual entering the NTS. The film badges were color-coded to indicate the month of issue. Computer cards, numbered to coincide with the number on each film badge, were labeled with the participant's identification information. Participants exchanged film badges upon leaving a radiation area and at the end of each month (28; 37; 49).

Permanent exchange stations were in Building 111 at the NTS Main Gate, in the Radiological Safety Division Office at Camp Mercury, and in Building 2 at the Control Point. During monthly exchange periods, temporary stations were established in the cafeteria and the recreation building at Mercury. Individuals leaving the test area turned in their film badges at one of these exchange stations. The film badges were developed and the optical density measured with an Eberline FD-11 densitometer. The corresponding dose information was entered on the computer cards that corresponded by number to the person's film badge. Master exposure record computer cards were then prepared from these cards to show individual cumulative exposures. These master exposure cards were color-coded by cumulative exposure:

- Manila cards indicated a gamma exposure of less than 2 rem for the quarter year and less than 4 rem for the year.
- Blue cards indicated a gamma exposure of 2 rem or more for the quarter year but less than 4 rem for the year.
- Red cards indicated an exposure of 4 rem or more for the year.

The exposure record cards were maintained and updated daily and made available to the radiological safety personnel who issued access permits to participants entering radiation areas. NTSO

supervisors used exposure reports generated from the master cards to control individual accumulated doses (37; 49).

The film badge issued to all personnel contained the Dupont Dosimeter film packet 559, consisting of a low-range and a high-range film component. The low-range film measured doses of 0.02 to 10 rem, and the high-range component recorded radiation levels of 5 to 800 rem. This packet of films, which had a lead clip covering a portion of both sides, was enclosed in a waterproof plastic covering (49).

More than 15,562 film badges were processed. The number of film badges processed daily ranged from 45 to more than 1,100, depending on participation in the various shot activities. The numbers of film badges issued for each weekly period during HARDTACK II are included with equipment and clothing distribution information in the next section. Exposure records were maintained on 7,657 individuals (28; 49).

The Radiological Safety Division also issued film badges in bulk lots to the AFSWC personnel at Indian Springs AFB and to the USPHS offsite radiological safety personnel. Indian Springs AFB badges were processed as onsite badges, while most of the badges for the offsite organization were collected and processed at the end of the operation (49).

Logistics

The Radiological Safety Division procured and maintained equipment and supplies for onsite and offsite personnel during HARDTACK II. This division's responsibilities included issuing, repairing, maintaining, and storing radiac devices, clothing, and equipment used by project participants as well as by division personnel.

Anticontamination clothing and supplies, such as coveralls, shoe covers, respiratory equipment, gloves, surgeon's caps,

socks, underclothing, plastic bags, and masking tape, were available in Building 2 at the Control Point for personnel entering radiation areas. The equipment was issued when an individual was given an access permit card. A record of the issued equipment was listed on the access permit. The equipment was returned to Building 2 for decontamination and laundering after personnel returned from a radiation area. The following listing presents the number of radiological safety items issued at HARDTACK II for weekly periods (49):

Period	Film Badges Processed	Coveralls	Shoe Covers (Pr.)	Respirators	Gloves (Pr.)	Miscel- laneous*
9/8-9/14	990	161	193	75	160	205
9/15-9/21	809	144	153	36	210	338
9/22-9/28	3,748	278	253	143	300	284
9/29-10/5	2,807	353	329	177	400	374
10/6-10/12	1,560	412	722	227	722	462
10/13-10/19	2,330	845	1,642	440	1,642	223
10/20-10/26	1,902	384	480	95	379	403
10/27-11/3	1,416	414	562	126	298	521

*Miscellaneous includes surgeon's caps, socks, underclothing, plastic bags, and masking tape.

Radiation detection instruments were serviced and made available through Building 2 at the Control Point. The instruments were checked and calibrated. Expendable parts, such as batteries, were replaced before release for field use.

Monitoring

The monitors of the Radiological Safety Division carried out daily assignments to protect personnel from unnecessary exposure to ionizing radiation. These activities included (49):

- Performing initial surveys and resurveys of areas around ground zero after a detonation
- Establishing and operating main and area access checkpoints
- Marking and establishing the radiation exclusion areas
- Serving as party monitors for personnel who were required to enter radiation exclusion areas.

Forty-eight hours before a detonation, personnel access to the shot area was controlled and mustering procedures commenced. Security force personnel established check stations on roads leading into the area. Personnel entering the area to conduct preshot activities were issued security muster badges at the check stations. About two hours before each detonation, personnel were cleared from the area. Exceptions were the arming party and a few participants given permission to man project stations. Radiological safety monitors stood by at the main access road check station awaiting release to begin the initial survey.

Before each detonation, the Weapons Test Branch Leader briefed the radiological safety personnel who were to conduct the initial ground survey on the expected fallout pattern. Four teams of two men each usually conducted the surveys. They drove into the shot areas as early as possible after each detonation. The teams used vehicle odometers to determine how far intensities of 0.01, 0.1, and 1 roentgen per hour (R/h) were from previously established reference stakes. The information was transmitted by radio to the Plotting and Briefing Station in Building 2 at the Control Point, where the isointensity lines were plotted and drawn onto plastic overlay maps. These maps were then made available to project personnel planning to retrieve project equipment and data from radiation areas. Maps were also prepared at Control Point Building 1 for the Test Manager's staff, who made decisions on reentry times. Survey

teams posted the test areas with radiation warning signs, and all traffic was routed to pass by the check stations. The survey teams also monitored radiation intensities up to 10 R/h in specified areas if the radiation information was requested by the Deputy Test Manager or project recovery parties. Radiological safety monitors could survey areas with intensities greater than 10 R/h only with the approval of the Deputy Test Manager (49).

When time between detonations permitted, survey teams resurveyed shot areas six hours and one, two, and three days after the shots. Warning signs and barricades were moved after each resurvey to indicate the current radiological situation. Survey teams conducted 144 radiological surveys during HARDTACK II (28).

After each detonation, radiological safety personnel established check stations outside the 0.01 R/h radiation area on access roads leading into the shot area. These check stations were trailers equipped with radios, radiation detection instruments, and other safety equipment. Barricades were placed on frequently used back roads with signs directing personnel to enter and exit through the check stations. No individual was permitted beyond these stations without a proper access permit stating the purpose of entry and the precise location of planned activities. Roving monitors also checked access permits of personnel in the radiation areas to ensure that they were authorized to be there and had not entered the area through a road other than at the check stations (28; 49).

All groups entering areas with radiation intensities greater than 0.1 R/h were accompanied by a radiological safety monitor. Project teams were generally required to provide their own certified monitors; however, if project monitors were not available, the Radiological Safety Division supplied them. These monitors were stationed at Building 2 at the Control Point or at

check stations. The monitors advised the project teams on measures to take to minimize exposure and avoid spread of contamination to uncontrolled areas (28; 49).

Plotting and Briefing

Personnel in the Plotting and Briefing Section performed the following functions (28; 49):

- Advised the Deputy Test Manager of the radiological aspects of test recoveries within radiation areas
- Planned with the Monitoring Section the survey requirements for each shot, based on recovery requirements
- Planned with the Monitoring Section the location of all checkpoints and signs
- Indicated to the Monitoring Section the position and extent of required stake lines
- Prepared permanent records of all survey data and developed isointensity situation maps showing the locations of the 10, 1, 0.1, and 0.01 R/h lines
- Furnished the Dosimetry and Records Section with personnel names to facilitate assignment of film badges and equipment
- Issued access permits
- Briefed recovery personnel on current radiological situations.

Isointensity contour maps were developed from the survey data that the radiological survey monitors radioed to plotting and briefing personnel. As an aid to both plotters and monitors, a numbering system was used that identified each location by a three-digit number. The first digit indicated the stake line. For example, stake line 1 was approximately 45 degrees from north, and stake line 2 was approximately 90 degrees from north. Stake lines extended from ground zero but not necessarily in straight lines, since they often followed available roads. The last two digits indicated the distance along the stake line from

ground zero to the survey location, in 100-yard (90-meter) intervals. For example, stake marker 213 indicated a location 1,300 yards from ground zero along line 2 (49).

Personnel at the radiological exclusion area information center advised all monitors and party leaders of the radiological environments they might encounter. When they issued access permits, each person's exposure record was consulted to determine that the cumulative exposure was within permissible limits. Necessary clothing and equipment were then issued. Records indicate that 2,393 access permits were issued at HARDTACK II (49).

Decontamination

Personnel of the Radiological Safety Division decontaminated personnel, equipment, and vehicles leaving the radiation areas and cleared radioactive samples removed from the test areas.

All personnel, vehicles, and equipment leaving the test area were monitored for contamination at designated checkpoints. Decontamination was required if radioactivity exceeded the following limits (28):

- Personnel: 0.007 R/h (beta and gamma) on personal clothing
 0.007 R/h (gamma) on shoes
 0.001 R/h (gamma) on surface of skin or underclothing
- Vehicles and
 Equipment: 0.007 R/h (gamma) outer surfaces
 0.007 R/h (beta and gamma) inner surfaces.

Monitoring was also performed for alpha-emitting contamination on personnel, vehicles, and equipment, and decontamination was conducted as required.

Decontamination facilities were maintained at Building 2 of the Control Point for personnel and at Building 6 for equipment and vehicles. Personnel arriving at the Building 2 decontamination station were cleaned of surface contamination by vacuuming

the dust and dirt from their garments. Personnel then removed anticontamination clothing and respiratory equipment and turned in film badges and pocket dosimeters. Each individual was then checked for radioactive contamination. If readings above the limits were found, the person was required to remove remaining clothing and, if necessary, take a shower. After showering, the individual was checked again, and if radiation readings were less than 0.001 R/h on the surface of the skin, the individual was released. If personal clothing was retained for decay or laundering, government-issue clothing was provided on a temporary basis (49).

Vehicles were parked in designated areas adjacent to the Building 6 decontamination station. Each vehicle had been monitored at the checkpoint, and decontamination was required if radiation readings above the limits were found. Contaminated vehicles were cleaned initially with a vacuum cleaner. All surfaces, including running boards, floorboards, and under-surfaces of fenders, were vacuumed. The vehicles were then resurveyed and, if still contaminated, rinsed with water, or sprayed and washed with a liquid detergent. When radiation intensities were reduced to less than 0.007 R/h, the contaminated material stickers were removed from the windshields and the vehicles were returned to service. Radiological safety personnel decontaminated 546 vehicles at HARDTACK II (28).

Contaminated material leaving the NTS by road was labeled and loaded onto vehicles according to Interstate Commerce Commission regulations for the transportation of radioactive materials. Radiological safety personnel monitored the packaged materials before their release from the NTS. These personnel completed forms and applied stickers to certify that the packaged material complied with regulations. Security officers did not permit materials to leave the NTS without proper forms and stickers (28).

3.1.3 Offsite Operations

Appropriate areas outside the test site were monitored out to a 320-kilometer radius from the Control Point. The Support Director delegated operational control of the offsite program to an offsite radiological safety officer (47). USPHS personnel provided operational support services. REECo provided film badges and radiation detection equipment.

The offsite radiological safety program was organized to (47):

- Assess the offsite radiological situation associated with each detonation
- Accumulate data regarding fallout patterns
- Conduct environmental monitoring of air, water, and milk
- Produce reports, maps, and records that describe findings of this monitoring and data collection
- Establish and maintain public relations.

USPHS personnel conducted offsite monitoring. In addition to monitoring, they were responsible for the placement and collection of film badges, for sample collection, and for public relations.

Three teams consisting of two men each were available at Camp Mercury as mobile monitors to survey the radiological situation immediately adjacent to the NTS and to furnish support to zones according to predicted fallout patterns. As occasions warranted prior to detonations, these mobile teams were deployed to selected locations to monitor any radioactivity resulting from fallout (47).

3.2 RADIATION PROTECTION FOR THE AIR FORCE SPECIAL WEAPONS CENTER

During Operation HARDTACK II, AFSWC conducted all aerial support missions, including cloud sampling, cloud tracking, and aerial surveys of onsite and offsite areas. AFSWC personnel followed the same radiation exposure limits established for NTSO personnel, except for sampling and ground crews who were permitted to receive a maximum of 10 rem during Operation HARDTACK II because of the nature of their mission. Sampling aircrews at HARDTACK II who were also at HARDTACK I were authorized to receive a maximum of 15 rem for the total operation (28; 40).

The NTSO was responsible for providing AFSWC radiological safety. The Test Manager delegated responsibility for developing these specialized radiological safety procedures to the 4950th Test Group, the major operational unit of AFSWC. The 4950th had three units that participated in HARDTACK II. The 4926th Test Squadron (Sampling), with personnel support from the 4935th Air Base Squadron, was responsible for all radiological safety activities at Indian Springs AFB. The 4900th Air Base Group established a similar radiation safety program at Kirtland AFB (28).

Orientation and Training

Prior to a cloud-sampling mission, pilots were briefed about flight patterns, the expected height of the radioactive cloud, penetration times into the radioactive cloud, and the location of other aircraft in the area. Cloud-tracking aircraft were ordered to stay clear of the cloud but to track it visually until the cloud samplers had completed their mission.

AFSWC radiological safety monitors were trained in compliance with Air Force technical orders and regulations. Personnel trained in an approved course at the NTS were considered qualified, subject to approval by the Nuclear Research

Officer of the 4950th Test Group. All other individuals were trained in the Radiological Safety Monitors Course presented by the Nuclear Application section of the 4926th Test Squadron. REECo trained the Indian Springs AFB support personnel (40; 49).

Dosimetry and Protective Equipment

AFSWC participants at Indian Springs AFB and Kirtland AFB were required to wear film badges while on cloud-sampling and cloud-tracking missions. In addition, each aircraft had a radiation survey meter on board. The personnel responsible for base operations at Indian Springs and Kirtland AFBs were not ordinarily issued film badges (40).

The 4926th Test Squadron provided AFSWC with film badges that had been furnished by REECo. At Indian Springs AFB, the 4926th distributed badges to all personnel whose duties could lead to radiation exposure. At Kirtland AFB, however, the 4926th provided the film badges to the 4900th Air Base Group, who then assumed responsibility for distributing the badges to appropriate personnel. REECo processed all film badges worn by AFSWC personnel and maintained exposure records.

Cloud-sampling aircraft were generally manned by a pilot and a radiological safety monitor, who both wore regulation flight suits and were on full oxygen before, during, and after cloud penetration. The pilot and co-pilot of the helicopters that conducted aerial surveys also wore regulation flight suits. Three other individuals usually participated in these helicopter surveys: another AFSWC crewman and two monitors provided by REECo. These individuals wore the regular anticontamination clothing. All persons in the survey helicopters wore respirators (33; 40).

Decontamination

Aircraft returning from cloud-sampling or cloud-tracking missions were parked in designated decontamination areas at Indian Springs AFB and Kirtland AFB, respectively. At the personnel decontamination stations, all pilots were monitored and were required to go through the complete decontamination procedures. This involved removing flight suits and undergarments, showering, and receiving fresh clothes. Showering was continued until radioactivity on the surface of the skin was less than 0.001 R/h (40).

Personnel from the 4935th Air Base Squadron decontaminated sampling aircraft. They used firehoses to spray and wash the aircraft with water. They then opened the canopy and wiped clean the cockpit and the inside of the canopy.

Radiological Safety Division personnel at the NTS monitored and decontaminated helicopters that landed at a pad east of the Control Point. At the completion of a mission, the crew turned in their film badges and respirators and, if required, were decontaminated at the personnel facilities at the Control Point building (40).

CHAPTER 4

DOSIMETRY FOR DEPARTMENT OF DEFENSE PERSONNEL AT OPERATION HARDTACK II

This chapter summarizes the data available as of December 1982 regarding the radiation doses received by Department of Defense personnel during their participation in various military and scientific activities at Operation HARDTACK II. It is based on research that identified the participants, their unit or organizational assignment, and their doses.

4.1 PARTICIPATION DATA

The identity of participants was determined from several sources:

- "NTS Personnel Gamma Radiation Exposures Summary" identifies personnel issued film badges during this period.
- Weapons test reports for AFSWP and other scientific projects often identified personnel, units, and organizations that participated in the operation.
- After-action reports, security rosters, and vehicle-loading rosters identified some participants.
- Morning reports, unit diaries, and muster rolls identified personnel assigned to participating units, absent from their home unit, or in transit for the purpose of participating in a nuclear weapons test.
- Discharge records, maintained by all services, aided in identification.
- Personnel and medical records identified some participants.
- The final report of the 4950th Test Group lists the names and ranks of cloud-sampling personnel and the doses they received at HARDTACK I and II (37).

- A widely publicized national call-in campaign sponsored by the Department of Defense has identified some participants.

4.2 SOURCES OF DOSIMETRY DATA

The dosimetry data for Operation HARDTACK II were derived from film badge records. As stated in chapter 3, the Radiological Safety Division, operated by REECo, maintained the dosimetry records.

During Operation HARDTACK II, the film badge was the primary device used to measure the radiation exposures of individual participants. The film badge, normally worn at chest level on the outside of clothing, was designed to measure the wearer's exposure to gamma radiation from external sources. The film badge did not, however, measure the amount of radioactive material, if any, that may have been inhaled or ingested. Special film badges that recorded information for fast neutron dose evaluation were issued to those personnel who anticipated neutron exposures.

Personnel from the Radiological Safety Division issued, received, developed, and interpreted film badges during Operation HARDTACK II. Personnel at the NTS were given an identification plate and a color-coded film badge. The colors were changed each month to permit quick and easy determination of valid film badges. Personnel exchanged the badges monthly or upon return from a mission into a radiation area. The Radiological Safety Division recorded individual exposures on a dosimetry card for each participant. The division used these cards to tabulate cumulative exposures and to prepare the various dosimetry and summary reports (28; 49).

At the conclusion of HARDTACK II, the services were to send individual dose records to each participant's home station for

inclusion in his medical records. When the individual left the service, his records were retired to a Federal records repository (31).

The film badge data summarized in this chapter were obtained from the following sources:

- Historical files of the Reynolds Electrical and Engineering Company, the prime support contractor to the Department of Energy (and previously to the AEC Nevada Operations Office). REECo assumed responsibility for onsite radiological safety after Operation TEAPOT in July 1955 and subsequently collected available dosimetry records for nuclear test participants at all nuclear testing operations from 1945 to the present. REECo has on microfilm the available exposure records for individuals working under the Nevada Test Site Organization at Operation HARDTACK II.
- Military medical records, maintained at the National Personnel Records Center, St. Louis, Missouri, for troops separated from military service, or at the Veterans Administration, for individuals who have filed for disability compensation or health benefits. Unfortunately, many records were destroyed in a fire at the St. Louis repository in July 1973. That fire destroyed 13 to 17 million Army records for personnel discharged through 31 December 1959 and for members of the Army Air Corps/Air Force discharged through 31 December 1963.
- The Onsite Radiological Safety Support Report, HARDTACK, Phase II, which provides some aggregate information on the number of participants who received gamma exposures (49).
- Report of the Test Manager for HARDTACK, Phase II, which provides some aggregate exposure information for NTSO personnel (28).
- Final Report of the 4950th Test Group, which lists the names, ranks, and exposures of AFSWC personnel involved with cloud-sampling activities at HARDTACK, Phases I and II (40).

4.3 DOSIMETRY DATA FOR OPERATION HARDTACK II PARTICIPANTS

This section presents data on the gamma exposures received by DOD participants at Operation HARDTACK II. Tables 4-1 through 4-5 present the gamma exposure data available from film badge records for the DOD participants. The tables indicate the following information by service, unit, or organization:

- The number of personnel identified by name
- The number of personnel identified by both name and film badge
- The average gamma exposure in roentgens
- The distribution of these exposures.

Table 4-1 summarizes all exposures for each service affiliation. Tables 4-2 through 4-5 provide information about the gamma exposures received by the various participants in each of the represented services (30).

The Test Manager's Report indicates that exposure records were maintained for 7,652 individuals who entered the Nevada Test Site. This number includes DOD military and civilian participants as well as non-DOD personnel, such as AEC personnel, scientists, security personnel, and other civilians (28).

Most of the participants in HARDTACK II were subject to a 3 rem limit on gamma exposures. Of those participants subject to the 3 rem limit, nine exceeded it. Of these nine personnel, four received gamma exposures between 3 and 5 rem; three received exposures between 5 and 10 rem; and two participants received exposures exceeding 10 rem. Most of these overexposed personnel participated in projects that required them to enter test areas to retrieve animals, instruments, and experimental data (29; 30; 49; 64).

Selected personnel from the 4950th Test Group and the 4926th Test Squadron were authorized to receive 15 rem per calendar year. Seven of these individuals are included in the 3.0 to 5.0 and 5.0+ columns of Table 4-4, but although they had gamma exposures over 3 rem, they did not exceed their exposure limit of 15 rem (28; 30; 40).

**Table 4-1: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR
OPERATION HARDTACK II PARTICIPANTS BY
AFFILIATION**

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (rem)	Gamma Exposure (rem)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Army	78	70	0.763	38	28	1	2	1
Navy	14	12	0.181	9	2	1	0	0
Air Force	319	210	0.509	107	69	27	5	2
Scientific Personnel, Contractors, Observers	962	962	0.139	776	159	21	2	4
Total	1,373	1,254	0.281	930	258	50	9	7

**Table 4-2: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR
ARMY PERSONNEL AND AFFILIATES, OPERATION
HARDTACK II**

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (rem)	Gamma Exposure (rem)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0 +
Army Chemical Center (Experimental Group)	1	0						
Atomic Energy Commission	1	0						
Ballistic Research Laboratories	4	4	0.148	3	1	0	0	0
Chemical Warfare Laboratories	3	3	0.155	1	2	0	0	0
Department of the Army General Staff	1	0						
Engineer Research and Development Laboratories	12	12	0.225	4	8	0	0	0
Joint Task Force 7.2	1	0						
Los Alamos Scientific Laboratory (sic)*	32	32	0.311	25	4	1	2	0
Test Command Unit (sic)	1	0						
US Army Artillery Board	1	0						
US Army Element, Field Command AFSWP	1	1	0.150	0	1	0	0	0
US Army Garrison, Sandia Base, NM	1	0						
Walter Reed Army Institute of Research	1	1	10.915	0	0	0	0	1
White Sands Missile Range	1	0						
53rd Transportation (sic)	1	1	0.315	0	1	0	0	0
526th Ordnance Company	1	1	0.170	0	1	0	0	0
Unit Unknown**	15	15	0.218	5	10	0	0	0
Total	78	70	0.763	38	28	1	2	1

*"Sic" indicates that entry for the unit and/or home station could not be verified.

**Unit information unavailable.

**Table 4-3: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR
NAVY PERSONNEL AND AFFILIATES, OPERATION
HARDTACK II**

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (rem)	Gamma Exposure (rem)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Armed Forces Special Weapons Project	4	4	0.101	2	2	0	0	0
Civil Effects Test Group	1	1	0.000	1	0	0	0	0
Directorate Effects Test Group	3	3	0.563	2	0	1	0	0
Los Alamos Scientific Laboratory	1	0						
Naval Administrative Unit, Sandia Base	1	1	0.000	1	0	0	0	0
San Francisco Naval Shipyard	1	0						
University of California Radiation Laboratory	3	3	0.025	3	0	0	0	0
Total	14	12	0.181	9	2	1	0	0

**Table 4-4: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR
AIR FORCE PERSONNEL AND AFFILIATES, OPERATION
HARDTACK II**

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (rem)	Gamma Exposure (rem)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Air Force Cambridge Research Center	1	1	0.400	0	1	0	0	0
Air Force Special Weapons Center	1	1	0.000	1	0	0	0	0
Air Research and Development Center	1	0						
Armed Forces Special Weapons Project	1	1	0.000	1	0	0	0	0
Directorate Effects Test Group	1	1	0.045	1	0	0	0	0
University of California Radiation Laboratory	1	1	0.240	0	1	0	0	0
20th Helicopter Squadron	1	1	0.135	0	1	0	0	0
21st Helicopter Squadron	1	0						
55th Weather Reconnaissance	1	0						
57th Weather Reconnaissance	3	0						
64th Air Rescue Squadron	1	0						
520th Installation Group	1	0						
1009th Special Weapons Squadron	6	4	0.038	3	1	0	0	0
1083rd Special Reporting Squadron	1	1	0.420	0	1	0	0	0
1090th Special Reporting Wing	3	3	0.016	3	0	0	0	0
1352nd Air Police Squadron	1	1	0.945	0	1	0	0	0
4520th Installation Group	1	0						
4900th Air Base Group	2	0						
4925th Test Squadron (Atomic)	4	2	0.832	1	0	1	0	0
4926th Test Squadron (Sampling)	45	42	0.903	14	17	9	0	2
4935th Air Base Squadron	56	3	0.008	3	0	0	0	0
4950th Test Group	137	133	0.483	66	45	17	5	0
4952nd Support Squadron (Test)	5	0						
6102nd Air Base Wing	1	0						
Unit Unknown*	43	15	0.047	14	1	0	0	0
Total	319	210	0.509	107	69	27	5	2

*Unit information unavailable.

**Table 4-5: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR
SCIENTIFIC PERSONNEL, CONTRACTORS, AND
OBSERVERS, OPERATION HARDTACK II**

Organizations	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (rem)	Gamma Exposure (rem)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Aerojet General Corporation	45	45	0.030	43	2	0	0	0
Associated Press	2	2	0.012	2	0	0	0	0
Carlsbad Airport, Manager	1	1	0.000	1	0	0	0	0
Carlsbad Argus, Editor	1	1	0.025	1	0	0	0	0
CBS News	4	4	0.068	4	0	0	0	0
Civil Effects Test Organization	1	1	0.000	1	0	0	0	0
Field Command, AFSWP	664	664	0.180	517	122	19	2	4
Observers*	105	105	0.011	103	2	0	0	0
Stanford Research Institute	10	10	0.268	2	6	2	0	0
Unknown*	129	129	0.068	102	27	0	0	0
Total	962	962	0.139	776	159	21	2	4

*Organizational affiliation is not available.

CHAPTER 5

NUCLEAR WEAPONS TESTS

The 19 nuclear weapons tests of Operation HARDTACK II were conducted from 19 September through 30 October 1958. Ten of the events were balloon shots, seven of which were sponsored by LASL and three by UCRL. Five tests were tower shots, two of them sponsored by LASL, one by UCRL, and two cosponsored by the DOD and UCRL. The other four shots, all UCRL events, were fired in tunnels. The HARDTACK II weapons tests were conducted in Areas 3, 5, 7, 9, and 12 of the Nevada Test Site. Figure 1-2 shows the location for each of these tests. Table 1-1 identifies the nuclear tests by presenting such information as the UTM coordinates of the points of detonation and the heights of burst.

Along with thermal and radiation phenomena, the nuclear weapons tests were designed to improve containment techniques for underground detonations and to evaluate nuclear yield and blast. To fulfill these objectives, the five test groups, identified in chapter 1, conducted scientific and diagnostic experiments at the shots. DOD personnel took part in projects conducted by the DOD Effects Test Group and the LASL and UCRL Test Groups. DOD Effects Test Group projects, which constituted most of the projects undertaken at the nuclear weapons events, were primarily conducted at the two detonations cosponsored by DOD and UCRL, Shots HAMILTON and HUMBOLDT. Table 1-3 indicates the DOD projects conducted at the nuclear weapons events, as well as at the safety experiments.

The other DOD participants were AFSWC personnel, who supported the nuclear weapons tests with cloud-sampling, sample

courier, cloud-tracking, and aerial survey missions. Cloud-sampling and sample courier missions were performed in support of a LASL Test Group project and a UCRL Test Group project. Cloud-tracking and aerial surveys were conducted in support of the Test Manager. In addition, AFSWC maintained operational control over all military aircraft flying in support of the nuclear weapons tests. Table 1-4 identifies AFSWC support for the nuclear weapons events.

5.1 SHOT EDDY

Shot EDDY, the first nuclear weapons detonation of Operation HARDTACK II, was fired at 0700 hours Pacific Daylight Time (PDT) on 19 September 1958, with a yield of 0.083 kiloton. The device was suspended from a balloon 500 feet above the ground in Area 7, at UTM coordinates 867047. The Los Alamos Scientific Laboratory developed the EDDY device (35).

At shot-time, the temperature was 14 degrees Celsius, and the surface winds were calm. Winds were seven knots from the southwest at 5,000 feet and 11 knots from the south-southwest at 10,000 feet.* The top of the cloud reached 11,000 feet and moved northeast from the point of detonation (35).

5.1.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in one DOD Effects Test Group project and one LASL Test Group project at Shot EDDY.

DOD Effects Test Group Projects

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was the one DOD Effects Test Group project performed

*Yucca Flat is approximately 4,000 feet above mean sea level. Throughout this report, altitudes are measured in feet above mean sea level, unless otherwise noted.

at Shot EDDY. Conducted by the Ballistic Research Laboratories, the project documented blast phenomena resulting from a nuclear detonation and evaluated new blast instruments. An estimated four Ballistic Research Laboratories personnel took part in the project. Participants installed blast gauges at seven stations approximately 60, 760, 910, 1,070, 1,220, 1,370, and 1,520 meters from ground zero. They made final checks of instruments the day before the detonation. After the detonation, participants reentered the shot area to recover records from the stations and to inspect the gauges. They then returned to Camp Mercury to analyze the data (45).

LASL Test Group Projects

The LASL Test Group conducted several projects at Shot EDDY. Only Project 11.2, Aircraft Sampling, involved DOD participation. The AFSWC 4926th Test Squadron (Sampling) provided cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot EDDY. The following information indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	4	8
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6
	T-33	1	2

Four B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fifth B-57B aircraft, with a pilot and a LASL technical advisor, acted as a sampler control aircraft, directing the four cloud-sampling aircraft to various sections of the EDDY cloud (39; 40).

The C-47 courier aircraft left Indian Springs AFB at 0855 hours on shot-day to transport the samples to Kirtland AFB. The samples were then taken to LASL for analysis. The AFSWC 4900th Air Base Group conducted the courier mission.

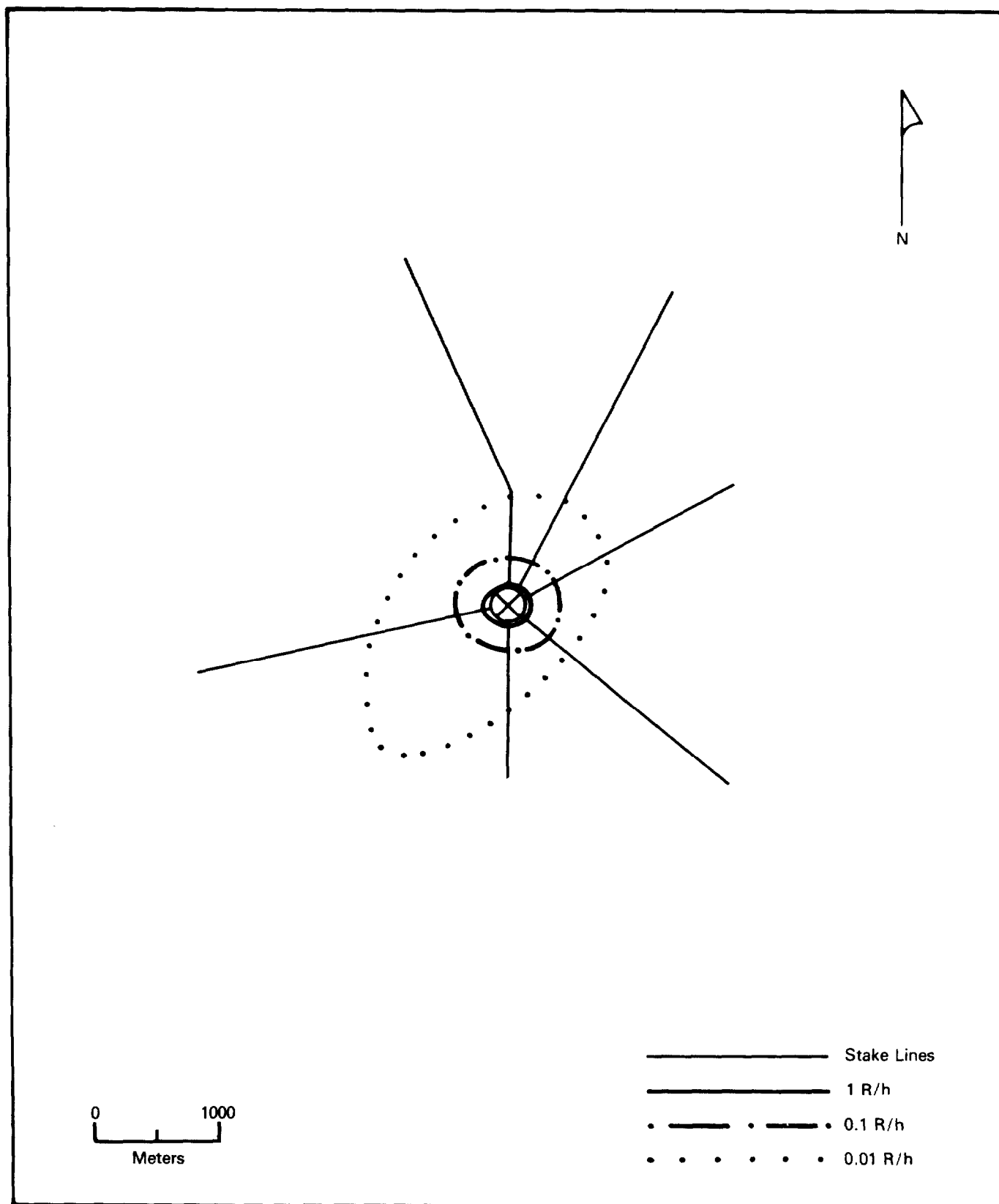
After the detonation, one C-47 aircraft performed a cloud-tracking mission to about 320 kilometers from ground zero, and one T-33 aircraft conducted a practice cloud-tracking mission (39; 40).

5.1.2 Radiological Safety Activities

The NTSO and AFSWC developed the radiological safety procedures for Operation HARDTACK II. Chapter 3 describes the procedures common to all shots in the series.

Onsite Monitoring

The initial survey team entered the test area shortly after the detonation to survey the shot area. Mid-time of the initial survey was 0730. Figure 5-1 shows a copy of the isointensity map generated from the initial survey (49). Gamma intensities of 8 R/h were encountered at ground zero. At distances of 200 meters and 1,600 meters, radiation intensities were 1 R/h and 0.01 R/h, respectively. Three days after the detonation, the gamma intensity was 0.01 R/h about 230 meters from ground zero and only 0.08 R/h at ground zero (49).



**Figure 5-1: INITIAL SURVEY FOR SHOT EDDY, 19 SEPTEMBER 1958,
MID-TIME 0730**

Offsite Monitoring

From one to eight hours after the detonation, USPHS personnel monitored offsite areas. They encountered gamma intensities above background in areas northwest of ground zero, particularly around Groom Mine, Lincoln Mine, and Crystal Springs, Nevada. Gamma intensities at these locations ranged from 0.001 R/h to 0.004 R/h (47).

5.2 SHOT MORA

Shot MORA was detonated at 0605 hours Pacific Standard Time (PST) on 29 September 1958. The shot had a yield of two kilotons. Developed by LASL, the device was suspended from a balloon 1,500 feet above the ground in Area 7, at UTM coordinates 867047, the same location as Shot EDDY (35).

At shot-time, the temperature was 12 degrees Celsius, and the winds were light and variable up to 5,000 feet. Winds were 13 knots from the north-northeast at 10,000 feet and 31 knots from the north-northeast at 18,000 feet. The top of the cloud reached 18,500 feet and moved south from the point of detonation. A dust cloud near the ground moved west from the detonation across Mercury Highway (35).

5.2.1 Department of Defense Participation in Scientific and Support Activities

At Shot MORA, DOD personnel took part in activities conducted by the DOD Effects Test Group and the LASL Test Group. The following information identifies these projects.

Project	Title	Fielding Agency
DOD Effects Test Group		
1.7	Airblast Phenomena and Instrumentation of Structures	Ballistic Research Laboratories
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories
LASL Test Group		
11.2	Aircraft Sampling	LASL; AFSWC

DOD Effects Test Group Projects

The DOD Effects Test Group conducted three projects.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories to document blast phenomena resulting from a nuclear detonation and to evaluate new blast instruments. An estimated four Ballistic Research Laboratories personnel took part in the project. Participants installed blast gauges at stations approximately 50, 60, 10,570, and 11,620 meters from the ground zero. Participants made final checks of instruments during the day before the detonation. After the detonation, project personnel reentered the shot area to recover records from the

stations and to inspect the gauges. They then returned to Camp Mercury to analyze the data (45).

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the operational capabilities of flash-ranging instrumentation. In the days prior to the detonation, project personnel set up flash-ranging equipment at sites 13, 17, and 29 kilometers from ground zero. Personnel probably operated equipment at these sites through shot-time. After the detonation, the data were taken to a laboratory for analysis (52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories. The objective was to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. An instrumented trailer was located about 160 kilometers southeast of the NTS, near Boulder City, Nevada. Project personnel manned the station several hours before the burst to prepare the instruments, during the burst to detect and record the electromagnetic pulses, and for a few hours afterward to analyze data and turn off equipment (29).

LASL Test Group Projects

The only LASL Test Group project involving DOD participation at Shot MORA was Project 11.2, Aircraft Sampling. The AFSWC 4926th Test Squadron (Sampling) provided cloud sampling for this project. Cloud sampling is discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted radio relay, cloud-sampling, sample courier, cloud-tracking, and aerial survey missions during Shot MORA. The following information indicates the type and

number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40).

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Radio Relay	T-33	1	2
Sampler Control	B-57B	1	1
Sampling	B-57B	4	8
Sample Courier	C-47	1	3
Cloud Tracking	C-47	2	12
Aerial Survey	H-21	2	8

Four B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fifth B-57B aircraft, with a pilot and LASL technical advisor, functioned as a sampler control aircraft and directed the sampling aircraft to various sections of the MORA cloud.

The C-47 courier aircraft transported the samples from Indian Springs AFB to Kirtland AFB, from where the samples were then taken to LASL for analysis. The 4900th Air Base Group conducted the courier missions (39; 40).

The C-47 cloud-tracking aircraft flew a cloud-tracking mission out to about 320 kilometers from ground zero (39; 40).

5.2.2 Radiological Safety Activities

The radiological safety procedures used at Shot MORA were the same as those employed at the other HARDTACK II shots. Chapter 3 describes these procedures and indicates the number of film badges and protective equipment issued during MORA.

Onsite Monitoring

The initial ground survey team entered the test area in radio-equipped vehicles as soon as possible after the detonation. The mid-time of their survey was 0635 hours (49). Figure 5-2 shows a copy of the initial isointensity map. The survey team detected gamma intensities of about 8 to 10 R/h at ground zero. These intensities decreased to 0.1 R/h and 0.01 R/h at distances of 1,300 meters and 2,500 meters to the south of ground zero, respectively. Five hours after the detonation, radiation levels of 0.01 R/h were confined to within 1,450 meters of ground zero, and levels of 0.1 R/h were within 1,000 meters. Two days after the detonation, gamma intensities of 0.01 R/h and 0.1 R/h were confined to 950 and 580 meters from ground zero, respectively (49).

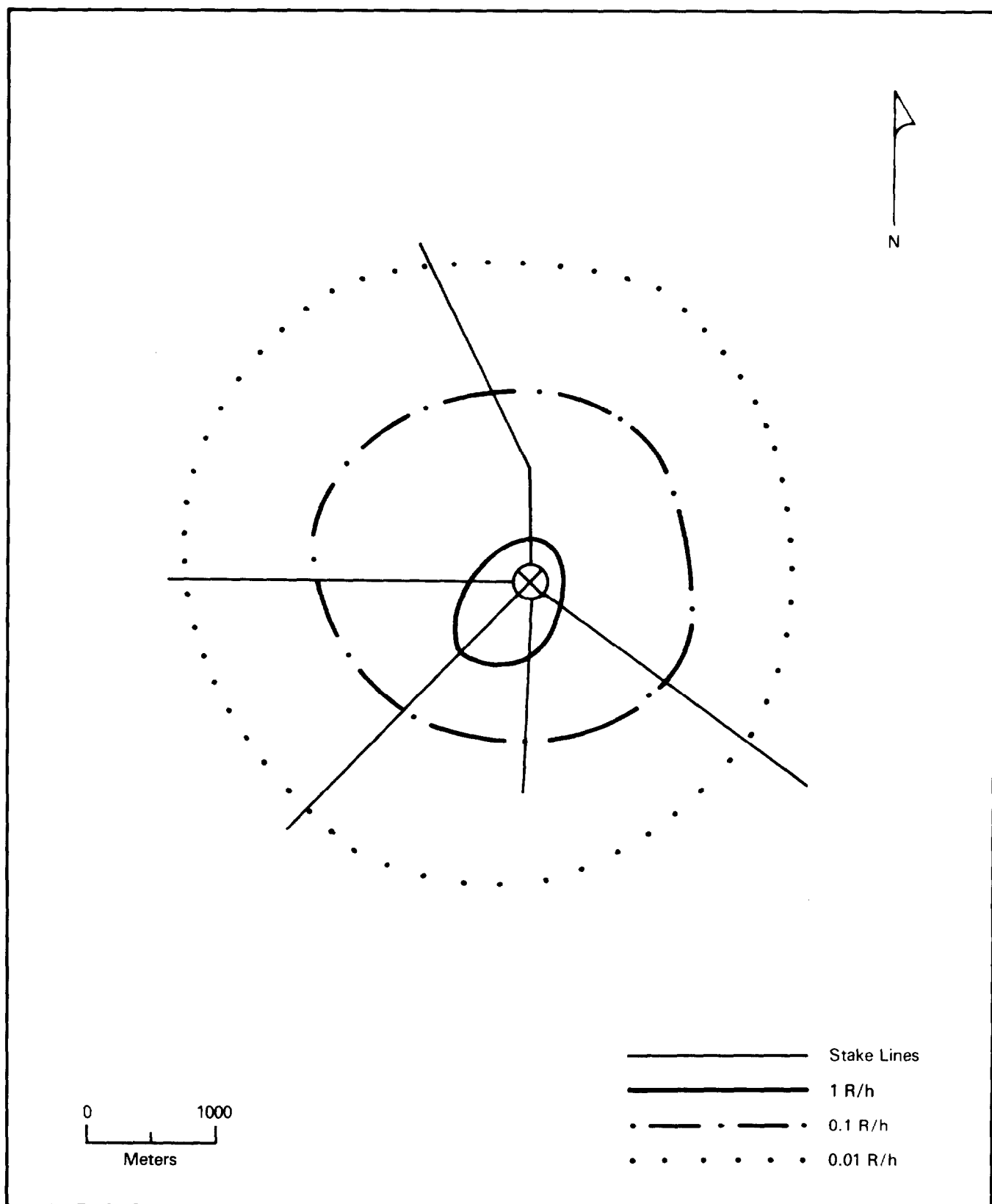
Offsite Monitoring

Four to five hours after the detonation, USPHS personnel conducted monitoring in the offsite areas. They encountered radiation levels slightly above background in areas southwest of ground zero, specifically around Lathrop Wells and Cactus Springs, Nevada (47).

5.3 SHOT TAMALPAIS

Shot TAMALPAIS was detonated with a yield of 0.072 kiloton at 1400 hours PST on 8 October 1958. The device, developed by the University of California Radiation Laboratory, was buried 407 feet underground in a tunnel in the Rainier Mesa of Area 12, at UTM coordinates 709167 (35).

At shot-time, winds on the Rainier Mesa, an area of mountainous terrain, were eight knots from the north at 6,725 feet at the top of the mesa and 15 knots from the west at 7,465 feet. A small amount of venting, a release of radioactive debris



**Figure 5-2: INITIAL SURVEY FOR SHOT MORA, 29 SEPTEMBER 1958,
MID-TIME 0635**

and gas, occurred through the tunnel portal. The vented debris traveled toward the southeast (35).

5.3.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in one experiment conducted by the DOD Effects Test Group. In addition, they took part in two other projects, probably conducted by Headquarters, AFSWP. No DOD participation has been documented in the several UCRL Test Group projects conducted at Shot TAMALPAIS.

DOD Effects Test Group Projects

The one DOD Effects Test Group project involving DOD participation was Project 6.15, Electromagnetic Pulses from Low-yield Bursts. The Signal Research and Development Laboratories conducted the project to detect, record, and analyze the electromagnetic pulse radiating from nuclear detonations. Personnel manned a project station near Boulder City, Nevada, several hours before the burst to prepare instruments, during the burst to detect and record the electromagnetic pulses, and for a few hours afterward to analyze data and turn off equipment (29).

Other Projects

The other two projects involving DOD personnel and probably conducted by Headquarters, AFSWP, were Projects 26.3 and 26.7.

Project 26.3, Earth Motion Measurements, was conducted by the Engineer Research and Development Laboratories to measure strong ground motion in the medium surrounding ground zero. To obtain data, personnel installed two accelerometers and two strain gauges at each of six stations located in the shot area. In addition to installing Project 26.3 instruments, project personnel provided instruments for Project 26.7 (4).

Project 26.7, Structural Response and Permanent Displacement Measurements, was conducted by the Engineer Research and Development Laboratories and the U.S. Coast and Geodetic Survey. The objective was to measure structural response to the detonation. For permanent displacement measurements, points were selected in the tunnel in which Shot TAMALPAIS was detonated. The points were chosen to provide coverage at locations of possible differential movement and to identify permanent effects of the detonation. Surface points were selected to give both overall area coverage and specific coverage at locations where differential movement appeared probable. Personnel conducted both pre- and postshot surveys of the permanent displacement points. The project was done in conjunction with Project 26.3 (53).

Air Force Special Weapons Center Activities

AFSWC did not participate in air support missions at Shot TAMALPAIS since radioactivity was expected to be completely contained. One airborne L-20 aircraft had, however, been placed on standby for a cloud-tracking mission. This mission was not required since only small amounts of radiation vented from the tunnel portal (39; 40).

5.3.2 Radiological Safety Activities

This section presents only the radiological safety information specific to Shot TAMALPAIS. The information common to the HARDTACK II shots is given in chapter 3.

Onsite Monitoring

Four men conducted the initial radiological survey of the tunnel portal and the tunnel. Mid-time for the survey was 1451 hours. The main portal to the tunnel registered a gamma

intensity of 50 R/h. The radiation levels were 1 R/h and 0.1 R/h 15 and 30 meters from the portal, respectively. A resurvey conducted 20 hours after the detonation indicated a maximum of 0.001 R/h at the tunnel portal.

The tunnel was reentered on 9 October. Because the tunnel had been ventilated overnight, relatively low levels of radiation, carbon monoxide, and explosive mixtures were detected. The Deputy Test Manager approved removal of the sandbag barrier to permit recovery operations to begin in the tunnel. At approximately 1650 hours, a mixture of explosive gases behind the sandbags ignited. The resulting explosion propelled six REECO mining personnel and two radiological safety monitors about 60 meters toward the portal and against a blast door. All of the personnel were contaminated, and three required medical attention. Personnel decontamination, medical procedures, and bioassay sample analysis were performed. None of the personnel was exposed above the permissible limit because of the accident. Only low levels of radioactivity were released to the atmosphere as a result of the explosion (60).

Offsite Monitoring

Survey teams monitored offsite areas for radioactivity. They found that radiation levels remained at background levels (47).

5.4 SHOT QUAY

Shot QUAY was fired with a yield of 0.079 kiloton at 0630 hours PST on 10 October 1958. The device, developed by the Los Alamos Scientific Laboratory, was detonated on a 100-foot tower in Area 7 of Yucca Flat, at UTM coordinates 867057 (35).

At shot-time, the temperature was 15 degrees Celsius. Winds were seven knots from the northwest at the surface, 16 knots from

the northeast at 5,000 feet, and 13 knots from the northeast at 10,000 feet. The top of the cloud reached 10,000 feet and moved southwest from the point of detonation (35).

5.4.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in five scientific and diagnostic experiments at Shot QUAY. As indicated in the listing below, four of these experiments were conducted by the DOD Effects Test Group and one by the LASL Test Group:

Project	Title	Fielding Agency
DOD Effects Test Group		
1.7	Airblast Phenomena and Instrumentation of Structures	Ballistic Research Laboratories
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories
8.8	Thermal Radiation from Low-yield Nuclear Bursts	Air Force Cambridge Research Center
LASL Test Group		
11.2	Aircraft Sampling	LASL; AFSWC

DOD Effects Test Group Projects

The following paragraphs discuss the DOD Effects Test Group projects having DOD participation.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories to document blast phenomena resulting from a nuclear detonation and to evaluate the ability of new instruments to measure blast waves. Project personnel installed blast gauges at two stations, one less than one meter and the other 20 meters from ground zero. The day before the detonation, personnel entered the area to make final checks of the instruments. After the detonation, they reentered the shot area to recover records from the stations and to inspect the gauges. They then returned to Camp Mercury to analyze the data (8; 45).

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the operational capabilities of flash-ranging instrumentation.

Project personnel set up flash-ranging equipment 7.5, 17, and 29 kilometers from ground zero in the days preceding the detonation. It is believed, based on information from similar projects, that personnel operated equipment at all three sites through shot-time. Immediately after the detonation, participants took data to a laboratory for analysis (8; 52).

Project personnel also performed photographic missions through shot-time. The detonation was photographed by two participants at Lookout Peak, three participants opposite the Control Point, and four other participants at Mine Mountain (8; 52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from nuclear detonations. As at the other shots, project personnel manned the station near Boulder City, Nevada, several hours before the burst to prepare instruments, during the burst to detect and record the electromagnetic pulse, and for a few hours afterward to analyze the data and turn off equipment (8; 29).

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from low-altitude detonations of low-yield nuclear devices. Project personnel instrumented a trailer, 2.8 kilometers southwest of ground zero, to measure thermal radiation during the shot. Between two and 12 project personnel checked equipment in the trailer several hours before the shot. Personnel occupied the station during the detonation. Immediately after the shock wave passed, they removed data records from the site and returned to Camp Mercury (8; 48).

In addition to conducting the four projects, the DOD Effects Test Group coordinated participation by a detachment from the 1352nd Motion Picture Squadron. This detachment filmed the assembly of the QUAY device and the detonation.

LASL Test Group Projects

The LASL Test Group conducted several projects at Shot QUAY. The only project involving DOD participation was Project 11.2, Aircraft Sampling. The AFSWC 4926th Test Squadron (Sampling) conducted cloud sampling for this project. This activity is discussed in the following section.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, cloud-tracking, and aerial survey missions during Shot QUAY. The following listing indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	4	8
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6
Aerial Survey	H-21	2	8

Four B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fifth B-57B aircraft, with a pilot and a LASL technical advisor, served as a sampler control aircraft. It directed the four sampling aircraft to various sections of the QUAY cloud (39; 40).

A C-47 aircraft, operated by personnel from the 4900th Air Base Group, left Indian Springs AFB to transport samples to Kirtland AFB. The samples were then taken to LASL for analysis (39; 40).

The other participating AFSWC aircraft included a C-47 that conducted a photography mission during the detonation and a cloud-tracking mission out to about 320 kilometers from ground zero after the detonation. In addition, two H-21 helicopters performed aerial surveys after the shot (39; 40).

5.4.2 Radiological Safety Activities

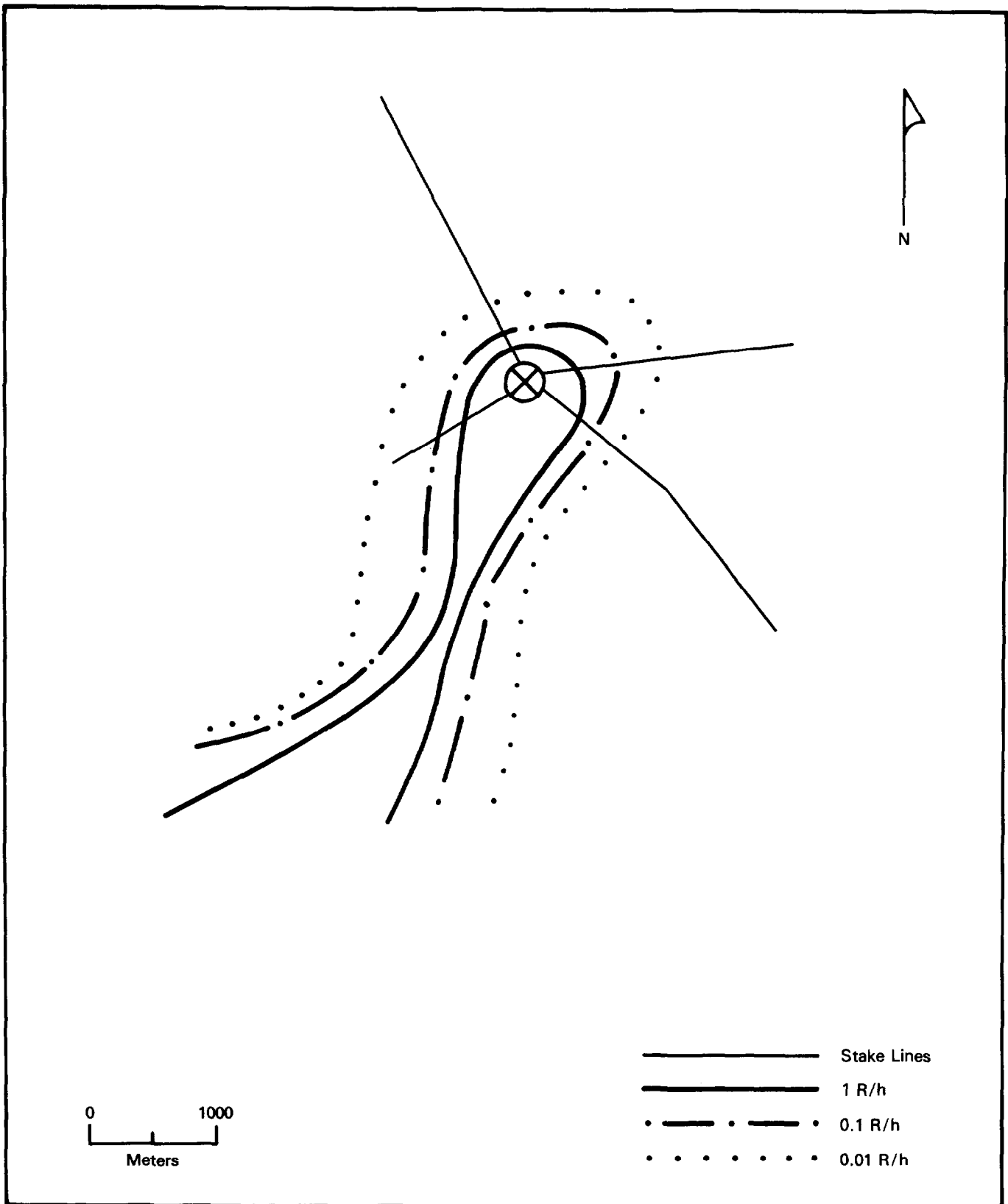
The NTSO and AFSWC radiological safety procedures common to all HARDTACK II shots are discussed in chapter 3. These include procedures for decontaminating personnel and vehicles. This section presents radiological safety information specific to Shot QUAY.

Onsite Monitoring

The initial survey team, consisting of five men in two vehicles, entered the test area shortly after the detonation. Mid-time of the initial survey was 0718 hours. Figure 5-3 presents a copy of the isointensity map generated from this survey (49). The survey team found that gamma intensities of 1 R/h extended about 250 meters north and northeast of ground zero and beyond seven kilometers southwest of ground zero. Radiation levels of 0.01 R/h, detected about 650 meters north of ground zero, continued for a considerable distance to the southwest. A survey conducted six hours later showed radiation intensities of 1 R/h confined to an area mostly south of ground zero, with a "hot" spot of 2.8 R/h detected within the southern end of this area. Parameters of the 0.01 R/h line were similar to those of the initial survey. Two days after the detonation, the 1 R/h area was limited to about 150 meters around ground zero, while the narrow 0.01 R/h area extended more than four kilometers southwest of ground zero (8; 49).

Offsite Monitoring

From two to seven hours after the detonation, USPHS personnel monitored offsite areas. They encountered gamma intensities above background in areas southwest of the test site, particularly around Beatty and Lathrop Wells, Nevada, and Shoshone and Death Valley Junction, California. Gamma intensities at these locations ranged from 0.001 R/h to 0.014 R/h (47).



**Figure 5-3: INITIAL SURVEY FOR SHOT QUAY,
10 OCTOBER 1958, MID-TIME 0718**

5.5 SHOT LEA

Shot LEA was detonated at 0520 hours Pacific Standard Time on 13 October 1958. The device, which had a yield of 1.4 kilotons, was suspended from a balloon 1,500 feet above the ground in Area 7, at UTM coordinates 867047, the same location as Shots EDDY and MORA. LASL developed the LEA device (35).

At shot-time, the temperature was 13.4 degrees Celsius. Winds were light and variable up to 5,000 feet. They were nine knots from the south at 10,000 feet and 13 knots from the north at 20,000 feet. The top of the cloud reached 17,000 feet and moved north from the point of detonation (35).

5.5.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in four scientific and diagnostic experiments, of which three were conducted by the DOD Effects Test Group and one by the LASL Test Group. The following listing identifies these projects:

Project	Title	Fielding Agency
DOD Effects Test Group		
1.7	Airblast Phenomena and Instrumentation of Structures	Ballistic Research Laboratories
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories

Project	Title	Fielding Agency
LASL Test Group		
11.2	Aircraft Sampling	LASL; AFSWC

DOD Effects Test Group Projects

The following paragraphs present the available information on the DOD Effects Test Group projects with DOD participation.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories to document blast phenomena resulting from a nuclear detonation and to evaluate new blast instruments. Project personnel installed blast gauges at two stations approximately 60 and 90 meters from ground zero in the days preceding the detonation. During the day before the detonation, personnel entered the area to make final checks of instruments. After the detonation, they reentered the shot area to recover records from the stations and inspect the gauges. They then returned to Camp Mercury to analyze the data (10; 45).

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the operational capabilities of flash-ranging instrumentation.

Project personnel set up flash-ranging equipment 12.8, 17, 29, and 97 kilometers from ground zero in the days preceding the detonation. Personnel probably operated equipment at all four sites through shot-time (10; 52). Project participants also

conducted photographic missions at shot-time from various locations onsite and offsite: four project personnel were on Lookout Peak, two other participants were at Angels' Peak, and three more participants were at Mine Mountain.

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories. The objective was to detect, record, and analyze the electromagnetic pulse radiating from nuclear detonations. Project personnel were at the station near Boulder City, Nevada, several hours before the burst to prepare instruments, during the burst to detect and record the electromagnetic pulse, and for a few hours afterward to analyze the data and turn off equipment (10; 29).

LASL Test Group Projects

The LASL Test Group conducted several projects at Shot LEA. Only Project 11.2, Aircraft Sampling, involved DOD participation, which was by the AFSWC 4926th Test Squadron (Sampling). The squadron conducted cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot LEA. The following listing indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	4	8
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6
	T-33	1	2

Four B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. One B-57B sampler aircraft had engine trouble and was replaced by another B-57B. A fifth B-57B aircraft, with a pilot and a LASL technical advisor, acted as a sampler control aircraft, directing the sampling aircraft to various sections of the LEA cloud (39; 40).

A C-47 aircraft, with a crew from the 4900th Air Base Group, transported sample filter papers from Indian Springs AFB to Kirtland AFB. The samples were then taken to LASL for analysis (39; 40).

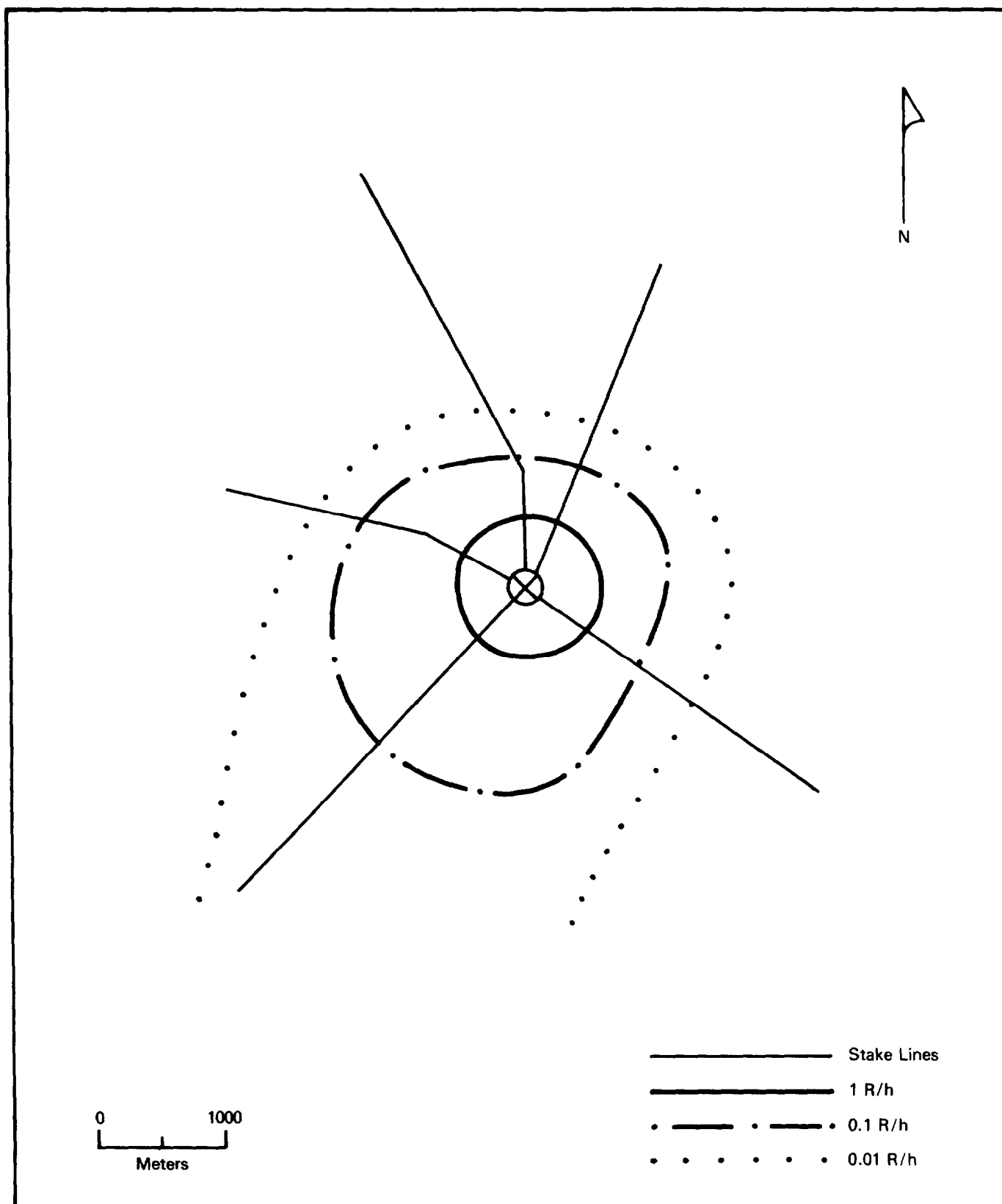
A C-47 and a T-33 aircraft conducted a cloud-tracking mission out to about 320 kilometers from ground zero. Three H-21 aerial survey helicopters were also scheduled for participation at LEA, but their mission was canceled two days before the detonation. However, one H-21 helicopter flew a support mission two days before the detonation. Another H-21 was scheduled to perform a mission the day after the shot (39; 40).

5.5.2 Radiological Safety Activities

This section presents radiological safety information specific to Shot LEA. Information on radiological protection procedures common to all HARDTACK II shots is given in chapter 3.

Onsite Monitoring

The initial survey team, consisting of 11 men in nine vehicles, entered the test area shortly after the detonation. Mid-time of the initial survey was 0552. Figure 5-4 shows a copy of the isointensity map generated from this survey (49). As found during the survey, gamma intensities of 1 R/h were confined to within about 600 meters of ground zero. At distances of 1,000 meters to the north and 1,800 meters to the southwest, radiation



**Figure 5-4: INITIAL SURVEY FOR SHOT LEA,
13 OCTOBER 1958, MID-TIME 0552**

1

levels decreased to 0.1 R/h. Radiation readings of 0.01 R/h were found about 1,500 to 1,800 meters from ground zero in all directions except southwest, where the 0.01 R/h line extended more than three kilometers. A resurvey conducted six hours after the detonation indicated that the 0.1 R/h and 0.01 R/h radiation lines had contracted to within 1,000 meters and 1,500 meters of ground zero, respectively. Radiation intensities of 1 R/h were still within about 600 meters of ground zero. After two days, radiation levels of 1 R/h were not encountered, and the 0.1 R/h and 0.01 R/h lines were limited to within 400 meters and 1,000 meters of ground zero, respectively (10; 49).

Offsite Monitoring

From seven to 32 hours after the detonation, USPHS personnel monitored offsite areas. They encountered gamma intensities above background in areas north of the NTS, particularly around Standard, Reed, and Cliff Springs, Nevada. Gamma intensities at these locations ranged from 0.001 R/h to 0.003 R/h (47).

5.6 SHOT HAMILTON

Shot HAMILTON was fired at 0800 hours PST on 15 October 1958. The device, which had a yield of 0.0012 kiloton, was detonated on a 50-foot wooden tower in Frenchman Flat, at UTM coordinates 952732. UCRL developed the device. The detonation was a joint UCRL-DOD weapons development and effects test and involved more DOD Effects Test Group projects than any other shot of Operation HARDTACK II (35).

At shot-time, the temperature was 15.7 degrees Celsius. The winds were light and variable up to 6,000 feet. The top of the cloud reached an altitude of 6,000 feet and moved southwest from the point of detonation (35).

5.6.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in 12 scientific and diagnostic experiments, 11 of which were conducted by the DOD Effects Test Group and one by the UCRL Test Group. Table 5-1 identifies these projects.

Table 5-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT HAMILTON

Project	Title	Fielding Agency
DOD Effects Test Group		
1.7	Airblast Phenomena and Instrumentation of Structures	Ballistic Research Laboratories
2.12a	Neutron Flux from Very-low-yield Bursts	Chemical Warfare Laboratories
2.12b	Gamma Dose from Very-low-yield Bursts	Army Chemical Warfare Laboratories; Army Chemical Corps Training Command
2.12c	Soil Activation by Neutrons from Very-low-yield Bursts	Army Chemical Warfare Laboratories; Army Chemical Center
2.12d	Thermal Radiation from Very-low-yield Bursts	Chemical Warfare Laboratories
2.13	Gamma Radiation and Induced Activity from Very-low-yield Bursts	AFSWC
4.2	Effects of Very-low-yield Bursts on Biological Specimens (Mice and Swine)	Walter Reed Army Institute of Research
4.3	Effects of Light from Very-low-yield Nuclear Detonations on Vision (Dazzle) of Combat Personnel	Headquarters, Continental Army Command
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories
8.8	Thermal Radiation from Low-yield Nuclear Bursts	Air Force Cambridge Research Center
UCRL Effects Test Group		
21.2	Radiochemical Sampling	UCRL; AFSWC

DOD Effects Test Group Projects

This section presents information on the DOD Effects Test Group projects involving DOD personnel at Shot HAMILTON.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories to document blast phenomena resulting from a nuclear detonation and to evaluate blast instruments. An estimated four Ballistic Research Laboratories personnel took part in the project. Participants installed blast gauges at 29 stations approximately ten to 3,050 meters from ground zero. At 2200 hours on the day preceding the detonation, personnel entered the area to make final checks of instruments. After the detonation, they reentered the shot area to recover records from the stations and to inspect the gauges. They then returned to Camp Mercury to analyze the data (9; 45). To obtain information on blast damage effects, personnel placed jeeps, M48 tanks, and M59 armored personnel carriers at distances ranging between 20 and 90 meters to the northwest and southeast of ground zero. Participants entered the area after the detonation to inspect the vehicles and photograph the damage (45).

Project 2.12a, Neutron Flux from Very-low-yield Bursts, was conducted by the Chemical Warfare Laboratories to:

- Measure neutron flux and dose at various distances from ground zero
- Measure neutron, thermal, and gamma radiation up to an altitude of 1,500 feet
- Provide dose measurements in support of Project 4.2
- Determine neutron flux and spectrum for induced activity studies in support of Project 2.12c.

Project personnel installed threshold detectors and chemical dosimeters along two cable lines running southeast and northwest of ground zero. The closest detector was about 30 meters and the

farthest about 870 meters from ground zero. After the detonation, personnel in a five-ton truck recovered the detectors and dosimeters by attaching the cable to the truck and pulling it away from ground zero. The detectors were then removed from the cable and taken for analysis to a mobile laboratory trailer in the forward area. Personnel spent approximately 30 minutes retrieving detectors (9; 51).

In support of Project 4.2, personnel placed additional detectors in open foxholes, two-thirds covered foxholes, M-48 tanks, and armored personnel carriers northwest and southeast of ground zero. Project 4.2 personnel recovered the detectors shortly after the detonation. These devices were then returned to the Chemical Warfare Laboratories for analysis (9; 46; 51).

Project 2.12b, Gamma Dose from Very-low-yield Bursts, was conducted by the Chemical Warfare Laboratories and the Chemical Corps Training Command. The objectives were to:

- Provide gamma dose measurements in support of Project 4.2
- Record the initial gamma dose in relation to distances from ground zero
- Record residual radiation intensities
- Determine the field gamma decay rate.

Several days before the shot, project personnel installed film badges and other instruments for measuring gamma dose on quick-recovery racks and stakes at distances out to approximately 730 meters from ground zero. They also placed 96 film badges on stakes placed on 12 radial lines out from ground zero at 90-meter intervals, at distances approximately 90 to 730 meters from ground zero. In addition, in support of Project 4.2, personnel installed 147 film badges in numerous foxholes and vehicles located between five and 70 meters north and south of ground zero (9; 44; 46). Air Force personnel from the 1352nd Motion Picture

Squadron photographed the installation of gamma-measuring instruments. Project participants then made final checks of instruments three hours before the detonation. Participants recovered the film dosimeters within 24 hours after the detonation. The dosimeters were sent to the Army Signal Research and Development Laboratories for development and interpretation.

To record residual radiation intensities, personnel of the Army Chemical Corps Training Command, Fort McClellan, Alabama, performed gamma field surveys to delineate the 10 R/h contour 15 minutes after the detonation and to detect any isolated 10 R/h "hot" spots. Immediately after passage of the blast wave, four two-man monitoring teams moved into the shot area. Traveling by jeep, one team surveyed the general outlying area around ground zero, particularly in the direction the cloud moved. The other three teams began immediate surveys along the 12 film badge stake lines. These teams recorded the location of the 10 R/h point on each stake line by dropping markers and then measuring the dose rate at each stake outside the 10 R/h line. This procedure was repeated on subsequent surveys, with readings taken at each point where 10 R/h had been noted previously. The three teams conducted the surveys two hours, six hours, one day, two days, and three days after the detonation. On the day after the detonation, project personnel also surveyed alpha activity along the film badge stake lines (9; 44; 46).

Project 2.12c, Soil Activation by Neutrons from Very-low-yield Bursts, was conducted by the Chemical Warfare Laboratories and the Army Chemical Center. The objectives were to:

- Obtain data on the neutron-induced gamma field produced by a very-low-yield nuclear burst detonated on a 50-foot wooden tower
- Determine factors relating the gamma dose rates measured over this neutron-induced field with dose-rate measurements made over small samples of the same activated soil.

Before the detonation, project personnel placed 12 soil samples in steel pipe containers and connected them to the cable used in Project 2.12a. The cable was placed so that one end was about 20 meters from ground zero and the other end extended 160 meters northwest of ground zero. A detachment from the 1352nd Motion Picture Squadron photographed preshot preparation.

Within five minutes after the detonation, a Project 2.12a recovery team proceeded in a truck to the end of the cable farthest from ground zero. They then dragged the cable to a more distant area and disconnected the soil samples attached to the cable. Project personnel then monitored most of the samples with survey meters to determine neutron and gamma soil activation.

Eight minutes after the detonation, participants took a survey meter and recorder to the 10 R/h line about 50 meters north-northwest of ground zero. Eleven minutes after the detonation, participants transported another recording gamma survey meter, mounted on two trucks, to a station some 60 meters from ground zero. Project personnel had planned to make a gamma dose rate survey by helicopter at the two survey locations ten minutes after the detonation. They did not, however, conduct the helicopter surveys. Ground survey parties entered the shot area shortly after the detonation and surveyed the area at various times for several days after the detonation (9; 61).

Project 2.12d, Thermal Radiation from Very-low-yield Bursts, was conducted by the Chemical Warfare Laboratories to determine the thermal radiant exposure value for a very-low-yield nuclear device and to compare this value with theoretical results obtained from existing scaling laws. Several days before the detonation, project personnel installed instruments to measure thermal exposure at eight ground stations 50 to 210 meters northwest of ground zero. A short time after the detonation, project personnel recovered the data (9; 43).

Project 2.13, Gamma Radiation and Induced Activity from Very-low-yield Bursts, was conducted by AFSWC to measure:

- Initial gamma dose rate
- Total initial gamma dose
- Total neutron dose in low dose regions
- The rate of induced activity decay in the soil.

A secondary objective was to field-test a new model of the standard Air Force fallout detector.

Project personnel installed gamma and neutron detectors and measuring devices along two lines oriented at approximately right angles from one another. One line, used also for Projects 2.12a and 2.12c, was oriented northwest of ground zero. In the days prior to the nuclear test, personnel installed film badges inside 3-inch steel pipes and attached these pipes to this cable. The second instrument line was oriented north-northeast of ground zero. Personnel installed film badges and other detectors on stakes driven into the ground at ranges of 270 to 1,460 meters from ground zero. They left the area about two and one-half hours before the detonation. A detachment from the 1352nd Motion Picture Squadron photographed preshot activities in the test area.

Within five minutes after the detonation, Project 2.12 personnel returned to the shot area by truck to the instrument line oriented northwest of ground zero to drag the cable to a recovery area. Once in the recovery area, the pipes were disconnected from the cable and the film badges removed and sent to the laboratory for processing and interpretation. Project personnel recovered all other film badges and associated instruments between seven minutes and two and one-half hours after the detonation (9; 36; 51).

Project 4.2, Effects of Very-low-yield Bursts on Biological Specimens (Mice and Swine), was conducted by the Walter Reed Army Institute of Research. The objective was to evaluate the effects of nuclear radiation on the animals in an attempt to define more specifically the effects on humans. Five hours before the detonation, project personnel placed several dozen mice and about 500 pigs in foxholes, tanks, aluminum containers, and armored personnel carriers located five to 730 meters north, south, and west of ground zero. Two minutes after the detonation, two teams of project personnel entered the shot area from the north and the south to make initial animal observations. Participants recovered the animals when the radiation survey indicated that the majority of animals in the exposure array were outside the 3 R/h radiation intensity line. A camera crew, consisting of three personnel from the 1352nd Motion Picture Squadron, photographed the recovery of the animals, which were sent to the animal-holding facility on the southern rim of Frenchman Flat for analysis. Three days after the detonation, 1352nd personnel photographed the ground zero area and the instrument array (3; 9; 46).

Project 4.3, Effects of Light from Very-low-yield Nuclear Detonations on Vision (Dazzle) of Combat Personnel, was conducted by Headquarters, Continental Army Command. The purpose was to evaluate the dazzle effect on front line combat personnel stationed at a minimum safe distance from a detonation. This information would be used in developing operational guidance for tactical commanders. Thirty-six Army and Marine Corps officers from various units, schools, and installations were selected for this project. However, only 25 participated because 11 officers had to return to home bases before the shot. The officers were divided into three groups, each stationed approximately 1,740 meters from ground zero at azimuths of 90, 135, and 180 degrees (9; 58).

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the operational capabilities of flash-ranging instrumentation. Before the detonation, project personnel set up flash-ranging equipment at three sites seven, 15, and 22 kilometers from the HAMILTON ground zero. Although no documentation has been found describing the activities of personnel at this project, it is believed, based on data from similar projects, that participants operated equipment at these sites through shot-time. Immediately after the detonation, data were taken to the laboratory for analysis (9; 52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from nuclear detonations. As at the other shots at which Project 6.15 was conducted, project personnel began operating the station at Boulder City, Nevada, several hours before the burst to prepare the instrumentation. They continued operating the station during the burst to detect and record the electromagnetic pulse and for a few hours afterward to analyze the data and turn off equipment (9; 29).

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low nuclear yield. An instrument station about one kilometer west of ground zero was used to measure thermal radiation from the detonation. Project personnel left the station before the shot and returned immediately after the shock wave passed to remove data records. During the shot, two project personnel operated instruments at a trailer about two kilometers west of ground zero (48).

Besides conducting the 11 projects, the DOD Effects Test Group coordinated participation of three camera crews, each consisting of an estimated two personnel from the 1352nd Motion Picture Squadron. The camera crews photographed the detonation from a ground position and in the air. One crew was at a station 1.6 kilometers from ground zero. Another was aboard a C-47 aircraft at a slant range of 6.4 kilometers from ground zero. The third crew was in a helicopter at a slant range of 13 kilometers from ground zero (3; 39; 40).

UCRL Test Group Projects

The UCRL Test Group conducted several projects at Shot HAMILTON. The only project involving DOD participation was Project 21.2, Radiochemical Sampling. The AFSWC 4926th Test Squadron (Sampling) conducted cloud sampling for this project, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, cloud-tracking, and aerial survey missions during Shot HAMILTON. The following listing indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	4	8
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6
Aerial Survey	H-21	2	8

Four B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 21.2, Radiochemical Sampling. A fifth B-57B aircraft, with a pilot and a UCRL technical advisor, served as a sampler control aircraft, directing the cloud-sampling aircraft to various sections of the cloud (39; 40).

A C-47 aircraft, with a crew of three from the 4900th Air Base Group, transported the samples from Indian Springs AFB to Alameda Naval Air Station. UCRL personnel then transported the samples to the laboratory for analysis (39; 40).

One C-47 aircraft performed both a cloud-tracking mission out to about 320 kilometers from ground zero and a photography mission. A T-33 aircraft was also scheduled to perform cloud tracking but was not needed (39; 40).

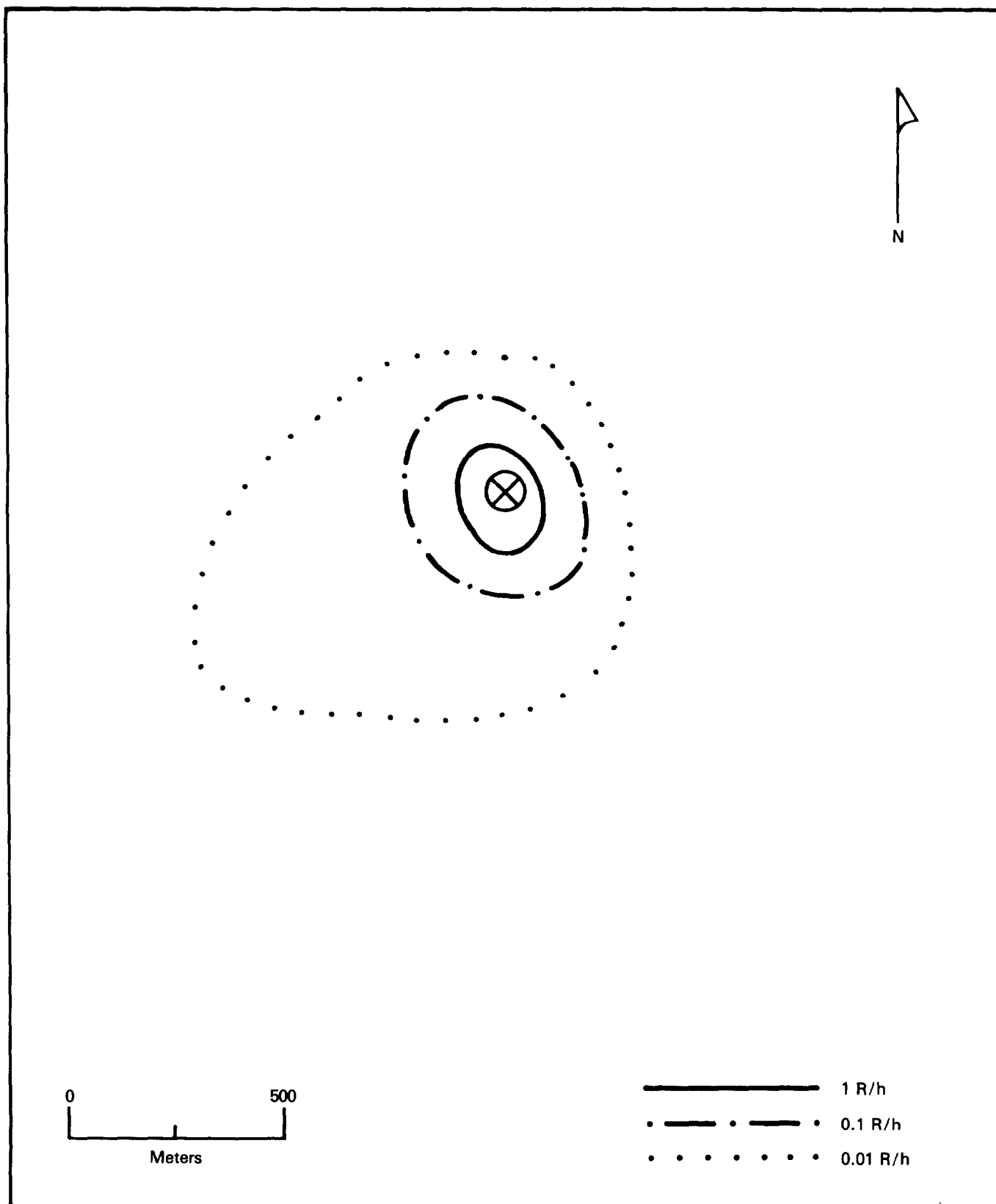
In addition to the other AFSWC aircraft, an L-20 was scheduled for a flight during this period (39; 40).

5.6.2 Radiological Safety Activities

The NTSO and AFSWC radiological safety procedures common to all HARDTACK II shots, such as decontamination procedures, are discussed in chapter 3. The following paragraphs present information on radiological protection specific to Shot HAMILTON.

Onsite Monitoring

The initial survey team, consisting of 16 men in eight vehicles, entered the test area shortly after the detonation. Mid-time of the initial survey was 0919. Figure 5-5 shows a copy of the isointensity map resulting from the initial survey (49). The survey team encountered gamma intensities of 1 R/h within about 140 meters of ground zero except to the east, where they took readings of 1 R/h within 110 meters of ground zero. At



**Figure 5-5: INITIAL SURVEY FOR SHOT HAMILTON, 15 OCTOBER 1958,
MID-TIME 0919**

300 meters, they detected radiation levels of 0.1 R/h. The team took radiation readings of 0.01 R/h within about 450 meters of ground zero except to the southwest, where the 0.01 R/h line extended to about 800 meters. Six hours later, the radiation level near ground zero had decreased to 1 R/h, while readings of 0.01 R/h were confined to a radius of 240 meters from ground zero. Results of subsequent surveys are not available (9; 49).

Alpha radiation was detected in the test area after the detonation. Readings of 20,000 counts per minute were registered at ground zero and 1,500 counts per minute at about 850 meters southwest of ground zero.

Offsite Monitoring

From three to seven hours after the detonation, USPHS personnel monitored offsite areas. Gamma intensities ranging from background levels to 0.021 R/h were encountered in areas southwest of ground zero. Readings of 0.002 R/h were registered 19 kilometers southwest of ground zero. Higher readings of 0.021 R/h were found outside Camp Mercury (35; 47).

5.7 SHOT LOGAN

Shot LOGAN was detonated at 2200 hours PST on 16 October 1958 with a yield of five kilotons. The shot was originally scheduled for 1600 hours, but because of technical difficulties, it was postponed until 2200. The device, developed by UCRL, was detonated in a tunnel 932 feet under the surface of Rainier Mesa in Area 12, at UTM coordinates 709154 (35).

At shot-time, the temperature at the Yucca Flat weather station was 12.8 degrees Celsius, and the surface winds were from the southeast at four knots. The LOGAN detonation was completely contained and, therefore, no radiation from this test was released into the atmosphere (35).

5.7.1 Department of Defense Participation in Scientific and Support Activities

At Shot LOGAN, DOD personnel took part in one project conducted by the DOD Effects Test Group and one project that was probably conducted by Headquarters, AFSWP. The UCRL Test Group also conducted several projects, but none of them had DOD participation.

DOD Effects Test Group Projects

The one DOD Effects Test Group project with DOD participation was Project 6.15, Electromagnetic Pulses from Low-yield Bursts. Conducted by the Signal Research and Development Laboratories, the project was designed to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. Project personnel were at the station in Boulder City, Nevada, several hours before the burst to prepare the instruments, during the burst to detect and record the electromagnetic pulse, and for a few hours afterward to analyze the data and turn off equipment (12; 29).

Other Project

The additional project involving DOD personnel and probably conducted by Headquarters, AFSWP, was Project 26.7, Structural Response and Permanent Displacement Measurements. This project was conducted by the Engineer Research and Development Laboratories and the U.S. Coast and Geodetic Survey. The objective was to measure structural response to the detonation. For permanent displacement measurements, points were selected in the tunnel in which Shot LOGAN was detonated. The points were chosen to provide coverage at locations of possible differential movement and to identify permanent effects of the detonation. Surface points were selected to give both overall area coverage and specific coverage at locations where differential movement appeared probable. Personnel conducted both pre- and postshot surveys of the permanent displacement points (53).

Air Force Special Weapons Center Activities

AFSWC personnel did not conduct any of the customary air support missions, such as cloud sampling and cloud tracking, because all the radiation was contained underground. Only a C-47 aircraft provided support to the Test Manager by dropping flares over the ground zero area before the detonation to provide light for night photography (39; 40).

5.7.2 Radiological Safety Activities

The following paragraphs present information on radiological safety procedures specific to Shot LOGAN. Chapter 3 presents radiological safety information common to the HARDTACK II shots.

Onsite Monitoring

Ten men, traveling in six vehicles, conducted a radiological survey of the area around the portal of the tunnel in which LOGAN was detonated. They encountered no radioactivity outside the tunnel. Thus, no isointensity maps of this survey were prepared. Offsite monitoring capability was available, but surveys were not required (12; 49).

5.8 SHOT DONA ANA

Shot DONA ANA was detonated at 0620 hours PST on 16 October 1958 with a yield of 0.037 kiloton. The device, developed by LASL, was suspended from a balloon 450 feet above the ground in Area 7, at UTM coordinates 867047. The DONA ANA device was detonated at the same location as Shots EDDY, MORA, and LEA (35).

At shot-time, the temperature was 13.7 degrees Celsius, and the surface winds were light and variable. Winds were eight knots from the north-northeast at 5,000 feet and six knots from the southeast at 10,000 feet. The cloud reached a height of

11,000 feet. Low-level fallout was detected to the southwest of the point of detonation (35).

5.8.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in three scientific and diagnostic experiments conducted by the DOD Effects Test Group and the LASL Test Group at Shot DONA ANA.

DOD Effects Test Group Projects

The DOD Effects Test Group conducted two projects.

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board to evaluate the operational capabilities of flash-ranging instrumentation. Before the detonation, project personnel set up flash-ranging equipment at three sites. Two individuals operated the camera equipment station on Lookout Peak, 29 kilometers from ground zero. Three more individuals manned a station opposite the Control Point, 17 kilometers away, and four personnel were on Mine Mountain, 15 kilometers from ground zero. All personnel were to remain at the stations from four hours before the detonation through shot-time (13; 52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories. The project was to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. Project personnel manned a station at Boulder City, Nevada, several hours before the burst to prepare the instruments. They remained at the station during the burst to detect and record the electromagnetic pulse and for a few hours afterward to analyze the data and turn off equipment (13; 29).

LASL Test Group Projects

The LASL Test Group conducted several projects at Shot DONA ANA. However, only Project 11.2, Aircraft Sampling, involved DOD participation. The AFSWC 4926th Test Squadron (Sampling) conducted cloud sampling in support of this project. Cloud sampling is discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot DONA ANA. The following indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	3	6
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6

Three B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fourth B-57B aircraft, with a pilot and a LASL technical advisor, acted as a sampler control aircraft directing the three cloud-sampling aircraft to various sections of the DONA ANA cloud. Another aircraft mission was canceled before takeoff (39; 40).

A C-47 courier aircraft, with a crew from the 4900th Air Base Group, delivered the samples from Indian Springs AFB to

Kirtland AFB. The samples were then transported to LASL for analysis (39; 40).

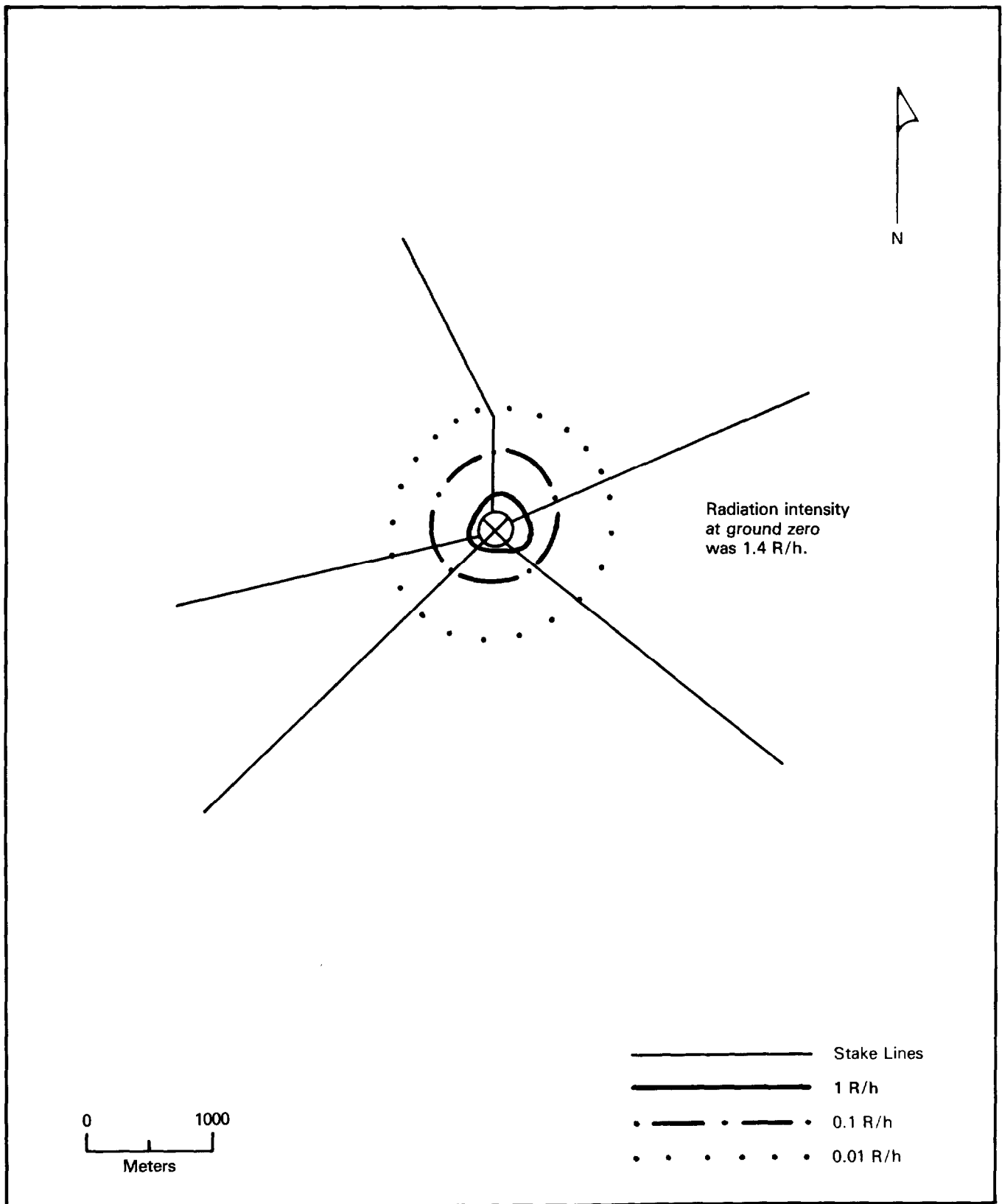
One C-47 aircraft performed a cloud-tracking mission out to about 320 kilometers from ground zero. A second C-47 and two T-33 cloud-tracking aircraft were on standby after the detonation but were not needed (39; 40).

5.8.2 Radiological Safety Activities

Radiological safety procedures common to all Operation HARDTACK II shots are described in chapter 3. The following paragraphs present information on radiological safety procedures specific to Shot DONA ANA.

Onsite Monitoring

The initial survey team, consisting of 11 men in nine vehicles, entered the test area shortly after the detonation to survey the shot area. Mid-time of the initial survey was 0653. Figure 5-6 shows a copy of the isointensity map generated from the initial survey (49). The survey team encountered gamma intensities of 1 R/h within a radius of about 150 meters from ground zero. At distances of 730 meters and 1,050 meters, the team found that radiation levels decreased to 0.1 R/h and 0.01 R/h, respectively. A survey conducted eight hours later showed that radiation intensities within 250 meters of ground zero decreased to 0.1 R/h. The same survey revealed gamma intensities of 0.01 R/h at a distance of 730 meters from ground zero. Twenty-four hours after the detonation, the 0.01 R/h line was 580 meters from ground zero. The 0.1 R/h line was at 290 meters, a greater distance from ground zero than on the previous day. The probable reason is that radioactive earth had been bulldozed away from ground zero to begin preparation for Shot SOCORRO, scheduled for six days later (13; 49).



**Figure 5-6: INITIAL SURVEY FOR SHOT DONA ANA,
16 OCTOBER 1958, MID-TIME 0653**

Offsite Monitoring

From three to five hours after the detonation, USPHS personnel monitored offsite areas. They encountered gamma intensities of about 0.0002 R/h in areas southwest of the NTS, particularly around Lathrop Wells, Nevada (47).

5.9 SHOT RIO ARRIBA

Shot RIO ARRIBA, fired at 0625 hours PST on 18 October 1958, had a yield of 0.090 kiloton. Developed by LASL, the device was detonated on a 72.5-foot tower in Area 3 of Yucca Flat, at UTM coordinates 867996 (35).

At shot-time, the temperature was 9.3 degrees Celsius, and the surface winds were light from the south. Winds were eight knots from the south at 5,000 feet and 30 knots from the southwest at 10,000 feet. The cloud reached 13,500 feet and moved north-northeast from the point of detonation (35).

5.9.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in four scientific and diagnostic experiments conducted at Shot RIO ARRIBA by the DOD Effects Test Group and the LASL Test Group, as indicated by the following listing:

Project	Title	Fielding Agency
DOD Effects Test Group		
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories
8.8	Thermal Radiation from Low-yield Nuclear Bursts	Air Force Cambridge Research Center
LASL Test Group		
11.2	Aircraft Sampling	LASL; AFSWC

DOD Effects Test Group Projects

The DOD Effects Test Group conducted three projects at Shot RIO ARRIBA.

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the operational capabilities of flash-ranging instrumentation. In the days before the detonation, project personnel set up flash-ranging equipment at two sites located 3.6 kilometers from ground zero at the BUSTER-JANGLE Y (BJY) and 11 kilometers from ground zero near the base of a mountain west of the BJY. During the detonation, three project personnel operated instruments at the BJY location, and four persons were at the site west of the

BJY. Immediately after the detonation, participants took records to the laboratory for analysis (15; 52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. Personnel operated the station at Boulder City, Nevada, for several hours before the burst to prepare instruments, during the burst to detect and record the electromagnetic pulse, and for a few hours afterward to analyze the data and turn off equipment (15; 29).

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low yield. Two project personnel operated instruments to measure thermal radiation through shot-time in a trailer located about three kilometers northwest of ground zero, near the BJY. Immediately after the shock wave passed, the participants took data records from the site and immediately returned to Camp Mercury (15). Concurrently, two project personnel operated instruments at Building 400, near the Control Point, about 12 kilometers south-southwest of ground zero (15; 48).

LASL Test Group Projects

Among the several LASL Test Group projects conducted at Shot RIO ARRIBA, only Project 11.2, Aircraft Sampling, involved DOD participation. The AFSWC 4926th Test Squadron (Sampling) conducted cloud sampling, discussed below, in support of this project.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions for Shot RIO ARRIBA. The following

listing indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	3	6
Sample Courier	C-47	1	3
Cloud Tracking	B-25	1	6
	L-20	1	2

Three B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fourth B-57B aircraft, with a pilot and a LASL technical advisor, performed as a sampler control aircraft, directing the three sampling aircraft to various sections of the cloud (39; 40). A C-47 aircraft, operated by personnel from the 4900th Air Base Group, transported the samples from Indian Springs AFB to Kirtland AFB, from where the samples were then transported to LASL for analysis (36; 37). One B-25 aircraft and one L-20 aircraft performed cloud-tracking missions out to about 320 kilometers from ground zero. A cloud-tracking mission by a T-33 aircraft was apparently canceled before takeoff. No other information is known concerning cloud-tracking activities at this shot (39; 40).

5.9.2 Radiological Safety Activities

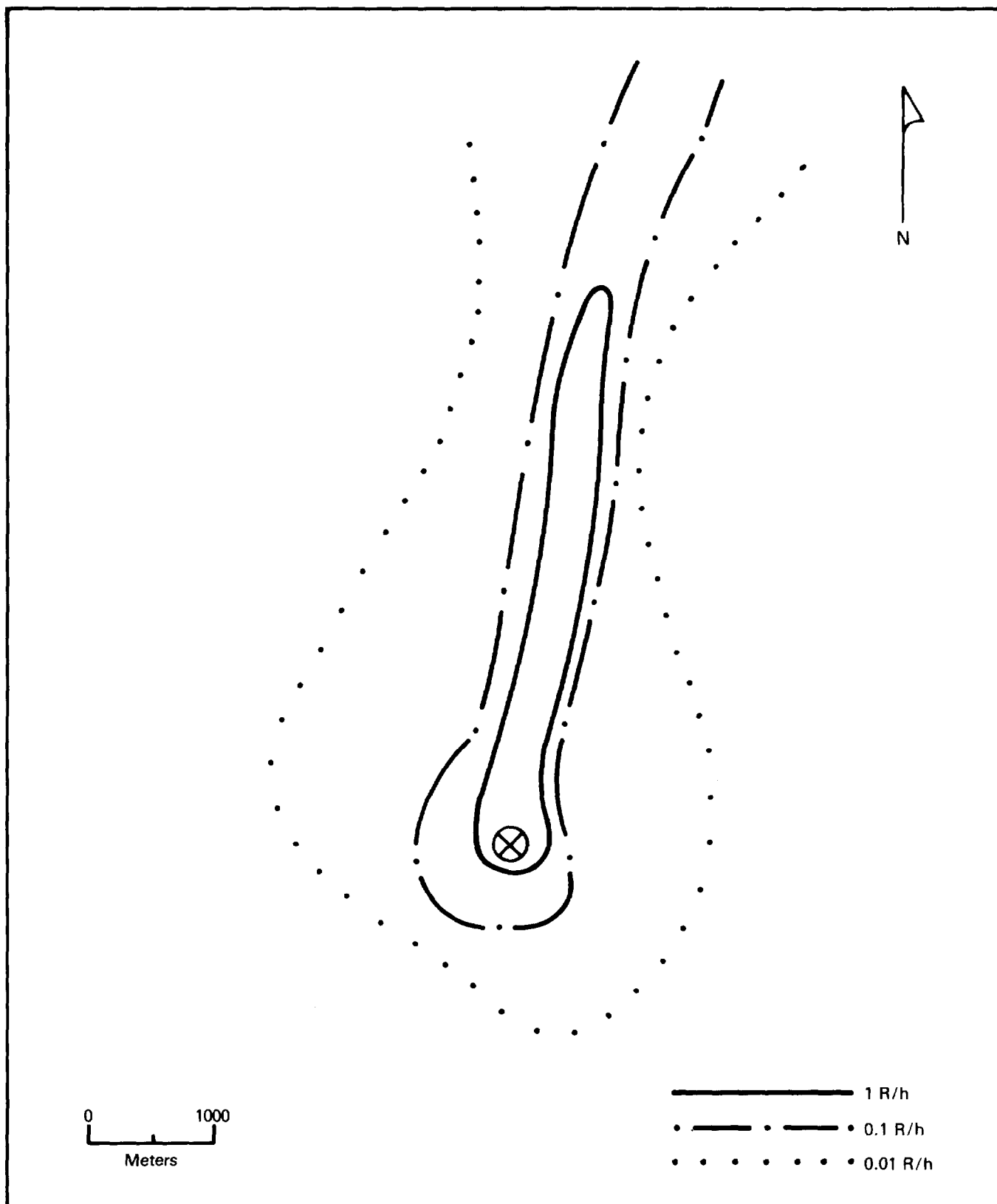
The following paragraphs present radiological safety information specific to Shot RIO ARRIBA. Chapter 3 presents information on radiological protection common to the HARDTACK II shots.

Onsite Monitoring

The initial survey team, consisting of ten men in eight vehicles, entered the test area shortly after the detonation to survey the shot area. Mid-time of the initial survey was 0710. Figure 5-7 shows a copy of the isointensity map generated from this survey (49). The radioactivity from the detonation extended for a considerable distance to the north. Gamma intensities of 1 R/h were within about 300 meters of ground zero except to the north, where the 1 R/h line extended for more than four kilometers. Radiation levels of 0.1 R/h were encountered within 700 meters of ground zero, and they extended to the north for more than six kilometers. In directions other than to the north, the 0.01 R/h area was confined to within 2,000 meters of ground zero. To the north, the 0.01 R/h area extended about 100 kilometers offsite. A resurvey conducted six hours later indicated that radiation areas had contracted around ground zero but still extended for a considerable distance to the north. Two days after the detonation, gamma readings of 1 R/h were found only within 70 to 150 meters from ground zero. Radiation levels of 0.1 R/h extended north about 600 meters and in all other directions to within 140 meters. Readings of 0.01 R/h were confined to an area within 210 meters of ground zero with a narrow extension continuing north for about 2.5 kilometers (35).

Offsite Monitoring

From one to nine hours after the detonation, USPHS personnel conducted offsite monitoring. They encountered gamma intensities above background in areas at the northern boundary of the NTS, particularly outside of Gate 385 and around Groom Lake and Oak Spring Butte. Gamma intensities outside of Gate 385 ranged from 0.009 R/h to 0.046 R/h. In the areas of Groom Lake and Oak Spring Butte, readings as high as 0.12 R/h were registered, but most readings ranged from 0.013 R/h to 0.04 R/h (47).



**Figure 5-7: INITIAL SURVEY FOR SHOT RIO ARRIBA,
18 OCTOBER 1958, MID-TIME 0710**

5.10 SHOT SOCORRO

Shot SOCORRO was detonated at 0530 hours PST on 22 October 1958 with a yield of six kilotons. The device was suspended from a balloon 1,450 feet above the ground in Area 7, at UTM coordinates 867047, the same location as Shots EDDY, MORA, LEA, and DONA ANA. LASL developed the SOCORRO device (35).

At shot-time, the temperature was 4.7 degrees Celsius, and the winds were light and variable up to 5,000 feet. Winds were 13 knots from the south at 10,000 feet and 22 knots from the southwest at 25,000 feet. The cloud reached a height of 26,000 feet and moved northeast from the point of detonation (35).

5.10.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in several scientific and diagnostic experiments conducted at Shot SOCORRO by the DOD Effects Test Group and the LASL Test Group. The following listing identifies these projects:

Project	Title	Fielding Agency
DOD Effects Test Group		
1.7	Airblast Phenomena and Instrumentation of Structures	Ballistic Research Laboratories
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories

Project	Title	Fielding Agency
DOD Effects Test Group		
8.8	Thermal Radiation from Low-yield Nuclear Bursts	Air Force Cambridge Research Center
LASL Test Group		
11.2	Aircraft Sampling	LASL; AFSWC

DOD Effects Test Group Projects

The DOD Effects Test Group conducted four projects at Shot SOCORRO.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories to document blast phenomena resulting from a nuclear detonation and to evaluate new blast instruments. Project personnel installed blast gauges at stations approximately 60, 90, 10,580, and 14,630 meters from ground zero in the days preceding the scheduled detonation. During the day before the detonation, personnel entered the area to make final checks of instruments. Project personnel reentered the shot area after the detonation to recover records from the stations and to inspect the damage to the gauges. They then returned to Camp Mercury to analyze the data (14; 45).

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the

operational capabilities of flash-ranging instrumentation. Project personnel set up flash-ranging equipment at three sites 12.8, 29, and 97 kilometers from ground zero in the days preceding the detonation. Participants operated equipment at the sites through shot-time: two persons were at Mine Mountain 12.8 kilometers away and two were on Lookout Peak 29 kilometers away. Immediately after the detonation, personnel took data to the laboratory for analysis (14; 52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. As with other shots at which the project was conducted, project personnel manned the station at Boulder City, Nevada, several hours before the burst to prepare instruments. They remained at the station during the burst to detect and record the electromagnetic pulse and for a few hours afterward to analyze the data and turn off equipment (14; 29).

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low yield. An instrumented trailer nine kilometers south-southwest of ground zero was used to conduct measurements of thermal radiation during the detonation. Two project participants arrived at the station before the burst and remained behind the trailer until the shock wave passed. The participants then removed data from the site and left the area no later than 30 minutes after the detonation (14; 48). Two other project personnel operated instruments during the detonation at Building 400, near the Control Point, about 17 kilometers south-southwest of ground zero.

LASL Test Group Projects

Only one LASL Test Group project involved DOD personnel at Shot SOCORRO. The AFSWC 4926th Test Squadron (Sampling) participated in Project 11.2, Aircraft Sampling. The squadron conducted cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot SOCORRO. The following indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	3	6
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6
	T-33	1	2

Three B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fourth B-57B aircraft, with a pilot and a LASL technical advisor, acted as a sampler control aircraft, directing the three cloud-sampling aircraft to various sections of the cloud. The sampler control aircraft also collected samples in this mission.

A C-47 aircraft, with a crew from the 4900th Air Base Group, transported the samples from Indian Springs AFB to Kirtland AFB. The samples were then taken to LASL for analysis (39; 40).

One C-47 aircraft performed a low-altitude cloud-tracking mission, and one T-33 conducted a high-altitude mission. They flew out to about 320 kilometers from ground zero (39; 40).

5.10.2 Radiological Safety Activities

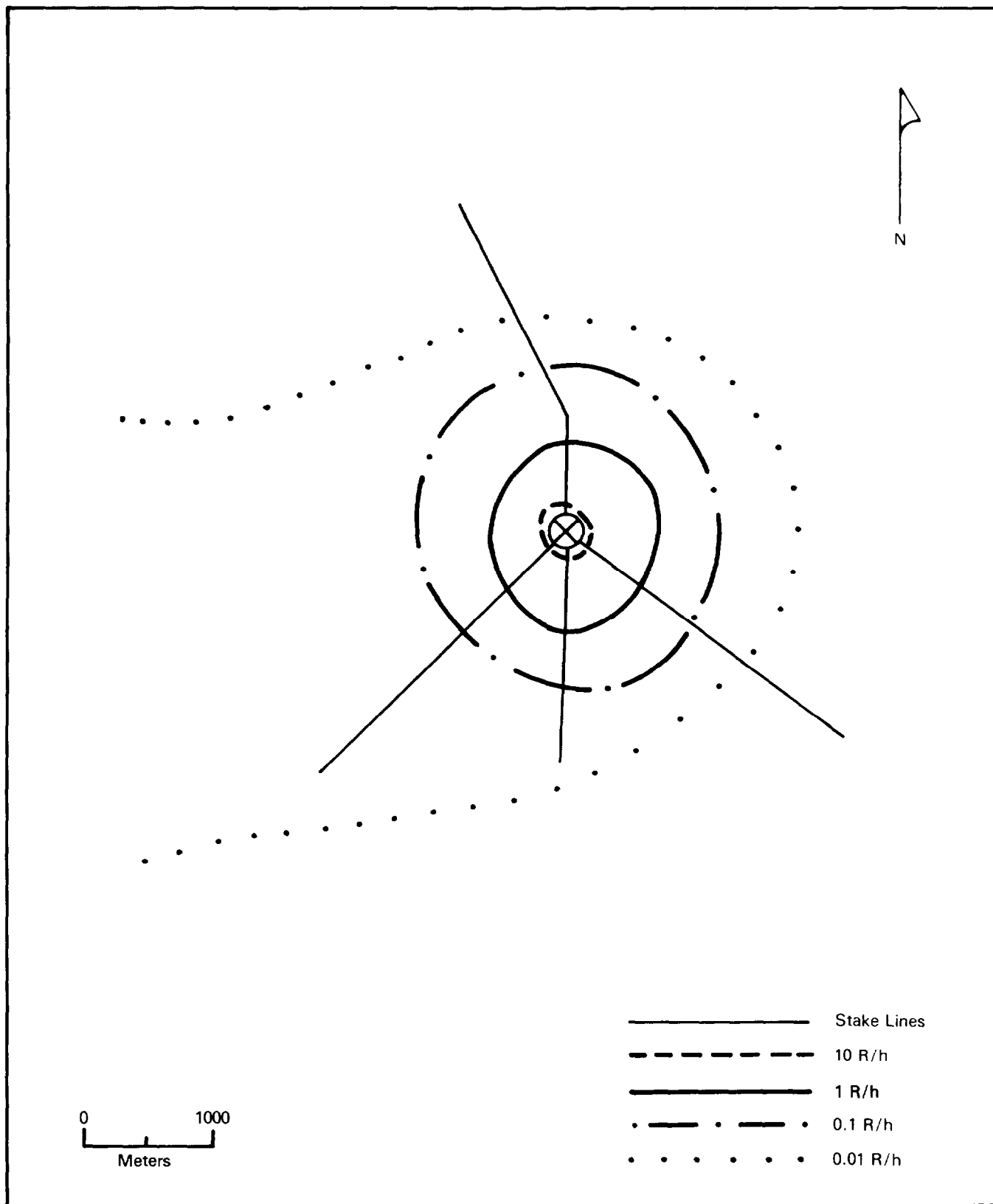
The following paragraphs present available information on radiological safety procedures specific to Shot SOCORRO. Information common to the HARDTACK II shots is in chapter 3.

Onsite Monitoring

The initial survey team, consisting of 11 men in nine vehicles, entered the test area shortly after the detonation. Mid-time of the initial survey was 0637. Figure 5-8 shows a copy of the isointensity map generated from the initial survey (49). The survey team encountered gamma intensities of 10 R/h within a 230-meter radius of ground zero. Monitors recorded radiation levels of 1 R/h about 870 meters from ground zero, while they took readings of 0.1 R/h within a radius of 1,350 meters from ground zero. Radiation levels of 0.01 R/h extended beyond four kilometers to the west of ground zero and about 1,800 meters in other directions. A resurvey of the test area conducted three days after the detonation showed that the area within about 70 meters of ground zero had a gamma intensity of 1 R/h or more. The 0.1 R/h radiation area was limited to within a 500-meter radius of ground zero, while the 0.01 R/h area was confined to within 1,070 meters from ground zero (49).

Offsite Monitoring

USPHS personnel conducted monitoring in offsite areas. Since several shots were detonated on 22 October, the offsite monitoring teams did not complete their surveys until after the final detonation of the day. They encountered radiation



**Figure 5-8: INITIAL SURVEY FOR SHOT SOCORRO,
22 OCTOBER 1958, MID-TIME 0637**

intensities above background but determined that this radio-activity originated from the second detonation of that day, Shot WRANGELL. Therefore, they recorded no offsite radioactivity for Shot SOCORRO (47).

5.11 SHOT WRANGELL

Shot WRANGELL was detonated with a yield of 0.115 kiloton at 0850 hours PST on 22 October 1958. The device, developed by UCRL, was suspended from a balloon 1,500 feet above the ground in Frenchman Flat, at UTM coordinates 956728 (35).

At shot-time, the temperature was 8.3 degrees Celsius, and the surface winds were light and variable. Winds were eight knots from the northeast at 5,000 feet and 11 knots from the southwest at 10,000 feet. The cloud top reached an altitude of 10,000 feet, and the cloud drifted toward the northeast (35).

5.11.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part at Shot WRANGELL in scientific and diagnostic experiments conducted by the DOD Effects Test Group and the LASL Test Group. These projects were:

Project	Title	Fielding Agency
DOD Effects Test Group		
6.14	Proof Test of Flash-ranging Equipment	Army Artillery Board; Signal Research and Development Laboratories

Project	Title	Fielding Agency
DOD Effects Test Group		
6.15	Electromagnetic Pulses from Low-yield Bursts	Signal Research and Development Laboratories
8.8	Thermal Radiation from Low-yield Nuclear Bursts	Air Force Cambridge Research Center
UCRL Test Group		
21.2	Radiochemical Sampling	UCRL; AFSWC

DOD Effects Test Group Projects

Three DOD Effects Test Group projects were conducted at Shot WRANGELL.

Project 6.14, Proof Test of Flash-ranging Equipment, was conducted by the Army Artillery Board and the Signal Research and Development Laboratories. The objective was to evaluate the operational capabilities of flash-ranging instrumentation. In the days preceding the detonation, project personnel set up flash-ranging equipment at two sites approximately 20 and 80 kilometers from ground zero. Two project participants operated the equipment at each site through shot-time. Immediately after the detonation, data were taken to a laboratory for analysis (7; 52).

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from nuclear detonations. As at the other HARDTACK II

shots, project personnel went to the station at Boulder City, Nevada, several hours before the burst to prepare instruments. They remained at the station during shot-time to detect and record the electromagnetic pulse and for a few hours afterward to analyze the data and turn off equipment (7; 29).

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low yield. Two project personnel operated instruments at Building 400, near the Control Point, about 19 kilometers northwest of ground zero. They operated the instruments through shot-time and left the area within 30 minutes after the detonation (7; 48).

UCRL Test Group Projects

Project 21.2, Radiochemical Sampling, was the only UCRL Test Group project at WRANGELL involving DOD participation. The 4926th Test Squadron (Sampling) conducted cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot WRANGELL. The following indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	2	4
Sample Courier	C-47	1	3
Cloud Tracking	B-25	1	6

Two B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 21.2, Radiochemical Sampling. A third B-57B aircraft, with a pilot and a UCRL technical advisor, acted as a sampler control aircraft, directing the two cloud-sampling aircraft to various sections of the cloud. A fourth B-57B was scheduled to participate but was not used.

A C-47 aircraft left Indian Springs AFB to transport samples to UCRL for analysis. The 4900th Air Base Group conducted this mission (39; 40).

One B-25 aircraft performed a low-altitude cloud-tracking mission out to about 320 kilometers from ground zero. A T-33 aircraft was scheduled to participate in a cloud-tracking mission but was not used (39; 40).

5.11.2 Radiological Safety Activities

Radiological safety procedures at Shot WRANGELL, including monitoring and decontamination of personnel and vehicles, were generally the same as at other shots in Operation HARDTACK II and are discussed in chapter 3. The following paragraphs present available information specific to Shot WRANGELL.

Onsite Monitoring

The initial survey team, consisting of 12 men in eight vehicles, entered the test area in Frenchman Flat shortly after the detonation. The survey was completed about one hour after the detonation. The maximum gamma reading at ground zero was about 10 R/h. Gamma intensities of 0.1 and 0.01 R/h were found 470 meters and 1,400 meters, respectively, from ground zero in all directions (7; 49).

Offsite Monitoring

From one to eight hours after the detonation, USPHS personnel monitored in offsite areas. They encountered gamma intensities above background in areas north of the NTS, particularly around Groom Lake and Lincoln Mine, Nevada. Gamma intensities at these locations ranged from 0.001 R/h to 0.004 R/h (47).

5.12 SHOT RUSHMORE

Shot RUSHMORE was detonated at 1540 hours PST on 22 October 1958 with a yield of 0.188 kiloton. The device, developed by UCRL, was suspended from a balloon 500 feet above the ground in Area 9, UTM coordinates 852100 (35).

At shot-time, the temperature was 17.8 degrees Celsius, and the surface winds were four knots from the southeast. Winds were seven knots from the south-southeast at 5,000 feet and 16 knots from the southwest at 10,000 feet. The top of the cloud reached a height of 11,500 feet, and the cloud moved northeast from the point of detonation (35).

5.12.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in three scientific and diagnostic experiments conducted by the DOD Effects Test Group and the UCRL Test Group at Shot RUSHMORE.

DOD Effects Test Group Projects

The DOD Effects Test Group conducted two projects at Shot RUSHMORE.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories

to document blast phenomena resulting from a nuclear detonation and to evaluate new instruments for measuring blast waves. An estimated four Ballistic Research Laboratories personnel took part in the project. In the days preceding the detonation, participants installed blast gauges at 11 stations approximately 90, 490, 1,000, 1,530, 2,440, 3,660, 4,270, 4,570, 6,100, 15,540, and 19,810 meters from ground zero. At about 2100 hours on the day before the detonation, personnel entered the shot area to make final checks of instruments. After the detonation, participants reentered the shot area to recover records from the stations and to inspect the gauges. They then returned to Camp Mercury to analyze the data (16; 45).

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low yield. An instrumented trailer 7.6 kilometers southwest of ground zero near the BJY measured thermal radiation during the detonation. Project participants checked equipment in the trailer several hours before the shot. Two participants occupied the station during the shot. They removed data records from the site immediately after the shock wave passed and left the area no later than 30 minutes after the detonation. Concurrently, two other project personnel operated instruments at Building 400, about 22 kilometers south-southwest of ground zero (16; 48).

In addition to conducting the two projects, the DOD Effects Test Group coordinated participation by a detachment from the 1352nd Motion Picture Squadron. Situated at the BJY, the detachment filmed the detonation (3).

UCRL Test Group Projects

Among the several UCRL Test Group projects conducted at Shot RUSHMORE, only Project 21.2, Radiochemical Sampling, involved DOD

participation. The AFSWC 4926th Test Squadron (Sampling) provided cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot RUSHMORE. The following listing indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	2	4
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6

Two B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 21.2, Radiochemical Sampling. A third B-57B aircraft, with a pilot and a UCRL technical advisor, was the sampler control aircraft, directing the two cloud-sampling aircraft to various sections of the cloud. Prior to takeoff, the B-57B sampler control aircraft had engine difficulties, and the crew performed the mission in another B-57B.

A C-47 aircraft, with a crew from the 4900th Air Base Group, transported the sample filter papers from Indian Springs AFB to Alameda Naval Air Station. UCRL personnel then took the samples to the laboratory for analysis (39; 40).

One C-47 aircraft conducted a cloud-tracking mission out to about 320 kilometers from ground zero. A T-33 aircraft was also scheduled for a cloud-tracking mission but was not used (39; 40).

5.12.2 Radiological Safety Activities

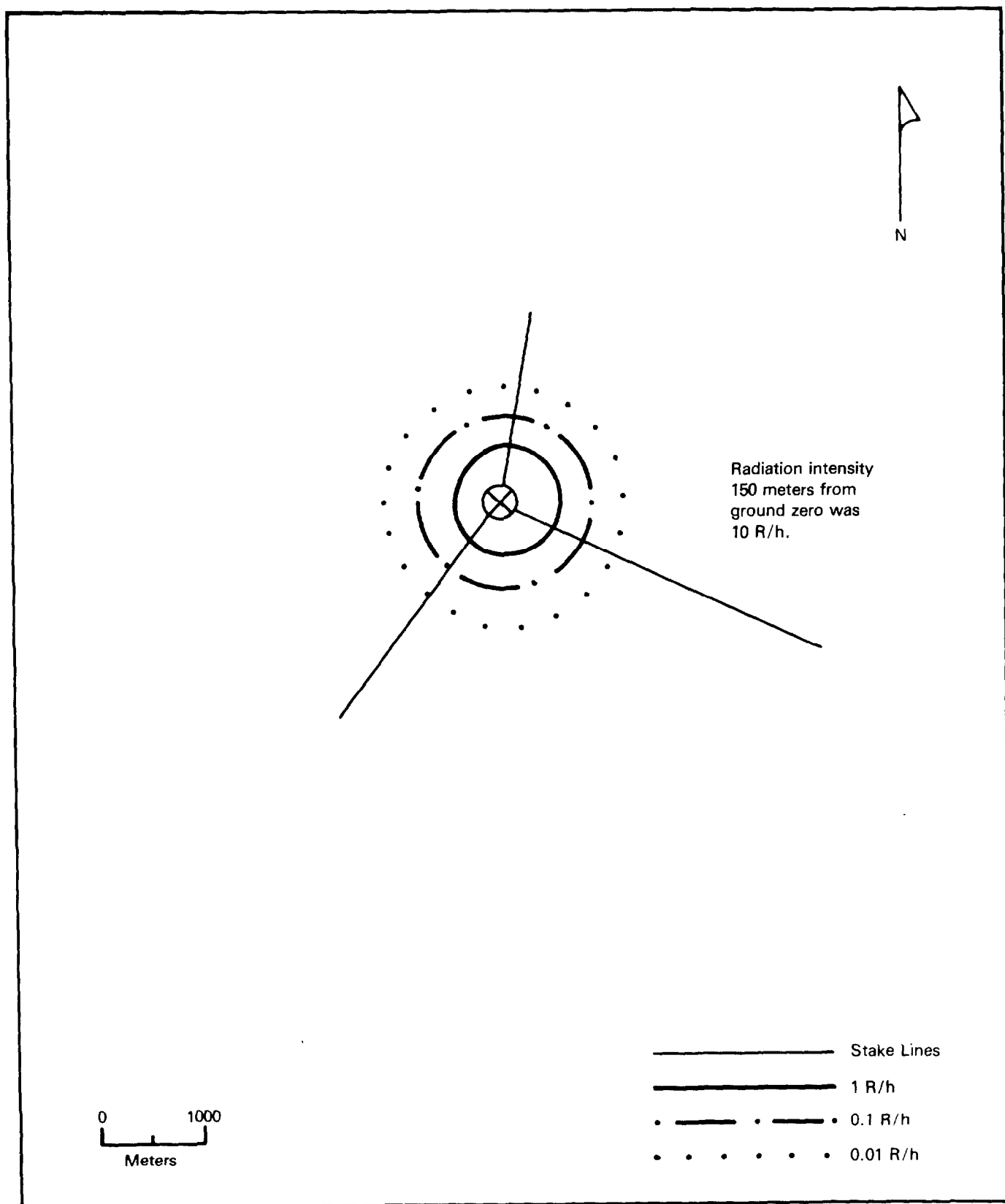
The radiological safety procedures common to the Operation HARDTACK II shots are discussed in chapter 3. Information specific to Shot RUSHMORE is presented in the next paragraphs.

Onsite Monitoring

The initial survey team, consisting of 11 men in nine vehicles, entered the shot area shortly after the detonation to conduct a radiological survey. Mid-time of the initial survey was 1600 hours. Figure 5-9 presents a copy of the isointensity map generated from this survey (49). Gamma intensities of 10 R/h were within a radius of about 150 meters of ground zero. At distances of 500 meters and 730 meters, radiation levels decreased to 1 R/h and 0.1 R/h, respectively. Gamma readings of 0.01 R/h were limited to within a radius of 1,050 meters from ground zero. A survey conducted 48 hours later showed radiation intensities at ground zero had decreased to 0.5 R/h. The 0.1 R/h or greater radiation area was confined to within 180 meters of ground zero, and the 0.01 R/h line did not extend beyond 580 meters from ground zero (16; 49).

Offsite Monitoring

USPHS personnel conducted offsite monitoring. Since three weapons-related events and one safety experiment were conducted on 22 October, the offsite monitoring teams did not complete their surveys until after the final detonation of the day. Radiation intensities above background were encountered, but it was determined that this radioactivity probably originated from the second detonation of that day, Shot WRANGELL. Therefore, no off-site radioactivity was recorded specifically for RUSHMORE (47).



**Figure 5-9: INITIAL SURVEY FOR SHOT RUSHMORE,
22 OCTOBER 1958, MID-TIME 1600**

5.13 SHOT SANFORD

Shot SANFORD was detonated with a yield of 4.9 kilotons at 0220 hours PST on 26 October 1958. Developed by UCRL, the device was suspended from a balloon 1,500 feet above the ground in Frenchman Flat, at UTM coordinates 856728 (35).

At shot-time, the temperature was 3.4 degrees Celsius, and the winds were light and variable up to 5,000 feet, with winds at seven knots from the southeast at 10,000 feet, 23 knots from the southwest at 20,000 feet, and 30 knots from the southwest at 25,000 feet. The cloud reached a height of 26,000 feet and moved to the northeast (35).

5.13.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel at Shot SANFORD took part in two scientific and diagnostic experiments, one conducted by the DOD Effects Test Group and the other by the UCRL Test Group.

DOD Effects Test Group Projects

The DOD Effects Test Group project was Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts. The Air Force Cambridge Research Center conducted the project to investigate the thermal radiation resulting from a detonation of low yield. During the detonation, two project personnel operated instruments at Building 400, about 19 kilometers northwest of ground zero (48).

UCRL Test Group Projects

The only UCRL Test Group project involving DOD participants was Project 21.2, Radiochemical Sampling. The AFSWC 4926th Test Squadron (Sampling) provided cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling and sample courier missions during Shot SANFORD. The following information indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	2	4
Sample Courier	C-47	1	3

Two B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 21.2, Radiochemical Sampling. A third B-57B aircraft, with a pilot and a technical advisor, was the sampler control aircraft, directing the two cloud-sampling aircraft to various sections of the cloud (39; 40).

The C-47 courier aircraft, with a crew from the 4900th Air Base Group, transported the samples from Indian Springs AFB to Alameda Naval Air Station. UCRL personnel then took the samples to the laboratory for analysis (39; 40).

5.13.2 Radiological Safety Activities

This section discusses radiological safety procedures specific to Shot SANFORD. Chapter 3 presents radiological safety information common to the Operation HARDTACK II shots.

Onsite Monitoring

The initial survey team entered the shot area shortly after the detonation. Mid-time of this survey was 0242 hours. Figure 5-10 shows a copy of the isointensity map generated from the survey (49). Gamma intensities of 1 R/h were confined to within about 1,000 meters of ground zero. Radiation levels of 0.1 R/h and 0.01 R/h were registered at distances of 1,600 and 2,800 meters, respectively. A survey conducted six hours later indicated radiation intensities of 1 R/h were within 500 meters of ground zero. Gamma intensities of 0.1 R/h and 0.01 R/h were encountered at distances of 1,000 and 1,500 meters from ground zero, respectively. A resurvey conducted two days after the detonation indicated that the 1 R/h contour did not extend beyond 70 meters from ground zero. The 0.1 R/h and 0.01 R/h contours were within 800 and 1,100 meters of ground zero, respectively (49).

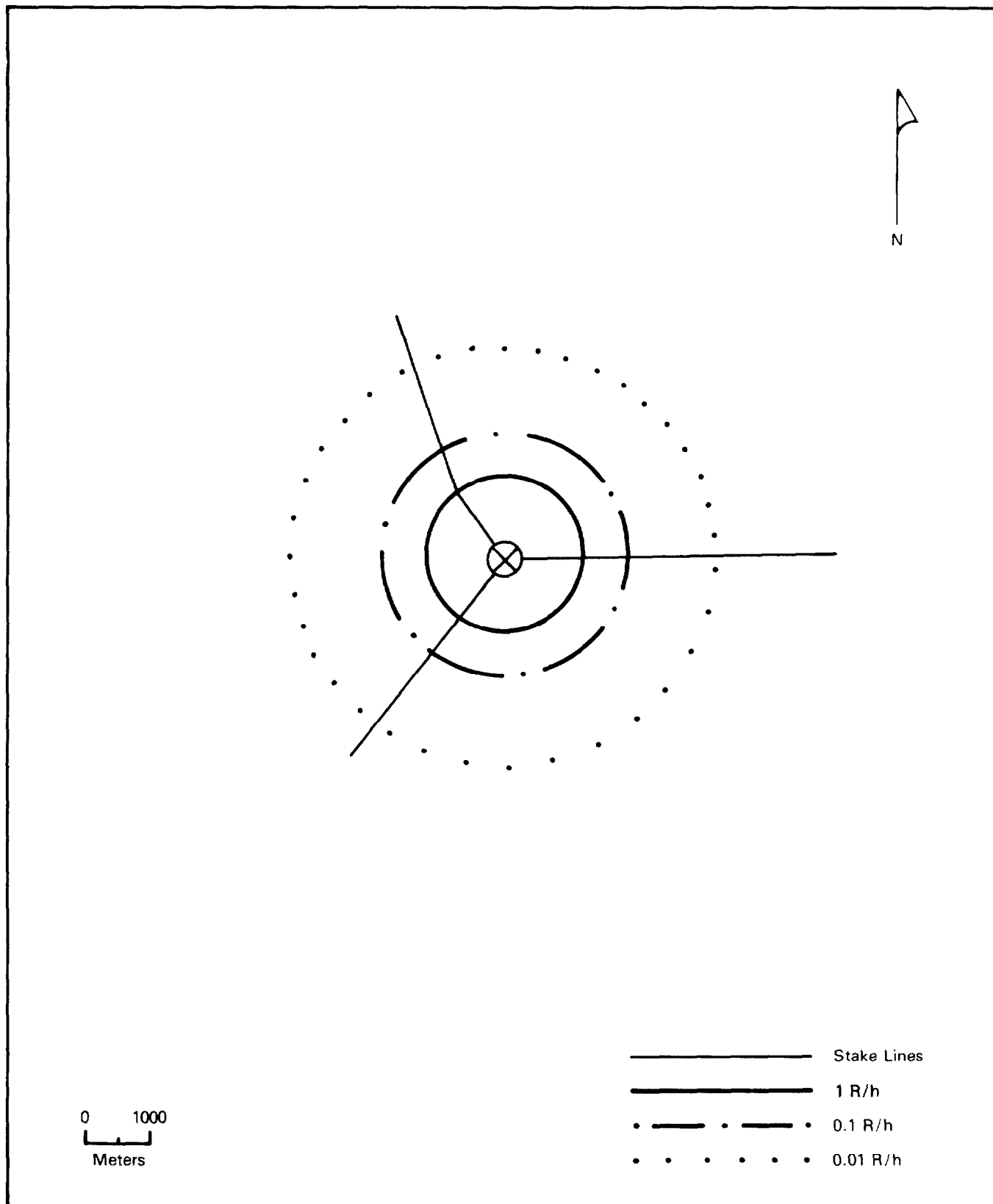
Offsite Monitoring

From two to eight hours after the detonation, USPHS personnel conducted offsite monitoring. They encountered gamma intensities above background in areas east and northwest of the NTS, particularly in areas around Alamo and Tonopah, Nevada. Gamma intensities at these locations ranged from 0.001 R/h to 0.006 R/h (47).

5.14 SHOT DE BACA

Shot DE BACA was detonated at 0800 hours PST on 26 October 1958 with a yield of 2.2 kilotons. The device, developed by LASL, was suspended from a balloon 1,500 feet above the ground in Area 7, at UTM coordinates 867047, the same location as Shots EDDY, MORA, LEA, DONA ANA, and SOCORRO (35).

At shot-time, the temperature was 8.3 degrees Celsius, and the winds were light and variable up to 5,000 feet. Winds were



**Figure 5-10: INITIAL SURVEY FOR SHOT SANFORD,
26 OCTOBER 1958, MID-TIME 0242**

six knots from the southwest at 10,000 feet and ten knots from the west at 15,000 feet. The cloud reached a height of 17,500 feet and moved northeast from the point of detonation (35).

5.14.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in two scientific and diagnostic experiments conducted by the effects test groups.

DOD Effects Test Group Projects

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was the only DOD Effects Test Group project at Shot DE BACA. Conducted by the Air Force Cambridge Research Center, the project was to investigate the thermal radiation resulting from a detonation of low nuclear yield. Project personnel used a trailer located approximately seven kilometers northwest of ground zero. During the detonation, two participants remained in the trailer, which was instrumented to measure thermal radiation. After the shock wave passed, the two personnel removed data records and, 30 minutes after the detonation, left the area. Also during the shot, two other project personnel operated instruments at Building 400, about 17 kilometers south-southwest of ground zero (19; 48).

LASL Test Group Projects

The LASL Test Group conducted several projects at Shot DE BACA. However, only Project 11.2, Aircraft Sampling, involved DOD participation. The AFSWC 4926th Test Squadron (Sampling) conducted cloud sampling, discussed below.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot DE BACA. The following

information indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	3	6
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6
	T-33	1	2

Three B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. A fourth B-57B aircraft, with a pilot and a LASL technical advisor, acted as a sampler control aircraft, directing the three cloud-sampling aircraft to various sections of the cloud (39; 40).

A C-47 courier aircraft, with a crew from the 4900th Air Base Group, transported the samples from Indian Springs AFB to Kirtland AFB. The samples were then transported to LASL for analysis (39; 40).

One C-47 aircraft and one T-33 performed cloud-tracking missions out to about 320 kilometers from ground zero (39; 40).

5.14.2 Radiological Safety Activities

This section discusses radiological safety procedures specific to Shot DE BACA. Chapter 3 presents radiological safety information common to all shots in the series.

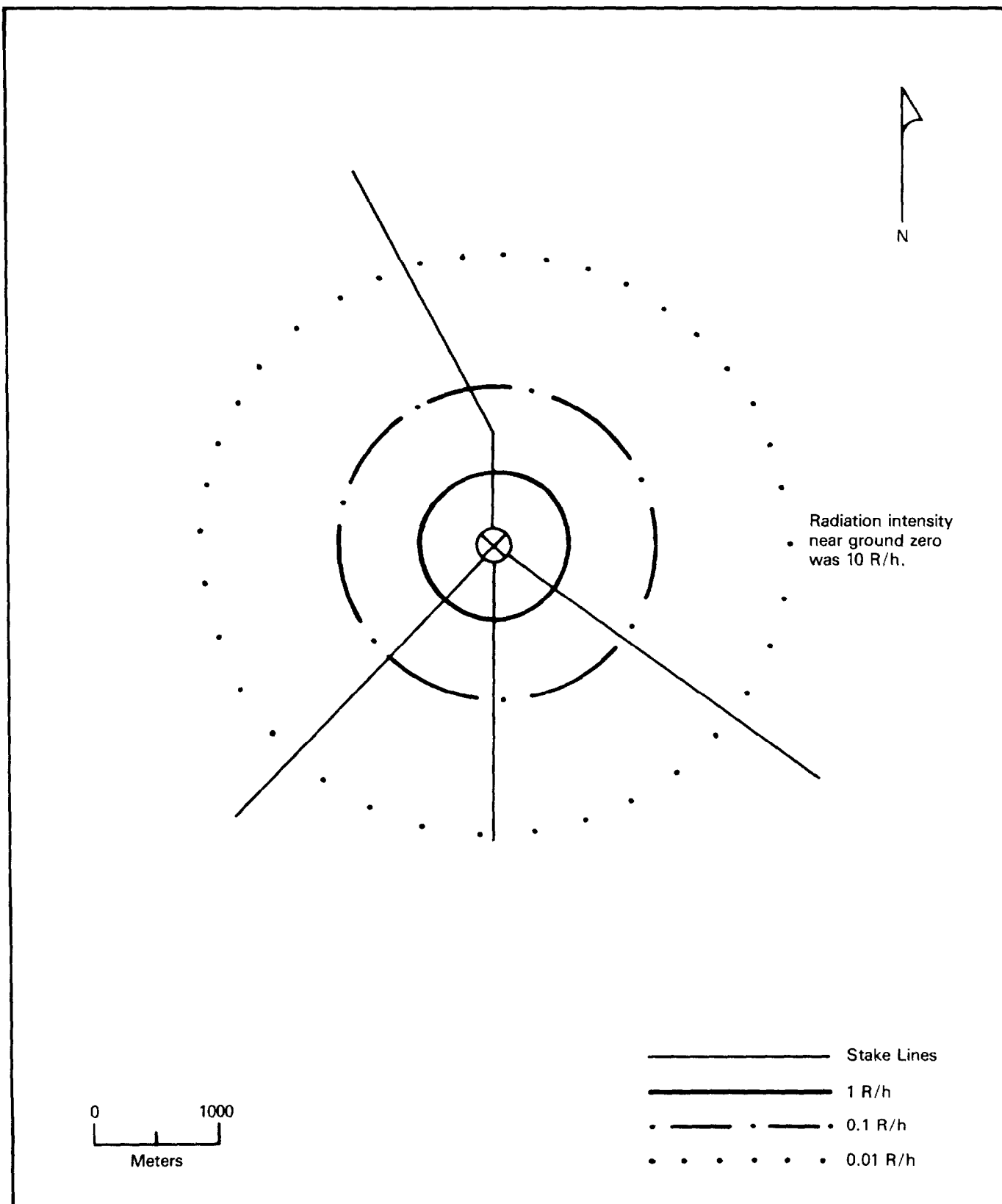
Onsite Monitoring

The initial survey team, consisting of ten men in six vehicles, entered the shot area shortly after the detonation to perform a survey (49). Mid-time of this survey was 0822 hours. Figure 5-11 presents a copy of the isointensity map generated from the initial survey. The survey team found gamma radiation intensities of 10 R/h or more out to 120 meters from ground zero. Radiation levels of 1 R/h were limited to within a radius of about 600 meters from ground zero. Readings of 0.1 R/h and 0.01 R/h extended out to 1,300 meters and 2,400 meters from ground zero, respectively.

Six hours after the detonation, the gamma intensity at ground zero had decreased to 5 R/h. The 1 R/h radiation line increased in radius to 760 meters from ground zero. The probable reason for this increase was the bulldozing of radioactive earth away from ground zero to begin preparations for the SANTA FE event, to be conducted at the same location three days later. The bulldozing of earth away from ground zero caused isointensity line anomalies at other balloon shots. The 0.1 R/h and 0.01 R/h areas were confined to within 930 meters and 1,240 meters of ground zero, respectively. Two days after the detonation, the 1 R/h line had contracted to within 60 meters of ground zero. Likewise, the 0.1 R/h and 0.01 R/h areas had contracted and did not extend beyond 490 meters and 770 meters from ground zero, respectively (19; 49).

Offsite Monitoring

Since Shots DE BACA and SANFORD were detonated less than six hours apart, USPHS personnel performed offsite monitoring for both shots simultaneously. Results of the offsite surveys are described in section 5.13.2, which describes monitoring after the SANFORD detonation (47).



**Figure 5-11: INITIAL SURVEY FOR SHOT DE BACA,
26 OCTOBER 1958, MID-TIME 0822**

5.15 SHOT EVANS

Shot EVANS was fired at 1600 hours PST on 29 October 1958 with a lower-than-expected yield of 0.055 kiloton. The device was detonated in a tunnel 852 feet below the surface of the Rainier Mesa in Area 12, at UTM coordinates 706167. UCRL developed the EVANS device (35).

At shot-time, the temperature was 20 degrees Celsius, and the winds were seven knots from the west-northwest on the mesa at an elevation of 6,725 feet. A small amount of venting took place. The vented material produced low levels of radiation in the vicinity of the tunnel portal and along the access road from the Area 12 camp (35).

5.15.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel at Shot EVANS took part in one project conducted by the DOD Effects Test Group and seven projects probably conducted by Headquarters, AFSWP.

DOD Effects Test Group Project

The DOD Effects Test Group project conducted at EVANS was Project 1.7, Airblast Phenomena and Instrumentation of Structures. Conducted by the Ballistic Research Laboratories, the project was to document blast phenomena resulting from a nuclear detonation and to evaluate new blast instruments. An estimated four Ballistic Research Laboratories personnel took part in the project.

Participants installed blast gauges at seven stations in the EVANS tunnel wall at various distances from the point of detonation in the days preceding the scheduled detonation. Project personnel received telemetered data at monitoring stations before the blast destroyed the instruments (21; 45).

The DOD Effects Test Group also coordinated participation by a detachment from the 1352nd Motion Picture Squadron. This detachment filmed the placement of the EVANS device on 27 October 1958 (3).

Other Projects

The additional projects involving DOD personnel and probably conducted by Headquarters, AFSWP, are discussed below.

Project 26.1, Postshot Disturbances and Surface Motions, was sponsored by the Lawrence Radiation Laboratory and conducted by the Stanford Research Institute. The primary objectives were to:

- Investigate the postshot underground disturbances and surface displacements as functions of time after a deep underground nuclear detonation, using the recorded output of seismometers and the readings of simple liquid-level gauges
- Evaluate the applicability of the seismometers and gauges in detailed location of such bursts subsequent to their general location by other means.

The gauges were 55 kilometers southeast of ground zero, and the seismometers were 55 and 40 kilometers southeast of ground zero (55).

Four hours before the detonation, four participants traveled to a station 2,800 meters northwest of ground zero. About two and one-half hours after the detonation, these personnel went to a Stanford Research Institute recording truck 610 meters west of ground zero. Two men then went to the west end of a liquid level gauge, 550 meters southwest of ground zero, to observe indications of subsidence at ground zero (21). A postshot reading of the instruments was made four hours after the detonation. Subsequent readings were continued for several days, extending until after Shot BLANCA, on 30 October 1958 (55). In addition, two participants worked for approximately one hour at

the portals of the U12B and the U12E tunnels, shown in figure 5-14, the survey map for Shot BLANCA. They then went to Rainier Mesa, where they conducted recovery activities for about two and one-half hours (21).

Project 26.3, Earth Motion Measurements, was conducted by the Engineer Research and Development Laboratories to measure strong ground motion occurring in the medium surrounding ground zero. To obtain data, personnel installed two accelerometers and two strain gauges at each of six stations located 40, 85, 110, 115, 215, and 260 meters from ground zero (4). They reentered the shot area to collect information after the area was opened for recovery activities (21). Because of the low yield of Shot EVANS, no usable records were obtained. In addition to installing Project 26.3 instruments, project personnel provided instruments for Project 26.7 (4).

Project 26.4 was conducted by the Stanford Research Institute. At the declaration of recovery hour, four project personnel proceeded to Rainier Mesa within 310 meters of ground zero. They worked there mapping cracks and fissures in the mesa surface (21).

Project 26.7, Structural Response and Permanent Displacement Measurements, was conducted by the Engineer Research and Development Laboratories and the U.S. Coast and Geodetic Survey. The objective was to measure structural response to the detonation. For permanent displacement measurements, points were selected in the tunnel in which Shot EVANS was detonated. The points were chosen to provide coverage at locations of possible differential movement and to identify permanent effects of the detonation. Surface points were selected to give both overall area coverage and specific coverage at locations where differential movement appeared probable. The project was done in conjunction with Projects 26.3 and 26.11 (53).

Project 26.8 was conducted by the Ballistics Research Laboratory. At the declaration of recovery hour, two project personnel went to a recording trailer near the bunker 110 meters east of the U12B portal (21).

Project 26.9 was conducted by the University of California Radiation Laboratory and Armour Research Foundation. At 0600 hours on shot-day, four personnel began working in the EVANS tunnel. They continued working until the commencement of arming, when they left the shot area. When the area was opened for recovery activities, two parties, each of three participants, proceeded in vehicles to a trailer directly below the bunker east of the U12B portal (21).

Project 26.11 was conducted by the U.S. Coast and Geodetic Survey in conjunction with Project 26.7 to measure permanent displacement of structures (53).

Air Force Special Weapons Center Activities

AFSWC personnel conducted a cloud-tracking mission and an aerial photography mission during Shot EVANS. Cloud sampling was not conducted, since there was no significant venting.

One L-20 aircraft performed the cloud-tracking mission. The L-20 also took photographs of the shot area during and after the detonation (39; 40).

Two C-45 aircraft were scheduled for an aerial photography mission. Because there is no documentation confirming that these C-45s performed the task, it is probable that the L-20 cloud tracker was the only aircraft conducting a photography mission (39; 40).

5.15.2 Radiological Safety Activities

The radiological safety procedures at Shot EVANS that were generally the same as those at the other HARDTACK II shots are discussed in chapter 3. This section presents information specific to Shot EVANS.

Onsite Monitoring

EVANS was detonated in a tunnel, and most of the radiation was contained within the ground. A radiological survey of the access road and the area around the tunnel portal was conducted by ten men who drove to the test area in eight vehicles. The mid-time of this initial survey was 1700 hours. Gamma intensities up to 0.28 R/h were encountered at a bunker about 600 meters east of the tunnel portal. Readings in other areas farther from the portal ranged up to 0.03 R/h (49).

5.16 SHOT MAZAMA

Shot MAZAMA was detonated at 0320 hours PST on 29 October 1958. The device did not have a measurable yield. The MAZAMA device, developed by UCRL, was detonated on a 50-foot steel tower in Area 9, at UTM coordinates 857091 (35).

At shot-time, the temperature was 7.6 degrees Celsius. Winds were predicted to be eight knots from the north to the northwest up to 5,000 feet. The top of the cloud reached a height of about 6,000 feet and moved southwest from the point of detonation (35).

5.16.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in scientific and diagnostic experiments conducted at Shot MAZAMA by the DOD Effects Test Group and the UCRL Test Group.

DOD Effects Test Group Projects

The DOD Effects Test Group conducted one project at Shot MAZAMA. Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low nuclear yield. A trailer, located three kilometers northwest of ground zero near the BJY, was instrumented to measure thermal radiation during the detonation.

Two project personnel operated equipment at the station during the shot. As with the other shots at which Project 8.8 was conducted, the participants were scheduled to remove data records from the site immediately after the shock wave passed and to leave the area within 30 minutes after the detonation. Also during shot-time, two to six other project personnel operated instruments at Building 400, located at Yucca Pass 22 kilometers south-southwest of the MAZAMA ground zero (20; 48).

In addition to conducting the one project, the DOD Effects Test Group coordinated the activities of a detachment from the 1352nd Motion Picture Squadron. This detachment filmed the placement of the MAZAMA device on 25 October 1958 (3).

UCRL Test Group Projects

Of the UCRL Test Group projects at Shot MAZAMA, only Project 21.2, Radiochemical Sampling, involved DOD participation. The AFSWC 4926th Test Squadron (Sampling) conducted cloud sampling to support this project. This activity is discussed in the next section.

Air Force Special Weapons Center Activities

AFSWC personnel conducted a cloud-sampling mission during Shot MAZAMA. There were no other air missions for this shot (39; 40).

One B-57B aircraft, with a pilot and a radiological safety monitor, conducted cloud sampling for Project 21.2, Radiochemical Sampling. A sampler control aircraft did not participate.

A C-47 aircraft had been scheduled to transport the samples to Alameda Naval Air Station, to be taken to UCRL for analysis. However, the mission was canceled (39; 40).

5.16.2 Radiological Safety Activities

Radiological safety procedures at Shot MAZAMA were generally the same as at other shots in Operation HARDTACK II, and are discussed in chapter 3. The following paragraphs present information on radiological protection specific to Shot MAZAMA.

Onsite Monitoring

The initial survey team, consisting of nine men in six vehicles, entered the test area shortly after the detonation. Mid-time of the initial survey was 0412 hours. The team encountered alpha radioactivity but no gamma radioactivity. A survey seven hours after the detonation indicated alpha activity on debris within a 300-meter radius of ground zero (20; 49).

Offsite Monitoring

From four to seven hours after the detonation, USPHS personnel monitored in offsite areas. No gamma intensities above background resulted from MAZAMA (47).

5.17 SHOT HUMBOLDT

Shot HUMBOLDT was fired with a yield of 0.0078 kiloton at 0645 hours PST on 29 October 1958. The device, developed by UCRL, was detonated on a 25-foot tower in Area 3, at UTM coordinates 867004. HUMBOLDT was a joint UCRL and DOD weapons

effects test with DOD participation in five DOD Effects Test Group projects. Among the HARDTACK II shots, only HAMILTON had more DOD project participation (35).

At shot-time, the temperature was 7.4 degrees Celsius and the surface winds were six knots from the northwest. Winds were 25 knots from the northeast at 5,000 feet and 14 knots from the northeast at 10,000 feet. The top of the cloud reached a height of 7,500 feet and moved southwest from the point of detonation (35).

5.17.1 Department of Defense Participation in Scientific and Support Activities

The following listing identifies the test group projects by number and title and indicates the participating agencies:

Project	Title	Fielding Agency
DOD Effects Test Group		
1.7	Airblast Phenomena and Instrumentation of Structures	Ballistic Research Laboratories
2.12a	Neutron Flux from Very-low-yield Bursts	Chemical Warfare Laboratories
2.12b	Gamma Dose from Very-low-yield Bursts	Chemical Warfare Laboratories
4.2	Effects of Very-low-yield Bursts on Biological Specimens (Mice and Swine)	Walter Reed Army Institute of Research
8.8	Thermal Radiation from Low-yield Nuclear Bursts	Air Force Cambridge Research Center
UCRL Test Group		
21.2	Radiochemical Sampling	UCRL; AFSWC

DOD Effects Test Group Projects

The DOD Effects Test Group conducted five projects at Shot HUMBOLDT.

Project 1.7, Airblast Phenomena and Instrumentation of Structures, was conducted by the Ballistic Research Laboratories to document blast phenomena resulting from a nuclear detonation and to evaluate the ability of new blast instruments to measure blast waves. An estimated four Ballistic Research Laboratories personnel took part in the project. Participants installed blast gauges at 22 stations between nine and 1,220 meters from ground zero in the days preceding the detonation. The day before the detonation, personnel entered the area to make final checks of instruments. Participants reentered the shot area after the detonation to recover records from the stations and to inspect the gauges. They then returned to Camp Mercury to analyze the data (25; 45).

Project personnel also obtained information on blast damage effects. They placed two armored personnel carriers 25 meters from ground zero before the detonation. After the detonation, personnel entered the area to inspect the vehicles and photograph damage (45).

Project 2.12a, Neutron Flux from Very-low-yield Bursts, was conducted by the Chemical Warfare Laboratories to:

- Measure neutron flux and dose at various distances from the detonation
- Measure neutron, thermal, and gamma radiation up to an altitude of 1,500 feet
- Provide dose measurements in support of Project 4.2
- Determine neutron flux and spectrum for induced activity studies in support of Project 2.12c.

Project personnel installed threshold detectors and chemical dosimeters 12 to 330 meters from ground zero along a cable that ran east of ground zero. In support of Projects 1.7 and 4.2, they placed additional detectors in open and two-thirds covered foxholes and in two armored personnel carriers containing Project 4.2 animals the day before the detonation. The foxholes and carriers ranged five to 30 meters from ground zero.

Shortly after the detonation, project personnel in a five-ton truck recovered the detectors and dosimeters on the cable by attaching the end of the cable farthest from ground zero to the back of the truck and pulling the cable to a recovery area, where the detectors were removed. Immediately after recovery, the detectors were returned to a mobile laboratory trailer, located in the forward area.

Participants also towed the personnel carriers to a recovery area, where the detectors and animals were removed. The dosimeters were returned to the Chemical Warfare Laboratories for analysis. Project 4.2 personnel later recovered the detectors in the foxholes (25; 45; 46; 51).

Project 2.12b, Gamma Dose from Very-low-yield Bursts, was conducted by the Chemical Warfare Laboratories to provide gamma dose measurements in support of Project 4.2 and to record the initial gamma dose at various distances from ground zero. Other objectives were to record residual radiation intensities and determine the field gamma decay rate.

On the day before the shot, project personnel installed film badges on stakes along four lines north, east, south, and west of ground zero. They placed the film badges out to approximately 730 meters from ground zero on each of the four stake lines. Participants also placed film badges in the two armored personnel carriers used for Projects 2.12a and 4.2.

A few minutes after the passage of the blast wave, a recovery team, consisting of personnel from Projects 2.12a, 2.12b, and 4.2, began retrieving the film badges. As stated in the Project 2.12a description, the personnel carriers were towed out of the ground zero area before the film badges were removed. Meanwhile, personnel of the Chemical Corps Training Command moved into the shot area, marking the 10 R/h point on the east film badge stake line and measuring the dose rate at each stake on that line outside of the 10 R/h intensity line. Fifteen minutes after the detonation, four other teams made similar surveys on all four of the film badge stake lines. A third team conducted a general radiological survey. The survey teams made additional surveys of the shot area up until six and one-half hours after the detonation. At that time, the area was evacuated for Shot SANTA FE (25; 44; 46; 51).

Project 4.2, Effects of Very-low-yield Bursts on Biological Specimens (Mice and Swine), was conducted by the Walter Reed Army Institute of Research. The objective was to evaluate the effects of nuclear radiation on the animals in an attempt to define the effects on humans.

Five hours before the detonation, project personnel placed about 65 pigs in the foxholes and the two armored personnel carriers used in Projects 2.12a and 2.12b. The foxholes were located about 5 to 20 meters from ground zero, and the vehicles were about 25 meters from ground zero. Within 15 minutes of the detonation, after the armored personnel carriers were towed to a recovery area, project personnel opened the vehicles and removed the animals. Camera crews from the 1352nd Motion Picture Squadron photographed recovery of the animals, which were taken by truck to the Frenchman Flat holding facility for analysis (25; 44; 46; 51).

Project personnel entered the shot area again ten hours after the detonation to recover the animals that had been placed in foxholes. They also recovered Project 2.12 instruments from the foxholes. It is probable that these participants were granted special permission to enter the area, because the area had been evacuated three and one-half hours earlier. The recovered animals were also taken to the holding facility for analysis.

Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts, was conducted by the Air Force Cambridge Research Center to investigate the thermal radiation resulting from a low-altitude detonation of low nuclear yield. A trailer, approximately two kilometers southwest of ground zero, was instrumented to measure thermal radiation during the detonation. Two project personnel occupied the station during the shot. The participants removed data records from the site immediately after the shock wave passed and left the area (24; 45). Also during shot-time, two other project personnel operated instruments at Building 400, near the Control Point, south-southwest of ground zero (25; 48).

Besides conducting five projects, the DOD Effects Test Group coordinated the activities of a detachment from the 1352nd Motion Picture Squadron. This detachment photographed the detonation from a station three kilometers from ground zero. It also provided aerial photography of the detonation (3).

UCRL Test Group Projects

The one UCRL Test Group project involving DOD participation was Project 21.2, Radiochemical Sampling. The 4926th Test Squadron (Sampling) supported the project with cloud sampling, discussed in the next section.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot HUMBOLDT. Two H-21

helicopters were scheduled to perform an aerial terrain survey mission after the detonation, but the mission was canceled. The following information indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Cloud Sampling and Control	B-57B	1	1
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6

One B-57B aircraft, with a pilot and a technical advisor from UCRL, acted as a sampler control and sampling aircraft for Project 21.2, Radiochemical Sampling.

A C-47 courier aircraft, with a crew from the 4900th Air Base Group, transported the samples from Indian Springs AFB to the Alameda Naval Air Station. UCRL personnel then took the samples to UCRL for analysis (39; 40).

One C-47 aircraft performed a cloud-tracking mission out to about 320 kilometers from ground zero. This same aircraft also conducted a photography mission during the detonation (39; 40).

5.17.2 Radiological Safety Activities

The radiological safety procedures generally common to all Operation HARDTACK II shots are discussed in chapter 3. The following paragraphs present the available information specific to Shot HUMBOLDT.

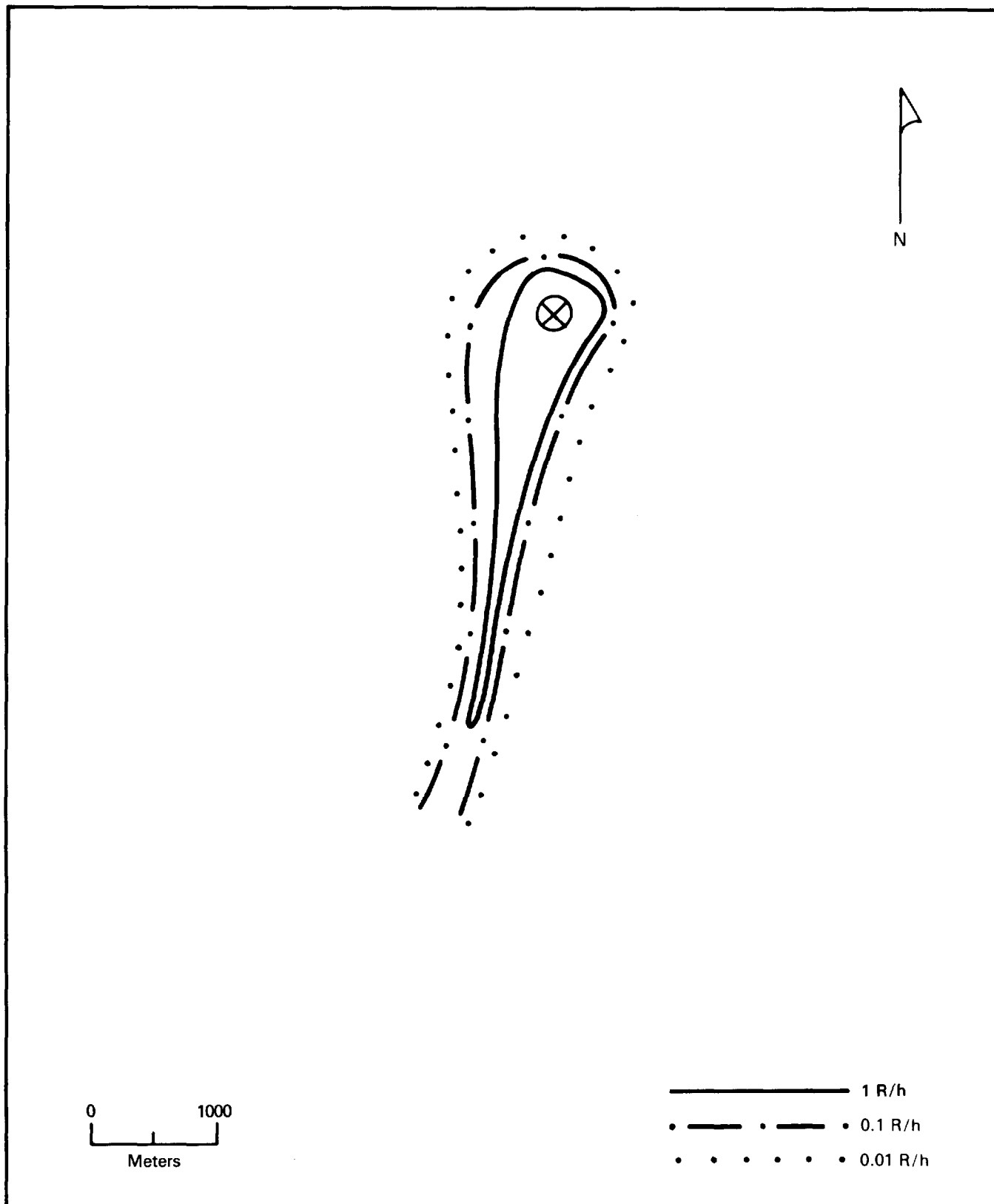
Onsite Monitoring

The initial survey team, consisting of 14 men in eight vehicles, entered the test area shortly after the detonation. Mid-time of the initial survey was 0721. Figure 5-12 presents a copy of the isointensity map generated from this survey (49). Because the HUMBOLDT cloud drifted to the south, radioactivity was found for a considerable distance in this direction. Gamma intensities of 1 R/h were limited to within 300 meters of ground zero except to the south, where the 1 R/h line extended for 3.5 kilometers. In all directions but south, the 0.1 R/h and 0.01 R/h radiation lines were within 650 to 870 meters of ground zero, respectively. The 0.1 and 0.01 R/h lines extended for more than four kilometers to the south (49).

A survey conducted six hours after the shot revealed that the 1 R/h radiation line was limited to within a radius of about 40 meters from ground zero except to the south, where it extended to 110 meters. The 0.1 R/h radiation line also contracted and extended about 800 meters to the south. In all directions except south, the 0.01 R/h radiation line was within 500 meters of ground zero. This line extended for about 2.6 kilometers to the south. By 27 hours after the detonation, gamma intensities of 1 R/h were still within about 40 meters of ground zero. The 0.1 R/h radiation area was confined to a radius of 140 meters, while the 0.01 R/h area was limited to within 470 meters of ground zero. The maximum reading at ground zero was greater than 10 R/h (49).

Offsite Monitoring

USPHS personnel conducted offsite monitoring. Since three shots were fired on 29 October, the offsite monitoring teams did not complete their surveys until after Shot SANTA FE, the final detonation of the day. At that time, gamma intensities above background were encountered in areas southwest of the NTS, particularly around Lathrop Wells, Nevada. Gamma intensities at this location ranged from 0.001 R/h to 0.007 R/h (47).



**Figure 5-12: INITIAL SURVEY FOR SHOT HUMBOLDT,
29 OCTOBER 1958, MID-TIME 0721**

5.18 SHOT SANTA FE

Shot SANTA FE was detonated at 1900 hours PST on 30 October 1958 with a yield of 1.3 kilotons. The device was suspended from a balloon 1,500 feet above the ground in Area 7, at UTM coordinates 867047, the same location as Shots EDDY, MORA, LEA, DONA ANA, SOCORRO, and DE BACA. LASL developed the SANTA FE device (35).

At shot-time, the temperature was 12.1 degrees Celsius, and the surface winds were light and variable. Winds were from the northeast at 11 knots at 5,000 feet, 24 knots at 10,000 feet, and 37 knots at 15,000 feet. The top of the cloud reached a height of 18,000 feet, and the cloud moved southwest from the point of detonation (35).

5.18.1 Department of Defense Participation in Scientific and Support Activities

DOD personnel took part in two scientific and diagnostic experiments conducted by the DOD Effects Test Group and the LASL Test Group.

DOD Effects Test Group Projects

The one DOD Effects Test Group project was Project 8.8, Thermal Radiation from Low-yield Nuclear Bursts. Conducted by the Air Force Cambridge Research Center, the project was to investigate the thermal radiation resulting from a nuclear detonation of low yield. A trailer, located nine kilometers southwest of ground zero, was instrumented to measure thermal radiation during the detonation. Two project personnel occupied the station during the shot. The participants removed data records from the site immediately after the shock wave passed and left the test area (24; 48). Also through shot-time, two project personnel operated instruments at Building 400, near the Control Point, about 17 kilometers south-southwest of ground zero (48).

LASL Test Group Projects

Among the several LASL Test Group projects, only Project 11.2, Aircraft Sampling, involved DOD participation. The 4926th Test Squadron (Sampling) conducted cloud sampling. This activity is discussed in the next section.

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions during Shot SANTA FE. The following information indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	2	4
Sample Courier	C-47	1	3
Cloud Tracking	C-47	1	6

Two B-57B aircraft, each with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 11.2, Aircraft Sampling. Another B-57B had been scheduled for cloud sampling, but aborted its mission before takeoff. A third B-57B aircraft, with a pilot and a LASL technical advisor, acted as a sampler control aircraft, directing the two cloud-sampling aircraft to various sections of the cloud (39; 40).

A C-47 courier aircraft, with a crew from the 4900th Air Base Group, transported the samples from Indian Springs AFB to Kirtland AFB. They were then taken to LASL for analysis (39; 40).

One C-47 aircraft performed a cloud-tracking mission out to about 320 kilometers from ground zero (39; 40).

5.18.2 Radiological Safety Activities

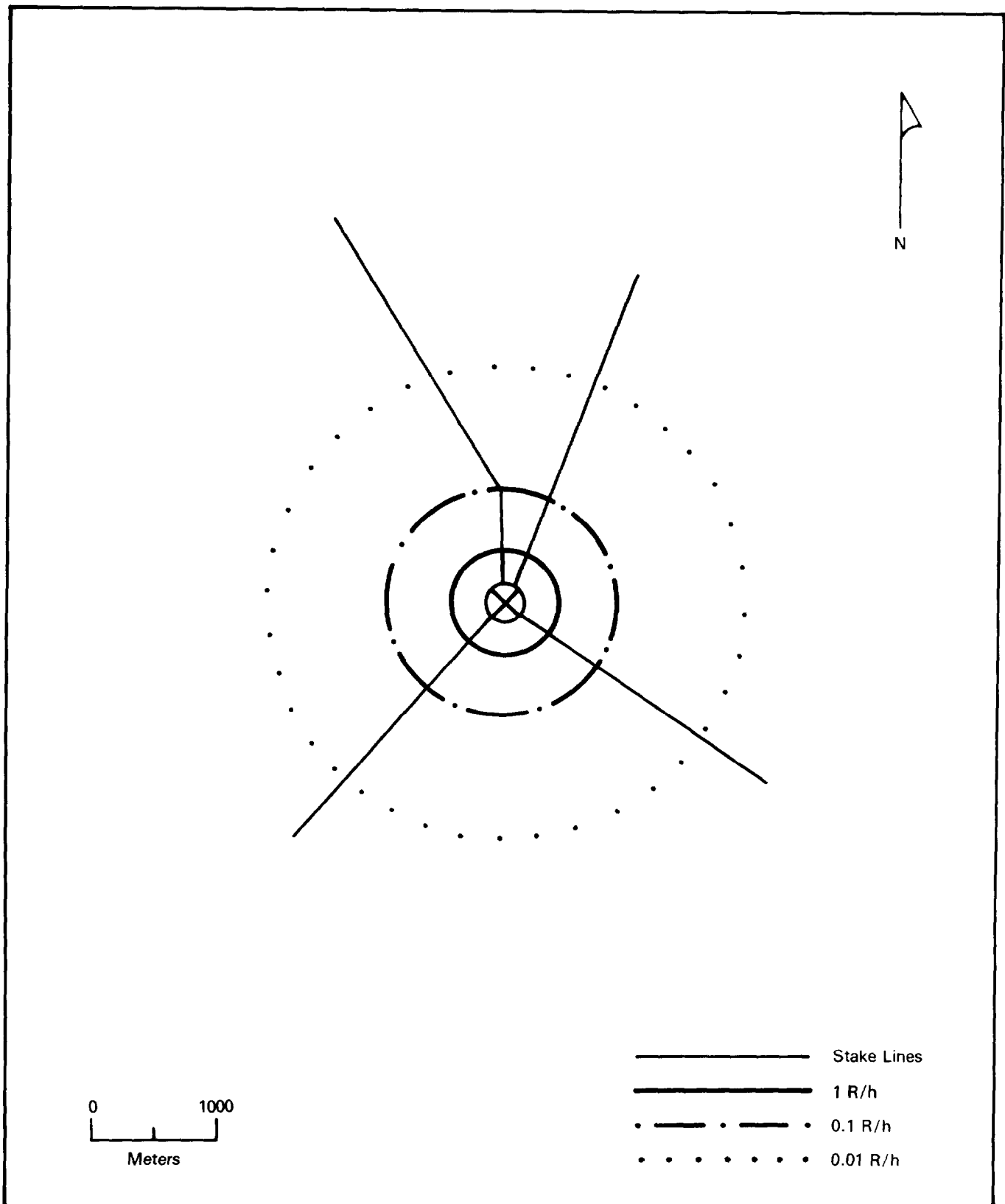
Radiological safety procedures at Shot SANTA FE, including monitoring and decontamination of personnel and vehicles, were generally the same as at other shots in Operation HARDTACK II and are discussed in chapter 3. This section presents information on radiological safety procedures specific to SANTA FE.

Onsite Monitoring

The initial survey team, consisting of ten men in eight vehicles, entered the test area shortly after the detonation to perform a survey of the shot area. Mid-time of the initial survey was 1940. Figure 5-13 presents a copy of the isointensity map generated from this survey (49). Radiation levels of 1 R/h were limited to within a radius of about 430 meters of ground zero. Readings of 0.1 R/h and 0.01 R/h or more were registered out to about 900 meters and 1,960 meters from ground zero, respectively. A survey conducted 15 hours later showed that the 1 R/h or more radiation area was reduced to within 260 meters of ground zero, while the 0.1 R/h and 0.01 R/h or more areas were limited to 730 and 1,200 meters from ground zero, respectively. Within three days after the detonation, the 0.1 R/h or more radiation area was limited to within 250 meters of ground zero, while the 0.01 R/h or more area did not extend beyond 730 meters (24; 49).

Offsite Monitoring

From two to five hours after the detonation, USPHS personnel conducted monitoring in offsite areas. They encountered gamma intensities above background in areas southwest of the NTS, particularly around Lathrop Wells, Nevada. Gamma intensities at this location ranged from 0.002 R/h to 0.007 R/h (47).



**Figure 5-13: INITIAL SURVEY FOR SHOT SANTA FE,
30 OCTOBER 1958, MID-TIME 1940**

5.19 SHOT BLANCA

Shot BLANCA was fired at 0700 hours PST on 30 October 1958. BLANCA had a yield of 22 kilotons and was the largest detonation of Operation HARDTACK II. The device, developed by UCRL, was detonated in a tunnel 987 feet below the ground in Area 12, at UTM coordinates 704157 (35).

At shot-time, the temperature was 7.9 degrees Celsius. Five and one-half hours after the detonation, winds were eight knots from the east-northeast at the surface, 13 knots from the northeast at 5,000 feet, and 12 knots from the east-northeast at 7,000 feet. The shot vented, and the top of the cloud reached a height of 580 feet above Rainier Mesa. The cloud moved west from the point of detonation (35).

5.19.1 Department of Defense Participation in Scientific and Support Activities

The UCRL Test Group performed projects at Shot BLANCA. The only one of these projects involving DOD participants was Project 21.2, Radiochemical Sampling. The 4926th Test Squadron (Sampling) conducted cloud sampling, discussed below with the AFSWC activities.

While the DOD Effects Test Group did not conduct projects at the shot, it did coordinate activities of a detachment from the 1352nd Motion Picture Squadron. On 18 October 1958, the detachment filmed assembly of the BLANCA device. It also photographed the mountain and the venting of the shot at a station 3.2 kilometers from ground zero (3).

In addition, Projects 26.1 and 26.7 were conducted at Shot BLANCA, probably by Headquarters, AFSWP.

Project 26.1, Postshot Disturbances and Surface Motion, was sponsored by the Lawrence Radiation Laboratory and conducted by the Stanford Research Institute. The primary objectives were to:

- Investigate the postshot underground disturbances and surface displacements as functions of time after a deep underground nuclear detonation, using the recorded output of seismometers and the readings of simple liquid-level gauges
- Evaluate the applicability of the seismometers and gauges in detailed location of such bursts subsequent to their general location by other means.

The instruments were southeast of ground zero, the gauges being 55 kilometers and the seismometers 55 and 40 kilometers. An effort was made to take a reading about five hours after the detonation, but radiation conditions and the destruction of the roads prevented access to the instruments. Two days after the detonation, participants reentered the shot area and found the equipment damaged. They made repairs three days after the detonation and took a series of readings at that time and on the fourth and sixth days following the detonation (55).

Project 26.7, Structural Response and Permanent Displacement Measurements, was conducted by the Engineer Research and Development Laboratories and the U.S. Coast and Geodetic Survey. The objective was to measure structural response to the detonation. For permanent displacement measurements, points were selected in the tunnel in which Shot BLANCA was detonated. The points were chosen to provide coverage at locations of possible differential movement and to identify permanent effects of the detonation. Surface points were selected to give both overall area coverage and specific coverage at locations where differential movement appeared probable. Personnel conducted both pre- and postshot surveys of the permanent displacement points (53).

Air Force Special Weapons Center Activities

AFSWC personnel conducted cloud-sampling, cloud-tracking, observer, and photography missions during Shot BLANCA. The following listing indicates the type and number of aircraft and the estimated number of DOD aircrew personnel involved in these missions (39; 40):

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampler Control	B-57B	1	1
Sampling	B-57B	1	2
Cloud Tracking	L-20	1	2
Observer	Bonanza	1	*
Photography	L-20	1	2

*Unknown

There is no evidence of any sample courier mission at the shot.

One B-57B aircraft, with a pilot and a radiological safety monitor, conducted the cloud-sampling mission for Project 21.2, Radiochemical Sampling. A second B-57B aircraft, with a pilot and a UCRL technical advisor, acted as a sampler control aircraft, directing the cloud-sampling aircraft to various sections of the BLANCA cloud. An L-20 aircraft conducted a cloud-tracking mission out to about 320 kilometers from ground zero (39; 40).

5.19.2 Radiological Safety Activities

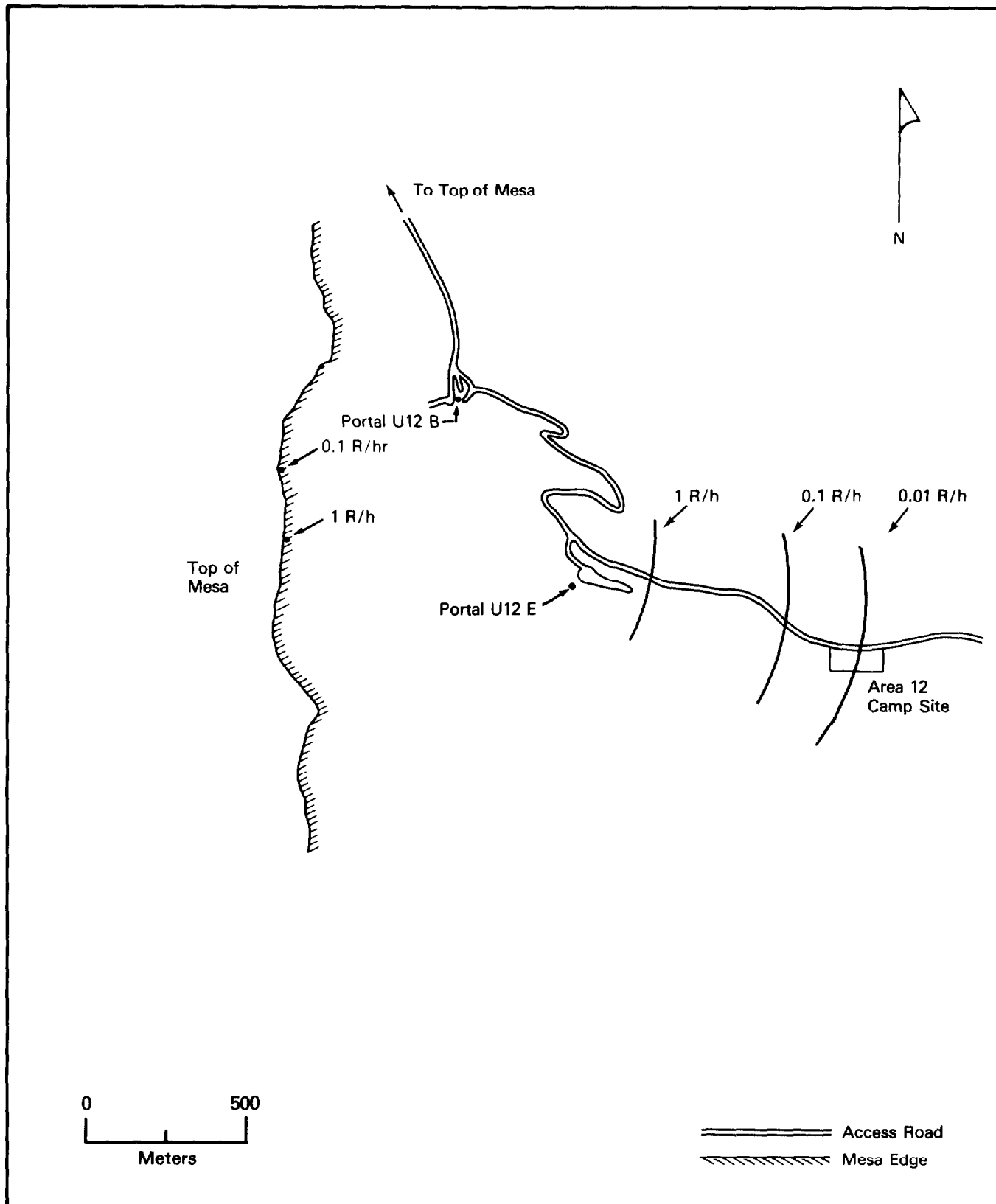
This section presents radiological safety information specific to Shot BLANCA. Chapter 3 discusses radiological safety procedures common to the Operation HARDTACK II shots.

Onsite Monitoring

Although BLANCA was detonated in a tunnel, it vented through the overburden and into the atmosphere. Venting occurred at the edge of Rainier Mesa in Area 12. The ensuing cloud rose to a height of 580 feet above the mesa and drifted off in a westerly direction. Ten men, who drove to the shot area in eight vehicles, surveyed the access road, the edge of the mesa, and the area around the tunnel portal. Readings were taken one-half hour, six hours, one day, and two days after the detonation. Figure 5-14 shows the radiation contours generated from the initial survey (49). Gamma intensities of 1 R/h were encountered along the access road out to about 600 meters from the tunnel portal. Radiation readings of 0.1 and 0.01 R/h were found farther down the road from the portal. Gamma intensities of 0.1 and 1 R/h were registered at 1343 hours along the edge of the mesa, approaching the venting location. A survey conducted two days after the detonation found similar readings along the mesa edge (22; 49; 59).

Offsite Monitoring

From one to eight hours after the detonation, USPHS personnel monitored in offsite areas. They did not encounter gamma intensities above background in any of these areas (47).



**Figure 5-14: INITIAL SURVEY FOR SHOT BLANCA,
30 OCTOBER 1958, MID-TIME 0730**

CHAPTER 6

SAFETY EXPERIMENTS

Operation HARDTACK II included 18 safety experiments, conducted from 12 September to 30 October 1958. Nine of the detonations were below ground. Six of these tests, sponsored by LASL, occurred in shafts in Area 3, while the other three, sponsored by UCRL, were detonated in tunnels in Area 12, a mountainous area of the NTS. Of the nine remaining safety experiments, LASL had one balloon and two tower tests, and UCRL had three tower and three surface detonations (35). Table 1-2 presents information on the safety experiments, which had yields up to 0.115 kiloton. Figure 1-3 shows the location of these experiments at the Nevada Test Site.

LASL and UCRL conducted the 18 experiments to determine the safety of newly developed nuclear weapons during transportation and storage. Some of the high-explosive portions of the devices were fired to simulate accidental damage. The objective was to determine the potential of such partial firings resulting in a nuclear yield above the defined safe limit of four pounds. LASL and UCRL used data gained from the tests to develop devices that could withstand shock, blast, fire, and other accidents.

Most of the participants in the safety experiments were employees of LASL, UCRL, EG&G, and REEC Co. Personnel from these AEC contractors developed devices and experiments, conducted sampling and scientific projects, and monitored the areas for radiation.

DOD personnel participation during these experiments is difficult to determine. Although most of the employees of LASL and UCRL were civilians, some DOD personnel were also assigned to these organizations. The DOD personnel who conducted a DOD

project in the safety experiments were associated with the DOD Effects Test Group Project 6.15, Electromagnetic Pulses from Low-yield Bursts, conducted at MARS, HIDALGO, NEPTUNE, and VESTA. During the detonation, these personnel were at a station near Boulder City, Nevada, about 160 kilometers from the NTS. Other DOD participants in the safety experiments flew cloud-sampling missions for LASL and UCRL Test Group projects and cloud-tracking missions for the Test Manager. Table 1-5 identifies AFSWC support for the safety experiments. Additional DOD personnel were a part of the NTSO staff (29).

6.1 OTERO

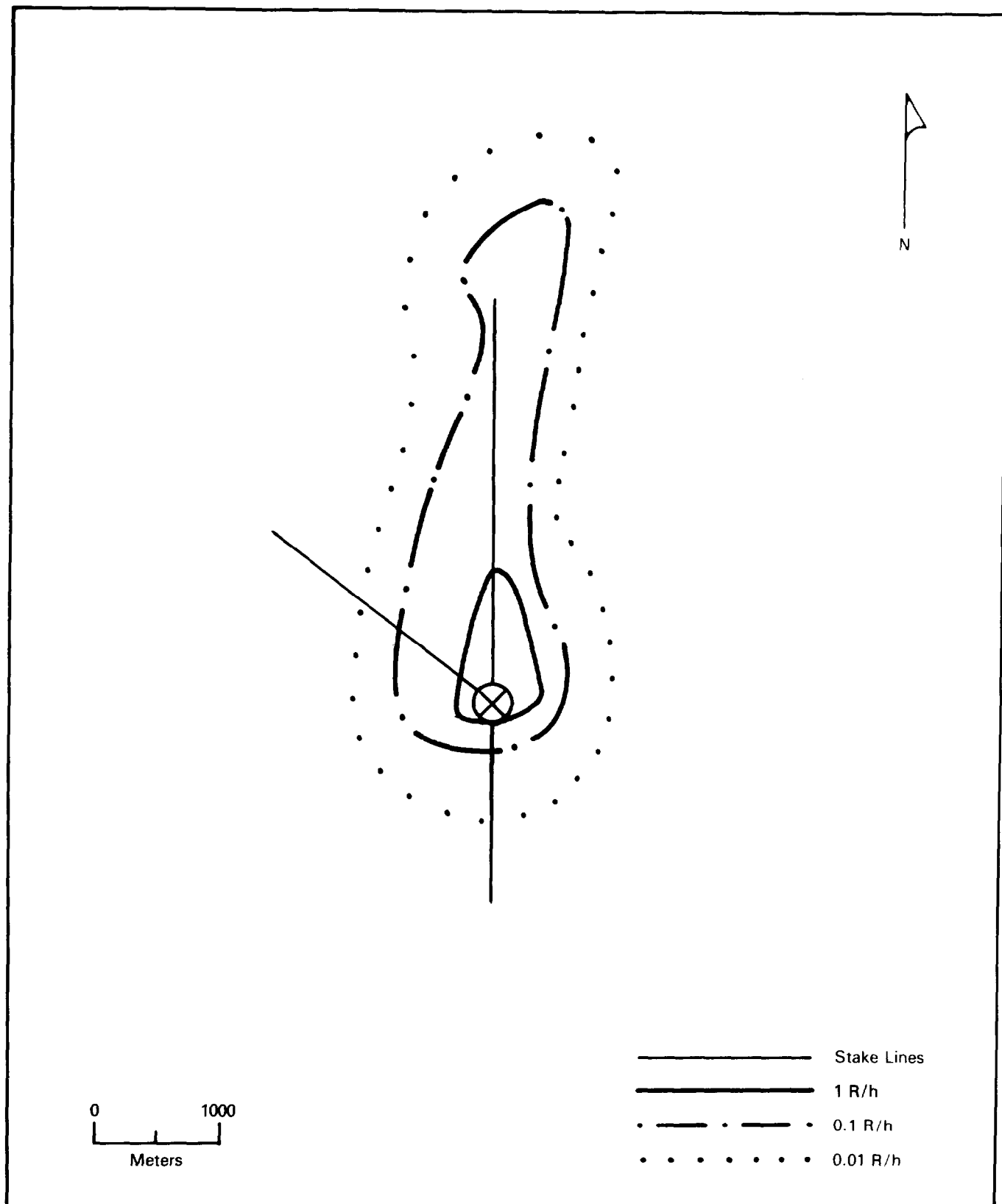
OTERO was detonated on 12 September 1958 at 1300 hours PDT. The device, developed by LASL, was fired in a shaft 480 feet deep in Area 3 at UTM coordinates 861007. The yield was 0.038 kiloton. At the time of detonation, surface winds were 25 knots from the south. The cloud rose to a height of 9,000 feet and drifted to the north (35).

6.1.1 DOD Participation

Department of Defense participation at this test included AFSWC cloud-sampling and cloud-tracking missions. Two B-57 aircraft from Indian Springs AFB conducted the cloud-sampling mission, and a C-47 from Indian Springs AFB performed the cloud-tracking mission (39; 40).

6.1.2 Radiological Safety Activities

Radiological safety personnel conducted onsite surveys at various times after the detonation. Figure 6-1 shows results of the initial survey (28; 49). USPHS personnel conducted offsite surveys in the areas north of ground zero. They encountered



**Figure 6-1: INITIAL SURVEY FOR OTERO, 12 SEPTEMBER 1958,
MID-TIME 1348**

gamma readings ranging from 0.009 R/h to 0.0009 R/h in areas around Groom Lake, Nevada (47).

6.2 BERNALILLO

BERNALILLO was a LASL device detonated in a 456-foot shaft in Area 3 at UTM coordinates 859006. The detonation, which had a yield of 0.015 kiloton, occurred at 1230 hours PDT on 17 September 1958. At the time of detonation, surface winds were 13 knots from the south. The cloud rose to a height of 7,500 feet and drifted to the north (35).

6.2.1 DOD Participation

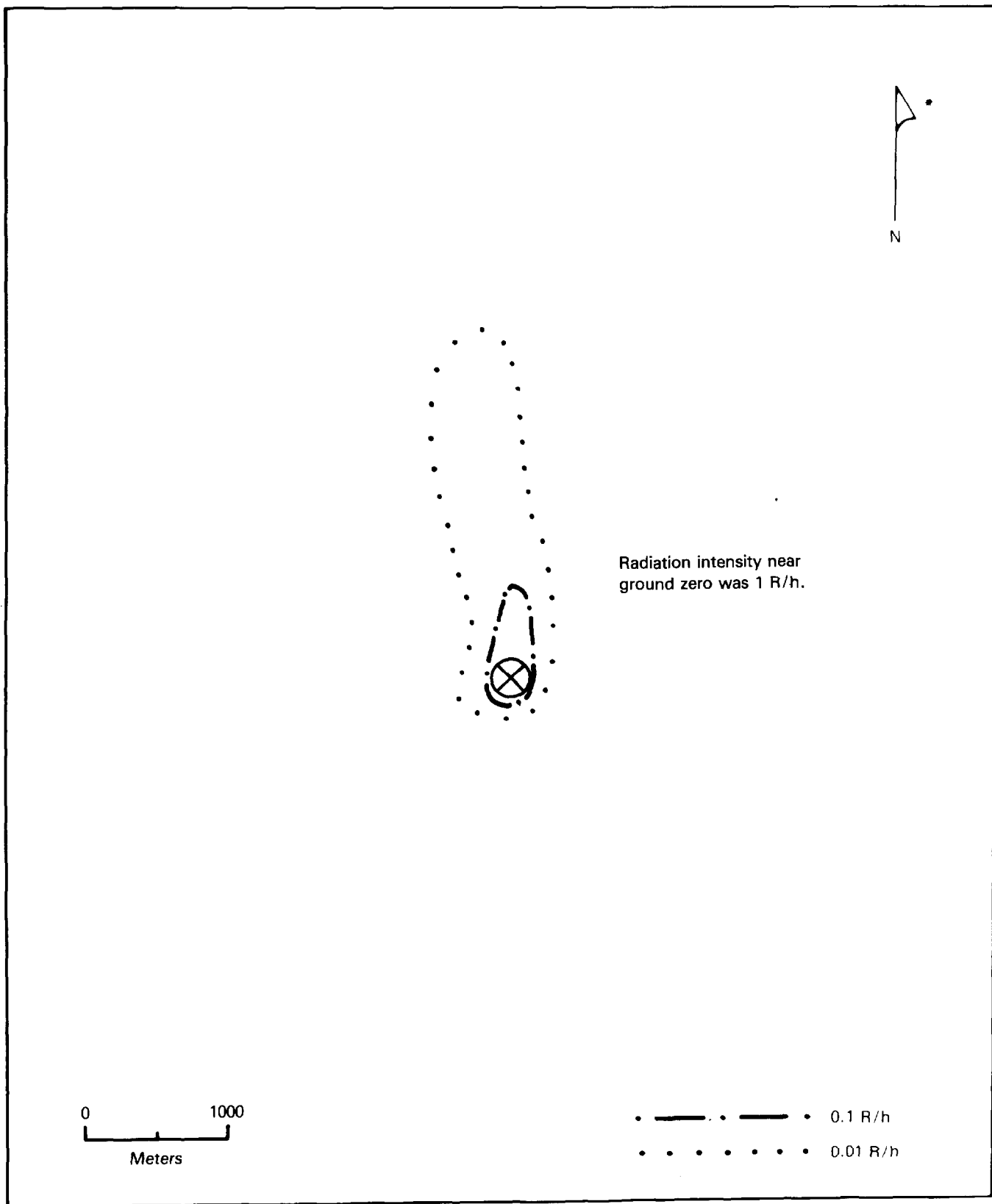
DOD participation consisted of four AFSWC B-57 aircraft from Indian Springs AFB conducting cloud-sampling operations. They returned to base upon completion of their mission. The sample filters were then removed, and the crew members and aircraft were decontaminated, as discussed in chapter 3 (39; 40).

6.2.2 Radiological Safety Activities

Surveys of the test area were conducted soon after the detonation. Figure 6-2 presents a copy of the isointensity map generated from the initial survey (49). Radiological safety monitors conducted additional surveys three hours and 45 minutes, one day, two days, and three days after the detonation. USPHS personnel conducted offsite surveys and found gamma intensities of 0.002 R/h to 0.006 R/h in areas north of the NTS (47).

6.3 LUNA

The LUNA device was detonated at 1200 hours PDT on 21 September 1958. Sponsored by LASL, LUNA was fired in a 484-foot



**Figure 6-2: INITIAL SURVEY FOR BERNALILLO, 17 SEPTEMBER 1958,
MID-TIME 1303**

shaft in Area 3, at UTM coordinates 859005. The device had a yield of 0.0015 kiloton. At the time of detonation, winds were light and variable (35).

6.3.1 DOD Participation

AFSWC personnel conducted cloud sampling using two B-57 aircraft from Indian Springs AFB. One B-57, with a pilot and a LASL scientific advisor, served as the sampler control aircraft. The other B-57, with a pilot and a radiological safety monitor, was the sampling aircraft. In addition, one L-20 aircraft conducted cloud tracking, and a C-47 provided sample courier service to Kirtland AFB (39; 40).

6.3.2 Radiological Safety Activities

Radiological monitors performed surveys of the shot area one-half hour, six hours, and one, two, and three days after the detonation. The initial survey found gamma intensities of about 1 R/h at ground zero. Radiation levels above 0.01 R/h did not extend beyond 300 meters from ground zero. The isointensity map resulting from the initial survey is available, but it does not provide additional information. Offsite monitoring revealed no radioactivity above background levels in any offsite area (47; 49).

6.4 MERCURY

MERCURY, sponsored by UCRL, was detonated in a tunnel 183 feet beneath the surface in Area 12 at UTM coordinates 709164. Detonation occurred at 1500 hours PDT on 23 September 1958 (35). This safety experiment had only a slight yield. Therefore, neither cloud-sampling nor cloud-tracking missions were conducted (39; 40).

6.4.1 Radiological Safety Activities

The initial survey encountered no radioactivity on the surface but detected some alpha contamination in the main tunnel (49).

REECo radiological safety personnel decontaminated the tunnel. The initial team consisted of four men, each equipped with an air-supplied respirator and full anticontamination clothing. The team spent 25 minutes washing the walls of the tunnel with water and taking samples to be assayed for radioactivity. A second decontamination team of two men, one of whom had been a member of the initial team, entered the tunnel and completed the washdown operation. These men also wore air-supplied respirators and full anticontamination clothing. Alpha contamination was still present after these washings, so another team entered the tunnel and applied coats of an oil-kerosene mixture or paint to the walls, ceiling, and floor of the tunnel. The tunnel was then surveyed and declared decontaminated. Individuals who participated in the decontamination activities were monitored for radioactivity and required to shower and change into fresh clothing. Nasal swabs were taken to check for possible inhaled alpha contamination (49; 60).

6.5 VALENCIA

VALENCIA, a LASL experiment, was detonated with a yield of 0.002 kiloton at 1300 hours PDT on 26 September 1958. The device was fired in a shaft at a depth of 484 feet in Area 3, UTM coordinates 859006. Surface winds were 15 knots from the north (35).

6.5.1 DOD Participation

AFSWC personnel performed cloud-sampling, sample courier, and cloud-tracking missions. Two B-57 aircraft from Indian

Springs AFB conducted cloud-sampling activities. One of the B-57s, with a pilot and a LASL advisor, acted as the sampler control aircraft. The second B-57, with a pilot and a monitor, collected samples from the cloud. After completion of the mission, they returned to base for sample filter removal and decontamination. The samples were loaded in a C-47 sample courier aircraft and flown to Kirtland AFB. After the sampling was completed, one L-20 aircraft conducted a cloud-tracking mission (39; 40).

6.5.2 Radiological Safety Activities

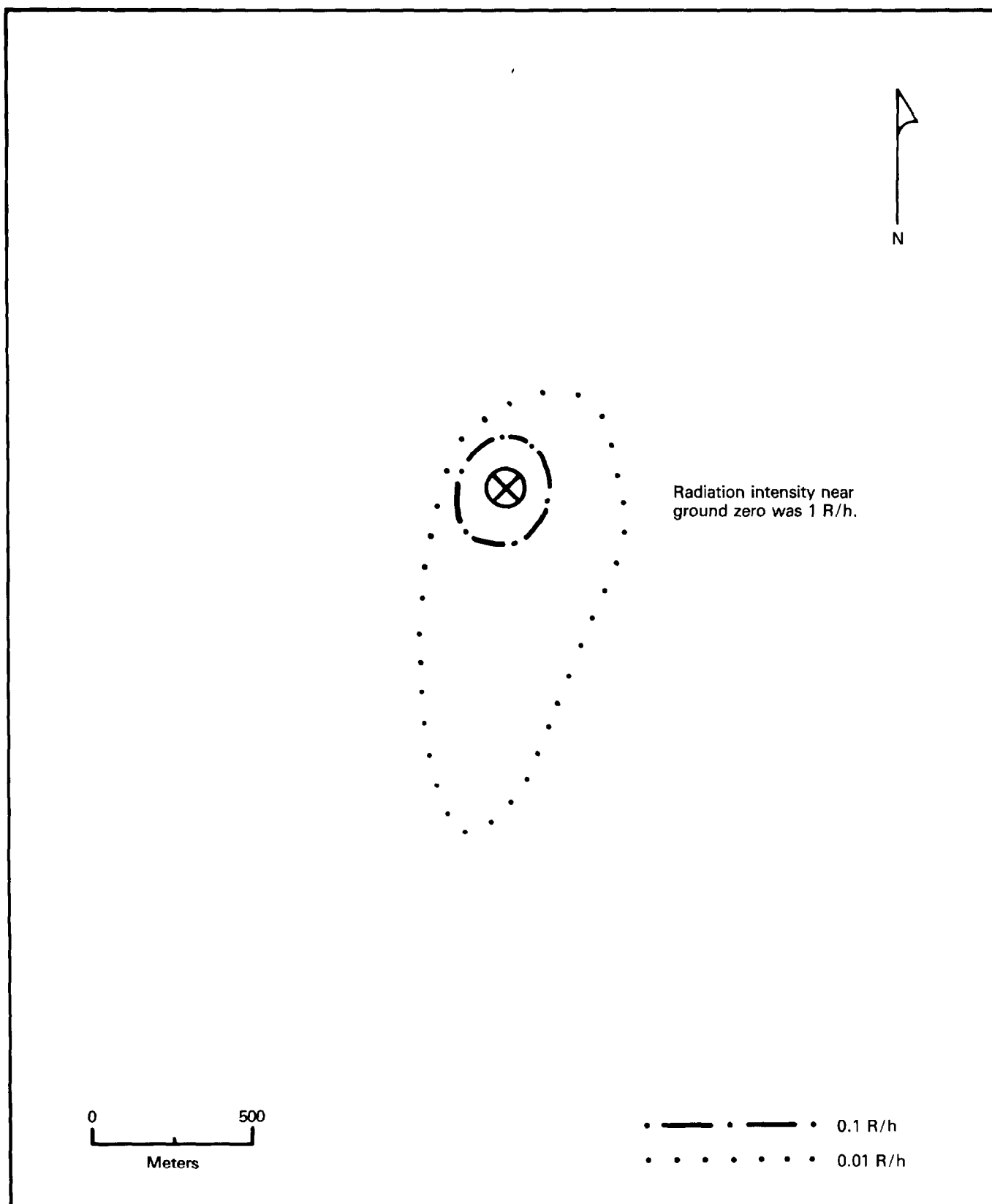
The detonation produced a small radioactive cloud that drifted in a south-southwesterly direction. Monitors surveyed the test area one-half hour, four hours, one day, and two days after the detonation. Figure 6-3 shows results of the initial survey (49). USPHS personnel surveyed offsite areas to the south-southwest of ground zero but found no radioactivity above the normal background level (28; 35; 47; 49).

6.6 MARS

The MARS device was developed by UCRL and fired at 1700 hours PDT on 28 September 1958. It was detonated with a yield of 0.013 kiloton in a tunnel 140 feet below the surface of the mesa in Area 12, UTM coordinates 709163 (35).

6.6.1 DOD Participation

The only DOD participation at MARS was in one DOD Effects Test Group project, Electromagnetic Pulses from Low-yield Bursts. Conducted by the Signal Research and Development Laboratories, this project was a continuation of similar studies undertaken at Operations TEAPOT and PLUMBBOB, which were designed to detect,



**Figure 6-3: INITIAL SURVEY FOR VALENCIA, 26 SEPTEMBER 1958,
MID-TIME 1329**

record, and analyze the electromagnetic pulse emitted from nuclear detonations. During the detonation of MARS, project personnel were monitoring instruments inside a trailer located on the outskirts of Boulder City, Nevada, approximately 160 kilometers southeast of the NTS (29).

6.6.2 Radiological Safety Activities

Radiological surveys revealed both alpha and gamma radioactivity in areas outside the tunnel. The initial survey also indicated alpha contamination in the main tunnel. Decontamination teams removed the contamination using the same procedures and techniques as described for the MERCURY tunnel decontamination. Figure 6-4 presents a copy of the isointensity map resulting from the initial survey. Additional surveys were conducted one and three days after the detonation (49).

Three individuals worked in the controlled area without anticontamination clothing. Alpha contamination, found on the hands and clothes of these individuals, was effectively removed by decontamination (49; 50).

Radioactivity dispersed by the detonation did not go offsite, and radiation levels above background were not encountered in any offsite area. No cloud-sampling activities were conducted (49).

6.7 HIDALGO

The HIDALGO device, a LASL safety experiment, was carried aloft by a balloon to 377 feet above the surface of the desert in Area 7, UTM coordinates 868048. The device was detonated with a yield of 0.077 kiloton at 0610 hours PST on 5 October 1958. At shot-time, surface winds were light. The cloud reached a height of 12,000 feet and drifted in a northeasterly direction (35).

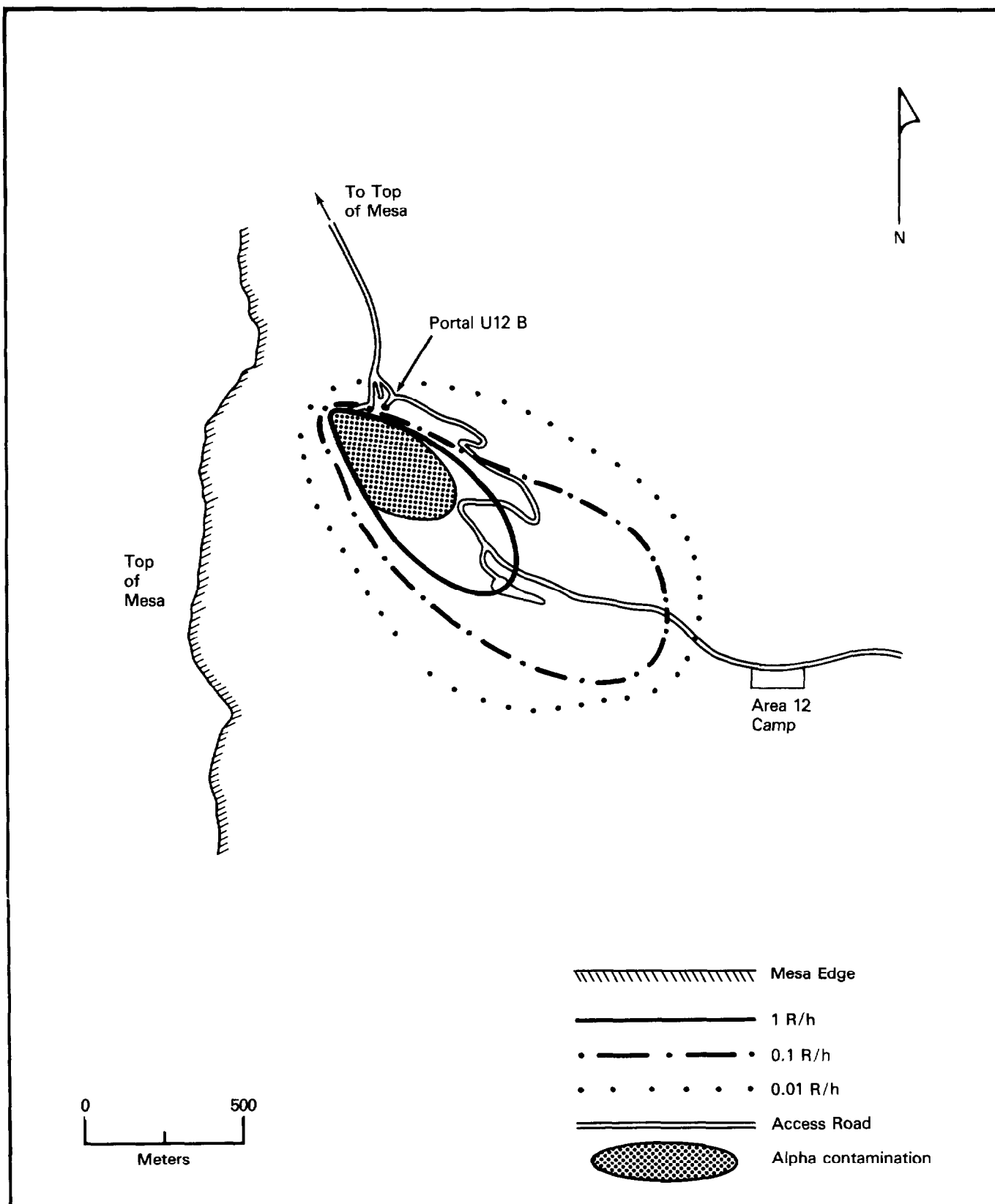


Figure 6-4: INITIAL SURVEY FOR MARS, 28 SEPTEMBER 1958, MID-TIME 1750

6.7.1 DOD Participation

DOD personnel participated in the DOD Effects Test Group Project 6.15, Electromagnetic Pulses from Low-yield Bursts, and in cloud-sampling, sample courier, and cloud-tracking missions.

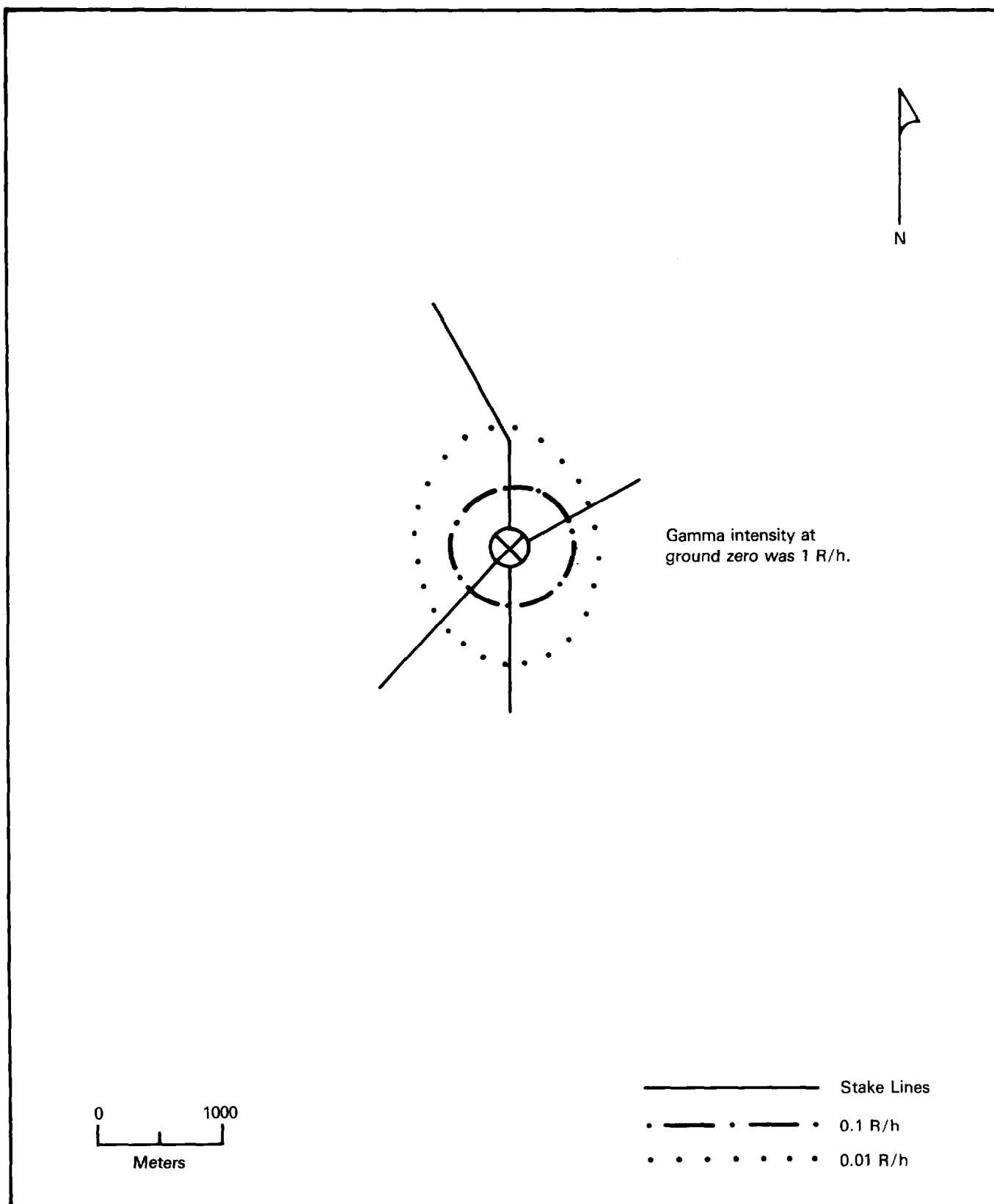
Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories. The objective of this project was to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. During the detonation, project personnel operated instruments in a trailer on the outskirts of Boulder City, Nevada (29).

Cloud-sampling activities were conducted by AFSWC personnel in two B-57 aircraft from Indian Springs AFB. One B-57, with a pilot and a LASL scientific advisor, acted as the sampler control aircraft. It directed the second B-57, with a pilot and a radiological safety officer, to various areas of the cloud to collect samples. After completing their mission, the aircraft returned to base for sample filter removal and for decontamination. The samples were loaded onto a C-47 and an H-21. The C-47 took samples to Kirtland AFB, and the H-21 transported them to Mercury. An L-20, staging from Indian Springs AFB, conducted the cloud-tracking mission for this shot (39; 40).

6.7.2 Radiological Safety Activities

Monitors conducted radiological surveys of the test area three hours, eight hours, one day, two days, and three days after the detonation. Figure 6-5 shows results of the initial survey (49).

USPHS personnel surveyed offsite areas to the east of ground zero. They encountered gamma radiation but could not determine if the radiation was from HIDALGO, COLFAX, or both detonations.



**Figure 6-5: INITIAL SURVEY FOR HIDALGO, 5 OCTOBER 1958,
MID-TIME 0910**

The personnel found gamma intensities of 0.0002 R/h in areas just outside of the NTS to the north and east of the HIDALGO ground zero (49).

6.8 COLFAX

COLFAX, sponsored by LASL, was detonated with a yield of 0.0055 kiloton in a 350-foot shaft in Area 3, UTM coordinates 859005, at 0815 hours PST on 5 October 1958. Shot-time was about two hours after the HIDALGO detonation in Area 7. Winds up to 5,000 feet were light and variable, with 11-knot winds from the southwest at 6,000 feet. The cloud formed by the detonation reached a height of 5,500 feet and drifted northeast (35).

6.8.1 DOD Participation

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions. Two B-57 aircraft, a sampler control with a pilot and a LASL advisor and a sample collector with a pilot and a radiological safety monitor, conducted the cloud-sampling mission. Afterward, the aircraft landed at Indian Springs AFB for sample filter removal and for decontamination. Once the filters were removed, the samples were delivered to Mercury by a C-47 aircraft and the H-21 that was also used to deliver the HIDALGO samples. A C-47 conducted the cloud-tracking mission (39; 40).

6.8.2 Radiological Safety Activities

Monitors made an initial survey of the area immediately around ground zero. Gamma intensities of 1 R/h or more were confined to within about 80 meters of ground zero, and radiation levels of 0.01 R/h were encountered up to 400 meters from the point of detonation. Additional surveys were conducted six hours, one day, and two days after the detonation (49).

USPHS personnel conducted offsite radiological surveys and found radioactivity slightly above background levels to the north of ground zero, immediately outside of the NTS (47).

6.9 NEPTUNE

NEPTUNE, a UCRL test, was detonated in U12C tunnel 110 feet below the surface of the mesa in Area 12, at UTM coordinates 710164. The detonation occurred with a yield of 0.115 kiloton at 1000 hours PST on 14 October 1958. The shot vented, and the resultant cloud rose to a height of about 4,000 feet above the mesa. The cloud traveled west-northwest (35).

6.9.1 DOD Participation

DOD personnel participated in the DOD Effects Test Group Project 6.15, Electromagnetic Pulses from Low-yield Bursts, and in Project 26.7, Structural Response and Permanent Displacement Measurements, probably an activity of Headquarters, AFSWP. In addition, DOD participants took part in a cloud-tracking mission.

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. During the detonation, project personnel operated equipment in a trailer near Boulder City, Nevada (11; 29).

Project 26.7, Structural Response and Permanent Displacement Measurements, was conducted by the Engineer Research and Development Laboratories and the U.S. Coast and Geodetic Survey. The objective was to measure structural response to the detonation. For permanent displacement measurements, points were selected in the tunnel in which Shot NEPTUNE was detonated. The points were chosen to provide coverage at locations of possible

differential movement and to identify permanent effects of the detonation. Surface points were selected to give both overall area coverage and specific coverage at locations where differential movement appeared probable (53).

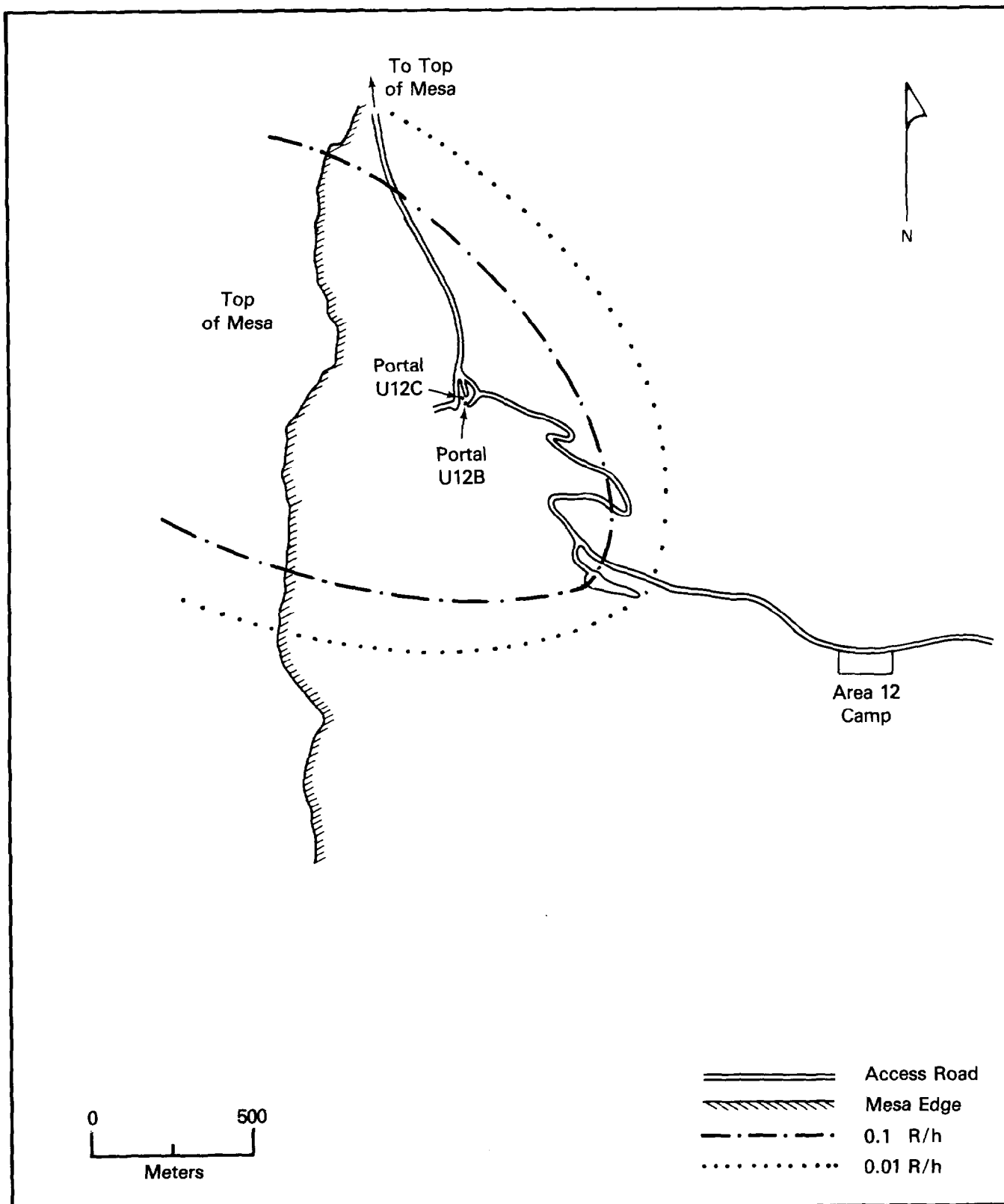
Cloud-sampling aircraft did not participate at NEPTUNE. One L-20 aircraft was used for cloud tracking (39; 40).

6.9.2 Radiological Safety Activities

A monitoring party of ten men drove to the tunnel area in six vehicles and conducted a radiological survey of areas outside the tunnel portal and on top of the mesa. The gamma intensity near the venting point was about 1,200 R/h one hour after the detonation. A radiation level of 0.1 R/h was registered from 300 to 700 meters northeast, southeast, and southwest of the venting site. A level of 0.01 R/h was detected out to 1,000 meters in the same directions from the venting site. To the northwest, on top of the mesa, the 0.1 R/h line extended beyond 2,000 meters. Figure 6-6 shows the results of this survey (49). Offsite monitoring, conducted by USPHS personnel, found no radioactivity in areas outside the NTS (47; 49).

6.10 VESTA

At 1500 hours PST on 17 October 1958, Shot VESTA, sponsored by UCRL, was detonated on the surface in a wooden shed covered with 20 feet of gravel. Ground zero was at UTM coordinates 857087, Area 9. The yield was 0.024 kiloton. At the time of detonation, the winds were five knots from the south. The cloud rose to 10,000 feet and moved north (35).



**Figure 6-6: INITIAL SURVEY FOR NEPTUNE, 14 OCTOBER 1958,
ABOUT 90 MINUTES AFTER DETONATION**

6.10.1 DOD Participation

The DOD Effects Test Group conducted Project 6.15, Electromagnetic Pulses from Low-yield Bursts, and AFSWC performed cloud-sampling and cloud-tracking missions.

Project 6.15, Electromagnetic Pulses from Low-yield Bursts, was conducted by the Signal Research and Development Laboratories to detect, record, and analyze the electromagnetic pulse radiating from a nuclear detonation. During the detonation, project personnel remained in an instrumented trailer about 160 kilometers southeast of the NTS on the outskirts of Boulder City, Nevada (29).

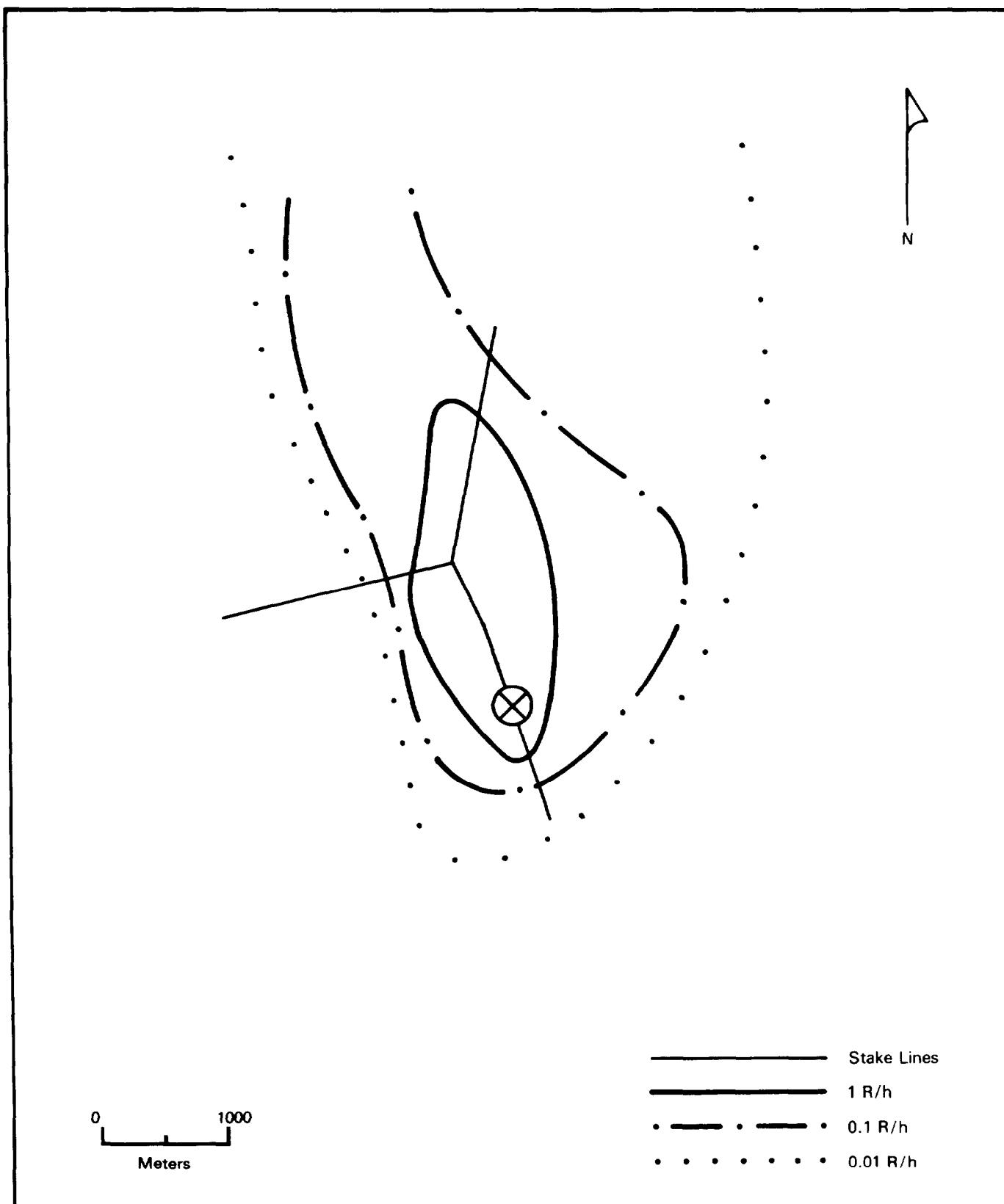
AFSWC provided two B-57 aircraft to conduct the cloud-sampling operation at VESTA. In addition, it provided a single L-20 aircraft from Indian Springs AFB for cloud tracking (39; 40).

6.10.2 Radiological Safety Activities

A survey team of eight monitors in six vehicles conducted radiological surveys of the test area 90 minutes after the detonation. Figure 6-7 shows the gamma radiation results of the initial survey. The monitoring team conducted additional surveys one day and two days later (49). Offsite monitoring in areas north of ground zero found 0.0004 R/h of gamma radioactivity around Groom Lake, Nevada (47).

6.11 SAN JUAN

SAN JUAN, a LASL device, was detonated in a shaft at a depth of 234 feet in Area 3, UTM coordinates 861008, at 0630 hours PST on 20 October 1958. The detonation did not produce a measurable nuclear yield. No visible venting occurred, and no cloud was produced (17; 35).



**Figure 6-7: INITIAL SURVEY FOR VESTA, 17 OCTOBER 1958,
MID-TIME 1633**

6.11.1 DOD Participation

No documented DOD participation took place at SAN JUAN. Two B-57 cloud-sampling aircraft and one L-20 cloud tracker were scheduled to participate but were not needed since no cloud was produced (39; 40).

6.11.2 Radiological Safety Activities

A survey party of nine monitors in six vehicles entered the test area about six hours after the detonation and conducted the radiological survey. The monitors did not encounter gamma radioactivity, but they did find alpha contamination in the immediate vicinity of the shaft opening. The USPHS monitoring teams did not encounter radioactivity offsite (47; 49).

6.12 OBERON

OBERON, sponsored by UCRL, was detonated on a 25-foot tower in Area 8 at UTM coordinates 826154. It was fired at 1230 hours PST on 22 October 1958. Three weapons-related detonations also occurred the same day, two before and one after OBERON. The four events of the day occurred two and one-half to three and one-half hours apart. The OBERON device produced no measurable nuclear yield. However, the detonation generated a small cloud of debris that rose to 6,000 feet and drifted to the north (35).

6.12.1 DOD Participation

DOD participation was limited to cloud-sampling and cloud-tracking missions by AFSWC personnel. One B-57 cloud-sampling aircraft and one L-20 cloud tracker, both staging from Indian Springs AFB, participated in air operations. Upon completion of their missions, the aircraft returned to base (39; 40).

6.12.2 Radiological Safety Activities

A survey party of nine monitors in six vehicles entered the shot area shortly after the detonation and conducted a radiological survey. The monitors encountered no gamma radioactivity but found alpha contamination in the vicinity of ground zero and to the northwest (6; 49).

Monitoring of offsite areas on 22 October 1958 revealed gamma radioactivity in areas north of the NTS. However, the USPHS monitors determined that the radioactivity was from Shot SOCORRO, a weapons-related detonation earlier on that day, and not from OBERON (47).

6.13 CATRON

CATRON was a LASL device detonated on a 72.5-foot tower in Area 3, UTM coordinates 866999. It was fired with a yield of 0.021 kiloton at 0700 hours PST on 24 October 1958. The CATRON cloud rose to a height of 3,500 feet above the ground and drifted in a southwesterly direction (35).

6.13.1 DOD Participation

AFSWC conducted cloud-sampling, sample courier, and cloud-tracking missions. Two B-57 aircraft from Indian Springs AFB conducted cloud sampling. After the B-57s completed the mission and landed at Indian Springs AFB, filter samples were removed, and aircraft and crew were decontaminated. The samples were placed in a C-47 aircraft for delivery to Kirtland AFB. One L-20 aircraft staging from Indian Springs AFB performed a cloud-tracking mission and then returned to base for debriefing and decontamination (39; 40).

6.13.2 Radiological Safety Activities

Shortly after the detonation, a survey party conducted the radiological survey. Figure 6-8 shows results of the initial ground survey. Additional surveys were performed seven hours, one day, and two days later (49).

USPHS personnel who conducted offsite radiological surveys encountered low levels of gamma radiation in areas southwest of ground zero. A gamma intensity of 0.001 R/h was registered near Beatty, Nevada (47).

6.14 JUNO

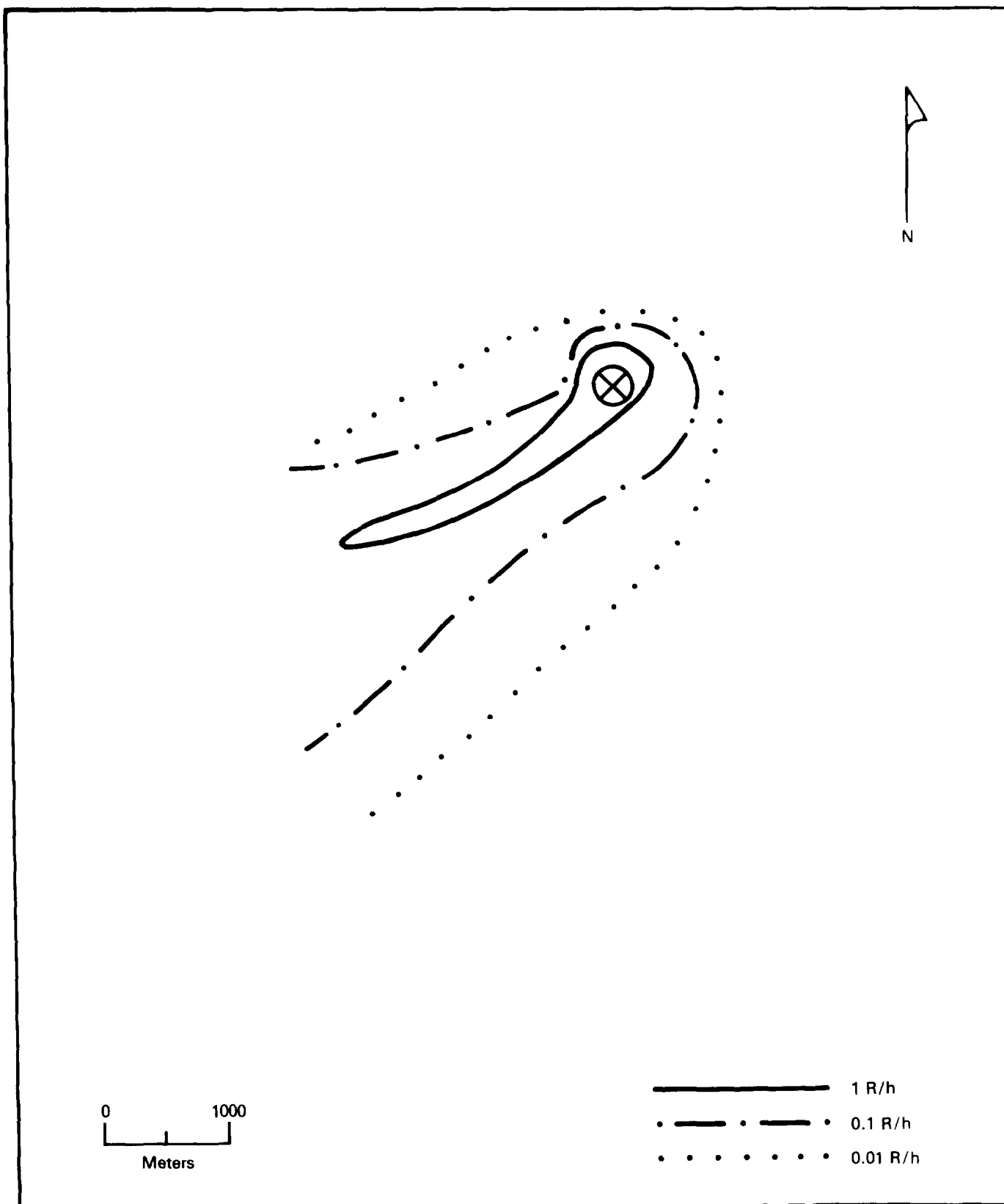
JUNO, the second safety experiment on 24 October 1958, was detonated with a yield of 0.0017 kiloton at 0801 hours PST, one hour after the CATRON detonation. JUNO was detonated in a wooden building covered with 20 feet of gravel in Area 9, UTM coordinates 855088. The cloud, which reached 1,300 feet above the ground, traveled south before turning west (35).

6.14.1 DOD Participation

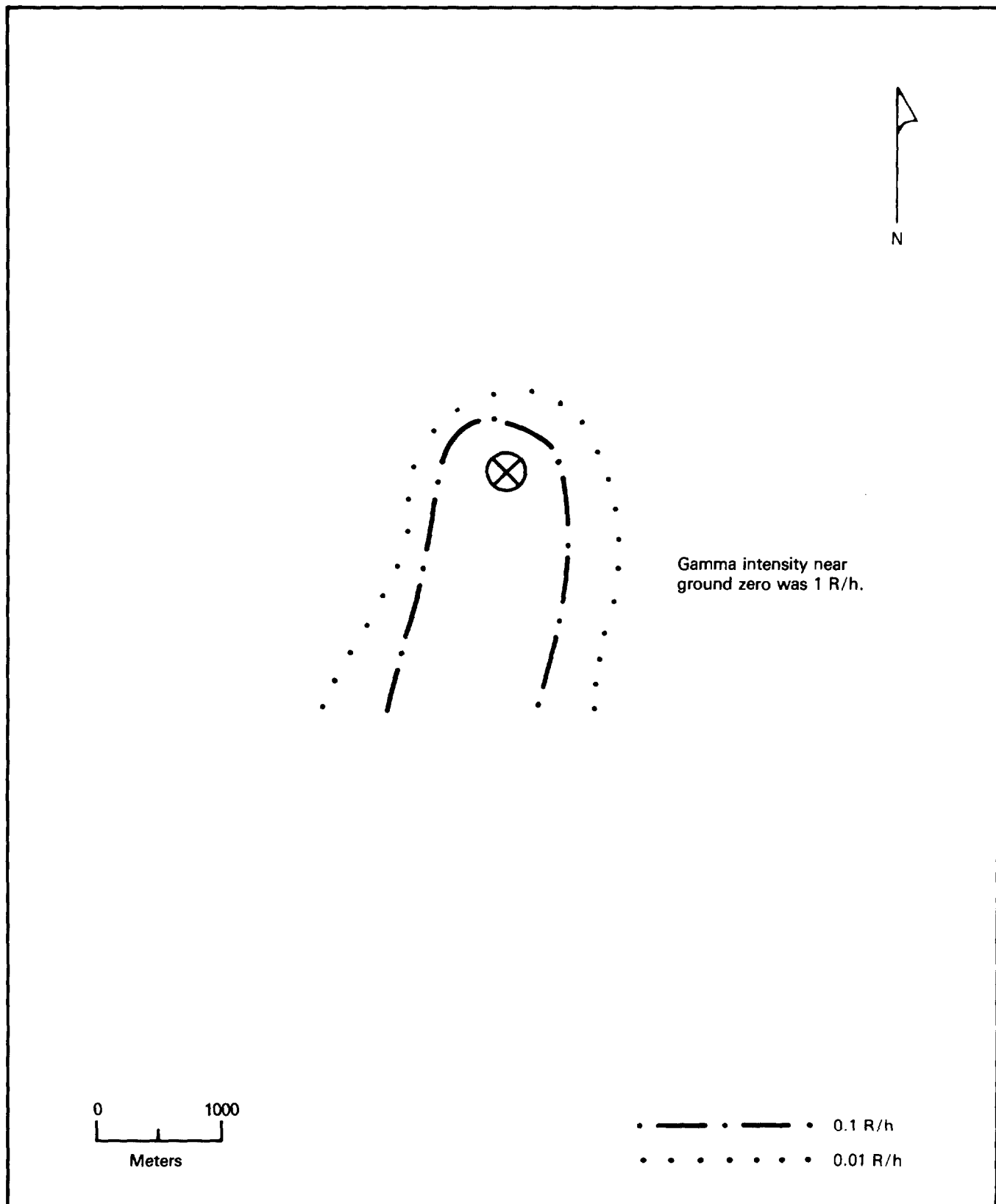
AFSWC conducted cloud-sampling, sample courier, and cloud-tracking missions. One B-57 aircraft from Indian Springs AFB performed the cloud sampling. After the aircraft returned to the base, the filter samples were removed and placed in a C-47 for delivery to Alameda Naval Air Station. An L-20 aircraft, staging from Indian Springs AFB, conducted cloud tracking (39; 40).

6.14.2 Radiological Safety Activities

A survey party of ten monitors in six vehicles conducted the radiological surveys of the test area. Figure 6-9 indicates the



**Figure 6-8: INITIAL SURVEY FOR CATRON, 24 OCTOBER 1958,
MID-TIME 0729**



**Figure 6-9: INITIAL SURVEY FOR JUNO, 24 OCTOBER 1958,
MID-TIME 0857**

gamma radiation encountered during the initial ground survey (49). Extensive alpha contamination occurred, generally extending the width of the 0.1 R/h contour lines and more than two kilometers to the south. The monitoring teams conducted additional surveys seven hours, one day, and two days after the detonation (49).

The offsite monitoring teams were unable to distinguish between offsite radiation produced by JUNO and that produced by CATRON because of the brief time between the tests and because of the identical wind conditions. Section 6.13.2, on monitoring at CATRON, describes the offsite radiological results (47).

6.15 CERES

UCRL detonated the CERES device at 2000 hours PST on 26 October 1958. It was detonated on a 25-foot tower in Area 8, UTM coordinates 826152. The detonation, which had a yield of 0.0007 kiloton, produced a small cloud that rose to 1,470 feet above the ground and drifted in a northerly direction. There was no DOD participation at this shot (35).

6.15.1 Radiological Safety Activities

Shortly after the detonation, a survey team of ten monitors in six vehicles conducted a radiological survey of the shot area. The initial survey indicated gamma intensities of 1 R/h or more confined to within 40 meters of ground zero. Radiation levels of 0.1 R/h or more were limited to about 470 meters from ground zero, and levels of 0.01 R/h extended more than 900 meters north of ground zero. A survey conducted 15 hours later showed all radioactivity above 0.01 R/h confined to within 145 meters of ground zero (18; 49). Offsite monitoring teams reported no offsite radioactivity (18; 47).

6.16 CHAVEZ

CHAVEZ was a LASL device detonated at 0630 hours PST on 27 October 1958. The device, which had a yield of 0.0006 kiloton, was detonated on a tower 52.5 feet above the ground in Area 3, UTM coordinates 862001. The cloud reached 2,500 feet above ground and drifted in a southerly direction (35).

6.16.1 DOD Participation

AFSWC personnel conducted cloud-sampling, sample courier, and cloud-tracking missions. Two B-57 aircraft performed the cloud sampling. After the filter samples were removed at Indian Springs AFB, they were loaded in a C-47 and taken to Kirtland AFB for LASL. A single L-20 aircraft conducted the cloud-tracking operation (39; 40).

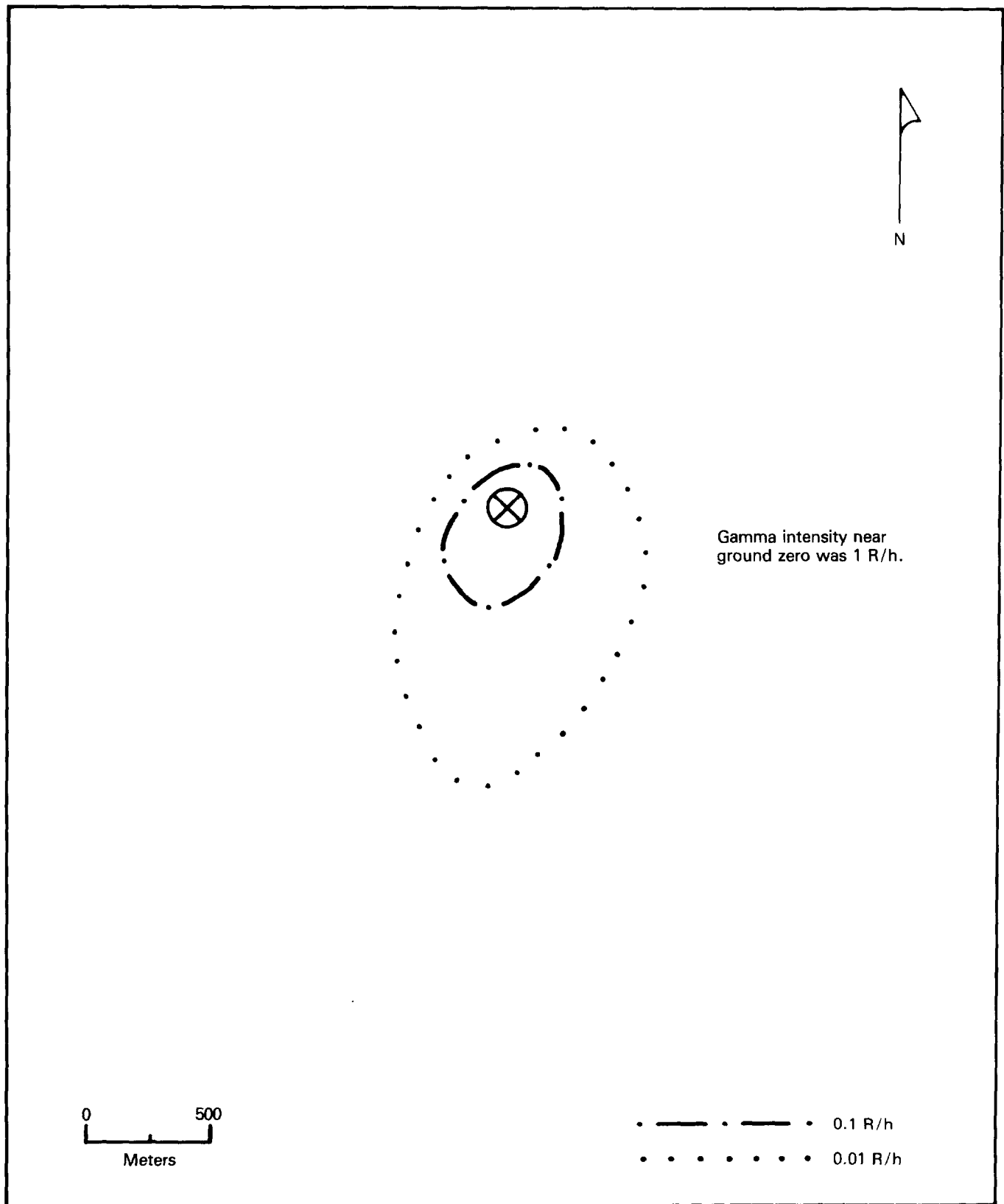
6.16.2 Radiological Safety Activities

A survey team of ten monitors in eight vehicles conducted radiological surveys of the shot area. Figure 6-10 shows results of the initial survey. Additional surveys were conducted eight hours and one day after the detonation (23; 49).

USPHS personnel conducted offsite monitoring in the area around Lathrop Wells, Nevada. They encountered 0.0003 R/h of gamma radiation (47).

6.17 GANYMEDE

The UCRL GANYMEDE device was detonated at 0300 hours PST on 30 October 1958. It was fired on the surface in a wooden building covered with 20 feet of gravel in Area 9, UTM coordinates 846090. The detonation produced no measurable yield and no cloud. One other safety experiment, TITANIA, and two



**Figure 6-10: INITIAL SURVEY FOR CHAVEZ, 27 OCTOBER 1958,
MID-TIME 0659**

weapons-related shots, BLANCA and SANTA FE, were also detonated on this day. There was no DOD participation for GANYMEDE (35).

6.17.1 Radiological Safety Activities

A survey team of nine men in six vehicles entered the test area and conducted a radiological ground survey. Negligible gamma radiation was found. The team, however, encountered alpha contamination in the immediate vicinity of ground zero (26; 49).

6.18 TITANIA

Sponsored by UCRL, TITANIA was detonated on a 25-foot tower in Area 8, UTM coordinates 826148, at 1234 hours PST on 30 October 1958. GANYMEDE and two weapons-related detonations also occurred that day. The yield of TITANIA was 0.0002 kiloton. The cloud rose to a height of 1,600 feet above the ground and drifted to the southwest (27).

6.18.1 DOD Participation

Five AFSWC aircraft conducted missions for TITANIA. Two B-57 aircraft from Indian Springs AFB conducted cloud-sampling operations. One L-20 from Indian Springs AFB performed the cloud-tracking mission, while another L-20 flew a photography mission. A Bonanza aircraft from Indian Springs AFB carried observers witnessing the detonation. It is probable that the L-20 conducting the photography mission and the Bonanza conducting the observer mission were also used for the same purpose during Shot BLANCA, a weapons-related detonation also conducted on 30 October. After completion of their missions, the crew and the aircraft returned to base for debriefing and decontamination.

6.18.2 Radiological Safety Activities

A party of ten monitors in eight vehicles conducted a radiological survey of the shot area. Gamma intensities of 10 R/h were measured 15 meters from ground zero, 1 R/h 23 meters from ground zero, and 0.1 R/h 90 meters from ground zero. The 0.01 R/h line extended out to about 290 meters from ground zero. The area was resurveyed six hours and 22 hours after the detonation. Monitoring teams found no radioactivity in offsite areas (47; 49).

HARDTACK II REFERENCE LIST

The following list of references represents only the documents cited in the HARDTACK II volume. When a WT document is followed by an EX, the latest version has been cited.

The name of the Armed Forces Special Weapons Project (AFSWP) was changed to Defense Atomic Support Agency (DASA) on May 6, 1959. The AFSWP project reports were published after May 6.

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ATTN: Fed Depository Collection

University of Guam
ATTN: Librarian

Gustavus Adolphus College
ATTN: Library

Hardin-Simmons University Library
ATTN: Librarian

Hartford Public Library
ATTN: Librarian

Harvard College Library
ATTN: Director of Libraries

Harvard College Library
ATTN: Librarian

University of Hawaii
ATTN: Government Docs Collection

Hawaii State Library
ATTN: Federal Documents Unit

University of Hawaii at Monoa
ATTN: Director of Libraries

University of Hawaii
ATTN: Librarian

Haydon Burns Library
ATTN: Librarian

Henry Ford Comm College Lib
ATTN: Librarian

Herbert H. Lehman College
ATTN: Library Documents Division

Hofstra Univ Library
ATTN: Documents Dept

Hollins College
ATTN: Librarian

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Hopkinsville Comm College
ATTN: Librarian

University of Houston, Library
ATTN: Documents Div

Houston Public Library
ATTN: Librarian

Hoyt Public Library
ATTN: Librarian

Humboldt State College Library
ATTN: Documents Dept

Huntington Park Library
ATTN: Librarian

Hutchinson Public Library
ATTN: Librarian

Idaho Public Lib & Info Center
ATTN: Librarian

Idaho State Library
ATTN: Librarian

Idaho State University Library
ATTN: Documents Dept

University of Idaho
ATTN: Documents Sect
ATTN: Dir of Libraries

University of Illinois, Library
ATTN: Documents Section

Illinois State Library
ATTN: Government Documents Branch

Illinois Univ at Urbana Champaign
ATTN: P. Watson, Documents Library

Illinois Valley Comm Coll
ATTN: Library

Indiana State Library
ATTN: Serial Section

Indiana State University
ATTN: Documents Libraries

Indiana University Library
ATTN: Documents Department

Indianapolis Marion Cty Pub Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Govt Documents Dept

Iowa University Library
ATTN: Government Documents Dept

OTHER (Continued)

Butler University, Irwin Library
ATTN: Librarian

Isaac Delchdo College
ATTN: Librarian

James Madison University
ATTN: Librarian

Jefferson County Public Lib
ATTN: Librarian

Jersey City State College
ATTN: Librarian

Johns Hopkins University
ATTN: Documents Library

John J. Wright Library, La Roche College
ATTN: Librarian

Johnson Free Public Lib
ATTN: Librarian

Kahului Library
ATTN: Librarian

Kalamazoo Public Library
ATTN: Librarian

Kansas City Public Library
ATTN: Documents Div

Kansas State Library
ATTN: Librarian

Kansas State Univ Library
ATTN: Documents Dept

University of Kansas
ATTN: Director of Libraries

Kent State University Library
ATTN: Documents Div

Kentucky Dept of Library & Archives
ATTN: Documents Section

University of Kentucky
ATTN: Governments Publication Dept
ATTN: Director of Libraries

Kenyon College Library
ATTN: Librarian

Lake Forest College
ATTN: Librarian

Lake Sumter Comm Coll Lib
ATTN: Librarian

Lakeland Public Library
ATTN: Librarian

OTHER (Continued)

Lancaster Regional Library
ATTN: Librarian

Lawrence University
ATTN: Documents Dept

Lee Library, Brigham Young University
ATTN: Documents & Map Section

Library & Statutory Distribution & Svc
2 cy ATTN: Librarian

Little Rock Public Library
ATTN: Librarian

Long Beach Publ Library
ATTN: Librarian

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

Louisiana State University
ATTN: Government Doc Dept
ATTN: Director of Libraries

Louisville Free Pub Lib
ATTN: Librarian

Louisville Univ Library
ATTN: Librarian

Lyndon B. Johnson Sch of Pub Affairs Lib
ATTN: Librarian

Maine Maritime Academy
ATTN: Librarian

Maine University at Orono
ATTN: Librarian

University of Maine
ATTN: Librarian

Manchester City Library
ATTN: Librarian

Mankato State College
ATTN: Govt Publications

Mantor Library
Univ of Maine at Farmington
ATTN: Director of Libraries

Marathon County Public Library
ATTN: Librarian

Marshall Brooks Library
ATTN: Librarian

University of Maryland
ATTN: McKeldin Libr Docs Div

University of Maryland
ATTN: Librarian

OTHER (Continued)

University of Massachusetts
ATTN: Government Docs College

McNeese State Univ
ATTN: Librarian

Memphis Shelby County Pub Lib & Info Ctr
ATTN: Librarian

Memphis State University
ATTN: Librarian

Mercer University
ATTN: Librarian

Mesa County Public Library
ATTN: Librarian

University of Miami, Library
ATTN: Government Publications

Miami Public Library
ATTN: Documents Division

Miami Univ Library
ATTN: Documents Dept

Michel Orradre Library
University of Santa Clara
ATTN: Documents Div

Michigan State Library
ATTN: Librarian

Michigan State University Library
ATTN: Librarian

Michigan Tech University
ATTN: Library Documents Dept

University of Michigan
ATTN: Acq Sec Documents Unit

Middlebury College Library
ATTN: Librarian

Millersville State Coll
ATTN: Librarian

Milne Library
State University of New York
ATTN: Docs Librn

Milwaukee Pub Lib
ATTN: Librarian

Minneapolis Public Lib
ATTN: Librarian

Minnesota Div of Emergency Svcs
ATTN: Librarian

Minot State College
ATTN: Librarian

Mississippi State University
ATTN: Librarian

OTHER (Continued)

University of Mississippi
ATTN: Director of Libraries

Missouri Univ at Kansas City Gen
ATTN: Librarian

Missouri University Library
ATTN: Government Documents

M.I.T. Libraries
ATTN: Librarian

Mobile Public Library
ATTN: Governmental Info Division

Moffett Library
ATTN: Librarian

Montana State Library
ATTN: Librarian

Montana State University, Library
ATTN: Librarian

University of Montana
ATTN: Documents Div

Moorhead State College
ATTN: Library

Mt Prospect Public Lib
ATTN: Librarian

Murray State Univ Lib
ATTN: Library

Nassau Library System
ATTN: Librarian

Natrona County Public Library
ATTN: Librarian

Nebraska Library Comm
ATTN: Librarian

Univ of Nebraska at Omaha
ATTN: Librarian

Nebraska Western College Library
ATTN: Librarian

Univ of Nebraska at Lincoln
ATTN: Director of Libraries

Univ of Nevada at Reno
ATTN: Governments Pub Dept

Univ of Nevada at Las Vegas
ATTN: Director of Libraries

New Hampshire University Lib
ATTN: Librarian

New Hanover County Public Library
ATTN: Librarian

Nebraska University
ATTN: Director of Libraries

OTHER (Continued)

New Mexico State Library
ATTN: Librarian

New Mexico State University
ATTN: Lib Documents Div

University of New Mexico
ATTN: Director of Libraries

University of New Orleans Library
ATTN: Govt Documents Div

New Orleans Public Lib
ATTN: Library

New York Public Library
ATTN: Librarian

New York State Library
ATTN: Doc Control, Cultural Ed Ctr

New York State Univ at Stony Brook
ATTN: Main Lib Doc Sect

New York State Univ Col at Cortland
ATTN: Librarian

State Univ of New York
ATTN: Library Documents Sec

State Univ of New York
ATTN: Librarian

New York State University
ATTN: Documents Center

State University of New York
ATTN: Documents Dept

New York University Library
ATTN: Documents Dept

Newark Free Library
ATTN: Librarian

Newark Public Library
ATTN: Librarian

Niagara Falls Pub Lib
ATTN: Librarian

Nicholls State Univ Library
ATTN: Docs Div

Nieves M. Flores Memorial Lib
ATTN: Librarian

Norfolk Public Library
ATTN: R. Parker

North Carolina Agri & Tech State Univ
ATTN: Librarian

Univ of North Carolina at Charlotte
ATTN: Atkins Library Documents Dept

Univ of North Carolina at Greensboro, Library
ATTN: Librarian

OTHER (Continued)

North Carolina Central University
ATTN: Librarian

North Carolina State University
ATTN: Librarian

North Carolina University at Wilmington
ATTN: Librarian

University of North Carolina
ATTN: BA SS Division Documents

North Dakota State University Lib
ATTN: Docs Librarian

University of North Dakota
ATTN: Librarian

North Georgia College
ATTN: Librarian

North Texas State University Library
ATTN: Librarian

Northeast Missouri State University
ATTN: Librarian

Northeastern Illinois University
ATTN: Library

Northeastern Oklahoma State Univ
ATTN: Librarian

Northeastern University
ATTN: Dodge Library

Northern Arizona University Lib
ATTN: Government Documents Dept

Northern Illinois University
ATTN: Librarian

Northern Iowa University
ATTN: Library

Northern Michigan Univ
ATTN: Documents

Northern Montana College Library
ATTN: Librarian

Northwestern Michigan College
ATTN: Librarian

Northwestern State Univ
ATTN: Librarian

Northwestern State Univ Library
ATTN: Librarian

Northwestern University Library
ATTN: Govt Publications Dept

Norwalk Public Library
ATTN: Librarian

OTHER (Continued)

University of Notre Dame
ATTN: Document Center

Oakland Comm College
ATTN: Librarian

Oakland Public Library
ATTN: Librarian

Oberlin College Library
ATTN: Librarian

Ocean County College
ATTN: Librarian

Ohio State Library
ATTN: Librarian

Ohio State University
ATTN: Libraries Documents Division

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librarian

Oklahoma City University Library
ATTN: Librarian

Oklahoma Dept of Libraries
ATTN: U.S. Govt Documents

University of Oklahoma
ATTN: Documents Div

Old Dominion University
ATTN: Doc Dept Univ Library

Olivet College Library
ATTN: Librarian

Omaha Pub Lib Clark Branch
ATTN: Librarian

Oregon State Library
ATTN: Librarian

University of Oregon
ATTN: Documents Section

Ouachita Baptist University
ATTN: Librarian

Pan American University Library
ATTN: Librarian

Passaic Public Library
ATTN: Librarian

Paul Klapper Library
ATTN: Documents Dept

Pennsylvania State Library
ATTN: Government Publications Section

OTHER (Continued)

Pennsylvania State University
ATTN: Library Document Sec

University of Pennsylvania
ATTN: Director of Libraries

Penrose Library
University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Govt Publications Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librarian

University of Pittsburgh
ATTN: Documents Office G 8

Plainfield Public Library
ATTN: Librarian

Popular Creek Public Lib District
ATTN: Librarian

Association of Portland Lib
ATTN: Librarian

Portland Public Library
ATTN: Librarian

Portland State University Library
ATTN: Librarian

Prescott Memorial Lib
Louisiana Tech Univ
ATTN: Librarian

Princeton University Library
ATTN: Documents Division

Providence College
ATTN: Librarian

Providence Public Library
ATTN: Librarian

Cincinnati & Hamilton County Public Library
ATTN: Librarian

Public Library of Nashville and Davidson County
ATTN: Library

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librarian

OTHER (Continued)

Quinebaug Valley Community Col
ATTN: Librarian

Ralph Brown Draughon Lib
Auburn University
ATTN: Microforms & Documents Dept

Rapid City Public Library
ATTN: Librarian

Reading Public Library
ATTN: Librarian

Reed College Library
ATTN: Librarian

Reese Library
Augusta College
ATTN: Librarian

University of Rhode Island Library
ATTN: Govt Publications Office

University of Rhode Island
ATTN: Director of Libraries

Rice University
ATTN: Director of Libraries

Richard W. Norton Mem Lib
Louisiana College
ATTN: Librarian

Richland County Pub Lib
ATTN: Librarian

University of Richmond
ATTN: Library

Riverside Public Library
ATTN: Librarian

University of Rochester Library
ATTN: Documents Section

Rutgers University, Camden Library
ATTN: Librarian

Rutgers State University
ATTN: Librarian

Rutgers University
ATTN: Director of Libraries

Rutgers University Law Library
ATTN: Federal Documents Dept

Salem College Library
ATTN: Librarian

Samford University
ATTN: Librarian

San Antonio Public Library
ATTN: Bus Science & Tech Dept

OTHER (Continued)

San Diego County Library
ATTN: C. Jones, Acquisitions

San Diego Public Library
ATTN: Librarian

San Diego State University Library
ATTN: Govt Pubs Dept

San Francisco Public Library
ATTN: Govt Documents Dept

San Francisco State College
ATTN: Govt Pub Collection

San Jose State College Library
ATTN: Documents Dept

San Luis Obispo City-County Library
ATTN: Librarian

Savannah Pub & Effingham Libty Reg Lib
ATTN: Librarian

Scottsbluff Public Library
ATTN: Librarian

Scranton Public Library
ATTN: Librarian

Seattle Public Library
ATTN: Ref Doc Asst

Selby Public Library
ATTN: Librarian

Shawnee Library System
ATTN: Librarian

Shreve Memorial Library
ATTN: Librarian

Silas Bronson Public Library
ATTN: Librarian

Simon Schwob Mem Lib
Columbus College
ATTN: Librarian

Sioux City Public Library
ATTN: Librarian

Skidmore College
ATTN: Librarian

Slippery Rock State College Library
ATTN: Librarian

South Carolina State Library
ATTN: Librarian

University of South Carolina
ATTN: Librarian

OTHER (Continued)

University of South Carolina
ATTN: Government Documents

South Dakota Sch of Mines & Tech
ATTN: Librarian

South Dakota State Library
ATTN: Federal Documents Department

University of South Dakota
ATTN: Documents Librarian

South Florida University Library
ATTN: Librarian

Southdale-Hennepin Area Library
ATTN: Government Documents

Southeast Missouri State University
ATTN: Librarian

Southeastern Massachusetts University Library
ATTN: Documents Sec

University of Southern Alabama
ATTN: Librarian

Southern California University Library
ATTN: Documents Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librarian

Southern Illinois University
ATTN: Documents Ctr

Southern Methodist University
ATTN: Librarian

University of Southern Mississippi
ATTN: Library

Southern Oregon College
ATTN: Library

Southern University in New Orleans, Library
ATTN: Librarian

Southern Utah State College Library
ATTN: Documents Department

Southwest Missouri State College
ATTN: Library

Southwestern University of Louisiana, Libraries
ATTN: Librarian

Southwestern University School of Law Library
ATTN: Librarian

OTHER (Continued)

Spokane Public Library
ATTN: Reference Dept

Springfield City Library
ATTN: Documents Section

St. Bonaventure University
ATTN: Librarian

St. Joseph Public Library
ATTN: Librarian

St. Lawrence University
ATTN: Librarian

St. Louis Public Library
ATTN: Librarian

St. Paul Public Library
ATTN: Librarian

Stanford University Library
ATTN: Govt Documents Dept

State Historical Soc Lib
ATTN: Docs Serials Section

State Library of Massachusetts
ATTN: Librarian

State University of New York
ATTN: Librarian

Stetson Univ
ATTN: Librarian

University of Steubenville
ATTN: Librarian

Stockton & San Joaquin Public Lib
ATTN: Librarian

Stockton State College Library
ATTN: Librarian

Superior Public Library
ATTN: Librarian

Swarthmore College Lib
ATTN: Reference Dept

Syracuse University Library
ATTN: Documents Div

Tacoma Public Library
ATTN: Librarian

Tampa, Hillsborough County Public Lib
ATTN: Librarian

Temple University
ATTN: Librarian

Tennessee Technological University
ATTN: Librarian

OTHER (Continued)

University of Tennessee
ATTN: Dir of Libraries

Terteling Library
College of Idaho
ATTN: Librarian

Texas A & M University Library
ATTN: Librarian

University of Texas at Arlington
ATTN: Library Documents

University of Texas at San Antonio
ATTN: Library

Texas Christian University
ATTN: Librarian

Texas State Library
ATTN: U.S. Documents Sect

Texas Tech University Library
ATTN: Govt Docs Dept

Texas University at Austin
ATTN: Documents Coll

Texas University at El Paso
ATTN: Documents and Maps Lib

University of Toledo Library
ATTN: Librarian

Toledo Public Library
ATTN: Social Science Dept

Torrance Civic Center Library
ATTN: Librarian

Traverse City Public Library
ATTN: Librarian

Trenton Free Public Library
ATTN: Librarian

Trinity College Library
ATTN: Librarian

Trinity University Library
ATTN: Documents Collection

Tufts University Library
ATTN: Documents Dept

Tulane University
ATTN: Documents Dept

University of Tulsa
ATTN: Librarian

UCLA Research Library
ATTN: Public Affairs Svc/US Docs

OTHER (Continued)

Uniformed Svcs Univ of the Hlth Sci
ATTN: LRC Library

University Libraries
ATTN: Dir of Libraries

Upper Iowa College
ATTN: Documents Collection

Utah State University
ATTN: Librarian

University of Utah
ATTN: Special Collections

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

Valencia Library
ATTN: Librarian

Vanderbilt University Library
ATTN: Govt Docs Sect

University of Vermont
ATTN: Director of Libraries

Virginia Commonwealth University
ATTN: Librarian

Virginia Military Institute
ATTN: Librarian

Virginia Polytechnic Inst Lib
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Section

University of Virginia
ATTN: Public Documents

Volusia County Public Libraries
ATTN: Librarian

Washington State Library
ATTN: Documents Section

Washington State University
ATTN: Lib Documents Section

Washington University Libraries
ATTN: Dir of Libraries

University of Washington
ATTN: Documents Div

Wayne State University Library
ATTN: Librarian

Wayne State University Law Library
ATTN: Documents Dept

Weber State College Library
ATTN: Librarian

Wagner College
ATTN: Librarian

OTHER (Continued)

Wesleyan University
ATTN: Documents Librarian

West Chester State Coll
ATTN: Documents Dept

West Covina Library
ATTN: Librarian

University of West Florida
ATTN: Librarian

West Hills Community Coll
ATTN: Library

West Texas State University
ATTN: Library

West Virginia Coll of Grad Studies Lib
ATTN: Librarian

University of West Virginia
ATTN: Dir of Libraries

Westerly Public Library
ATTN: Librarian

Western Carolina University
ATTN: Librarian

Western Illinois University Lib
ATTN: Librarian

Western Washington Univ
ATTN: Librarian

Western Wyoming Community College Lib
ATTN: Librarian

Westmoreland Cty Comm Coll
ATTN: Learning Resource Ctr

Whitman College
ATTN: Librarian

Wichita State Univ Library
ATTN: Librarian

William & Mary College
ATTN: Docs Dept

William Allen White Library
Emporia Kansas State College
ATTN: Govt Documents Div

William College Library
ATTN: Librarian

Willimantic Public Library
ATTN: Librarian

Winthrop College
ATTN: Documents Dept

University of Wisconsin at Whitewater
ATTN: Governments Documents Library

OTHER (Continued)

Wisconsin Milwaukee University
ATTN: Librarian

Wisconsin Oshkosh University
ATTN: Librarian

Wisconsin Platteville University
ATTN: Librarian

Wisconsin University at Stevens Point
ATTN: Docs Section

University of Wisconsin
ATTN: Govt Pubs Dept

University of Wisconsin
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librarian

OTHER (Continued)

Yale University
ATTN: Director of Libraries

Yeshiva University
ATTN: Librarian

Yuma City County Library
ATTN: Librarian

Wright State Univ Library
ATTN: Govts Documents Dept

Wyoming State Library
ATTN: Librarian

University of Wyoming
ATTN: Documents Div

