

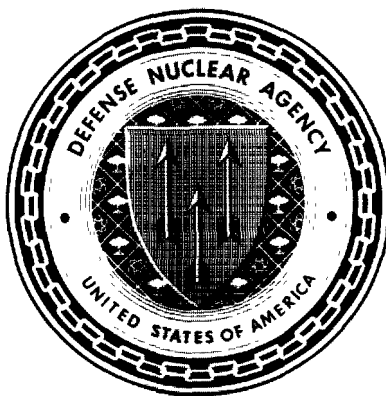
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SHOTS

WHEELER TO MORGAN

The Final Eight Tests of the PLUMBBOB Series

6 SEPTEMBER - 7 OCTOBER 1957



United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

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NEWTON	Ionizing Radiation	Atmospheric Nuclear Tests
RAINIER	Exercise Desert Rock	AFSWP
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the activities of DOD personnel, both military and civilian, in Shots WHEELER to MORGAN, the final eight nuclear tests in the PLUMBBOB atmospheric weapons testing series. The tests were conducted between 6 September and 7 October 1957 and involved participants from Exercise Desert Rock VII and VIII, AFSWP, AFSWC, and various AEC test groups. This volume also describes the radiological safety criteria and procedures in effect at Shots WHEELER to MORGAN.		

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.

PREFACE

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

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

In late 1977, the Department of Defense began a study to provide data to both the Center for Disease Control and Veterans Administration on potential exposures to ionizing radiation among

*Formerly called the Nevada Proving Ground, the name of the test range was changed to the Nevada Test Site in 1955.

+Part of the U.S. Department of Health and Human Services, formerly the U.S. Department of Health, Education, and Welfare.

the atmospheric testing veterans. The Department of Defense responded by organizing an effort to:

- Identify Department of Defense personnel who had taken part in the atmospheric nuclear weapons tests
- Provide public disclosure of information concerning participation by DOD personnel in the atmospheric nuclear weapons tests.

This report on the last eight PLUMBBOB shots is based on the historical record of military and technical documents associated with each of the nuclear weapons test events. These reports provide a public record of the activities and associated potential for radiation exposure of DOD personnel, for use in ongoing public health research and policy analysis.

Many of the documents pertaining specifically to DOD involvement during Shots WHEELER to MORGAN were found in the Defense Nuclear Agency Technical Library, the National Federal Archives Record Center, the Department of Energy Nevada Operations Office, and the Los Alamos National Laboratory.* In certain cases, the surviving historical documentation addresses test specifications and technical information, rather than personnel data critical to the study undertaken by the Department of Defense. Moreover, these documents sometimes have revealed 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 in data 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 distinguish between projects that were only planned and those that were actually conducted.

*Formerly the Los Alamos Scientific Laboratory (LASL)

This report discusses only those projects verified by documentation as having been conducted.

For several of the Exercise Desert Rock and test organization projects discussed in this volume, the only documents available are the Sixth Army Desert Rock operation orders, the annexes to the Test Director's "Operation Plan CTDN-22," and Air Force air mission summary reports. These sources detail the plans developed by DOD and AEC personnel prior to Operation PLUMBBOB; they do not necessarily describe operations as they were actually conducted at the NTS. Although some of the after-action documents summarize the projects performed during the operation, 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. Because accomplishment of PLUMBBOB objectives required detailed planning and adherence to operations orders, plans and operations orders should provide a reasonably accurate account of personnel activities. The references indicate whether the description of activities is based on the annexes, operation orders, air mission summary reports, or after-action reports.

CONTENTS OF PLUMBBOB REPORTS

This volume details participation by DOD personnel in the last eight Operation PLUMBBOB events. Seven other publications address DOD activities during the operation:

- Series volume: PLUMBBOB Series, 1957
- Multi-shot volume: Shots BOLTZMANN to WILSON, the First Four Tests of the PLUMBBOB Series
- Shot volume: Shot PRISCILLA, a Test of the PLUMBBOB Series
- Shot volume: Shot HOOD, a Test of the PLUMBBOB Series

- Multi-shot volume: Shots DIABLO to FRANKLIN PRIME, the Mid-series PLUMBBOB Tests
- Shot volume: Shot SMOKY, a Test of the PLUMBBOB Series
- Shot volume: Shot GALILEO, a Test of the PLUMBBOB Series.

These volumes have been designed for use with one another. The series volume provides information common to the PLUMBBOB shots, such as historical background, organizational relationships, and radiation-safety procedures. In addition, that volume contains a bibliography of works consulted in the preparation of all Operation PLUMBBOB reports.

The single-shot volumes describe DOD participation in Shots PRISCILLA, HOOD, SMOKY, and GALILEO. These volumes have been bound separately because the shots included substantial numbers of Desert Rock participants. Each multi-shot volume combines shot-specific descriptions for several nuclear events. The shot and multi-shot volumes list the sources referenced in each text. Descriptions of activities concerning **any** particular PLUMBBOB shot, whether the event is addressed in a single- or in a multi-shot volume, may be supplemented **by** the general organizational and radiological safety information in the PLUMBBOB Series volume.

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

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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 "
CBR	Chemical, Biological, Radiological
CETG	Civil Effects Test Group
DOD	Department of Defense
EG and G	Edgerton, Germeshausen, and Grier
FCDA	Federal Civil Defense Administration
LASL	Los Alamos Scientific Laboratory
NTO	Nevada Test Organization
NTS	Nevada Test Site
REECo	Reynolds Electrical and Engineering Company
R/h	Roentgen per hour
UCRL	University of California Radiation Laboratory
USAF	United States Air Force
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Shots WHEELER, LAPLACE, FIZEAU, NEWTON, RAINIER, WHITNEY, CHARLESTON, and MORGAN were tests of nuclear devices conducted between 6 September and 7 October 1957 at the Nevada Test Site, the Atomic Energy Commission continental nuclear test site located northwest of Las Vegas. These shots were the last eight test events of Operation PLUMBBOB, a series of 24 nuclear weapons tests and six safety experiments performed between 24 April and 7 October 1957 (40).*

The nuclear devices were sponsored, designed, and built by AEC laboratories. The Los Alamos Scientific Laboratory (LASL) was responsible for the LA PLACE, FIZEAU, and NEWTON devices, while the University of California Radiation Laboratory (UCRL) was responsible for the WHEELER, RAINIER, WHITNEY, CHARLESTON, and MORGAN devices. The primary objective of these nuclear tests was to evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by the devices. To fulfill this objective, LASL and UCRL test groups conducted scientific experiments to measure the physical characteristics of the detonations. The Armed Forces Special Weapons Project (AFSWP) Field Command Weapons Effects Test Group conducted effects projects to evaluate the utility of the devices for military applications and to investigate additional requirements for future nuclear weapons development (37). The Federal Civil Defense Administration (FCDA) Civil Effects Test Group (CETG) conducted projects to assess the effects of nuclear detonations on civilian structures, products, and food supplies and to evaluate Civil Defense emergency preparedness plans (22).

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

A number of other activities related to the conditions and phenomena produced by a nuclear detonation were also conducted at these eight events. The Department of Defense conducted operational training projects to indoctrinate personnel in the effects of nuclear detonations and to test equipment. The armed services also fielded projects to evaluate military equipment and tactics and to indoctrinate troops in weapons effects as part of Exercise Desert Rock VII and VIII, the Army technical testing and training program at Operation PLUMBBOB.

Table 1-1 presents a summary of the last eight tests of Operation PLUMBBOB (29). The table provides such information as the dates of shots, the UTM coordinates* of the points of detonation, the heights of burst,+ and the explosive yields. Figure 1-1 displays a map of the NTS in 1957, indicating the location of each PLUMBBOB test and highlighting the shots discussed in this volume.

1.1 DEPARTMENT OF DEFENSE PARTICIPATION IN NEVADA TEST ORGANIZATION ACTIVITIES AT THE LAST EIGHT PLUMBBOB EVENTS

The Nevada Test Organization (NTO) was established for planning, coordinating, and conducting atmospheric nuclear weapons tests during Operation PLUMBBOB. All activities were under the control of an AEC-appointed Test Manager assisted by the Test Director. The NTO consisted of personnel from the AEC, the DOD, and the FCDA. These personnel were assigned to four NTO

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

+Vertical distances are given in feet. Altitudes are measured from mean sea level, while heights are measured from the ground surface. Yucca Flat, the area of the NTS where all of the final eight shots but RAINIER were tested, is about 4,000 feet above mean sea level.

Table I-I: SUMMARY OF THE FINAL EIGHT PLUMBBOB SHOTS

Shot	WHEELER	LAPLACE	FIZEAU	NEWTON	RAINIER	W H I T N	CHARLESTON	MORGAN
Sponsor	UCRL	LASL	LASL	LASL	UCRL	UCRL	UCRL	UCRL
Planned Date	09/06/57	09/06/57	09/08/57	07/25/57	09/03/57	08/08/57	09/15/57	09/10/57
Actual Date	09/06/57	09/08/57	09/14/57	09/16/57	09/19/57	09/23/57	09/28/57	10/07/57
Local Time	0545	0600	0945	0550	1000	0530	0600	0500
NTS Location	Area 9	Area 7	Area 3	Area 7	Area 12	Area 2	Area 9	Area 9
UTM Coordinates	852100	867047	861988	867047	707167	794104	852100	852100
Type	Balloon	Balloon	Tower	Balloon	Tunnel	Tower	Balloon	Balloon
Height of Burst (Feet)	500	750	500	1,500	-899	500	1,500	500
Actual Yield (Kilotons)	.197	1	11	12	17	19	12	8

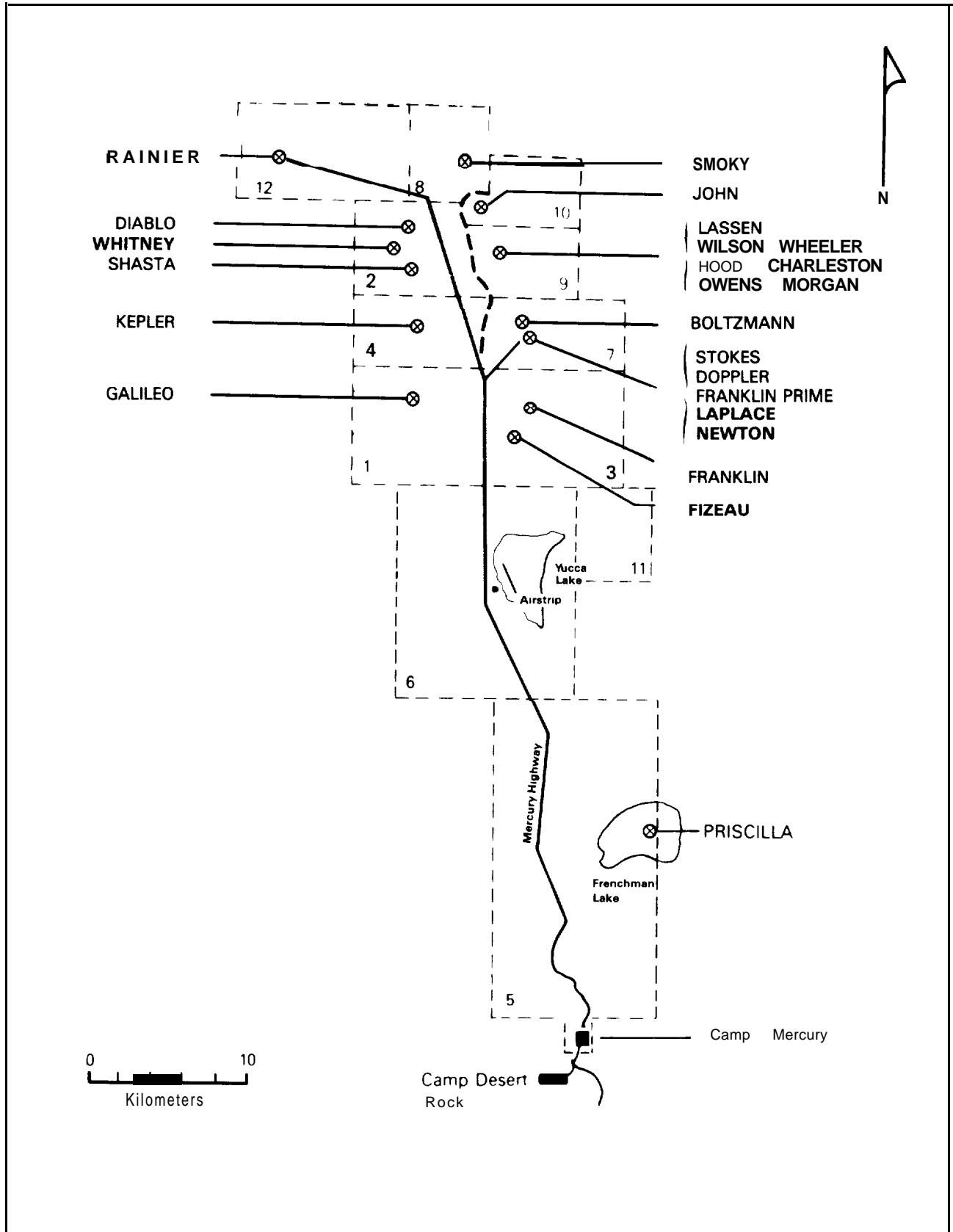


Figure I-I: LOCATION OF THE FINAL EIGHT PLUMBBOB SHOTS AT THE NEVADA TEST SITE IN RELATION TO OTHER SHOTS IN THE PLUMBBOB SERIES

test groups: the AFSWP Field Command Weapons Effects Test Group, the LASL Test Group, the UCRL Test Group, and the FCDA Civil Effects Test Group. In addition to the projects of the test groups, the DOD conducted the operational training projects and support activities.

Overall, the largest area of DOD participation in the NTO was in the Weapons Effects Test Group projects, designed to study yield and weapons effects characteristics in order to understand the militarily useful effects of nuclear weapons for offensive and defensive deployment (28). Personnel from DOD agencies and the armed services participated in the experiments conducted by LASL, UCRL, and CETG, but participation was limited. Most DOD participation in these experiments was provided by the Air Force Special Weapons Command (AFSWC) 4926th Test Squadron [Sampling] in LASL and UCRL radiochemistry cloud-sampling projects (26).

The DOD operational training projects, designed to test service tactics and equipment and to instruct military personnel in nuclear detonation effects, were conducted at all but Shots RAINIER and MORGAN. Most of the projects were conducted in aircraft by pilots from the Air Force Tactical Air Command or Strategic Air Command (27).

The Air Force Special Weapons Center, at Kirtland Air Force Base (AFB), New Mexico, exercised operational control of all military aircraft flying over the area of the NTS during PLUMBBOB and provided air support to the NTO and its projects, in addition to conducting some test activities of its own. AFSWC was composed of units from the 4950th Test Group (Nuclear), including the 4926th Test Squadron (Sampling) and the 4935th Air Base Squadron. These units operated out of Indian Springs AFB,

30 kilometers* south of Camp Mercury, and were supported by the 4900th Air Base Group stationed at Kirtland AFB. AFSWC air and ground personnel provided air support to NTO projects, conducting cloud-sampling and cloud-tracking missions, and providing courier, aerial survey, and transportation services (26; 30; 56; 61).

The Radiological Safety Division of Reynolds Electrical and Engineering Company (REECo), augmented by 38 personnel from the 1st Radiological Safety Support Unit, Fort McClellan, Alabama, conducted radiation protection procedures established by the NTO (60). These safety procedures, detailed in the Operation PLUMBBOB volume, were designed to minimize exposure to ionizing radiation by limiting radiation exposures to no more than three roentgens of whole-body gamma radiation for any 13-week period and five roentgens annually. Unless approved by the Test Manager in advance, access to radiation areas by AFSWP project participants was not allowed until the Test Manager declared the area open for recovery operations. Personnel were not permitted into areas of ten roentgens per hour (R/h) or greater unless they had received special permission from the Test Director (37; 60). Project participants recovering test instruments from radioactive areas were accompanied by radiological safety monitors who surveyed the radiation intensity in the recovery area and informed the project managers of the radiological conditions. To monitor cumulative exposures, project personnel were issued film badges. After the film badges were collected, developed, and evaluated, any individuals whose accumulated dose approached or exceeded the established limits were not permitted further access to the forward area. Personnel decontamination procedures were implemented, and emergency evacuation plans were prepared for the test events (60).

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

The radiation protection procedures for AFSWC included the same exposure limits for aircrews and ground-crew personnel as those established for the NTO personnel, with the exception of cloud sampler pilots. These AFSWC personnel were authorized by the Test Manager to receive a maximum of 7.5 roentgens of gamma radiation annually. Decontamination, including removal of anticontamination clothing and showers, was required of all aircrew members after each project mission, regardless of the exposure received on the flight. Aircraft were decontaminated by washing or were isolated until radiation intensities had decayed to acceptable levels (1; 30; 43).

1.2 EXERCISE DESERT ROCK VII AND VIII ACTIVITIES AT THE LAST EIGHT PLUMBBOB EVENTS

The operations of Exercise Desert Rock VII and VIII, the Army testing and training program conducted during the PLUMBBOB shots, were not as extensive during Shots WHEELER through MORGAN as during the first PLUMBBOB events. Desert Rock activities were basically concluded by mid-September 1957, before the end of Operation PLUMBBOB. Most Desert Rock participants in Shots WHEELER through MORGAN took part in two technical service projects. In addition to these participants, Camp Desert Rock troops provided communication, transportation, traffic control, and radiological monitoring for the Desert Rock projects. For example, soldiers from the 50th Chemical Service Platoon provided radiological safety monitoring for Desert Rock personnel in the test area until mid-September 1957, when the platoon returned to its home station. AFSWP and the 1st Radiological Safety Support Unit probably provided radiological monitoring for Desert Rock troops as needed thereafter (33; 53).

Radiation protection procedures for Exercise Desert Rock, like those for the NTO, are detailed in the Operation PLUMBBOB volume. Procedures were designed to minimize potential exposure

to ionizing radiation while allowing participants to accomplish their objectives. Desert Rock personnel were limited to five roentgens of whole-body gamma radiation during any six-month period. The radiation protection procedures of Exercise Desert Rock included provisions for (32; 33):

- Maintaining minimum safe distances from nuclear detonations
- Enforcing protective procedures for personnel observing the detonations
- Controlling access to radiation areas
- Film-badging and monitoring the cumulative exposures of Desert Rock personnel
- Decontaminating all equipment and personnel leaving the shot area after each detonation
- Preparing emergency evacuation plans for personnel in the forward area.

1.3 DOSIMETRY FOR PLUMBBOB PARTICIPANTS

For Operation PLUMBBOB, REECO maintained cumulative exposure lists of NTO and AFSWC personnel. The lists provided the shot-specific dosimetry information described in the radiological safety sections of the following chapters. For example, lists were developed that showed the personnel who had, during a shot-specific period, exceeded a cumulative dose of two roentgens. A few surviving disposition forms, specifying personnel exposures exceeding three roentgens, indicate that Exercise Desert Rock similarly monitored cumulative exposures. Personnel whose exposures reached five roentgens were prohibited from further entry into the shot area. The Operation PLUMBBOB volume summarizes dosimetry totals and overexposure information for PLUMBBOB participants.

SHOT WHEELER SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: Desert Rock VII and VIII
DATE/TIME: 6 September 1957, 0545 hours
YIELD: 0.197 kilotons
HEIGHT OF BURST: 500 feet (balloon shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate the ability of military personnel and equipment to locate and detect nuclear detonations.

Weather: At shot-time, the temperature was 15°C, and surface winds were calm. Winds were 11 knots from the east-southeast at 10,000 feet and 17 knots from the east-southeast at 15,000 feet.

Radiation Data: The initial survey, mid-time of 0652 hours, determined that radiation intensities greater than 0.1 R/h were limited to within about 750 meters from ground zero except to the north, where the residual radiation field from a previous shot was encountered.

Participants: Exercise Desert Rock troops, Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, University of California Radiation Laboratory, other contractors.

CHAPTER 2

SHOT WHEELER

Shot WHEELER, the seventeenth nuclear weapons test of Operation PLUMBBOB, was detonated at 0545 hours Pacific Daylight Time on 6 September 1957. The device, which had a yield of 0.197 kiloton, was suspended from a balloon and fired 500 feet above the ground in Area 9 of the Nevada Test Site. The cloud top reached 17,000 feet and traveled west-northwest (29).

2.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT WHEELER

Two technical service projects were conducted at Shot WHEELER: Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, and Project 50.8, Detection of Atomic Burst and Radioactive Fallout. These two projects involved 128 Desert Rock participants. In addition, 12 Desert Rock support troops witnessed the detonation from a location near News Nob, approximately 21 kilometers south of ground zero. The 12 observers probably returned to Camp Desert Rock after the detonation (33).

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by a detachment from the Army Signal Research and Development Laboratories, Fort Monmouth, New Jersey; personnel from Fort Meade, Maryland; and personnel from Fort Huachuca, Arizona. The project had two purposes: to test the capacity of Army radar equipment in detecting the nuclear detonation and tracking the radioactive cloud, and to examine Army fallout prediction methods. Participants were divided into a radar section and two fallout prediction teams. The radar section detected and tracked the cloud, recorded fireball growth, and determined the rate of rise

of the cloud, the height of burst, and the yield. In addition, the radar section collected data to evaluate the capability of radar equipment in cloud detection. Three radar sets were used: one about 180 kilometers southeast of ground zero at Boulder City, Nevada, and the other two about 13 kilometers west of ground zero at UTM coordinates 766106. All three sets were manned at the time of the detonation (19; 32; 52).

One of the fallout prediction teams used upper wind data to test an Army Signal Research and Development Laboratories technique for predicting fallout patterns. The fallout team consisted of personnel from the Meteorological Division, Army Signal Research and Development Laboratories. This team operated out of an M-109 mobile van, which contained the teletype and recording equipment necessary for obtaining meteorological data for plotting fallout. The mobile van, manned at the time of the detonation, was located next to the weather station at Camp Mercury. A second fallout prediction team, with personnel from the Army Electronic Proving Ground, Fort Huachuca, operated near Alamo, Nevada, 92 kilometers northeast of the Control Point. Project activities involved an estimated 23 DOD personnel (19; 32; 52).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the Army Air Defense Board, supported by the 495th Antiaircraft Artillery Missile Battalion. The project, which involved an estimated 105 DOD personnel, was designed to determine how well equipment found in a typical Army unit could (57; 58; 59):

- Determine the location, height of burst, and yield of a detonation
- Track targets and guided missiles through a radioactive cloud or fireball.

During the detonation, personnel operated three radar sets about 20 kilometers from ground zero and a fourth radar set approximately 70 kilometers from ground zero. In addition, participants

manned a project control point southeast of ground zero, at UTM coordinates 832962 (32).

2.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT WHEELER

Besides participating in Exercise Desert Rock activities, Department of Defense personnel took part in other test activities during Shot WHEELER that required them to enter the forward area. Table 2-1 identifies the test group projects involving DOD participants. The Air Force also sponsored one operational training project. In addition to the test group projects and the operational training project, support activities accounted for a number of DOD participants. The Air Force Special Weapons Center supported one test group project and flew routine air missions for the Test Manager.

Table 2-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT WHEELER

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
6 4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
91	Support Photography	AFSWP, EG and G	12
University of California Radiation Laboratory Test Group			
21 2	Radiochemistry Sampling	University of California Radiation Laboratory; 4926th Test Squadron (Sampling), Air Force Special Weapons Center	8

* Unknown

2.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted two projects during Shot WHEELER. In identifying these projects, table 2-1 lists the

estimated numbers of DOD personnel. These estimates, as well as DOD personnel estimates in the project tables of the following chapters, reflect the minimum number of project participants in an experiment as given in the schedule of events for the shot or in the weapons test reports.

Project 6.4, Accuracy of the Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to determine the electromagnetic pulse from the nuclear burst in order to detect the position and measure the yield of that burst. The Indirect Bomb Damage Assessment NAROL system tested in this operation consisted of nets located in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net had two unmanned slave stations and one manned station (34).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Nine personnel established and then manned a photography station at the BJY from five hours before to 30 minutes after the detonation (10). In addition, Edgerton, Germeshausen, and Grier (EG and G) personnel provided technical photographic support to AFSWP and the AEC, operating camera stations to record fireball and cloud growth. After the detonation, three EG and G participants spent about 90 minutes in the shot area recovering film from the stations. Although Project 9.1 also included

aerial photography at other shots, no data are available concerning an air photographic mission at WHEELER (10; 24).

2.2.2 Department of Defense Participation in University of California Radiation Laboratory Test Group Projects

Of the ten projects conducted by the University of California Radiation Laboratory Test Group at WHEELER, only Project 21.2, Radiochemistry Sampling, involved DOD participants, as shown in table 2-1. The project required cloud sampling, discussed in section 2.2.4.

2.2.3 Department of Defense Operational Training Project

The one operational training project conducted by the Air Force at Shot WHEELER was Project 53.1, Aerial Sampling Missions. This project was designed to train Air National Guard units in cloud sampling. Two F-33A aircraft, each with a crew of two from the Wisconsin Air National Guard, participated in the activity (27). It is probable that the project involved cloud sampling and was conducted in conjunction with UCRL Project 21.2, Radiochemistry Sampling.

2.2.4 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support to the Test Manager and the test groups at Shot WHEELER consisted of cloud-sampling and sample courier missions in support of Project 21.2, **cloud-tracking** missions, security sweeps, and aerial surveys.

Cloud Sampling

Six F-84 aircraft, with one pilot each, collected samples of the cloud for Project 21.2, Radiochemistry Sampling. A B-57 sampler control aircraft, manned by a pilot and a UCRL scientific

advisor, also participated. Pilots of the 4926th Test Squadron (Sampling) flew all seven aircraft (1; 2).

The B-57 sampler control aircraft, which guided the six sampler aircraft through the missions, left Indian Springs AFB at 0445 hours, one hour before the detonation. The aircraft reached an altitude of 35,000 feet and began a right-hand holding pattern about 50 nautical miles east of ground zero at 0550 hours (1; 2).

The six sampler aircraft proceeded as follows. At 0605 hours, 15 minutes after the sampler control aircraft began its orbit, the first F-84 entered the vicinity of the burst at 35,000 feet and established visual contact with the control aircraft. After the detonation, the control aircraft left its orbit to view the cloud from all sides. The scientific advisor in the B-57 then directed the samplers to penetrate the cloud at the altitude necessary to acquire the samples. The first F-84 left the area 35 minutes later, landing at Indian Springs AFB at 0645 hours. The remaining five F-84 samplers followed the pattern set by the first sampler and entered the area of the cloud at altitudes of 35,000 feet at ten-minute intervals, between 0615 hours and 0655 hours. Each aircraft followed the same procedures as the first F-84, and remained in the area collecting samples for about 30 minutes. The final sampler aircraft landed at Indian Springs AFB at 0735 hours. The control aircraft ended its pattern at 0725 hours, after the six sampler aircraft had collected cloud samples, and landed at Indian Springs at 0736 hours (1; 2).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations. There, ground personnel used long-handled poles to remove the samples and place them in metal containers to be sent by courier to UCRL. With the mission complete, the aircraft and the pilots were decontaminated, as described in the Operation PLUMBBOB volume (1; 2).

Courier Missions

The 4900th Air Base Group from Kirtland AFB flew the courier sample return missions. Two C-47 aircraft, each with a minimum crew of three, flew samples out of Indian Springs AFB to UCRL for analysis (1; 2).

Cloud Tracking

Five minutes after the WHEELER detonation, two B-25 aircraft, each with an estimated crew of four, left Indian Springs AFB and flew over and beyond the NTS at 15,000 feet. The purpose of the mission was to determine the direction the cloud traveled and to keep the airways clear of any aircraft unrelated to the test projects (1; 2).

Security Sweep

The evening before the detonation, one L-20 aircraft, with at least two people aboard, left the airstrip near Camp Mercury and flew a security sweep mission over the NTS to ensure that no unauthorized personnel remained in the shot area (1; 2).

Helicopter Surveys

Ninety minutes after the detonation, one H-21 helicopter, with two AFSWC crewmen and two radiological safety monitors, left the airstrip near Camp Mercury and flew a survey mission over the WHEELER shot area and other designated points to record radiation intensities. The survey took an estimated 40 minutes. Crew members wore anticontamination clothing and respirators during the flight. After the mission, the helicopter returned to the helicopter area at Camp Mercury, where aircraft and crew were monitored and decontaminated as required. Subsequent surveys were canceled, as discussed in section 2.3. A survey to assess detonation damage, planned for about two hours after the shot, was also canceled (1; 2; 44).

2.3 RADIATION PROTECTION AT SHOT WHEELER

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that individuals would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs. The available information includes NTO isointensity contour maps, monitoring data, and some NTO personnel dosimetry data. Radiological safety procedures and dosimetry information for Desert Rock and AFSWC personnel are described in the Operation PLUMBBOB volume.

Dosimetry Records

Film badge records turned in on the WHEELER shot-day indicate that four Desert Rock participants reached or exceeded two roentgens of cumulative gamma exposure. Three of these personnel were from the 232nd Signal Company and had film badge readings of 4.35, 9.5, and 10.2 roentgens. The latter two readings, which exceeded the Desert Rock limit of five roentgens, represented the greatest exposures for any Operation PLUMBBOB participants. The fourth individual, a member of the Desert Rock Instructor Group, received two roentgens, according to a film badge worn over a four-day period. The shots with which this exposure and the others are associated are not known (39; 44; 54; 60).

On 5 and 6 September 1957, including the 6 September detonation of WHEELER, the NTO Personnel Dosimetry Branch issued 516 film badges and 272 pocket dosimeters (60). One DOD participant, from the Ballistic Research Laboratories, received a cumulative gamma exposure of 2.12 roentgens. The Desert Rock Radiological Safety Officer, listed among the NTO participants, received a cumulative gamma exposure of 2.23 roentgens. It is not known why he wore an NTO film badge in addition to his Desert

Rock film badge. If no duplication occurred, his cumulative exposure was 6.9 roentgens, in excess of the five roentgen limit (39; 44; 60).

Logistics

For Shot WHEELER, the General Supply Section issued protective supplies to 613 personnel. These supplies consisted of coveralls, shoe covers, respirators, and other protective equipment (44; 60).

Monitoring Procedures and Support

Five minutes after the detonation, a total of 11 monitors traveling in eight vehicles proceeded into the shot area and performed the initial ground radiological survey of the shot area. The survey took about an hour to complete. Resurveys were made about six hours after the detonation and again on 7, 8, and 9 September (44; 60).

The initial aerial survey team, consisting of two radiological monitors and two AFSWC crewmen, departed from the Control Point helicopter pad at 0715 hours, 90 minutes after the detonation. The highest radiation intensity in the shot area was 4.8 R/h, encountered 25 feet above ground zero about two hours after the detonation. Outside the shot area, the highest intensity was 7.5 R/h, detected 25 feet above the ground zero of Shot GALILEO, fired five days earlier. Aerial resurveys were canceled for Shot WHEELER because ground resurveys supplied sufficient information (44; 60).

Plotting and Briefing

Using information from the initial surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 2-1 shows a copy of the initial contour map, with a mid-time of 0652 hours. Figure 2-2 presents copies of the isointensity maps

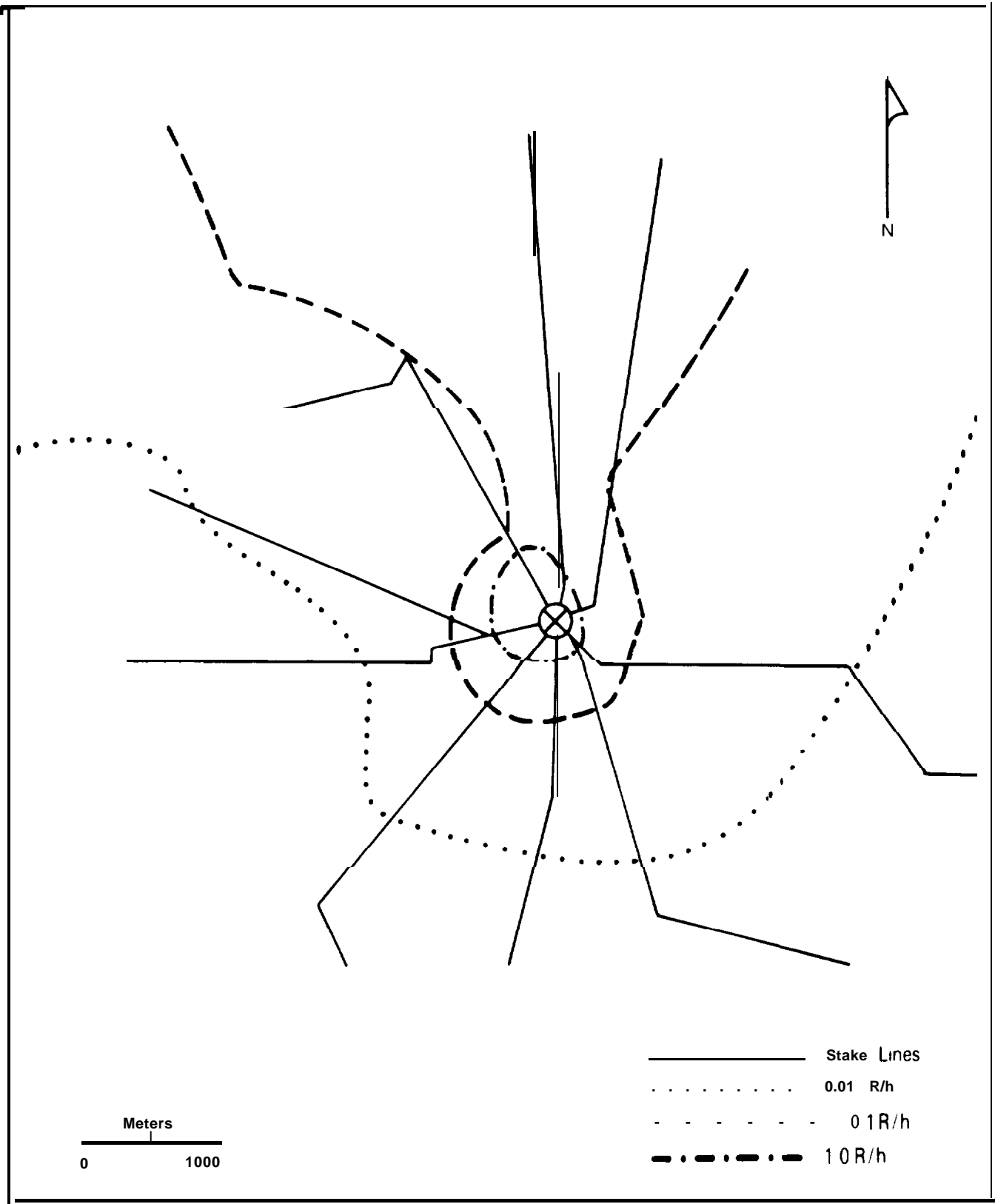
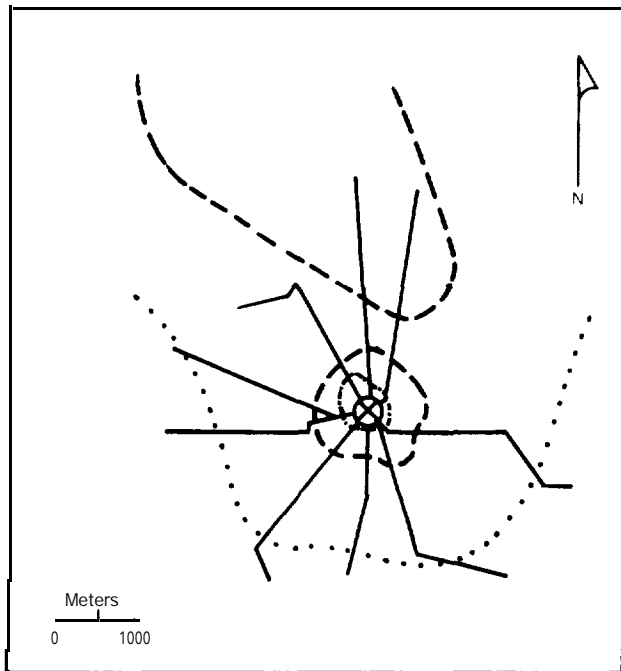
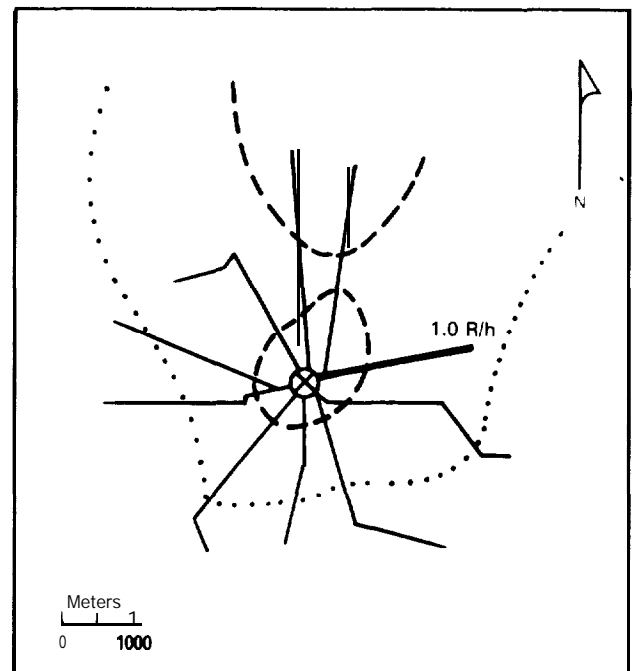


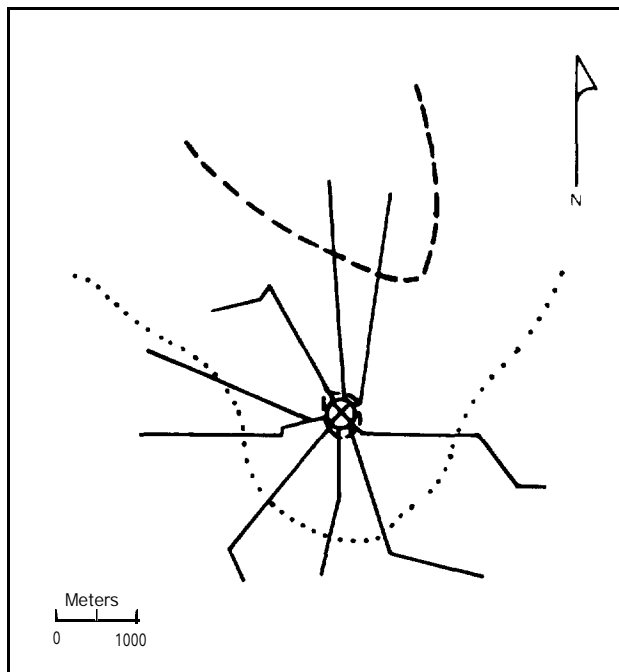
Figure 2-1: INITIAL SURVEY FOR SHOT WHEELER,
6 SEPTEMBER 1957, MID-TIME 0662



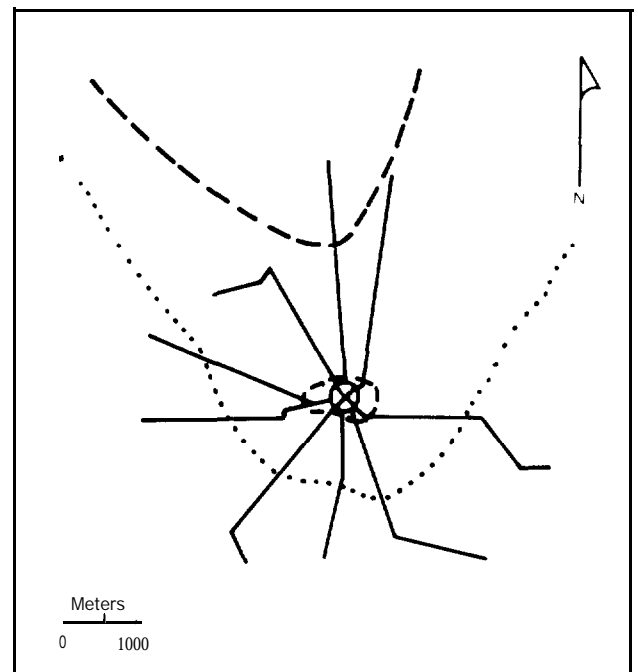
6 September 1957, Mid-Time: 1206



7 September 1957, Mid-Time: 0745



8 September 1957, Mid-Time: 0804



9 September 1957, Mid-Time: 0845

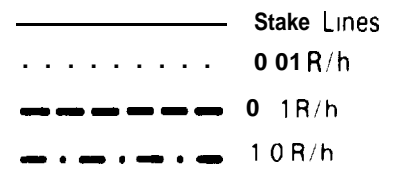


Figure 2-2: SUBSEQUENT SURVEYS FOR SHOT WHEELER

developed from 6 to 9 September. Most of the radiation field, except for within about one kilometer of ground zero, was residual from Shot SMOKY, fired on 31 August (60).

Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, described in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas. During the period of 5 and 6 September, access permits were issued to 443 individuals involved in 26 projects (60).

Decontamination Activities

During the period covering Shot WHEELER, personnel of the Decontamination Branch decontaminated 58 vehicles (60). In addition, personnel decontaminated the area within a 90-meter radius of the WHEELER balloon site in Area 9, contaminated by radioactive fallout from Shot SMOKY. Decontamination operations began on 3 September 1957, as participants scraped the surface soil with a bulldozer, removed contaminated soil from the area by trucks, and backfilled the area with uncontaminated soil. Radiation readings were taken after each phase of activity to determine its effectiveness (60).

SHOT LAPLACE SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: Desert Rock VII and VIII
DATE/TIME: 8 September 1957, 0600 hours
YIELD: 1 kiloton
HEIGHT OF BURST: 750 feet (balloon shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate the effects of nuclear radiation for civil defense purposes.

Weather: At shot-time, the temperature was 19°C, and surface winds were calm. Winds were ten knots from the west-northwest at 10,000 feet and four knots from the east-southeast at 20,000 feet.

Radiation Data: The initial survey, mid-time of 0712 hours, determined that radiation intensities greater than 0.1 R/h were confined to within 950 meters of ground zero.

Participants: Exercise Desert Rock troops, Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 3

SHOT LAPLACE

Shot **LAPLACE** was conducted with a yield of one kiloton at 0600 hours Pacific Daylight Time on 8 September 1957. The device was suspended from a balloon and fired 750 feet above the ground in Area 7 of the Nevada Test Site. The top of the cloud resulting from the detonation reached a height of 20,000 feet (29).

3.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT **LAPLACE**

Two technical service projects were conducted at Shot **LAPLACE**: 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, and 50.8, Detection of Atomic Hurst and Radioactive Fallout. These projects involved an estimated 128 Desert Rock participants. In addition, seven Desert Rock support troops witnessed the detonation from a location near News Nob, 16 kilometers south of ground zero. The seven observers probably returned to Camp Desert Rock following the detonation without going into the forward testing area (33).

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by a detachment from the Army Signal Research and Development Laboratories, Fort Monmouth, New Jersey; personnel from Fort Meade, Maryland; and personnel from Fort Huachuca, Arizona. The project had two purposes: to test the capacity of Army radar equipment in detecting the nuclear detonation and tracking the radioactive cloud, and to examine Army fallout prediction methods. The activities involved an estimated 23 DOD participants, who were divided into a radar section and two fallout prediction teams. The radar section detected and tracked the nuclear cloud,

recorded fireball growth, and determined the rate of rise of the cloud, the height of burst, and the yield. In addition, the radar section collected data to determine the use of radar equipment in cloud detection. Four radar sets were used: one was about 180 kilometers southeast of ground zero, one was approximately 90 kilometers south of ground zero at Angel's Peak, and two were about 12 kilometers west of ground zero, at UTM coordinates 766106. The 865th Aircraft Control and Warning Squadron operated the Angel's Peak radar unit. All sets were manned at the time of the detonation (19; 32; 52).

One of the fallout prediction teams used upper wind data to test a Signal Research and Development Laboratory technique for predicting fallout patterns. The team included personnel from the Meteorological Division, Army Signal Research and Development Laboratories. This team operated out of an M-109 mobile van, which contained the teletype and recording equipment necessary for obtaining meteorological data for plotting fallout. The mobile van, manned at the time of the detonation, was next to the weather station at Camp Mercury. A second fallout prediction team, with personnel from the Army Electronic Proving Ground, Fort Huachuca, operated near Alamo, Nevada, 92 kilometers northeast of the Control Point (19; 39; 52).

During the shot, a DOD civilian, while obtaining meteorological data about 18 kilometers from ground zero, may have developed mild conjunctivitis from the flash. He was examined by the Deputy Surgeon of Field Command, who found no evidence of retinal injury.

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the Army Air Defense Board, supported by the 495th Antiaircraft Missile Battalion. The project, which involved an estimated 105 DOD personnel, was designed to

determine how well equipment found in a typical Army unit could (32; 39; 57-60):

- Determine the location, height of burst, and yield of a nuclear detonation
- Track targets and guided missiles through a radioactive cloud or fireball.

Personnel operated radar sets about 70, 19, and 17 kilometers from the NTS. In addition, participants manned a project control point southeast of ground zero, at LJTM coordinates 832962 (11; 57-59).

3.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT LAPLACE

In addition to participating in Exercise Desert Rock activities, Department of Defense personnel took part in other test activities during Shot LAPLACE that required them to enter the forward area. Table 3-1, given on the next page, identifies the test group projects involving DOD participants. The Air Force also sponsored one operational training project at the shot. In addition to the test group projects and the operational training project, AFSWC and other support activities accounted for a number of other DOD participants. The Air Force Special Weapons Center supported LASL Project 11.2 and flew four routine air missions for the Test Manager.

3.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted three projects during Shot LAPLACE.

Project 2.0, Neutron and Gamma Radiation from Shot LAPLACE, was fielded by personnel from the Naval Radiological Defense Laboratory, the Army Chemical Warfare Laboratories, and other

PLUMBBOB participants outside of the Weapons Effects Test Group. The personnel fielding this project included the same individuals participating in Projects 2.2, 2.3, and 2.10 at other shots, plus other members of the Program 2 staff (11; 21). The primary objective of this project was to obtain information correlating neutron-flux with radioactivity induced in surface soils. Shot LAPLACE was chosen for this activity because it was to be an event of reasonably predictable neutron flux (11; 21).

Table 3-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT LAPLACE

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
2 0	Neutron and Gamma Radiation from Shot LAPLACE	Naval Radiological Defense Laboratory; Army Chemical Warfare Laboratories	6
6 4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
9 1	Support Photography	AFSWP; EC and G	8
Los Alamos Scientific Laboratory Test Group			
11 2	Radiochemistry Sampling	Los Alamos Scientific Laboratory, 4926th Test Squadron (Sampling), Air Force Special Weapons Center	7
Civil Effects Test Group			
39 1	Radiation Measurements Utilizing the Air Force Chemical Dosimeters	Air Force School of Aviation Medicine	24

* Unknown

Personnel placed neutron detectors, film badges, survey meters, and dosimeters in a line extending 90 to 2,740 meters from ground zero. They attached the neutron detectors to a cable at 90-meter intervals from about 90 to 1,000 meters from ground zero. One hour after the detonation, three Project 2.10

personnel recovered the neutron detectors by towing the cable on which the detectors were attached out of the radiation field. Three Project 2.3 participants entered the shot area two, three, four, seven, eight, 14, and 15 hours after the detonation to monitor instruments 730 meters northwest of ground zero (11; 21; 45).

Another part of the **study** involved using chemical dosimeters to measure gamma radiation from the detonation. This experiment, discussed in section 3.2.3, was performed by personnel from the Civil Effects Test Group in conjunction with Project 39.1, Radiation Measurements Utilizing the Air Force Chemical Dosimeters.

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and measure the yield of that burst. The Indirect Bomb Damage Assessment NAROL system had nets in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net consisted of two unmanned slave stations and one manned station (34).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Eight personnel established and then manned a photography station at UTM coordinates 852975 from five hours before to 30 minutes

after the detonation (11). In addition, EG and G personnel provided technical photographic support to AFSWP and the AEC, operating camera stations to record fireball and cloud growth. After the detonation, EG and G participants entered the shot area to recover the film (11; 24).

3.2.2 Department of Defense Participation in Los Alamos Scientific Laboratory Test Group Projects

Of the ten projects conducted **by** the LASL Test Group at **LAPLACE**, only Project 11.2, Radiochemistry Sampling, had DOD personnel participation. The project involved cloud-sampling missions, discussed in section 3.2.5.

3.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The CETG conducted six projects at **LAPLACE**. Among these six, only Project 39.1, Radiation Measurements Utilizing the Air Force Chemical Dosimeters, involved DOD personnel. The objective of this project was to use film dosimetry techniques, particularly chemical dosimeters, to measure initial gamma radiation from a nuclear detonation. An estimated 24 military personnel from the Air Force School of Aviation Medicine, Randolph AFB, Texas, performed **pre-** and **postshot** exposure analyses (55). DOD personnel of Projects 2.3 and 2.10 placed dosimeters on the project's recovery cable in the forward area and helped retrieve the instruments after the detonation. Three Project 39.1 personnel recovered chemical dosimeters one hour after the shot from stations 270 to 1,830 meters from ground zero (11; 45; 55).

3.2.4 Department of Defense Operational Training Project

The one operational training project conducted by the Air Force at Shot **LAPLACE** was Project 53.5, Aircrew Indoctrination

(Early Cloud Penetration). Sponsored by the Air Defense Command, the project was to enable Air Defense Command aircrews to witness a nuclear detonation and to penetrate its cloud. One T-33 aircraft, with a crew of two, flew a left-hand pattern at 25,000 feet heading inbound so as to be approximately ten nautical miles north of ground zero at the time of the detonation (3; 27). The aircraft penetrated the cloud after given clearance by the sampler control aircraft, discussed in section 3.2.5.

In addition, two F-84 aircraft from Project 53.9, Photographic Reconnaissance Training, were scheduled to participate at LAPLACE. The aircraft, which were from the Tennessee National Guard, did not, however, take part as scheduled (3; 27).

3.2.5 Air Force Special Weapons Center Activities

AFSWC support at Shot LAPLACE consisted of cloud-sampling and sample courier missions in support of the LASL test group project, cloud-tracking missions, security sweeps, and aerial surveys (3).

Cloud Sampling

Five F-84 aircraft, with one pilot each, collected samples of the nuclear cloud for LASL Project 11.2, Radiochemistry Sampling. A B-57 sampler control aircraft, manned by a pilot and a LASL scientific advisor, also participated. Pilots of the 4926th Test Squadron (Sampling) flew all six aircraft (1; 3; 61).

The sampler control aircraft, which guided the other five sampler aircraft through their missions, left Indian Springs AFB at 0510 hours, 50 minutes before the detonation. The aircraft reached an altitude of 35,000 feet and began an orbit pattern at 0525 hours. After the detonation, the control aircraft left its orbit to view the cloud (3).

The five sampler aircraft proceeded as follows. At 0615, the first F-84 sampler aircraft entered the area of the cloud at 35,000 feet and established visual contact with the B-57 sampler control aircraft. The scientific advisor in the B-57 then directed the sampler to penetrate the cloud at the altitude necessary to acquire the samples. The F-84 left the area at 0650 hours and landed at Indian Springs AFB at 0655 hours. The next two F-84 samplers followed the first sampler aircraft and entered the area of the cloud at altitudes of 35,000 feet at 0630 hours and 0645 hours. The last two aircraft entered the area at 0700 hours. All four aircraft followed the same procedures as did the first F-84, and remained in the area of the cloud for about 35 minutes. The last two F-84 samplers landed at Indian Springs AFB at 0740 hours. The control aircraft ended its pattern at 0730 hours, after the sampler aircraft had completed their missions, and landed at Indian Springs AFB at 0741 hours (1; 3; 61).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations. There, ground personnel used long-handled poles to remove the samples and place them in metal containers to be sent by courier aircraft to LASL. With the mission complete, the aircraft and pilots were decontaminated as described in the Operation PLUMBBOB volume (1; 3; 61).

Courier Missions

The 4900th Air Base Group from Kirtland AFB flew the courier sample return missions. Three C-47 aircraft flew samples out of Indian Springs AFB to LASL for analysis (1; 3; 61).

Cloud Tracking

At 0535 hours, one B-25 (serial number 118) left Indian Springs AFB and orbited at 15,000 feet over Mormon Mesa, 150 kilometers east of the NTS. The purpose of the mission was to determine the direction the cloud traveled and to keep the

airways clear of any aircraft unrelated to the test projects. In addition to the B-25, a B-50 aircraft was scheduled for cloud tracking, but the Test Manager canceled its mission prior to takeoff (1; 3; 61).

Security Sweep

The evening before the detonation, one L-20 aircraft, with at least two personnel aboard, left the airstrip near Camp Mercury and flew a survey mission over the NTS to ensure that the area was clear of unauthorized personnel (1; 3; 61).

Helicopter Surveys

After the detonation, one H-21 helicopter, with an AFSWC crew of two and at least two REECo monitors, left the airstrip near Camp Mercury and flew survey missions over the area to assess detonation damage. Crew members wore anticontamination clothing and respirators during the flight. Following the mission, the H-21 returned to the helicopter area, and aircraft and crew were monitored and decontaminated as required. The initial aerial radiological survey team, with an AFSWC crew of two and two REECo monitors, departed from the Control Point helicopter pad at 0733 hours, about 90 minutes after the detonation. After completing the mission, the team returned to the Control Point helicopter pad (1; 3; 45).

3.3 RADIATION PROTECTION AT SHOT **LAPLACE**

The purpose of the radiation protection procedures developed for Operation **PLUMBBOB** was to ensure that individuals would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs include isointensity contour maps, monitoring data, and **some** NTO personnel dosimetry information. The Operation **PLUMBBOB**

volume provides a description of radiological safety procedures and presents total dosimetry information for Desert Rock and AFSWC participants.

Dosimetry Records

From 7 to 12 September 1957, including the 8 September detonation of **LAPLACE**, the Personnel Dosimetry Branch issued 1,289 film badges and 392 pocket dosimeters (60). A film badge turned in after Shot **LAPLACE** indicates that one Desert Rock participant from the 232nd Signal Company exceeded three roentgens of cumulative gamma exposure. The exposure recorded was, however, accumulated during previous shots. Six NTO/DOD personnel, four of whom were from the 1st Radiological Safety Support Unit and two from the Ballistic Research Laboratories, received cumulative gamma exposures greater than two roentgens, ranging from 2.03 to 3.07 roentgens (39). Another participant listed in the NTO dosimetry records was from the Desert Rock Instructor Group, who received 2.43 roentgens. It is not known why he wore an NTO film badge in addition to his Desert Rock film badges. If no duplication occurred, his cumulative gamma exposure was 5.63 roentgens, which exceeded the five roentgens authorized for Desert Rock personnel (39; 54).

Logistics

The Logistics Branch issued protective clothing and equipment to 1,153 **LAPLACE** personnel. These supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

About one hour after the detonation, 12 monitors traveling in eight vehicles entered the shot area to perform the initial ground survey. The survey took about 90 minutes to complete. Resurveys were made later on shot-day and again on 9, 10, 11, and 13 September (45; 60).

The initial aerial survey team, consisting of an AFSWC crew of two and two REECO monitors, departed by helicopter from the Control Point helicopter pad at 0733 hours, about 90 minutes after the detonation. The highest radiation intensity was 23 R/h, encountered 50 feet above ground zero of the most recent safety shot, COULOMB B. An intensity of 22 R/h was encountered in the LAPLACE shot area (45; 60).

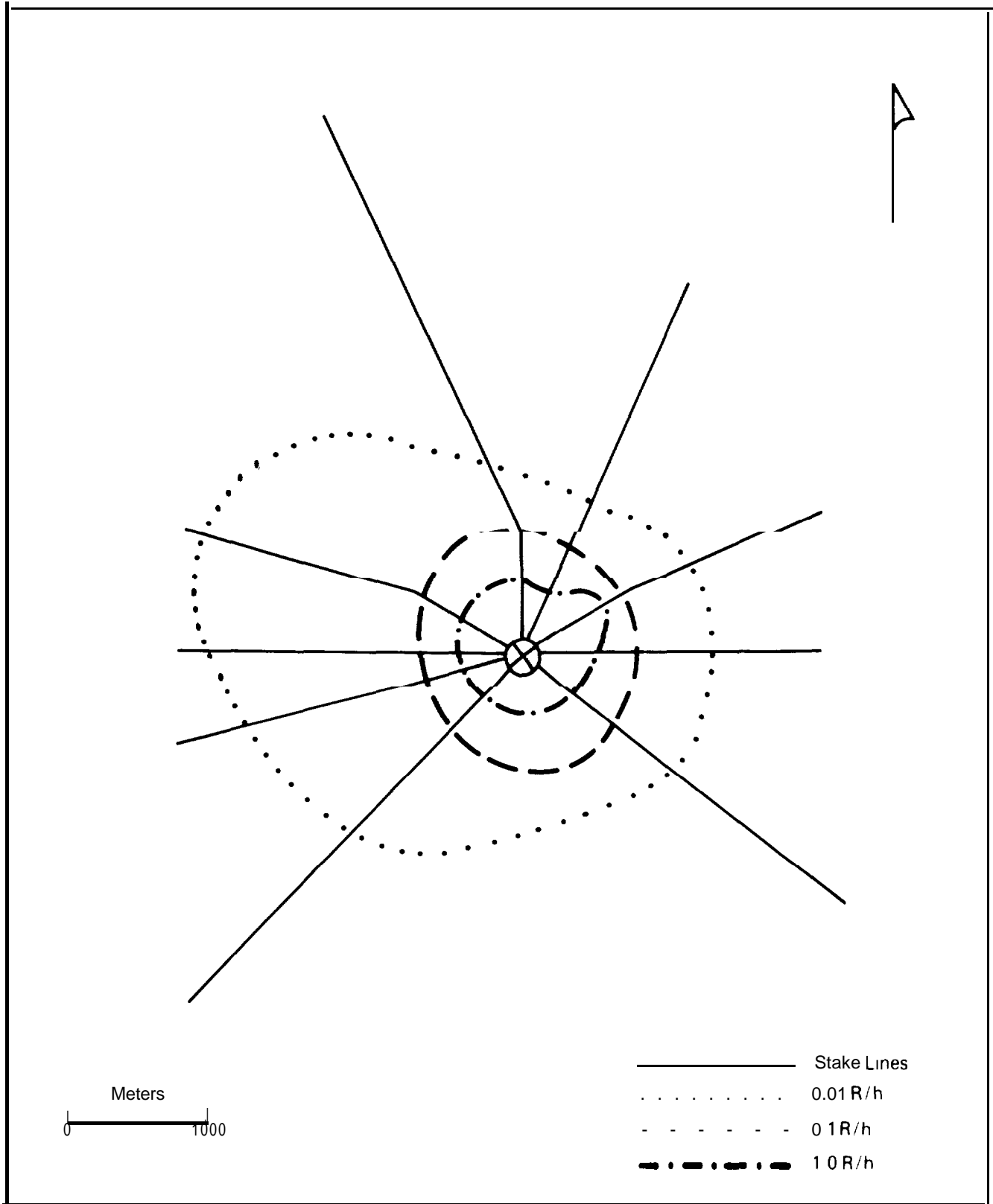
Plotting and Briefing

Using information from the initial surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 3-1 presents a copy of the initial contour map, with a mid-time of 0712 hours. Figure 3-2 shows the data resulting from the resurveys performed from 8 to 11 September (60).

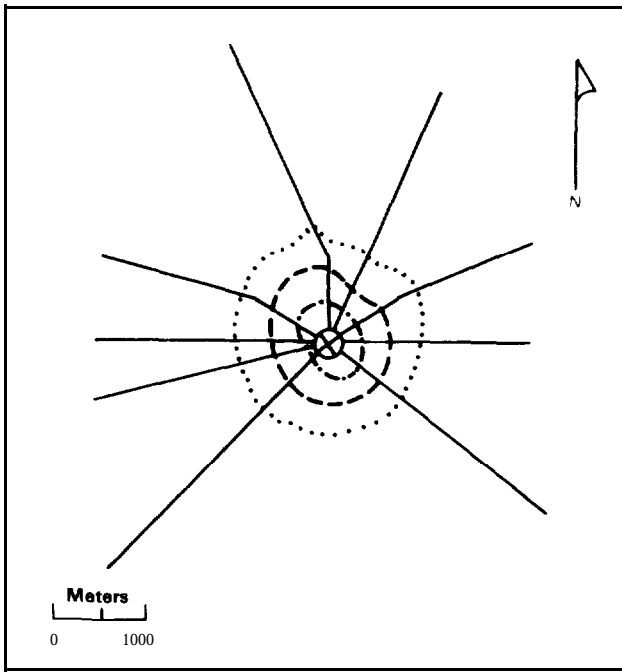
Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, identified in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas. During the period 7 through 12 September, access permits were issued to 631 personnel involved in 60 projects (60).

Decontamination Activities

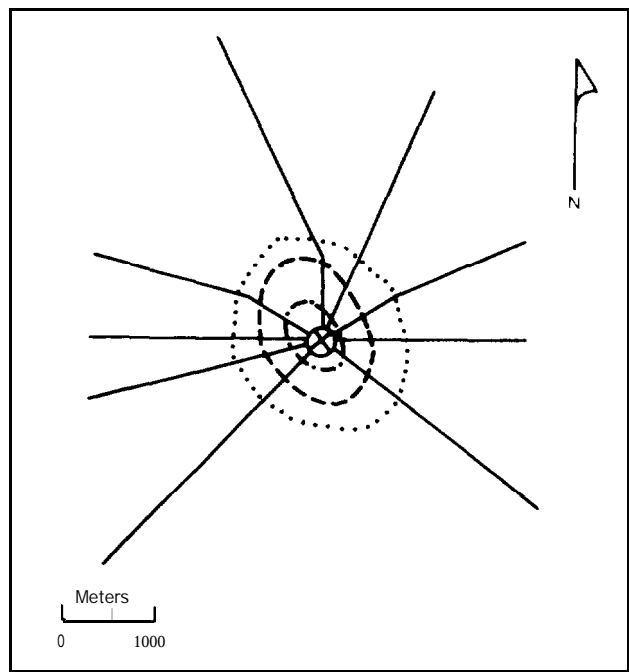
During the period covering Shot LAPLACE, personnel of the Decontamination Branch decontaminated 28 vehicles (60).



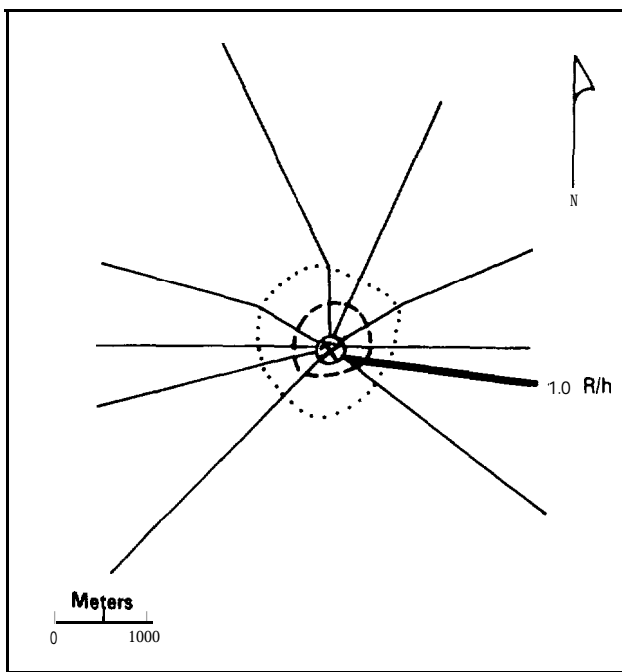
**Figure 3-1: INITIAL SURVEY FOR SHOT LAPLACE,
8 SEPTEMBER 1957, MID-TIME 0712**



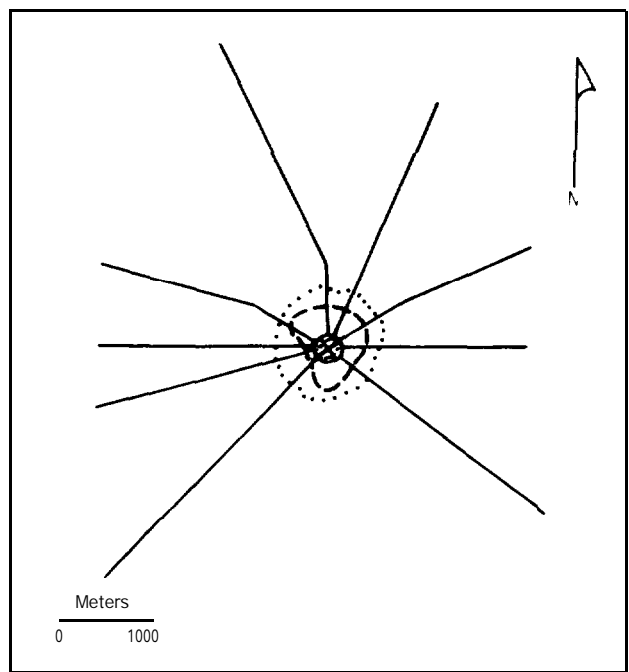
8 September 1957, Mid-Time: 1213



9 September 1957, Mid-Time: 0620



10 September 1957, Mid-Time 0554



11 September 1957, Mid-Time: 0620

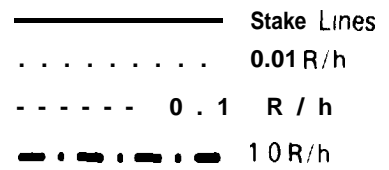


Figure 3-2: SUBSEQUENT SURVEYS FOR SHOT LAPLACE

SHOT FIZEAU SYNOPSIS

AEC TEST SERIES: **PLUMBBOB**
DOD EXERCISE: Desert Rock VII and VIII
DATE/TIME: 14 September 1957, 0945 hours
YIELD: 11 kilotons
HEIGHT OF BURST: 500 feet (tower shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate the capability of military personnel and equipment to detect nuclear detonations
(4) To evaluate the effects of nuclear radiation for civil defense purposes.

Weather: At shot-time, the temperature was 25°C, and the surface winds were calm. Winds were four knots from the east-southeast at 10,000 feet, 15 knots from the east-southeast at 20,000 feet, 34 knots from the east-southeast at 30,000 feet, and 12 knots from the south-southwest at 40,000 feet (cloud top height).

Radiation Data: The initial survey, mid-time of 1118 hours, determined that radiation intensities of 1.0 R/h and greater were limited to within 950 meters of ground zero to the east through southwest and within 1,800 meters to the northeast and west. Most of the fallout was in the northwestern quadrant.

Participants: Exercise Desert Rock troops, Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 4

SHOT FIZEAU

Shot FIZEAU was detonated with a yield of 11 kilotons at 0945 hours Pacific Daylight Time on 14 September 1957. The device was positioned on top of a 500-foot steel tower in Area 3 of the Nevada Test Site. The fallout pattern both onsite and offsite extended to the northwest of ground zero (29).

4.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT FIZEAU

Two technical service projects were conducted at Shot FIZEAU: Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Svtems, and Project 50.8, Detection of Atomic Burst and Radioactive Fallout. These projects involved an estimated 133 Desert Rock participants. In addition, ten Camp Desert Rock personnel witnessed the detonation from a location near News Nob, ten kilometers south of ground zero. The ten observers probably returned to Camp Desert Rock following the detonation (33).

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Svstems, was fielded by the Army Signal Research and Development Laboratories. The project, which involved an estimated 28 DOD personnel, had two purposes: to test the capacity of Army radar equipment in detecting the nuclear detonation and tracking the radioactive cloud, and to examine Army fallout prediction methods. Project participants were divided into a radar section and two fallout prediction teams. The radar section detected and tracked the nuclear cloud, recorded fireball growth, and determined the rate of rise of the cloud, the height of burst, and the yield. In addition, the radar section collected data to determine the use of radar equipment in cloud detection. Four radar sets were used: one was

about 170 kilometers south of ground zero near Boulder City, Nevada; one was about 50 kilometers from ground zero, at Angel's Peak; one was about 13 kilometers from ground zero; and one was approximately 12 kilometers from ground zero on the ridge between Yucca Lake and Frenchman Flat. All sets were manned at the time of the detonation. The personnel at the Angel's Peak location were from the 865th Aircraft Control and Warning Squadron.

One of the fallout prediction teams used upper wind data to test an Army Signal Research and Development Laboratories technique for predicting fallout patterns. The fallout team consisted of personnel from the Meteorological Division, Army Signal Research and Development Laboratories. This team operated out of an M-109 mobile van, which contained the teletype and recording equipment necessary for obtaining meteorological data for plotting fallout. The mobile van, manned at the time of the detonation, was next to the weather station at Camp Mercury. A second fallout prediction team, with personnel from the Army Electronic Proving Ground, Fort Huachuca, Arizona, operated near Alamo, Nevada, 92 kilometers northeast of the Control Point (19; 52).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the Army Air Defense Board, supported by the 495th Antiaircraft Artillery Missile Battalion. The project, which involved an estimated 105 DOD personnel, was designed to determine the capability of Army equipment in determining the location, height of burst, and yield of a nuclear detonation, and in tracking targets and guided missiles through a radioactive cloud or fireball. The Army installed radar-tracking equipment about 70 kilometers, 20 kilometers, and ten kilometers from ground zero. Project personnel monitored the radar sets from a few hours before the shot through shot-time. In addition, participants manned a project control point southeast of ground zero near Yucca Lake, at UTM coordinates 885895 (13; 57-59).

4.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT FIZEAU

Besides participating in Exercise Desert Rock activities, Department of Defense personnel took part in other test activities during Shot FIZEAU that required them to enter the forward area. Table 4-1 identifies the test group projects involving DOD participants. The Air Force also sponsored two operational training projects. In addition to the test group and the operational training projects, support activities accounted for a number of DOD participants. The Air Force Special Weapons Center supported one test group project and four routine missions for the Test Manager.

Table 4-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT FIZEAU

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
6 4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
6 5	Effects of Nuclear Detonations on Nike Hercules	White Sands Missile Range, Bell Telephone Laboratories	*
9 1	Support Photography	AFSWP; Military Air Transport Service	15
Los Alamos Scientific Laboratory Test Group			
11 2	Radiochemistry Sampling	Los Alamos Scientific Laboratory, 4926th Test Squadron (Sampling), Air Force Special Weapons Center	10
Civil Effects Test Group			
39 1a	Gamma Dosimetry by Film-badge Techniques	EG and G	*
39 5	Radiation Dosimetry for Human Exposures	Air Force School of Aviation Medicine, Oak Ridge National Laboratory, EG and G, General Electric Company	17
39 6	Biological Effects of Nuclear Radiation on the Monkey	Air Force School of Aviation Medicine	24

* Unknown

4.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted three projects during Shot FIZEAU. Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and measure the yield of the burst. The Indirect Bomb Damage Assessment NAROL system had nets located in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net consisted of two unmanned slave stations and one manned station (34).

Project 6.5, Effects of Nuclear Detonations on Nike Hercules, was fielded by the White Sands Missile Range, New Mexico, with assistance from Bell Telephone Laboratories of Whippany, New Jersey. The principal objective was to investigate the effects of nuclear radiation on the operational and structural characteristics of components, materials, and electronic systems of the Nike Hercules guided-missile system. Project personnel installed standard vacuum-tube and experimental transistorized versions of the guidance system at three sites located 180 meters, 410 meters, and 670 meters from ground zero. At shot-time, participants manned a radar station ten kilometers from ground zero. After the detonation, personnel recovered data and equipment at the exposure sites (25).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes

- General photographic support of Department of Defense projects.

Nine personnel established and then manned a photography station at UTM coordinates 844920 from five hours before to 30 minutes after the detonation (13). Two or three photographers also took pictures from an RC-47, operated by a pilot and two or three crewmen from the Military Air Transport Service. The aircraft flew a holding pattern inbound at 90 degrees (4; 13). The photography may have been performed by AFSWP personnel, but documentation concerning personnel is not available. In addition, EG and G operated camera stations in support of AFSWP and AEC activities (24). One unmanned station was near the Control Point, and two unmanned stations were three to eight kilometers from ground zero (13).

4.2.2 Department of Defense Participation in Los Alamos Scientific Laboratory Test Group Projects

Of the ten projects conducted by the Los Alamos Scientific Laboratory Test Group at Shot FIZEAU, only Project 11.2, Radio-chemistry Sampling, had DOD participation, as shown in table 4-1. The project involved cloud-sampling missions, discussed in section 4.2.5.

4.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted nine projects at FIZEAU. Of these, three involved DOD participation, as shown in table 4-1.

Project 39.1a, Gamma Dosimetry by Film-badge Techniques, was conducted by personnel from EG and G and probably from the DOD. The objective was to obtain information on integrated gamma dose at various points along the ground. The day before the

detonation, EG and G participants placed film badges on stakes at 183-meter intervals from 730 to 1,460 meters from ground zero. Personnel recovered the badges about one hour after the shot (55).

Project 39.5, Radiation Dosimetry for Human Exposures, was fielded by personnel from the Air Force School of Aviation Medicine, as well as participants from the Oak Ridge National Laboratory, EG and G, and General Electric Company. The objective was to make shielding and scatter measurements simulating the effects from the detonations at Hiroshima and Nagasaki. To achieve this objective, personnel constructed two light frame houses 910 meters from ground zero and installed dosimeters attached to a cable inside. Other structures and equipment with neutron and gamma-measuring instruments attached were placed in other parts of the forward area, probably in the vicinity of the houses. Instrumentation was arrayed from 920 to 945 meters south of ground zero. Five minutes after the detonation, 17 participants recovered instruments in the shot area (35). In addition, three participants assisted by Project 39.1 participants recovered gamma instruments near ground zero one hour after the shot (13; 35).

Project 39.6, Biological Effects of Nuclear Radiation on the Monkey, was fielded by 24 personnel from the Radiobiological Laboratory, Air Force School of Aviation Medicine. The objective was to correlate neutron and gamma measurements made on monkeys with the biological effects of the exposure. From 2345 hours on the day before the detonation to 0030 hours on shot-day, seven personnel placed the monkeys and two types of dosimeters at stations between 1.3 and 1.5 kilometers from ground zero. Two hours after the detonation, seven participants began recovering the monkeys and instruments (13). The monkeys were taken to the Radiobiological Laboratory for observation (13; 41; 42).

Twenty-one personnel also took part in a subproject of Project 39.6. Between 1730 and 1830 hours on the night before the detonation, they entered the shot area to place burros in shelters 1,280 to 1,510 meters south-southeast of ground zero. They left the area by 2100 hours. One hour after the detonation, 21 participants reentered the shot area to recover the burros from the shelters, a procedure taking about three hours (13; 41; 42).

4.2.4 Department of Defense Operational Training Projects

The Air Force conducted two operational training projects at Shot FIZEAU:

- Project 53.1, Aerial Sampling Missions
- Project 53.5, Aircrew Indoctrination (Early Cloud Penetration).

The primary objective of these projects was to indoctrinate Air Force personnel.

Project 53.1, Aerial Sampling Missions, was designed to train Air National Guard units in cloud sampling. This project was probably conducted in conjunction with LASL Project 11.2.

Project 53.5, Aircrew Indoctrination (Early Cloud Penetration), was designed to enable Air Defense Command **aircrews** to witness a nuclear detonation and to penetrate its cloud. Six T-33 aircraft, each with two crewmen, flew holding patterns at 30,000 feet heading inbound at shot-time. The aircraft were then located about ten nautical miles north of ground zero (4; 27). The T-33s required clearance from the sampler control aircraft, discussed in section 4.2.5, before penetrating the cloud (4; 27).

4.2.5 Air Force Special Weapons Center Activities

AFSWC support at Shot FIZEAU consisted of cloud-sampling and sample courier missions in support of the LASL project, cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Two B-57B aircraft, with two crewmen each, and four F-84G aircraft, with one pilot each, collected samples of the cloud for LASL Project 11.2, Radiochemistry Sampling. A B-57 sampler control aircraft, with a pilot and a LASL scientific advisor, also participated. Pilots of the 4926th Test Squadron (Sampling) flew the seven aircraft (1; 4; 61).

The sampler control aircraft, which guided the five sampler aircraft through their missions, left Indian Springs AFB at 0615 hours and reached an altitude of 30,000 feet. At shot-time, the aircraft was in a right-hand holding pattern 50 nautical **miles east of** ground zero. The B-57 control aircraft ended its orbit after the sampler aircraft completed their missions and landed at Indian Springs at 0911 hours (1; 4; 61).

The six sampler aircraft proceeded as follows. Over an hour after the control aircraft began its orbit, the first B-57B sampler aircraft entered the vicinity of the burst at 30,000 feet and established visual contact with the sampler control aircraft. The scientific advisor then directed the samplers to penetrate the cloud at the altitude necessary to acquire samples. The first B-57B left the area 35 minutes later and proceeded to Indian Springs AFB. The four F-84G samplers and the second B-57B followed the pattern established by the first sampler aircraft. The F-84Gs, proceeding two at a time, entered the area of the cloud at altitudes of 30,000 feet. The second B-57B entered the area 15 minutes after the last two F-84Gs entered. Each aircraft remained in the cloud area for 35 minutes and then began its return to base (1; 4; 61).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations. There, ground personnel used long-handled poles to remove the samples and place them in metal containers to be sent by courier to the laboratory. With the mission complete, the aircraft and pilots were decontaminated as described in chapter 3 of the Operation PLUMBBOB volume (1; 4; 61).

Courier Missions

The 4900th Air Base Group from Kirtland AFB flew the courier sample return missions. Three C-47 aircraft flew samples out of Indian Springs AFB to LASL for analysis (1; 4; 61).

Cloud Tracking

Five minutes after the detonation, one B-25, one B-29, and one B-50 aircraft left Indian Springs AFB to conduct cloud tracking. The aircraft orbited over Mormon Mesa, about 150 kilometers east of the NTS, at altitudes of 15,000, 22,000, and 25,000 feet, respectively. The purpose of the mission was to determine the direction the cloud traveled and to keep the airways clear of any aircraft unrelated to the test projects (1; 4; 61).

Security Sweep

Before the detonation, one L-20 and one Bonanza aircraft, each with at least two participants aboard, left the airstrip near Camp Mercury and flew a mission over the NTS to ensure that no unauthorized personnel were in the shot area (1; 4; 61).

Helicopter Surveys

After the detonation, two H-21 helicopters, each with an AFSWC crew of two and at least two REECO monitors, left the airstrip near Camp Mercury and flew survey missions over the FIZEAU shot area to assess and record radiation intensities.

Another H-21, with an AFSWC crew of two and one REECO monitor, made a damage assessment survey of electrical poles along Mercury highway. An H-21 photography mission was canceled prior to takeoff because it was not needed. After the mission, the helicopters returned to the helicopter area, where aircraft and crew were monitored and decontaminated as required (1; 4; 47; 61).

4.3 RADIATION PROTECTION AT SHOT FIZEAU

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs. The available information includes NTO isointensity contour maps, monitoring data, and some NTO personnel dosimetry data. Radiological safety procedures and dosimetry information for Desert Rock and AFSWC personnel are described in the Operation PLUMBBOB volume.

Dosimetry Records

On 13 and 14 September 1957, including the 14 September detonation of FIZEAU, the Personnel Dosimetry Branch issued 376 film badges and 170 pocket dosimeters (60). A film badge turned in on the day of detonation indicates that one Desert Rock participant from the 50th Chemical Platoon exceeded three roentgens of cumulative gamma exposure. The exposure recorded was, however, accumulated during previous shots. The REECO Onsite Support Report indicates that seven NTO/DOD personnel, four of whom were from the 1st Radiological Safety Support Unit and three from AFSWC, received gamma exposures greater than two roentgens. Five of these personnel had exposures over three roentgens, ranging from 3.45 to 4.92 roentgens (47). The most significant exposure was during the initial aerial survey,

discussed below, at which three personnel exceeded the NTO limit of three roentgens for 13 weeks. In separate discussions of apparently the same incident, the source documents attribute the overexposure to the pilot's failure to heed the monitor's instruction to leave the radiation field or to improper mission planning (43; 47; 54).

Logistics

The Logistics Branch issued protective clothing and equipment to 251 FIZEAU participants. These supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

Five minutes after the detonation, 12 monitors traveling in eight vehicles entered the shot area to conduct the initial ground survey. The survey took about 2 1/2 hours to complete. Resurveys were made later that day and again on 15, 16, 17, and 19 September (60).

The initial aerial survey team, consisting of two AFSWC crewmen and at least two REECO monitors, departed by helicopter from the Control Point helicopter pad at 1050 hours, about one hour after the detonation. The highest reading was 500 R/h, encountered 150 feet above ground zero at 1116 hours. An aerial survey team, with two AFSWC crewmen and at least two REECO monitors, resurveyed the area around ground zero on 15 and 16 September. The maximum intensity was 20 R/h, detected 500 feet above ground zero on 16 September, two days after the detonation (60).

Plotting and Briefing

Using information from the initial surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 4-1 shows a copy of the initial contour map, and figure 4-2 shows

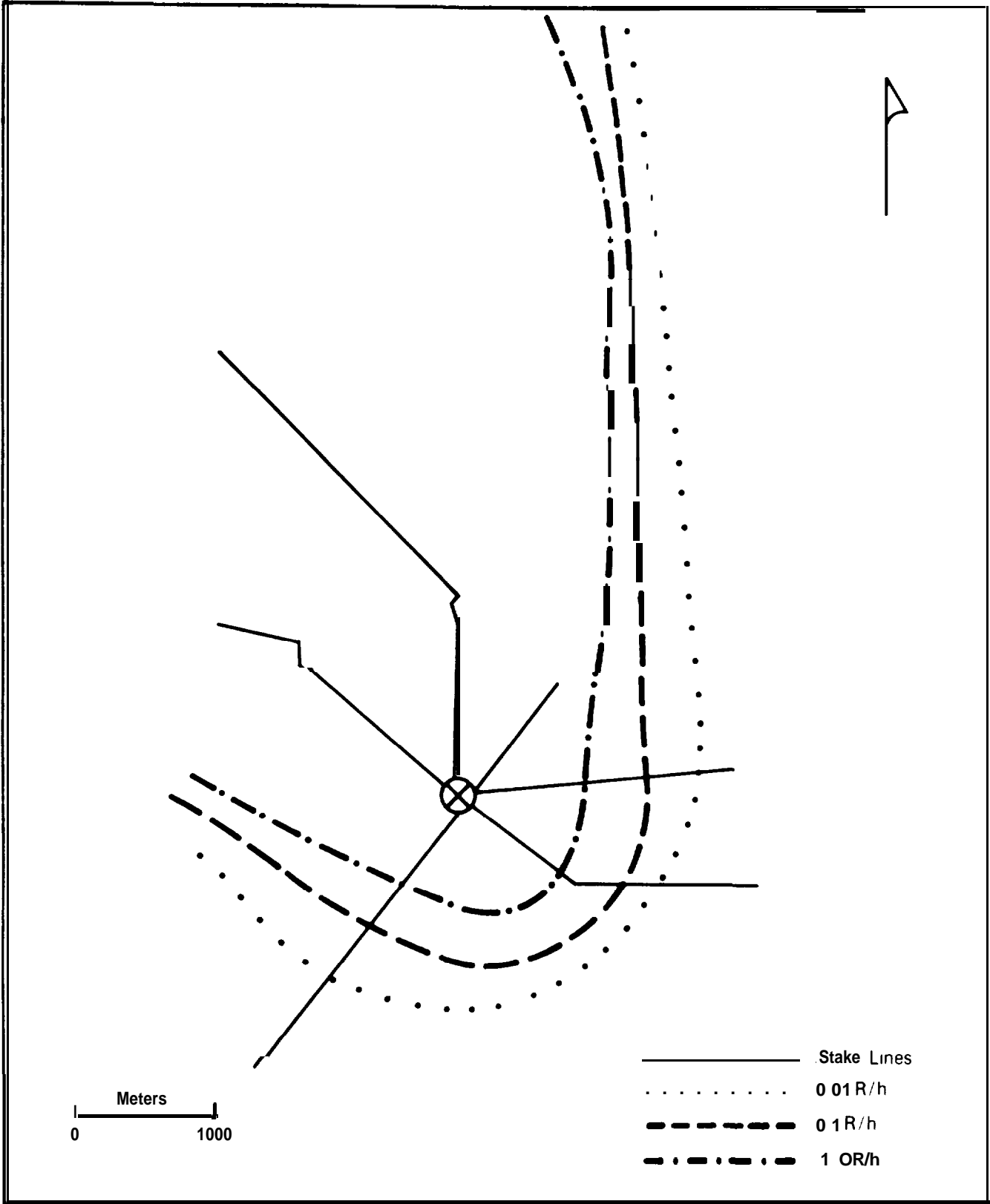
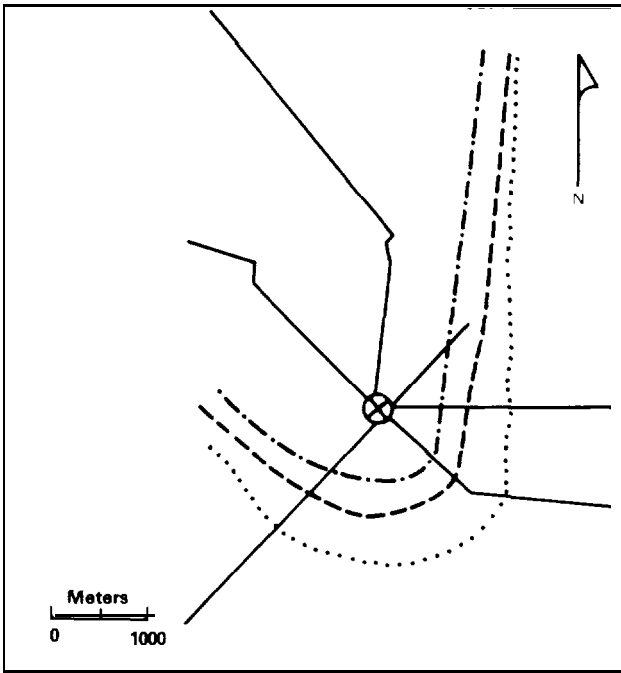
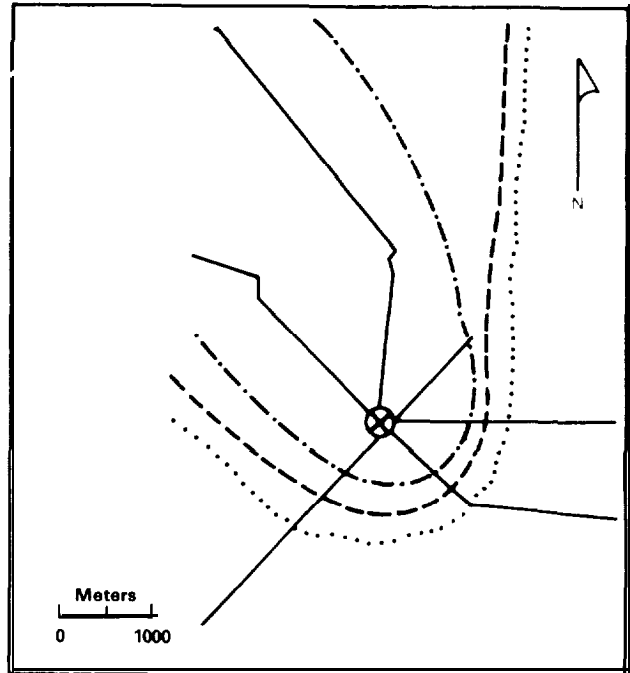


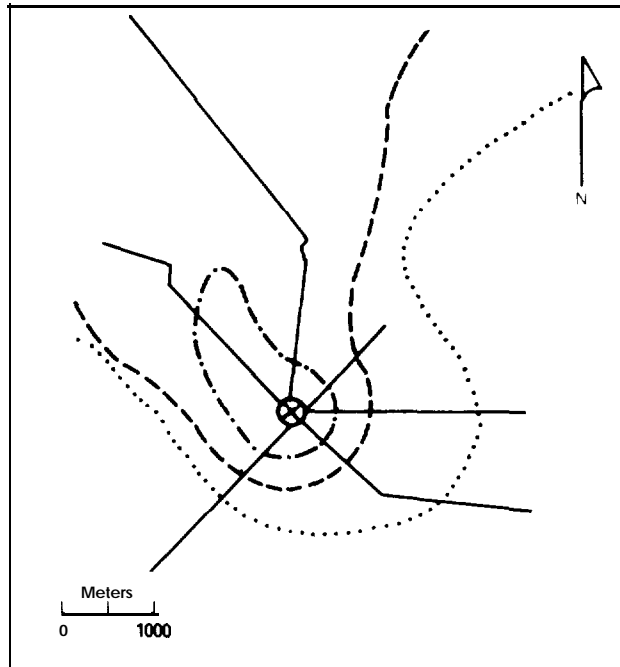
Figure 4-1: INITIAL SURVEY FOR SHOT FIZEAU,
14 SEPTEMBER 1957, MID-TIME 1118



14 September 1957, Mid-Time: 1557



15 September 1957, Mid-Time: 0625



16 September 1957, Mid-Time: 0947

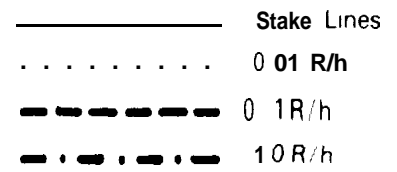


Figure 4-2: SUBSEQUENT SURVEYS FOR SHOT FIZEAU

copies of the resurveys performed from 14 to 16 September (60). The last resurvey presented includes a contribution in the northeast corner from Shot NEWTON, fired on 16 September.

Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, discussed in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required to enter these areas. During the period 13 and 14 September, access permits were issued to 140 individuals involved in 17 projects (60).

Decontamination Activities

During the period covering Shot FIZEAU, personnel of the Decontamination Branch decontaminated 82 vehicles (60).

SHOT NEWTON SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: Desert Rock VII and VIII
DATE/TIME: 16 September 1957, 0550 hours
YIELD: 12 kilotons
HEIGHT OF BURST: 1,500 feet (balloon shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate military equipment for monitoring nuclear events
(4) To evaluate the effects of nuclear radiation for civil defense purposes.

Weather: At shot-time, the temperature was 13°C, and surface winds were calm. Winds were 17 knots from the south-southwest at 10,000 feet, 28 knots from the west-southwest at 20,000 feet, and 71 knots from the west at 30,000 feet.

Radiation Data: At the time of the initial survey, mid-time of 0812 hours, radiation intensities exceeding 1.0 R/h were confined to within 900 meters of ground zero.

Participants: Exercise Desert Rock troops, Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 5

SHOT NEWTON

Shot NEWTON was detonated with a yield of 12 kilotons at 0550 hours Pacific Daylight Time on 16 September 1957. The device was suspended from a balloon and fired 1,500 feet above the ground in Area 7 of the Nevada Test Site. The cloud top rose to 32,000 feet and traveled northeast. Most onsite radiation was neutron induced activity around ground zero (29).

5.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT NEWTON

Two technical service projects were conducted at Shot NEWTON: 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, and 50.8, Detection of Atomic Burst and Radioactive Fallout. These projects involved an estimated 78 Desert Rock personnel.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by a detachment from the Army Signal Research and Development Laboratories. The project was designed to test the capacity of Army radar equipment in detecting the nuclear detonation and tracking the radioactive cloud and to examine Army fallout prediction methods. The 28 project participants were divided into a radar section and two fallout prediction teams (19; 52).

The radar section detected and tracked the cloud, recorded fireball growth, and determined the rate of rise of the cloud, the height of burst, and the yield. In addition, the radar section collected data to determine the use of radar equipment in cloud detection. Three radar sets were used: one was about 170 kilometers south of ground zero at Boulder City, Nevada; a second

was approximately 60 kilometers south of ground zero at Angel's Peak; and a third was approximately 25 kilometers from ground zero on the ridge between Yucca Lake and Frenchman Lake. All three sets were manned at the time of detonation. Personnel from the 865th Aircraft Control and Warning Squadron operated the set at Angel's Peak (19; 52).

One of the fallout prediction teams used upper wind data to test an Army Signal Research and Development Laboratories technique for predicting fallout patterns. The fallout team consisted of personnel from the Meteorological Division, Army Signal Research and Development Laboratories. The team operated out of an M-109 mobile van, which contained the teletype and recording equipment necessary for obtaining meteorological data for plotting fallout. The mobile van, manned at the time of the detonation, was next to the weather station at Camp Mercury. A second fallout prediction team, with personnel from the Army Electronic Proving Ground, Fort Huachuca, Arizona, operated near Alamo, Nevada, 92 kilometers northeast of the Control Point (19; 52).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the Army Air Defense Board, supported by the 495th Antiaircraft Artillery Missile Battalion. The purpose of the project, which involved an estimated 50 DOD personnel, was to determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation, and track targets and guided missiles through a radioactive cloud or fireball. From a few hours before the detonation through the detonation, Army personnel monitored several different types of radar sets about 70, 18, and 17 kilometers from ground zero. In addition, participants at the radar stations operated a B-26 aircraft by remote control, placing it within the shot area at the time of the detonation. The NEWTON detonation destroyed the B-26.

Personnel also manned a project control point southeast of ground zero at Yucca Lake, UTM coordinates 905865 (14; 57-59).

5.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT NEWTON

Besides participating in Exercise Desert Rock activities, Department of Defense personnel took part in other test activities during Shot NEWTON that required them to enter the forward area. Table 5-1 identifies the test group projects involving DOD participants. The Navy and the Air Force each conducted one DOD operational training project. In addition to the test group and the operational training projects, support activities accounted for a number of DOD participants. The Air Force Special Weapons Center supported one test group project and flew routine air missions for the Test Manager.

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

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
64	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
91	Support Photography	AFSWP, Military Air Transport Service, EG and G	9
Los Alamos Scientific Laboratory Test Group			
112	Radiochemistry Sampling	Los Alamos Scientific Laboratory, 4926th Test Squadron (Sampling), Air Force Special Weapons Center	12
Civil Effects Test Group			
372	Biophysical Aspects of Fallout	Air Force Special Weapons Center	3

* Unknown

5.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted two projects during Shot NEWTON.

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and measure the yield of the burst. The Indirect Bomb Damage Assessment NAROL system consisted of nets located in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net had two unmanned slave stations and one manned station (34).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Two or three photographers took pictures in the forward area, probably at News Nob or near the Control Point at Yucca Pass. Another two or three photographers took pictures from an RC-47 aircraft operated by at least three crewmen from the Military Air Transport Service. In addition, EG and G personnel provided technical photography support to AFSWP and the AEC, operating camera stations to record fireball and cloud growth (5; 14; 24).

5.2.2 Department of Defense Participation in Los Alamos Scientific Laboratory Test Group Projects

Of the 11 projects conducted by the LASL Test Group at NEWTON, only Project 11.2, Radiochemistry Sampling, involved DOD personnel. The project required AFSWC cloud-sampling missions, discussed in section 5.2.5.

5.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted four projects at NEWTON. Of these four, one project involved DOD personnel, as shown in table 5.1. Project 37.2, Biophysical Aspects of Fallout, required AFSWC support in the form of radio relays. This mission is discussed in section 5.2.5 (38).

5.2.4 Department of Defense Operational Training Projects

Two operational training projects were conducted at Shot NEWTON. The primary objectives of these projects were to test equipment and techniques and to indoctrinate Air Force personnel.

Project 51.3, Navy Heavy Attack Indoctrination (A3D), was designed to enable A3D combat crews to witness a nuclear detonation. Conducted by the Navy Pacific Command, the mission was staged from San Diego, California, and/or Whidbey Island, Washington. At the time of the detonation, two A3D aircraft, each carrying three or four crewmen, were flying at 30,000 feet. One aircraft was five nautical miles southwest of ground zero heading north, and the other A3D was five nautical miles south of ground zero heading south. Six A4D aircraft were also planned for this project, but they did not arrive at the NTS as scheduled and their participation was canceled (5; 27).

Project 53.8, Indirect Bomb Damage Assessment, was designed by the Strategic Air Command to test Indirect Bomb Damage Assessment equipment and techniques under simulated bomb and actual burst conditions. Two B-47s with three crewmen aboard orbited at altitudes between 12,000 and 14,000 feet, east of ground zero. Just before the detonation, the aircraft were 17 nautical miles from ground zero heading north. The two aircraft executed a breakaway maneuver at the time of the detonation (5; 27).

5.2.5 Air Force Special Weapons Center Activities

AFSWC support consisted of cloud-sampling and sample courier missions in support of the LASL test group project, a radio relay for one CETG project, and cloud-tracking missions, security sweeps, and helicopter surveys.

Cloud Sampling

Four B-57 aircraft, each with a crew of two, and two T-33s, each with one pilot, collected samples of the cloud for LASL Project 11.2, Radiochemistry Sampling. A B-57 sampler control aircraft, manned by a pilot and a LASL scientific advisor, also participated. Pilots of the 4926th Test Squadron (Sampling) flew the seven aircraft (1; 5; 61).

The control aircraft, which guided the sampler aircraft through the sample missions, left Indian Springs AFB at 0530 hours. The control aircraft reached an altitude of 30,000 feet and began a holding pattern 50 nautical miles east of ground zero at 0545 hours. After the detonation, the control aircraft left its orbit to view the cloud from all sides (1; 5; 61).

The four B-57 sampler aircraft proceeded as follows. At 0735, nearly two hours after the control aircraft began its holding pattern, the first B-57 sampler entered the area of the cloud at 30,000 feet and established visual contact with the

sampler control aircraft. The scientific advisor in the control aircraft then directed the sampler to penetrate the cloud as necessary to acquire samples. The B-57 sampler left the area 40 minutes later, landing at Indian Springs AFB at 0820 hours. The other three B-57 samplers followed the pattern established by the first sampler aircraft and entered the area of the cloud at altitudes of 30,000 feet at 15-minute intervals between 0755 hours and 0820 hours. Each aircraft remained in the area collecting samples for 35, 40, and 55 minutes. The two T-33 samplers also collected samples at 30,000 feet. The control aircraft ended its orbit at 0910 hours, after the other sampler aircraft had completed their missions, and landed at Indian Springs at 0940 hours (1; 5; 61).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations. There, ground personnel used long-handled tools to remove the samples and place them in metal containers to be sent by courier to LASL. With the mission complete, both aircraft and pilots were decontaminated, as described in chapter 3 of the Operation PLUMBBOB volume (1; 5; 61).

Courier Missions

The 4900th Air Base Group from Kirtland AFB flew the courier sample return missions. Three C-47 aircraft flew samples out of Indian Springs AFB to LASL for analysis (1; 5; 61).

Radio Relay

AFSWC support for CETG Project 37.2, Biophysical Aspects of Fallout, was provided by one C-47, which flew a radio relay. The C-47 flew a holding pattern at 17,000 feet 20 nautical miles east of ground zero on a northeast heading at the time of detonation (1; 5; 38; 61).

Cloud Tracking

Five minutes after the detonation, one B-25 aircraft left Indian Springs AFB and flew over the NTS at 15,000 feet. The objectives were to determine the direction the cloud traveled and to keep the airways clear of any aircraft unrelated to the test projects. The missions of two additional cloud-tracking aircraft, a B-25 and a B-29, were canceled before takeoff because the aircraft were not needed (1; 5; 61).

Security Sweep

Before the detonation, one L-20 and one Bonanza aircraft, each with at least two people aboard, left the airstrip near Camp Mercury and flew a mission over the NTS to ensure that no unauthorized personnel remained in the shot area (1; 5; 61).

Helicopter Surveys

One hour after the detonation, one H-21 helicopter, with an AFSWC crew of two and at least two REECo monitors, left the airstrip near Camp Mercury to survey and record radiation intensities in Area 7 and other non-test areas of the NTS. The helicopter spent about 40 minutes in the test area. Subsequent helicopter radiological surveys occurred on 17 September. Following the mission, the helicopter returned to the helicopter area. Aircraft and crew were monitored and decontaminated as required (1; 5; 48).

5.3 RADIATION PROTECTION AT SHOT NEWTON

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the

effectiveness of its radiation protection programs. The available information includes NTO isointensity contour maps, monitoring data, and some NTO personnel dosimetry data. Radiological safety procedures and dosimetry information for Desert Rock and AFSWC personnel are described in the Operation PLUMBBOB volume.

Dosimetry Records

From 16 to 21 September 1957, including the 8 September detonation of NEWTON, the Personnel Dosimetry Branch issued 1,049 film badges and 299 pocket dosimeters (60). Three NTO/DOD personnel received cumulative gamma exposures slightly greater than two roentgens. The personnel included one cloud-sampling pilot, one participant from AFSWP, and another participant from the 1st Radiological Safety and Support Unit (48; 54; 60).

Logistics

The Logistics Branch issued protective clothing and equipment to 1,158 NEWTON participants. These supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

Five minutes after the detonation, 12 monitors traveling in eight vehicles performed the initial ground survey of the shot area. The survey took about 2 1/2 hours to complete. Resurveys were made later on shot-day and again on 16, 17, 18, 19, 20, 21, and 22 September (60).

The initial aerial survey team, with an AFSWC crew of two and at least two REECo monitors, departed by helicopter from the Control Point helicopter pad at 0845 hours, about 90 minutes after the detonation. The highest radiation intensity encountered was 20 R/h, measured 200 feet above the FIZEAU ground zero about three hours after the NEWTON detonation. Aerial resurveys were made on 17 September (60).

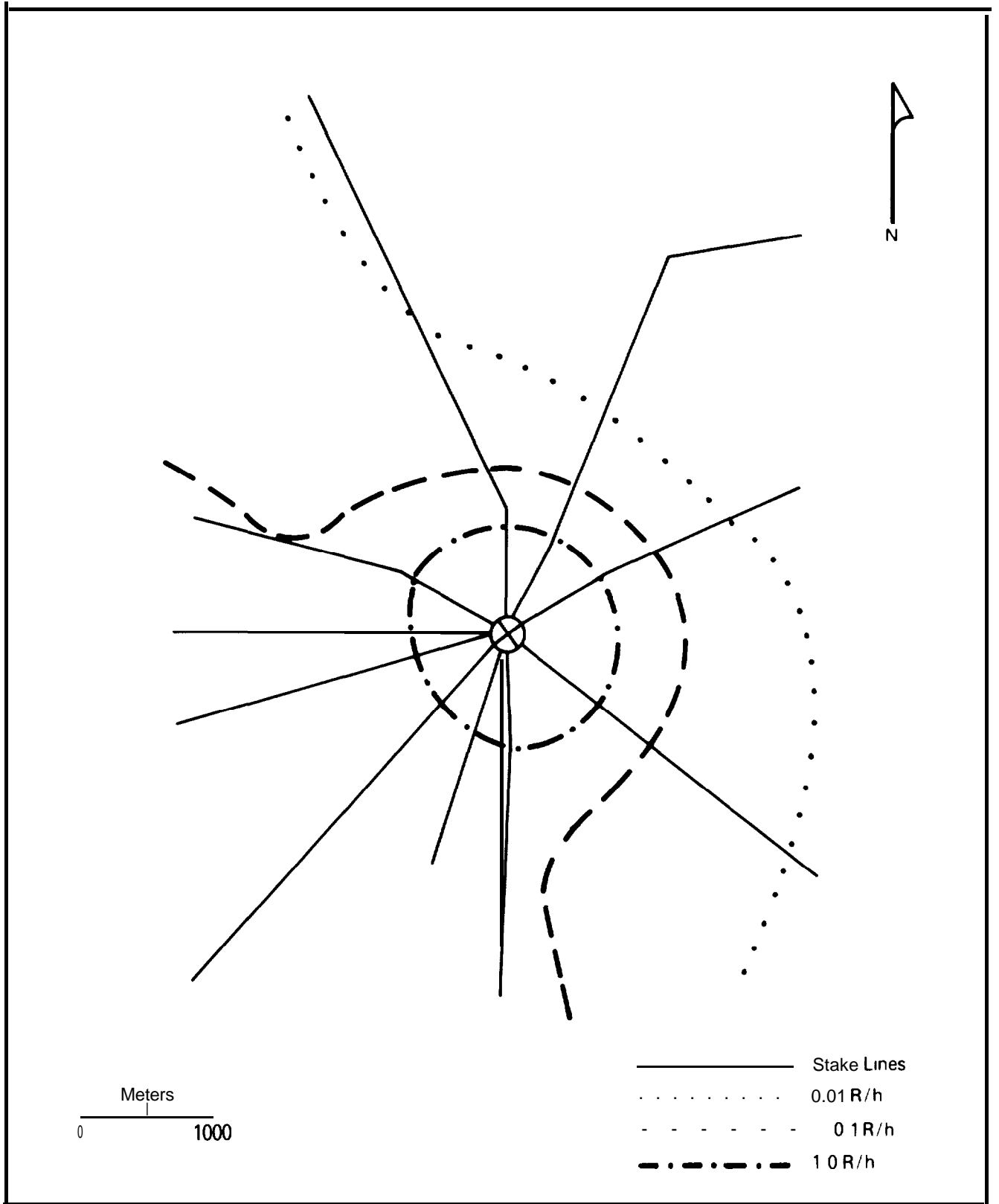
Plotting and Briefing

Using information from the initial surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 5-1 presents a copy of the initial contour map, and figure 5-2 shows copies of isointensity maps developed from the 16 to 19 September resurveys (60). The open contours reflect the contribution of the residual radiation field from Shot FIZEAU, fired on 14 September. The residual radiation was dominant except within about two kilometers of the NEWTON ground zero.

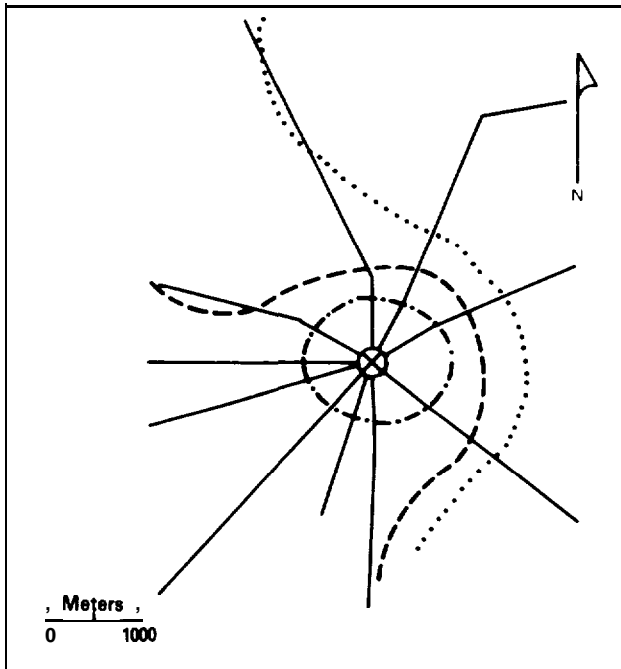
Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, described in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas during the period 15 through 21 September. Access permits were issued to 428 individuals involved in 57 projects (60).

Decontamination Activities

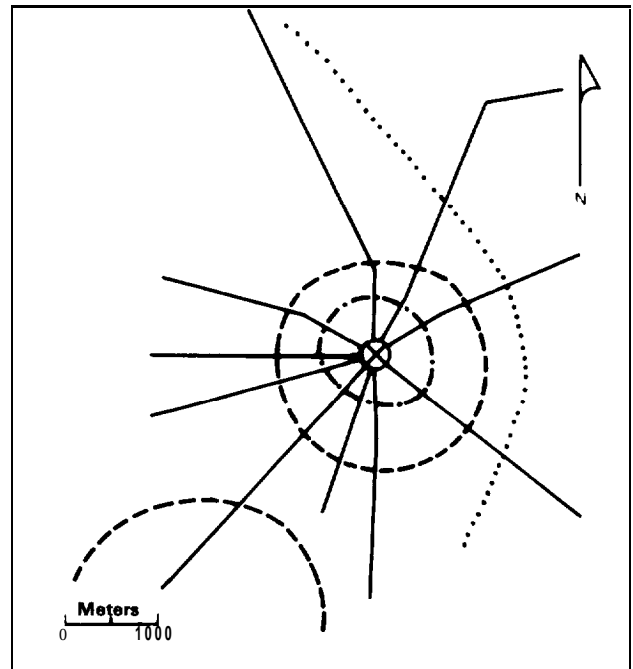
During the period covering Shot NEWTON, personnel of the Decontamination Branch decontaminated 55 vehicles and a number of personnel (60).



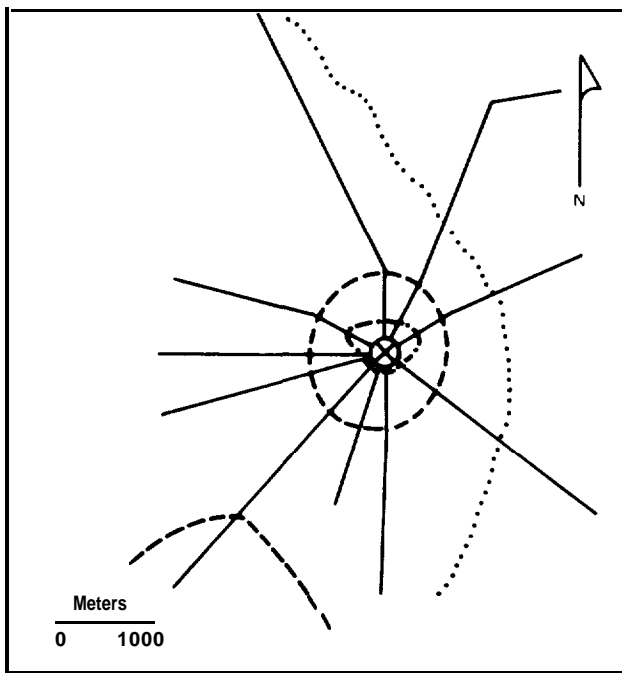
**Figure 5-1: INITIAL SURVEY FOR SHOT NEWTON,
16 SEPTEMBER 1957, MID-TIME 0612**



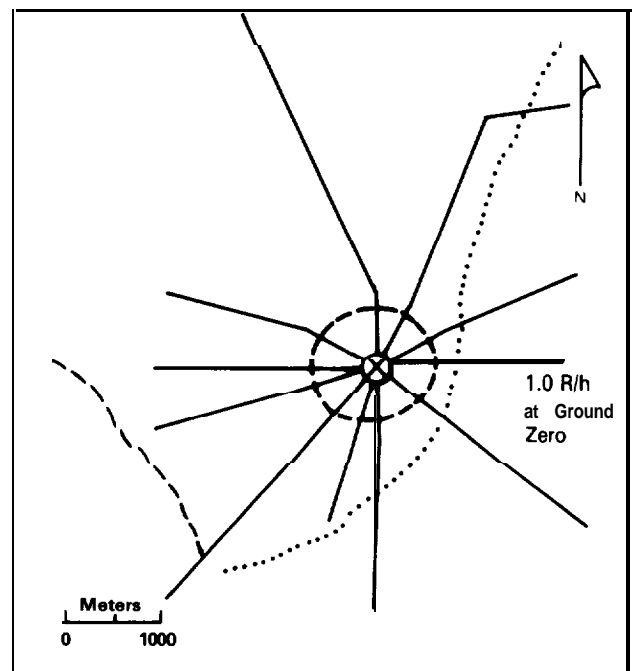
16 September 1957, Mid-Time: 1152



17 September 1957, Mid-Time: 0601



18 September 1957, Mid-Time: 0547



19 September 1957, Mid-Time: 0637

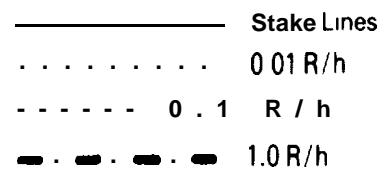


Figure 5-2: SUBSEQUENT SURVEYS FOR SHOT NEWTON

SHOT RAINIER SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: None
DATE/TIME: 19 September 1957, 1000 hours
YIELD: 1.7 kilotons
DEPTH OF BURST: 899 feet

Objectives: (1) To determine the feasibility and safety of a deep underground nuclear detonation
(2) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(3) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by underground nuclear devices.

Weather: Because a cloud did not develop after the detonation, wind data are not included.

Radiation Data: No fallout resulted from this detonation. The blast collapsed the tunnel wall, and the radiation was contained in the tunnel.

Participants: Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, University of California Radiation Laboratory, other contractors.

CHAPTER 6

SHOT RAINIER

Shot RAINIER was detonated with a yield of 1.7 kilotons at 1000 hours Pacific Daylight Time on 19 September 1957. The device was fired 899 feet underground in a sealed tunnel in Area 12, a mountainous area in the northwest corner of the Nevada Test Site. The tunnel went in 1,672 feet horizontally from the mountain slope, and the burst was as close as 790 feet to the surface on the slope. RAINIER was the first detonation to be contained underground. There was no flash of light, no wave of heat, and no cloud following the detonation. The blast collapsed the tunnel and contained the radiation (29; 60). While test group projects were conducted at the shot, there were no Exercise Desert Rock VII and VIII operations at RAINIER.

6.1 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT RAINIER

Department of Defense personnel took part in a variety of tasks during RAINIER that required them to enter the forward area. Table 6-1, on the following page, identifies the test group projects involving DOD participation. In addition to the test group projects, support activities accounted for a number of DOD participants. The Air Force Special Weapons Center flew routine air missions for the Test Manager.

6.1.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted two projects during Shot RAINIER, as listed in table 6-1.

Table 6-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT RAINIER

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
6.4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
9.1	Support Photography	Armed Forces Special Weapons Project; Military Air Transport Service	9

* Unknown

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and measure the yield of that burst. The Indirect Bomb Damage Assessment NAROL system consisted of nets located in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net had two unmanned slave stations and one manned station (34).

Project 9.1, Support Photography, was sponsored AFSWP to provide the following support services:

- Technical photographic support of the **military-effects** program
- **Documentation** of the overall military-effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

At shot-time, pictures were taken by two or three photographers in the forward area and two or three other photographers from a C-47 aircraft flown by at least three members of the Military Air Transport Service. The C-47 flew a holding pattern 2,000 feet above the terrain so as to be over surface zero at the time of the detonation (6; 16; 24).

6.1.2 Department of Defense Participation in University of California Radiation Laboratory Test Group Projects

Of the nine projects conducted by the Los Alamos Scientific Laboratory Test Group and the five projects conducted by the University of California Radiation Laboratory Test Group, only UCRL Project 21.2, Radiochemistry Sampling, was planned to include DOD participants. This project was to involve cloud sampling but was canceled because RAINIER was totally contained underground.

6.1.3 Air Force Special Weapons Center Activities

At Shot RAINIER, AFSWC support to the Test Manager consisted of security sweeps and helicopter surveys (6).

Security Sweep

Prior to the detonation, one Bonanza aircraft with at least two personnel aboard left the airstrip near Camp Mercury and flew a mission over the NTS to ensure that no unauthorized personnel were in the shot area (1; 6).

Helicopter Surveys

After the detonation, one or two H-21 helicopters, each with at least two AFSWC crewmen and a REECO monitor, left the airstrip near Camp Mercury and flew survey missions over the RAINIER test area to assess detonation damage. Following the mission, the

helicopter returned to the helicopter area. Aircraft and crew were monitored and decontaminated as required (6; 16; 46).

6.2 RADIATION PROTECTION AT SHOT RAINIER

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs. The available information includes dosimetry, logistics, and monitoring information. Radiological safety procedures and dosimetry information for AFSWC personnel are described in the Operation PLUMBBOB volume.

Dosimetry Records

For the 19 September 1957 detonation of RAINIER, the Personnel Dosimetry Branch issued 24 film badges and 12 pocket dosimeters. Dosimetry records indicate that none of the personnel at the shot accumulated a gamma exposure exceeding two roentgens (54; 60).

Logistics

The Logistics Branch issued protective clothing and equipment to 104 personnel. These supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

The initial ground survey team, consisting of ten monitors, left 15 minutes after the detonation to survey the shot area. The survey indicated that there was no increase in alpha, beta, or gamma radiation due to RAINIER because the tunnel had contained the radiation. A ground resurvey conducted 90 minutes

after the detonation found no increased radiation intensities at that time (60).

The initial aerial survey team, with at least two AFSWC crewmen and a REECO monitor, left the helicopter pad after the detonation to monitor radiation. No radiation was detected and subsequent aerial surveys were not made (60).

Plotting and Briefing

Because the ground surveys showed no increase in radiation intensities, isointensity maps were not plotted for Shot RAINIER. The Plotting and Briefing Branch issued 55 access permits required for entry into radiological exclusion areas (60).

Decontamination Activities

During the period covering Shot RAINIER, personnel of the Decontamination Branch did not decontaminate any vehicles (60).

SHOT WHITNEY SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: Desert Rock VII and VIII
DATE/TIME: 23 September 1957, 0530 hours
YIELD: 19 kilotons
HEIGHT OF BURST: 500 feet (tower shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate the effects of nuclear radiation for civil defense purposes.

Weather: At shot-time, the temperature was 16°C, and surface winds were calm. Winds were eight knots from the south-southeast at 10,000 feet, eight knots from the east at 20,000 feet, and 11 knots from the east at 30,000 feet.

Radiation Data: During the initial survey, mid-time of 0725 hours, radiation intensities greater than 1.0 R/h were within 700 meters of ground zero confined to the north, east, and south but extended **offsite** to the west.

Participants: Exercise Desert Rock troops, Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, University of California Radiation Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 7

SHOT WHITNEY

Shot WHITNEY was detonated with a yield of 19 kilotons at 0530 hours Pacific Daylight Time on 23 September 1957. The device was positioned on top of a 500-foot steel tower in Area 2 of the Nevada Test Site. The cloud top rose to 30,000 feet and moved west. The fallout pattern turned to the northwest offsite (29).

7.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT WHITNEY

An estimated 28 Exercise Desert Rock personnel participated in one technical service project.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by the Army Signal Research and Development Laboratories. The project was to test the capacity of Army radar equipment in detecting the nuclear detonation and tracking the radioactive cloud and to examine Army fallout prediction methods. The 28 project participants were divided into a radar section and two fallout prediction teams (19; 52).

The radar section detected and tracked the cloud, recorded fireball growth, and determined the rate of rise of the cloud, the height of burst, and the yield. In addition, the radar section collected data to determine the use of radar equipment in cloud detection. Three radar sets were used: one was about 145 kilometers south of ground zero at Boulder City, Nevada, a second set was about 30 kilometers from ground zero on the ridge between Yucca Lake and Frenchman Flat, and the third was about 25 kilometers from ground zero. All three sets were manned during the detonation (19; 52).

One fallout prediction team used upper wind data to test an Army Signal Research and Development Laboratories technique for predicting fallout patterns. This fallout team was composed of personnel from the Meteorological Division, Army Signal Research and Development Laboratories. The team operated out of an M-109 mobile van, which contained the teletype and recording equipment necessary for obtaining meteorological data for plotting fallout. The mobile van, manned at the time of the WHITNEY detonation, was next to the weather station at Camp Mercury. A second fallout prediction team, composed of personnel from the Army Electronic Proving Ground, Fort Huachuca, Arizona, operated near Alamo, Nevada, 92 kilometers northeast of the Control Point (19, 52).

7.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT WHITNEY

Besides participating in an Exercise Desert Rock project, Department of Defense personnel took part in other test activities during Shot WHITNEY that required them to enter the forward area. Table 7-1, on the following page, identifies the test group projects involving DOD participants. The Air Force conducted two DOD operational training projects. In addition to the test group and operational training projects, support activities accounted for a number of DOD participants at Shot WHITNEY. AFSWC supported one test group project and flew routine air missions for the Test Manager.

7.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted two projects during Shot WHITNEY, as indicated in table 7-1.

Table 7-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT WHITNEY

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
19	Spectra of Ground Shocks Produced by Nuclear Detonations	Air Research and Development Command, Ramo-Woolridge Corporation	*
91	Support Photography	AFSWP, Military Air Transport Service, EG and G	15
University of California Radiation Laboratory Test Group			
21 2	Radiochemistry Sampling	University of California Radiation Laboratory, 4926th Test Squadron (Sampling), Air Force Special Weapons Center	16
Civil Effects Test Group			
37 2	Biophysical Aspects of Fallout	Air Force Special Weapons Center	3
39 1a	Gamma Dosimetry by Film-badge Techniques	EG and G	*

* Unknown

Project 1.9, Spectra of Ground Shocks Produced by Nuclear Detonations, was conducted by the Air Research and Development Command and fielded by personnel from Ramo-Woolridge Corporation. The project was to measure and analyze the velocity and movement of the ground shock wave produced by a nuclear detonation. Project personnel placed two self-contained, mechanical, reed-type shock gauges inside cylindrical canisters that were fastened to a concrete anchor block, buried three feet in the ground about 180 meters west of ground zero, and surrounded by sandbags. In recovering instruments, personnel had difficulty finding the canisters, which had been moved by the shock wave some nine meters from their original position (31).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program

- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Nine personnel established and then manned a photography station at UTM coordinates 8431022 from five hours before to 30 minutes after the detonation (12). Two or three photographers also took pictures from a C-47 aircraft operated by at least three crewmen from the Military Air Transport Service. The C-47 flew a right-hand holding pattern at 8,000 feet, eight nautical miles south of ground zero at shot-time. In addition, EG and G personnel provided technical photography support to AFSWP and the AEC, operating three camera stations to record fireball and cloud growth. One manned camera station was near the Control Point, and two unmanned stations were three to eight kilometers from ground zero (7; 12; 24).

7.2.2 Department of Defense Participation in University of California Radiation Laboratory Test Group Projects

Of the six projects conducted by the University of California Radiation Laboratory Test Group, only Project 21.2, Radiochemistry Sampling, involved DOD personnel participation, as shown in table 7-1. AFSWC 4926th Test Squadron (Sampling) performed cloud-sampling missions required by the project, as discussed in section 7.2.5.

7.2.3 Department of Defense Participation in Civil Effects Test Group Project

Of the four Civil Effects Test Group projects conducted at Shot WHITNEY, the two listed in table 7-1 involved DOD personnel. Project 37.2, Biophysical Aspects of Fallout, required AFSWC

support for radio relays, discussed in section 7.2.5. Project 39.1a, Gamma Dosimetry by Film-badge Techniques, was conducted by personnel from EG and G and probably from the DOD. The objective was to obtain information on integrated gamma dose at various points along the ground. Two days before the shot, personnel placed film badges at 228-meter intervals on a stake line 690 to 1,600 meters from ground zero. Participants recovered the film badges on the morning of shot-day after the detonation (12; 23).

7.2.4 Department of Defense Operational Training Projects

The Air Force conducted two operational training projects, the primary objectives of which were to test equipment and techniques and to indoctrinate personnel.

Project 53.5, Aircrew Indoctrination (Early Cloud Penetration), was designed to enable Air Defense Command aircrews to witness a nuclear detonation and penetrate its cloud. Two T-33 aircraft, each with two crewmen, took off from Indian Springs Air Force Base at 0620 hours and 0720 hours, respectively. Each aircraft remained in the vicinity of the cloud for 20 minutes, landing at 0705 hours and 0805 hours, respectively (7; 27).

Project 53.8, Indirect Bomb Damage Assessment, was sponsored by the Strategic Air Command to test Indirect Bomb Damage Assessment equipment and techniques under simulated and actual bomb conditions. Two B-47s took part at WHITNEY. The aircraft orbited at altitudes of 11,000 to 16,000 feet and were 35 nautical miles east of ground zero on a northerly heading just before the detonation. At the time of detonation, the two aircraft executed a breakaway maneuver (7; 27).

7.2.5 Air Force Special Weapons Center Activities

AFSWC support consisted of cloud-sampling and sample courier missions in support of the UCRL test group project, a radio relay mission for CETG, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Four F-84 aircraft, with one pilot each, and two B-57s, with five crewmen each, collected samples of the cloud for UCRL Project 21.2, Radiochemistry Sampling. A B-57 sampler control aircraft, with a pilot and a UCRL scientific advisor, also participated. Pilots of the 4926th Test Squadron (Sampling) flew the seven aircraft (1; 7; 61).

The B-57 sampler control aircraft, which guided the six sampler aircraft through the sample missions, left Indian Springs AFB at 0510 hours. The control aircraft reached an altitude of 30,000 feet and began a right-hand holding pattern at 0525 hours. After the detonation, the control aircraft left its orbit to view the cloud from all sides (1; 7; 61).

The six sampler aircraft proceeded as follows. At 0630, the first F-84 sampler aircraft entered the vicinity of the burst at 30,000 feet and established visual contact with the control aircraft. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire samples. The F-84 left the area 35 minutes later and landed at Indian Springs AFB at 0710 hours. The other three F-84 samplers and the two B-57 samplers followed the pattern established by the first sampler and entered the area of the cloud at altitudes of 30,000 feet at five- and ten-minute intervals between 0635 hours and 0715 hours. Each aircraft remained in the area collecting samples for 35 minutes. The final sampler aircraft landed at Indian Springs AFB at 0755 hours. The control aircraft ended its pattern at 0755 hours, after the six sampler aircraft completed their missions, and landed at Indian Springs at 0806 hours (1; 7; 61).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations. There, ground personnel used long-handled poles to remove the samples and place them in metal containers to be sent by courier to UCRL. With the mission complete, the aircraft and pilots were decontaminated as described in the Operation PLUMBBOB volume (1; 7; 61).

Courier Missions

The 4900th Air Base Group from Kirtland AFB conducted the courier sample return missions. Three C-47 aircraft, with a minimum of three personnel each, flew samples out of Indian Springs AFB to UCRL for analyses (1; 7; 61).

Cloud Tracking

Five minutes after the detonation, one B-50 and two B-25 aircraft left Indian Springs AFB and flew over the NTS at 25,000 and 15,000 feet. One B-25 replaced a B-29 that had been scheduled for cloud tracking. The purpose of the mission was to determine the direction the cloud traveled and to keep the airways clear of any aircraft unrelated to the test projects (1; 7; 61).

Radio Relay

AFSWC support for Project 37.2, Biophysical Aspects of Fall-out, was provided by one C-47, which flew a radio relay. The C-47 flew a right-hand holding pattern at 10,000 feet and was 20 nautical miles southeast of ground zero at the time of detonation (1; 7; 61).

Security Sweep

Prior to the detonation, two L-20 aircraft, each with at least two personnel aboard, left the airstrip near Camp Mercury and flew a mission over the NTS to ensure that no unauthorized personnel were in the shot area (1; 7; 61).

Helicopter Surveys

After the detonation, two H-21 helicopters, each with an AFSWC crew of two and two REECo monitors, conducted aerial radiological safety surveys of Area 2 and other non-shot areas. The helicopters surveyed for about 40 minutes, whereupon they returned to Camp Mercury. Resurveys took place later on shot-day. Two other H-21 helicopters, each with an AFSWC crew of two and REECo radiological safety monitors, conducted a damage assessment survey over the shot area after the detonation. After the mission, the helicopters returned to the helicopter area at Camp Mercury. The aircraft and crews were monitored and decontaminated as required (7; 49).

7.3 RADIATION PROTECTION AT SHOT WHITNEY

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs. The available information includes NTO isointensity contour maps, monitoring procedures, and some NTO personnel dosimetry data. Radiological safety procedures and dosimetry information for Desert Rock and AFSWC personnel are described in the Operation PLUMBBOB volume.

Dosimetry Records

From 22 to 26 September 1957, including the 23 September detonation of WHITNEY, the Personnel Dosimetry Branch issued 916 film badges and 166 pocket dosimeters (60). Four NTO/DOD personnel received cumulative gamma exposures slightly greater than two roentgens. Two of these personnel were from the 1st

Radiological Safety and Support Unit and one each was from the Chemical Warfare Laboratories and AFSWC (54; 60).

Logistics

The Logistics Branch issued protective clothing and supplies to 480 personnel. These supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

Ten minutes after the detonation, 14 monitors traveling in eight vehicles performed the initial ground survey of the shot area. The survey took about 90 minutes to complete. Resurveys were made later on shot-day and again on 24, 25, and 26 September (49; 60).

The initial helicopter survey team, consisting of two AFSWC crewmen and two radiological monitors, departed from the Control Point helicopter pad at 0748 hours, almost 90 minutes after the detonation. Aerial resurveys were made for Shot WHITNEY later on shot-day. The maximum radiation intensity was 100 R/h, encountered 500 feet above a location about 30 meters east of ground zero, approximately two-and-one-half hours after the detonation (7; 49; 60).

Plotting and Briefing

Using information from the surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 7-1 presents a copy of the initial contour map, with a mid-time of 0725 hours, and figure 7-2 shows copies of the iosintensity maps resulting from resurveys on 23 to 26 September (60).

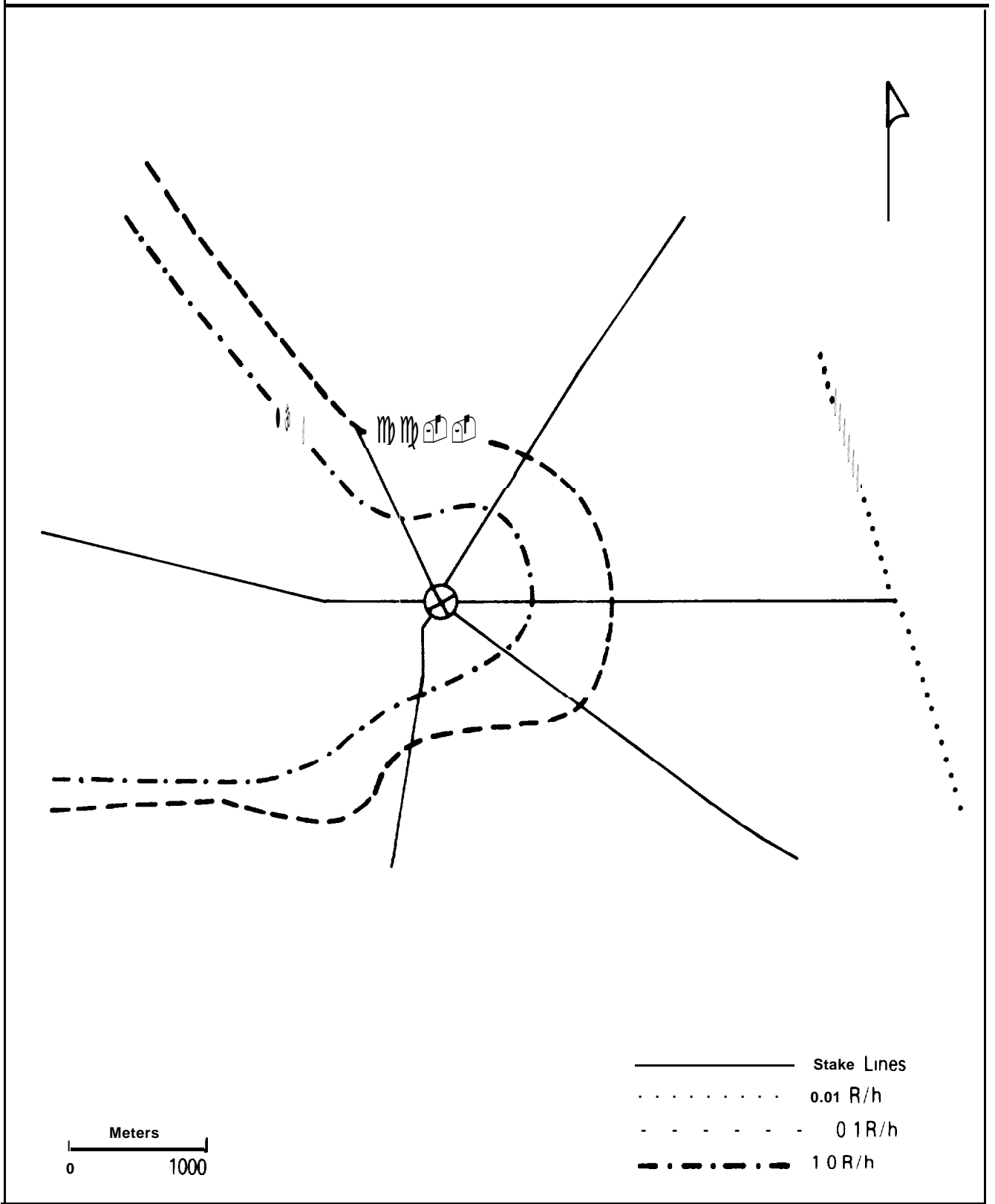
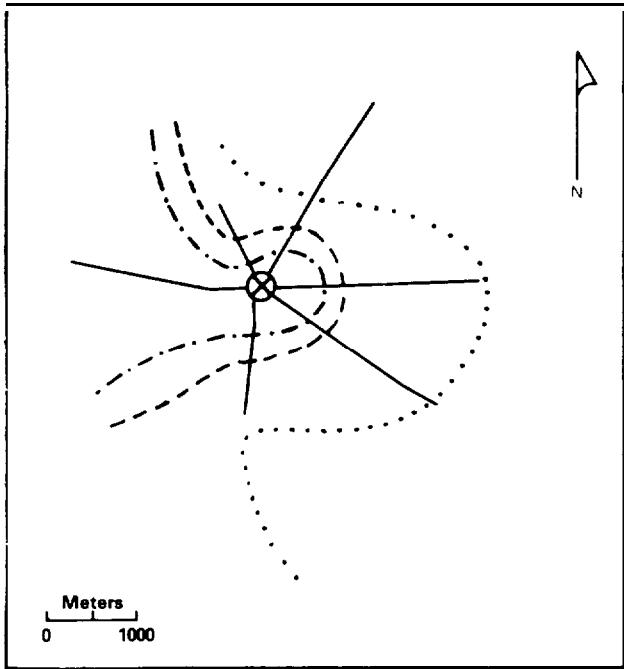
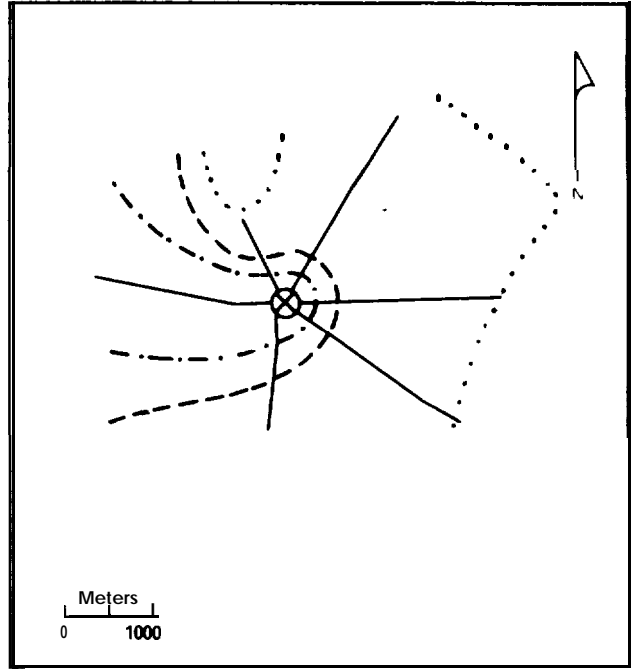


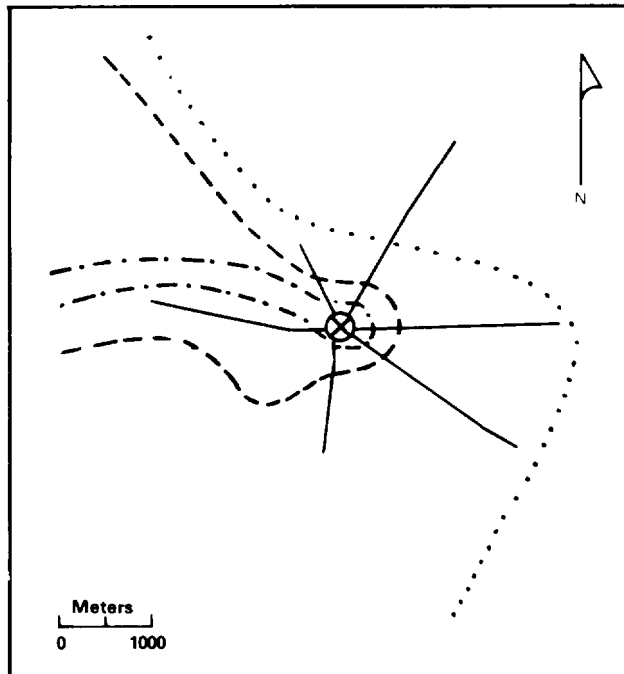
Figure 7-1: INITIAL SURVEY FOR SHOT WHITNEY,
23 SEPTEMBER 1957, MID-TIME 0725



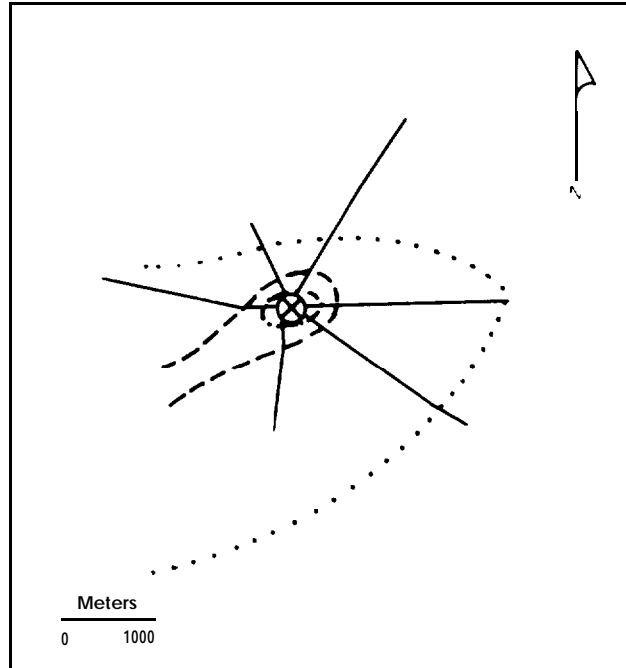
23 September 1957, Mid-Time: 1152



24 September 1957, Mid-Time: 0635



25 September 1957, Mid-Time 0633



26 September 1957, Mid-Time 0624

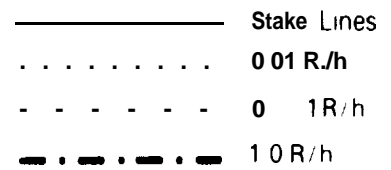


Figure 7-2: SUBSEQUENT SURVEYS FOR SHOT WHITNEY

Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, described in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas. From 22 to 26 September, access permits were issued to a total of 200 individuals involved in a total of 34 projects (60).

Decontamination Activities

During the period covering Shot WHITNEY, personnel of the Decontamination Branch decontaminated 28 vehicles (60).

SHOT CHARLESTON SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: None
DATE/TIME: 28 September 1957, 0600 Hours
YIELD: 12 kilotons
HEIGHT OF BURST: 1,500 feet (balloon shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate the effects of nuclear radiation for civil defense purposes.

Weather: At shot-time, surface winds were calm. Winds were from the south at 20 knots at 10,000 feet, 34 knots at 20,000 feet, and 38 knots at 30,000 feet.

Radiation Data: During the initial survey, mid-time of 0716 hours, radiation intensities greater than 1.0 R/h were confined to within 900 meters of ground zero.

Participants: Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, University of California Radiation Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 8

SHOT CHARLESTON

Shot CHARLESTON was detonated with a yield of 12 kilotons at 0600 hours Pacific Daylight Time on 28 September 1957. The device was suspended from a balloon 1,500 feet above the ground in Area 9 of the Nevada Test Site. The cloud top rose to 32,000 feet and traveled north from the point of detonation (29).

8.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT CHARLESTON

According to the Desert Rock Final Report for Operation PLUMBBOB, 28 personnel conducted Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, at the time of Shot CHARLESTON. However, the report on Project 50.3 does not address radar locations for Shot CHARLESTON. The schedule of events indicates that a manned station was planned at UTM coordinates 859869, but it is not known if the station was used (15). Possibly, the 28 personnel were still stationed at Camp Desert Rock following the WHITNEY event but did not participate in the project at Shot CHARLESTON (19; 33; 52).

8.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT CHARLESTON

Department of Defense personnel took part in test activities during CHARLESTON that required them to enter the forward area. Table 8-1 identifies the test group projects involving DOD participants. The Air Force sponsored one operational training project. In addition to test group projects and the operational training project, support activities accounted for a number of DOD participants. AFSWC personnel supported one test group project and flew routine air missions for the Test Manager.

Table 8-I: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT CHARLESTON

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
11	Basic Airblast Phenomena	Ballistic Research Laboratories	*
19	Spectra of Ground Shocks Produced by Nuclear Detonations	Air Research and Development Command, Ramo-Woolridge Corporation	*
64	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
91	Support Photography	AFSWP, Military Air Transport Service	9
University of California Radiation Laboratory Test Group			
212	Radiochemistry Sampling	University of California Radiation Laboratory, 4926th Test Squadron (Sampling), Air Force Special Weapons Center	10
Civil Effects Test Group			
398	Depth Dose Studies in Phantoms with Initial Bomb Gamma and Neutron Radiation	Naval Medical Research Institute	5

* Unknown

8.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted four projects during Shot CHARLESTON, as listed in table 8-1.

Project 1.1, Basic **Airblast** Phenomena, was designed by the Ballistic Research Laboratories to obtain data on overpressure and dynamic pressure values as a function of time and distance from ground zero. Performance of various pressure gauges, measurement devices, and measurement techniques was also evaluated. To obtain data, project participants installed **self-**recording pressure time gauges at 12 stations along the main blast line between 335 and 22,240 meters south and southeast of ground zero. Personnel recovered the gauges after the detonation (15; 20).

Project 1.9, Spectra of Ground Shocks Produced by Nuclear Detonations, was conducted by the Air Research and Development Command and personnel from the Ramo-Woolridge Corporation. The objective of the project was to measure and analyze the velocity and movement of the ground shock wave produced by the nuclear detonation. Project personnel placed one shock gauge in each of seven cylindrical canisters that were fastened to concrete anchor blocks, buried three feet in the ground at specific overexposure levels 335 to 700 meters south of ground zero, and surrounded by sandbags. Personnel later reentered the shot area to remove the sandbags, excavate the cylinders, and remove the gauges (31).

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and measure the yield of that burst. The Indirect Bomb Damage Assessment NAROL system consisted of nets located in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net had two unmanned slave stations and one manned station (34).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Two or three photographers took pictures in the forward area, probably at News Nob or near the Control Point at Yucca Pass. Another two or three photographers also took pictures from a C-47 aircraft operated by at least three members of the Military Air Transport Service. The C-47 flew a right-hand holding pattern at 10,000 feet heading east toward ground zero at the time of detonation. In addition, EG and G provided technical photography support to AFSWP and the AEC, operating five camera stations to record fireball and cloud growth (8; 15; 24).

8.2.2 Department of Defense Participation in University of California Radiation Laboratory Test Group Projects

Of the ten projects conducted by the University of California Radiation Laboratory Test Group, only Project 21.2, Radiochemistry Sampling, involved DOD personnel participation, as shown in table 8-1. The AFSWC 4926th Test Squadron (Sampling) performed the cloud-sampling missions required by this project, as is discussed in section 8.2.5.

8.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group performed one project at Shot CHARLESTON with DOD involvement, as shown in table 8-1.

Project 39.8, Depth Dose Studies in Phantoms with Initial Bomb Gamma and Neutron Radiation, was fielded by personnel from the Naval Medical Research Institute. The objectives were to determine the relation of the air exposure or incident dose to absorbed dose, and to determine the distribution of absorbed dose through tissue material equivalent to human tissue. Personnel placed dosimeters in masonite phantoms, which were placed about 140 meters southeast of ground zero. Five minutes after the detonation, five personnel entered the shot area to recover the phantoms and to place three additional phantoms on a line southeast of ground zero (15; 36; 50).

8.2.4 Department of Defense Operational Training Project

The PLUMBBOB operational summary (27) indicates that the Air Force sponsored one operational training project at Shot CHARLESTON. Project 53.9, Photographic Reconnaissance Training, was fielded by the Tactical Air Command to indoctrinate Air National Guard Tactical Reconnaissance Units from George AFB, California, in conducting photographic missions over a nuclear target. Air National Guard Units participated in the project on a rotational basis (27). At Shot CHARLESTON, one T-33 with two crewmen aboard passed over ground zero ten minutes after the detonation at an altitude of 10,000 feet to photograph the nuclear target (8; 27).

8.2.5 Air Force Special Weapons Center Activities

AFSWC support consisted of cloud-sampling and sample courier missions in support of the UCRL test group project, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Four F-84 aircraft, with one pilot each, and two B-57s, with two crewmen each, collected samples of the cloud for UCRL Project

21.2, Radiochemistry Sampling. A B-57 sampler control aircraft, which had a pilot and a UCRL scientific advisor, also participated. Pilots of the 4926th Test Squadron (Sampling) flew the seven aircraft (1; 8; 61).

The control aircraft, which guided the other six sampler aircraft through the sample missions, left Indian Springs AFB at 0540 hours. The aircraft reached an altitude of 30,000 feet and began a right-hand pattern at 0555 hours. After the detonation, the control aircraft left its orbit to view the cloud from all sides (1; 8; 61).

The six sampler aircraft proceeded as follows. At 0625 hours, the first B-57 sampler aircraft entered the vicinity of the burst at 30,000 feet and established visual contact with the sampler control aircraft. The scientific advisor in the control aircraft then directed the samplers to penetrate the cloud as necessary to acquire samples. The first B-57 left the area 30 minutes later and landed at Indian Springs AFB at 0710 hours. The second B-57 and four F-84 samplers followed the pattern established by the first sampler aircraft. These aircraft entered the area of the cloud at altitudes of 30,000 feet at ten-minute intervals between 0635 hours and 0715 hours. Each aircraft remained in the area collecting samples for 35 to 50 minutes. The final sampler aircraft landed at Indian Springs AFB at 0800 hours. The control aircraft ended its pattern at 0840 hours, after the six sampler aircraft completed their missions, and landed at Indian Springs at 0805 hours (1; 8; 61).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations. There, ground personnel used long-handled poles to remove the samples and place them in metal containers to be sent by courier to UCRL. With the mission complete, the aircraft and pilots were decontaminated as described in the Operation PLUMBBOB volume (1; 8; 61).

Courier Missions

The 4900th Air Base Group from Kirtland AFB conducted the courier sample return missions. Three C-47 aircraft, with a minimum of three personnel each, flew samples out of Indian Springs AFB to UCRL for analysis (1; 8; 61).

Cloud Tracking

Five minutes after the detonation, one B-29 with a crew of ten and one H-25 aircraft with a crew of four left Indian Springs AFB and flew over and beyond the NTS at 15,000 feet and 25,000 feet. The purpose of the mission was to determine the direction the cloud traveled and to keep the airways clear of any aircraft unrelated to the test projects (1; 8; 61).

Security Sweep

Before the detonation, one L-20 aircraft with at least two personnel aboard left the airstrip near Camp Mercury and flew a mission over the NTS to ensure that no unauthorized personnel were in the shot area. The mission of a second L-20 scheduled for a security sweep was cancelled because the aircraft was not needed (1; 8).

Helicopter Surveys

After the detonation, one H-19 helicopter, with an AFSWC crew of two and at least two REECO monitors, conducted a radiological survey over the shot area. Two other H-19 survey missions were canceled because they were not needed. Following the mission, the helicopters returned to the helicopter area. Aircraft and crew were monitored and decontaminated as required (8; 50).

8.3 RADIATION PROTECTION AT SHOT CHARLESTON

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs. The available information includes NTO isointensity contour maps, monitoring data, and some NTO personnel dosimetry data. Radiological safety procedures and dosimetry information for AFSWC participants are described in the Operation PLUMBBOB volume.

Dosimetry Records

From 5 to 27 September 1957, including the 28 September detonation of CHARLESTON, the Personnel Dosimetry Branch issued 4,874 film badges and 187 pocket dosimeters (60). Two AFSWC personnel received cumulative gamma exposures greater than two roentgens; these were 2.01 and 2.55 roentgens (54; 60).

Logistics

The Logistics Branch issued protective clothing and supplies to 897 personnel. The supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

Five minutes after the detonation, 11 monitors traveling in eight vehicles performed the initial ground survey of the shot area. The survey took about two hours to complete. Resurveys were made later on shot-day and again on 29 and 30 September, and 1 and 3 October (60).

The initial helicopter survey team, consisting of two AFSWC crewmen and at least two radiological monitors, departed from the

Control Point helicopter pad at 0736 hours, about 90 minutes after the detonation. The highest radiation intensity was 25 R/h, encountered 100 feet above ground zero 14 minutes later. Aerial resurveys were not made for Shot CHARLESTON because the necessary measurements could be obtained from the ground resurveys (50; 60).

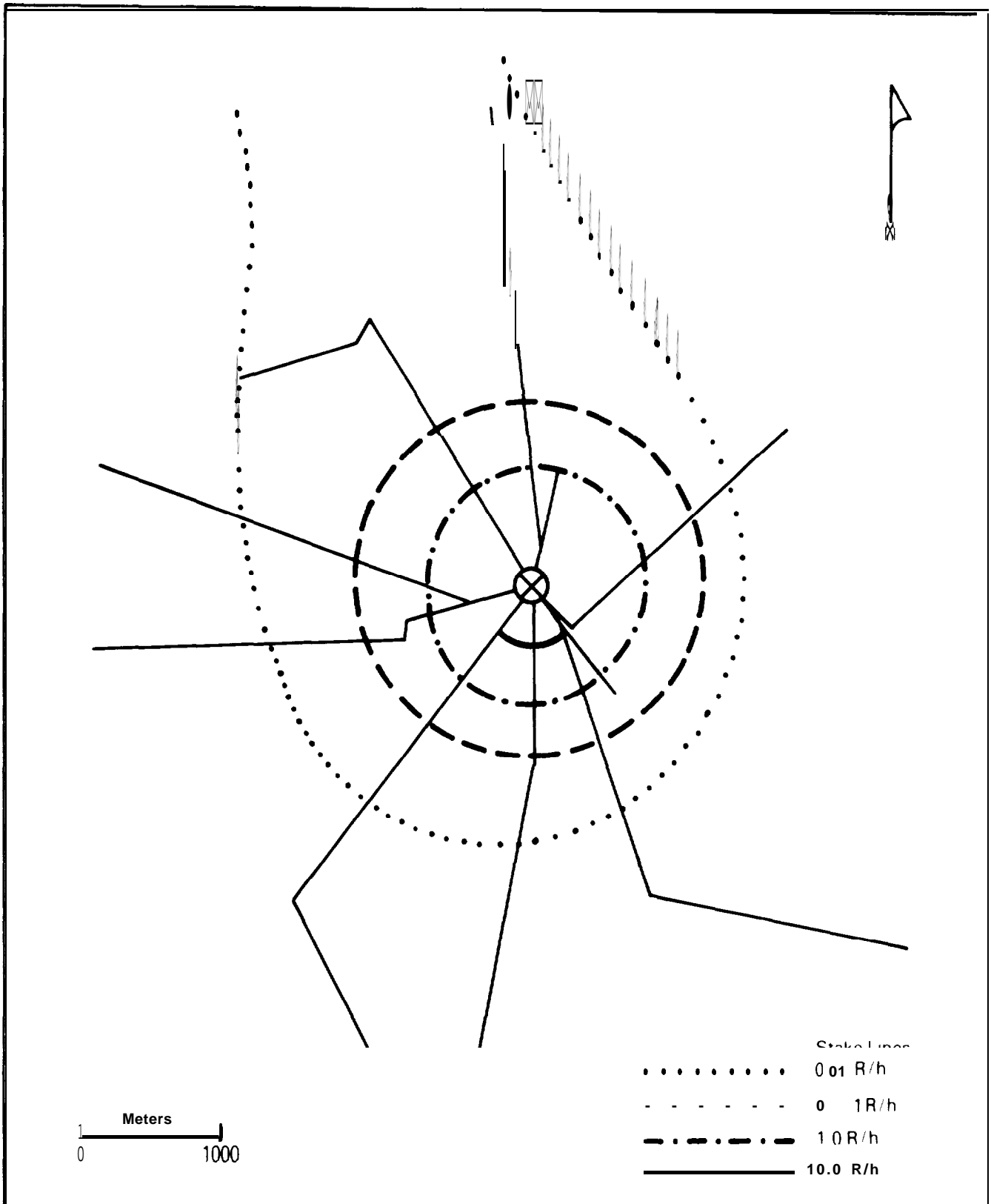
Plotting and Briefing

Using information from the initial surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 8-1 presents a copy of the initial contour map, and figure 8-2 shows copies of the isointensity maps resulting from resurveys on 28 September to 1 October (60).

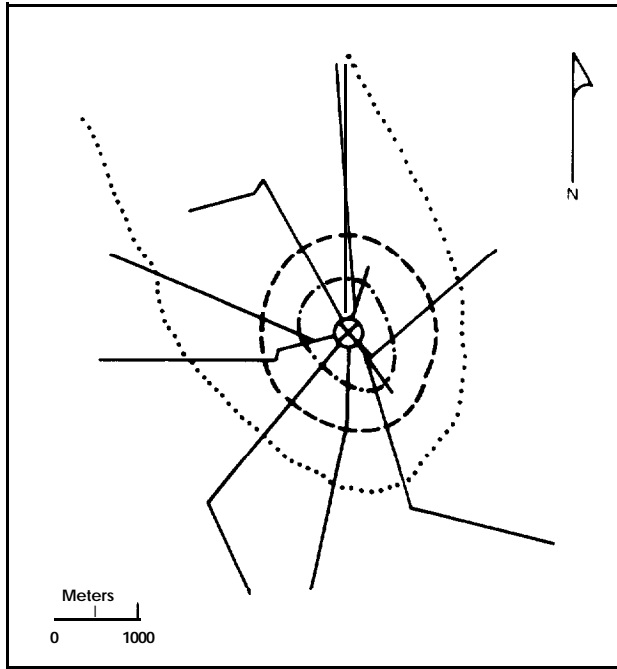
Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, described in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas. From 27 September through 5 October, access permits were issued to a total of 454 individuals involved in a total of 55 projects (60).

Decontamination Activities

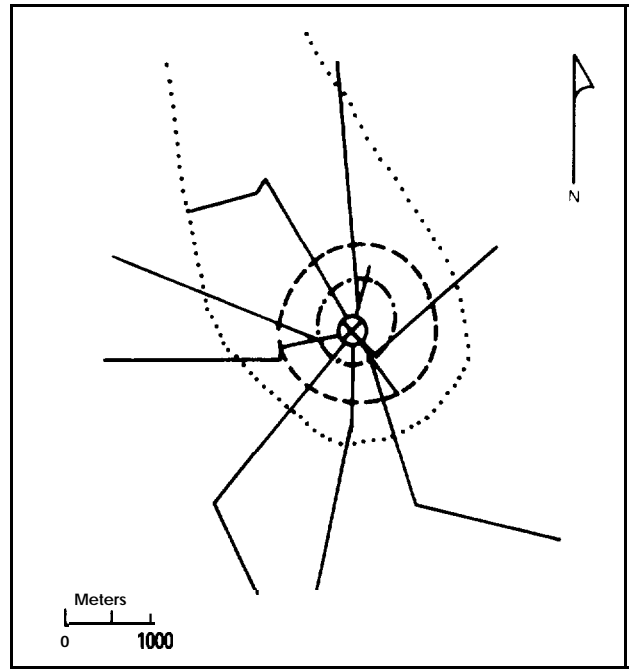
During the period covering Shot CHARLESTON, personnel of the Decontamination Branch decontaminated 29 vehicles (60).



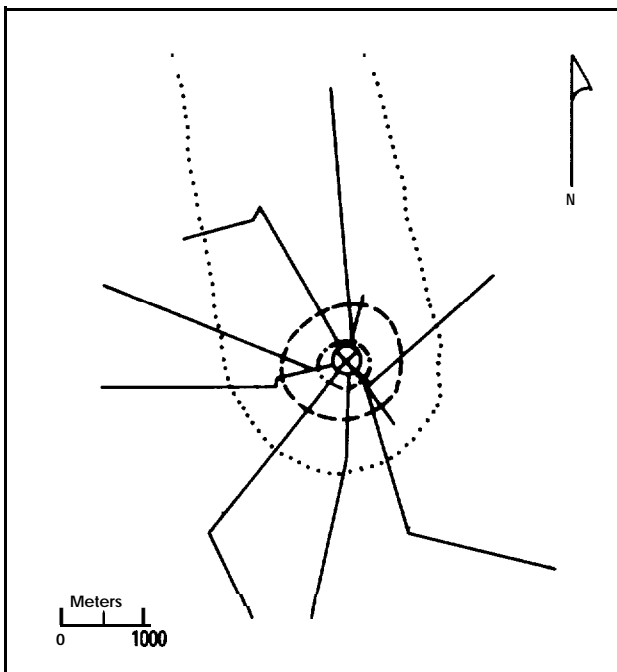
**Figure 8-1: INITIAL SURVEY FOR SHOT CHARLESTON, —
28 SEPTEMBER 1957, MID-TIME 0716**



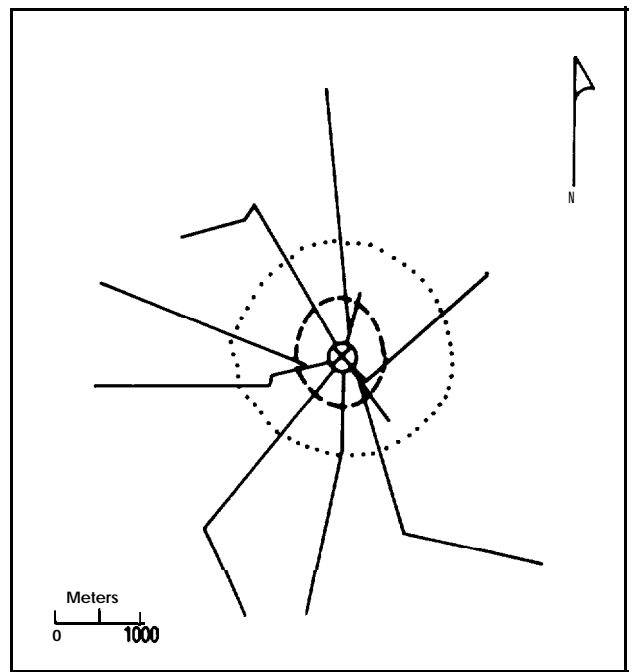
28 September 1957, Mid-Time: 1213



29 September 1957, Mid-Time: 0533



30 September 1957, Mid-Time: 0625



1 October 1957, Mid-Time: 0644

- Stake Lines
- 0.01 R/h
- - - - - 0.1 R/h
- . - . - . 1.0 R/h

Figure 8-2: SUBSEQUENT SURVEYS FOR SHOT CHARLESTON

SHOT MORGAN SYNOPSIS

AEC TEST SERIES: PLUMBBOB
DOD EXERCISE: None
DATE/TIME: 7 October 1957, 0500 hours
YIELD: 8 kilotons
HEIGHT OF BURST: 500 feet (balloon shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by these nuclear devices
(3) To evaluate the effects of nuclear radiation for civil defense purposes.

Weather: At shot-time, the temperature was 7°C, and surface winds were calm. Winds were 12 knots from the west-northwest at 10,000 feet, 30 knots from the west at 20,000 feet, 41 knots from the west at 30,000 feet, and 48 knots from the west-southwest at 40,000 feet.

Radiation Data: During the initial survey, mid-time of 0545 hours, radiation intensities of 1.0 R/h and greater were confined to within 950 meters of ground zero.

Participants: Armed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, University of California Radiation Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 9

SHOT MORGAN

Shot MORGAN, the twenty-fourth and final nuclear weapons test of Operation PLUMBBOB, was detonated at 0500 hours Pacific Daylight Time on 7 October 1957. The device, which had a yield of eight kilotons, was suspended from a balloon 500 feet above the ground in Area 9 of the Nevada Test Site. The cloud top rose to 40,000 feet and traveled east from the point of detonation. Most of the onsite radiation was from neutron activation of the soil around ground zero (29).

9.1 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP AND SUPPORT ACTIVITIES AT SHOT MORGAN

Department of Defense personnel took part in several test groups projects conducted at Shot MORGAN. Table 9-1, on the following page, identifies these projects. In addition to the projects, AFSWC and other support activities accounted for a number of DOD participants. AFSWC personnel supported one test group project and flew routine air missions for the Test Manager. Exercise Desert Rock activities were not conducted at Shot MORGAN.

9.1.1 AFSWP FIELD COMMAND WEAPONS EFFECTS TEST GROUP PROJECTS

The Weapons Effects Test Group conducted three projects during Shot MORGAN, as indicated in table 9-1.

Project 1.1, Basic **Airblast** Phenomena, was conducted by the Ballistic Research Laboratories to obtain data on overpressure and dynamic pressure values as a function of time and distance from ground zero. The performance of various pressure gauges,

measurement devices, and measurement techniques was also evaluated. To obtain data, personnel placed self-recording pressure-time gauges at 13 stations along a blast line between 90 and 10,660 meters southeast of ground zero. Personnel reentered the area after the shot to recover the gauges (7; 20).

Table 9-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT MORGAN

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
1 1	Basic Airblast Phenomena	Ballistic Research Laboratories	*
6 5	Effects of Nuclear Detonations on Nike Hercules	White Sands Missile Range, Bell Telephone Laboratories	18
91	Support Photography	AFSWP, Military Air Transport Service, EG and G	15
University of California Radiation Laboratory Test Group			
21 2	Radiochemistry Sampling	University of California Radiation Laboratory, 4926th Test Squadron (Sampling), Air Force Special Weapons Center	8
Civil Effects Test Group			
398	Depth Dose Studies in Phantoms with Initial Bomb Gamma and Neutron Radiation	U S Naval Medical Research Institute	*

* Unknown

Project 6.5, Effects of Nuclear Detonations on Nike Hercules, was fielded by personnel from White Sands Missile Range, New Mexico, with assistance from Bell Telephone Laboratories personnel. The principal objective was to investigate the effects of radiation produced by a nuclear detonation on the operational and structural characteristics of components, materials, and systems of the Nike Hercules guided-missile system. To obtain data, personnel installed standard vacuum-tube and experimental transistorized versions of the guidance system at sites 180, 410, and 670 meters from ground

zero. From 2000 to 2330 hours on the day before the detonation, five participants checked equipment at the three sites. From 2330 hours on the day before the shot to two hours after the detonation, 18 personnel manned a radar station ten kilometers from ground zero, at UTM coordinates 765031 (17; 25).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Nine personnel established and then manned a photography station at UTM coordinates 843050 from 0001 on shot-day to 0530 (17). Two or three men also took pictures in an L-20 aircraft operated by at least three members of the Military Air Transport Service. The L-20 flew a right-hand holding pattern heading east toward ground zero at 8,500 feet at the time of detonation. In addition, EG and G personnel provided technical photography support to AFSWP and the AEC, operating camera stations to record fireball and cloud growth (9; 17; 24).

9.1.2 Department of Defense Participation in University of California Radiation Laboratory Test Group Projects

Of the three projects conducted by the LASL Test Group and the ten projects conducted by the UCRL Test Group, only UCRL Project 21.2, Radiochemistry Sampling, involved DOD personnel participation. AFSWC 4926th Test Squadron (Sampling) performed the cloud-sampling missions required by this project, as discussed in section 9.1.4.

9.1.3 Department of Defense Participation in Civil Effects Test Group Projects

Of the three CETG projects conducted at Shot MORGAN, one involved DOD personnel, as shown in table 9-1.

Project 39.8, Depth Dose Studies in Phantoms with Initial Bomb Gamma and Neutron Radiation, was fielded by the Naval Medical Research Institute. The objectives of the project were to determine the relation of the air exposure or incident dose to absorbed dose, and to determine the distribution of absorbed dose through tissue material equivalent to human tissue (36). Personnel installed dosimeters in a masonite phantom, which was then placed in the shot area. After the detonation, participants retrieved the phantom and analyzed the radiation exposure obtained (17; 36; 51).

9.1.4 Air Force Special Weapons Center Activities

AFSWC support consisted of cloud-sampling and sample courier missions in support of the UCRL test group project, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Six F-84 aircraft, with one pilot each, collected samples of the cloud for UCRL Project 21.2, Radio-chemistry Sampling. A B-57 sampler control aircraft, with one pilot and a scientific advisor from UCRL, also participated. Pilots of the 4926th Test Squadron (Sampling) flew the seven aircraft (1; 9; 61).

Upon landing, each sampler aircraft taxied to the strip farthest from base operations where ground personnel used long-handled poles to remove the samples and place them in metal containers, which were sent by courier to UCRL. With the mission complete, the aircraft and pilots were decontaminated as described the Operation PLUMBBOB volume (1; 9; 61).

Courier Missions

The 4900th Air Base Group from Kirtland Air Force Base conducted the courier sample returns. Three C-47 aircraft flew samples out of Indian Springs AFB to UCRL for analysis (1; 9; 61).

Cloud Tracking

One B-25 low-altitude cloud tracker aborted its mission after the shot because of communications difficulties (1; 9; 61).

Helicopter Surveys

One hour after the detonation, an H-21 helicopter, with an AFSWC crew of two and at least two REECo radiological safety monitors, conducted an initial radiological survey of Area 9 and other locations. A second H-21 helicopter, with an AFSWC crew of two, a REECo radiological monitor, and UCRL project participants, left the Control Point an hour after the detonation to recover project equipment east of Area 9. About two hours after the shot, an H-21 helicopter, with an AFSWC crew of two and REECo radiological safety monitors, conducted a bomb damage survey mission of Area 9. Following the mission, the helicopters returned to the helicopter area. Aircraft and crew were monitored and decontaminated as required (9; 51).

9.2 RADIATION PROTECTION AT SHOT MORGAN

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of its radiation protection programs. The available information includes NTO isointensity contour maps, monitoring data, and some NTO personnel dosimetry data. Radiological safety procedures and

dosimetry information for AFSWC personnel are described in the Operation PLUMBBOB volume.

Dosimetry Records

From 6 to 12 October 1957, including the 7 October detonation of MORGAN, the Personnel Dosimetry Branch issued 286 film badges and 147 pocket dosimeters (60). The REECo Onsite Support Report indicates that ten NTO/DOD personnel received cumulative gamma exposures greater than two roentgens, ranging from 2.03 to 3.59 roentgens. Among the ten personnel, one was from AFSWP, two were cloud samplers, and seven were other AFSWC personnel. Three of the latter group had cumulative exposures over three roentgens (54; 60).

Logistics

The Logistics Branch issued protective clothing and supplies to 249 personnel. These supplies included coveralls, shoe covers, respirators, and other items (60).

Monitoring Procedures and Support

Five minutes after the detonation, seven monitors traveling by vehicle performed the initial ground survey of the shot area. The survey took about one hour to complete. Resurveys were made six hours after the detonation and again on 8, 9, and 10 October (60).

The initial helicopter survey team, with an AFSWC crew of two and at least two REECo monitors, departed from the Control Point helicopter pad at 0630 hours, 90 minutes after the detonation. Aerial resurveys were not made for Shot MORGAN because the Test Director's radiological safety adviser determined that the necessary measurements could be obtained from ground resurveys (51; 60). The highest radiation intensity was 75 R/h, encountered 500 feet above ground zero 100 minutes after the detonation.

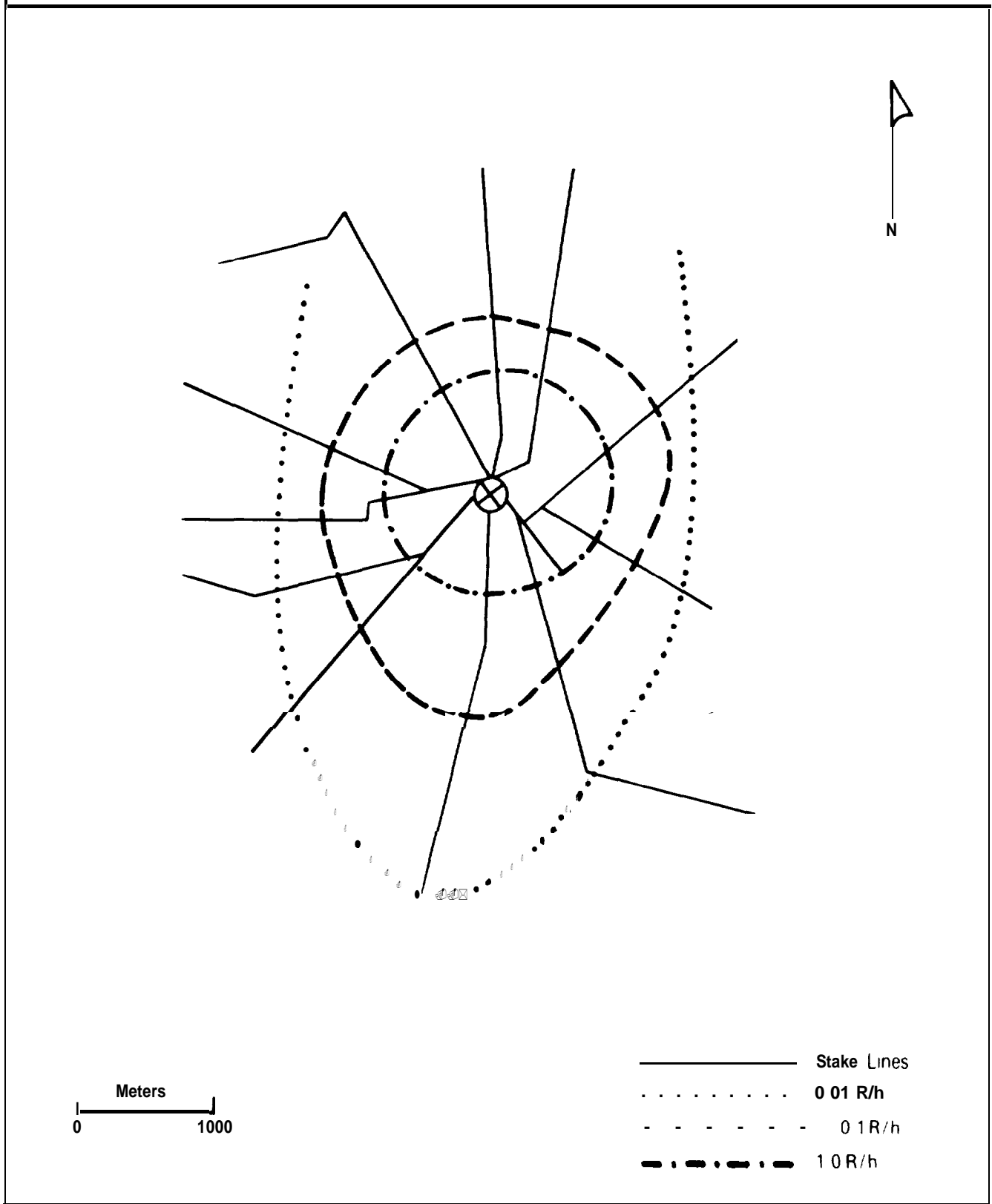
Plotting and Briefing

Using information from the initial surveys, the Plotting and Briefing Branch developed isointensity contour maps. Figure 9-1 shows a copy of the initial contour map, with a mid-time of 0545 hours. Figure 9-2 presents copies of the isointensity maps resulting from resurveys on 7 to 10 October (60).

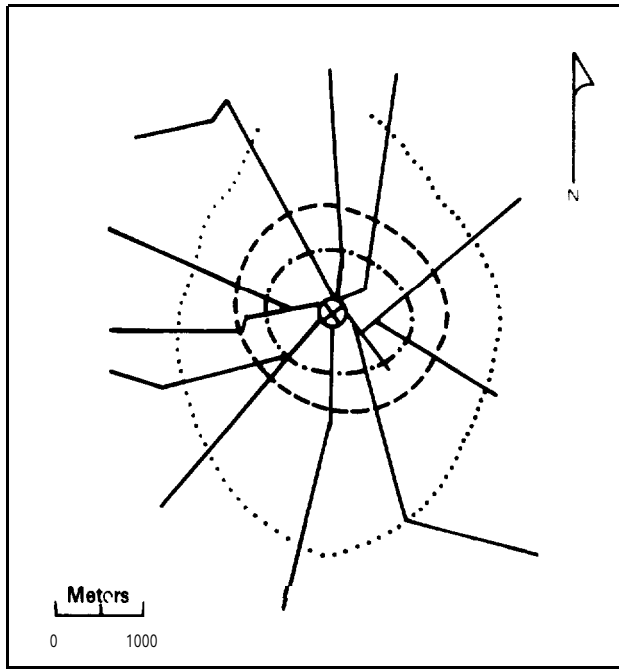
Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, defined in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas. From 7 through 9 October, access permits were issued to a total of 93 individuals involved in a total of 15 projects (60).

Decontamination Activities

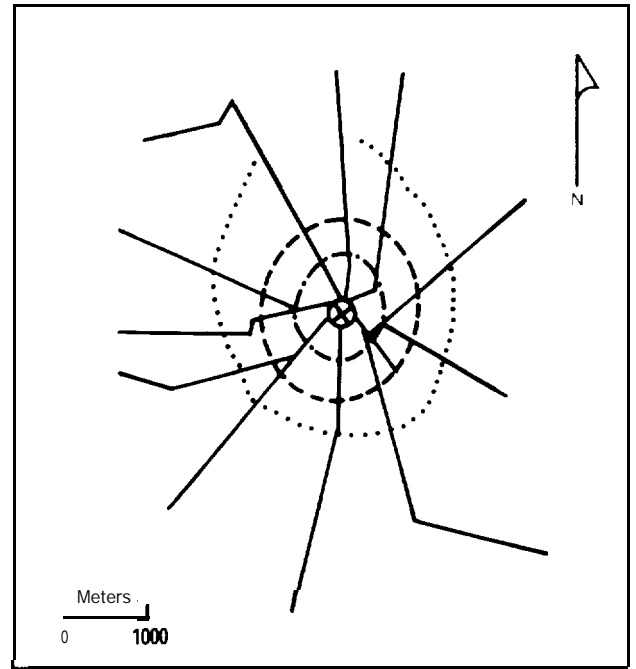
During the period covering Shot MORGAN, personnel of the Decontamination Branch decontaminated 93 vehicles (60).



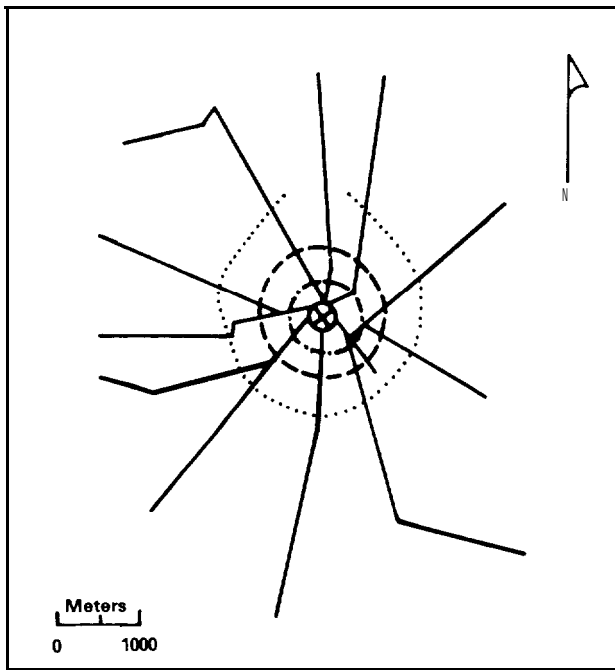
**Figure 9-1: INITIAL SURVEY FOR SHOT MORGAN,
7 OCTOBER 1957, MID-TIME 0545**



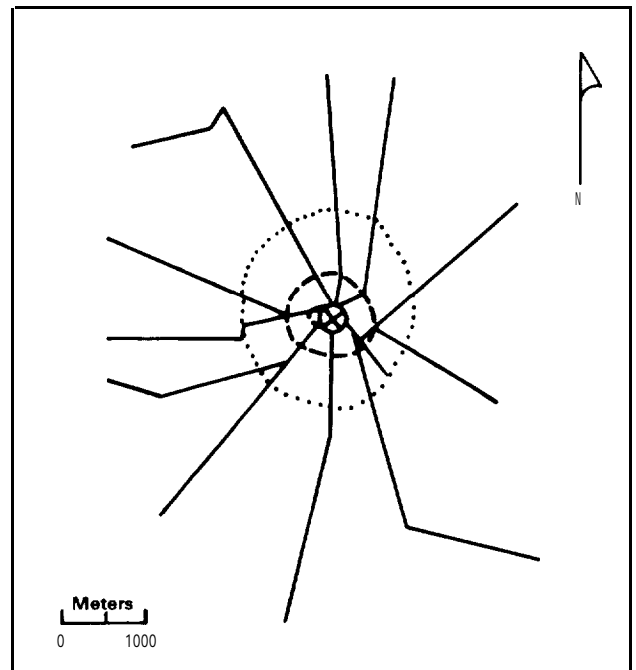
7 October 1957, Mid-Time 1112



8 October 1957, Mid-Time 0648



9 October 1957, Mid-Time 0700



10 October 1957, Mid-Time 0928

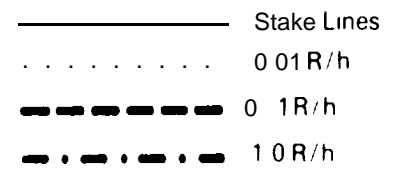


Figure 9-2: SUBSEQUENT SURVEYS FOR SHOT MORGAN

REFERENCE LIST

The following list of references represents only those documents cited in the WHEELER through MORGAN volume. When a DASA-WT or DNA-WT document is followed by an EX, the latest version has been cited. The bibliography of documents consulted during the preparation of the PLUMBBOB Series volumes is contained in the Operation PLUMBBOB volume.

The WHEELER through MORGAN volume was completed after the publication of the series volume. References 11-17, 24, 39, 44-50, and 59 do not appear in the PLUMBBOB Series bibliography.

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California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Librn

California State University at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Librn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Librn

California University Library
ATTN: Gov Docs Dept

California University Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN: Librn

Kearney State College
ATTN: Gov Docs Dept

Cambridge County Library Sys
ATTN: Librn

Carleton College Library
ATTN: Librn

OTHER (Continued)

Carnegie Library of Pittsburgh
ATTN: Librn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Librn

Casper College
ATTN: Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Missouri State Univ
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN: Librn

Charleston County Library
ATTN: Librn

Charlotte & flechlenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Librn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

Chicago University Library
ATTN: Dir of Libraries
ATTN: Docs Processing

Cincinnati University Library
ATTN: Librn

Claremont Colleges Libraries
ATTN: Doc Collection

Clemson University
ATTN: Dir of Libraries

OTHER (Continued)

Cleveland Public Library
ATTN: DOCS Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: DOCS Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: DOCS Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

University of North Carolina at Asheville
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

OTHER (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College So Cpus
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: DOCS Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN: Librn

Burlington Library
ATTN: Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: DOCS Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN: Librn

East Islip Public Library
ATTN: Librn

OTHER (Continued)

East Orange Public Library
ATTN: U. S. Gov't Depository

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN: Librn

Eastern Kentucky University
ATTN: Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Dir of Library (Reg)
ATTN: Docs Dept

Fond Du Lac Public Library
ATTN: Librn

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

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Geauga Cty Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Grinnell College Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

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

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

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

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

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

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

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

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

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

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

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

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Lewis University Library
ATTN: Librn

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

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

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

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

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Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Mauı Public Library
Kahuluı Branch
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McNeese State University
ATTN: Librn

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

Mercer University
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Mesa County Public Library
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Miami Public Library
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University of Santa Clara
ATTN: Docs Div

Michigan State Library
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Michigan State University Library
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Murray State University Library
ATTN: Lib

OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
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Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
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Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Missot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN. Librn

University of Nebraska
ATTN Dir of Libraries (Reg)

University of Nebraska Library
ATTN Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN Librn

New Hanover County Public Library
ATTN. Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

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

University of New Orleans Library
ATTN Gov Docs Div

New Orleans Public Library
ATTN Librn

New York Public Library
ATTN Librn

New York State Library
ATTN DOCS Control Cultural Ed Ctr

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

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

State University of New York
ATTN Lib Docs Sec

North Texas State University Library
ATTN Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN: DOCS Ctr

State University of New York
ATTN. Docs Dept

New York University Library
ATTN DOCS Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN. DOCS Div

Nieves M Flores Memorial Library
ATTN Librn

Norfolk Public Library
ATTN. R. Parker

North Carolina Agricultural & Tech State
University
ATTN. Librn

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

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN Librn

North Carolina Central University
ATTN. Librn

North Carolina State University
ATTN Librn

University of North Carolina
ATTN BA SS Div Docs

North Dakota State University Library
ATTN: DOCS Librn

University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

OTHER (Continued)

Northeast Missouri State University
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
ATTN: Librn

Northwestern Michigan College
ATTN: Librn

Northwestern State University
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Northwestern State University Library
ATTN: Librn

Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN: Librn

Oakland Public Library
ATTN: Librn

Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN: Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librn

Oklahoma City University Library
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OTHER (Continued)

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

University of Oklahoma
ATTN: Docs Div

Old Dominion University
ATTN: Doc Dept Univ Lib

Olivet College Library
ATTN: Librn

Omaha Public Library Clark Branch
ATTN: Librn

Onondaga County Public Library
ATTN: Gov Docs Sec

Oregon State Library
ATTN: Librn

University of Oregon
ATTN: Docs Sec

Ouachita Baptist University
ATTN: Librn

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Phillipsburg Free Public Library
ATTN: Librn

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN: Librn

Portland Public Library
ATTN: Librn

Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN: Librn

Princeton University Library
ATTN: Oocs Oiv

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN: Librn

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College Library
ATTN: Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
ATTN: Gov Pubs Ofc

University of Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
ATTN: Librn

OTHER (Continued)

Richland County Public Library
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Riverside Public Library
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University of Rochester Library
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University of Rutgers Camden Library
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State University of Rutgers
ATTN: Librn

Rutgers University
ATTN: Dir of Libraries (Reg)

Rutgers University Law Library
ATTN: Fed Docs Dept

Salem College Library
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Samford University
ATTN: Librn

San Antonio Public Library
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San Diego County Library
ATTN: C. Jones, Acquisitions

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

San Francisco State College
ATTN: Gov Pubs Coll

San Jose State College Library
ATTN: Docs Dept

San Luis Obispo City-County Library
ATTN: Librn

Savannah Public & Effingham Liberty Regional
Library
ATTN: Librn

Scottsbluff Public Library
ATTN: Librn

Scranton Public Library
ATTN: Librn

Seattle Public Library
ATTN: Ref Docs Asst

OTHER (Continued)

Selby Public Library
ATTN: Librn

Shawnee Library System
ATTN: Librn

Shreve Memorial Library
ATTN: Librn

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

University of South Carolina
ATTN: Librn

University of South Carolina
ATTN: Gov Docs

South Dakota School of Mines & Technical Library
ATTN: Librn

South Dakota State Library
ATTN: Fed Docs Dept

University of South Dakota
ATTN: Docs Librn

South Florida University Library
ATTN: Librn

Southeast Missouri State University
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Southeastern Massachusetts University Library
ATTN: Docs Sec

University of Southern Alabama
ATTN: Librn

Southern California University Library
ATTN: Docs Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librn

Southern Illinois University
ATTN: Oocs Ctr

Southern Methodist University
ATTN: Librn

University of Southern Mississippi
ATTN: Library

OTHER (Continued)

Southern Oregon College
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Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN: Librn

St Louis Public Library
ATTN: Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN: Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
ATTN: Librn

State University of New York
ATTN: Librn

Stetson University
ATTN: Librn

University of Steubenville
ATTN: Librn

Stockton & San Joaquin Public Library
ATTN: Librn

Stockton State College Library
ATTN: Librn

Albion College
ATTN: Gov Docs Librn

OTHER (Continued)

Superior Public Library
ATTN: Librn

Swarthmore College Library
ATTN. Ref Dept

Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
ATTN: Librn

Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN- Librn

Tennessee Technological University
ATTN. Librn

University of Tennessee
ATTN. Dir of Libraries

College of Idaho
ATTN: Librn

Texas A & M University Library
ATTN: Librn

University of Texas at Arlington
ATTN: Library Docs

University of Texas at San Antonio
ATTN Library

Texas Christian University
ATTN: Librn

Texas State Library
ATTN: U S. Docs Sec

Texas Tech University Library
ATTN Gov Docs Dept

Texas University at Austin
ATTN. Docs Coll

University of Toledo Library
ATTN: Librn

Toledo Public Library
ATTN. Social Science Dept

Torrance Civic Center Library
ATTN. Librn

Traverse City Public Library
ATTN. Librn

Trenton Free Public Library
ATTN Librn

Trinity College Library
ATTN Librn

Trinity University Library
ATTN. Docs Coll

OTHER (Continued)

Tufts University Library
ATTN. Docs Dept

University of Tulsa
ATTN. Librn

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

Uniformed Services University of the Health Sciences
ATTN: LRC Library

University Libraries
ATTN. Dir of Lib

University of Maine at Orono
ATTN: Librn

University of Northern Iowa
ATTN. Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN: Librn

University of Utah
ATTN: Special Collections

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

Utica Public Library
ATTN Librn

Valencia Library
ATTN. Librn

Valparaiso University
ATTN Librn

Vanderbilt University Library
ATTN: Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Librn

Virginia Military Institute
ATTN: Librn

Virginia Polytechnic Institute Library
ATTN. Docs Dept

Virginia State Library
ATTN. Serials Sec

University of Virginia
ATTN Pub Docs

Volusia County Public Library
ATTN. Librn

OTHER (Continued)

Washington State Library
ATTN: Docs Sec

Washington State University
ATTN: Lib Docs Sec

Washington University Libraries
ATTN: Dir of Lib

University of Washington
ATTN: Docs Div

Wayne State University Library
ATTN: Librn

Wayne State University Law Library
ATTN: Docs Dept

Weber State College Library
ATTN: Librn

Wesleyan University
ATTN: Docs Librn

West Chester State College
ATTN: Docs Dept

West Covina Library
ATTN: Librn

University of West Florida
ATTN: Librn

West Georgia College
ATTN: Librn

West Hills Community College
ATTN: Library

West Texas State University
ATTN: Library

West Virginia College of Grad Studies Library
ATTN: Librn

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

Westerly Public Library
ATTN: Librn

Western Carolina University
ATTN: Librn

Western Illinois University Library
ATTN: Librn

Western Washington University
ATTN: Librn

Western Wyoming Community College Library
ATTN: Librn

Westmoreland City Community College
ATTN: Learning Resource Ctr

OTHER (Continued)

Whitman College
ATTN: Librn

Wichita State University Library
ATTN: Librn

Williams & Mary College
ATTN: Docs Dept

Emporia Kansas State College
ATTN: Gov Docs Div

William College Library
ATTN: Librn

Willimantic Public Library
ATTN: Librn

Winthrop College
ATTN: Docs Dept

University of Wisconsin at Whitewater
ATTN: Gov Docs Lib

University of Wisconsin at Milwaukee
ATTN: Lib Docs

University of Wisconsin at Oshkosh
ATTN: Librn

University of Wisconsin at Platteville
ATTN: Doc Unit Lib

University of Wisconsin at Stevens Point
ATTN: Docs Sec

University of Wisconsin
ATTN: Gov Pubs Dept

University of Wisconsin
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Worcester Public Library
ATTN: Librn

Wright State University Library
ATTN: Gov Docs Librn

Wyoming State Library
ATTN: Librn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Librn

Yuma City County Library
ATTN: Librn

Simon Schwob Mem Lib, Columbus Col
ATTN: Librn

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DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

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National Academy of Sciences
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Pacific-Sierra Research Corp
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