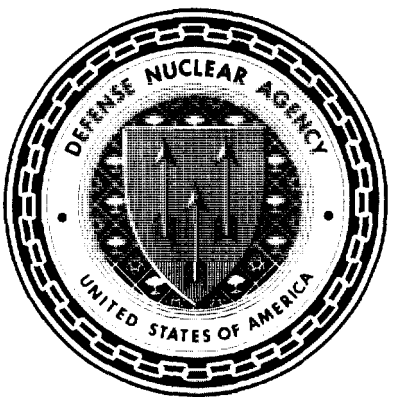
DNA 6006F

SHOTS DIABLO TO FRANKLIN PRIME

The Mid-Series Tests of the PLUMBBOB Series

15 JULY - 30 AUGUST 1957



United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

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

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JOHN	DOPPLER	Nevada Test Organization
KEPLER	FRANKLIN PRIME	Nevada Test Site
OWENS	PLUMBBOB	AFSWP
STOKES	Ionizing Radiation	AFSWC

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 the eight mid-series shots of Operation PLUMBBOB, an atmospheric weapons testing series. The tests were conducted from 15 July 1957 through 30 August 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 the mid-series PLUMBBOB shots.

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 Engineeer 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 eight mid-series PLUMBBOB shots, DIABLO through FRANKLIN PRIME, 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 at Shots DIABLO through FRANKLIN PRIME were found at the Defense Nuclear Agency Technical Library, the National Federal Archives Record Center, and the U.S. Air Force Weapons Laboratory Technical Library. 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. This report discusses only those projects verified by documentation as having been conducted.

For several of the Exercise Desert Flock and test organization projects discussed in this volume, the only documents available are the Sixth Armv 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 PLIJMBBOB 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 PLUMBBOR REPORTS

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

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

- Multi-shot volume: Shots WHEELER to MORGAN, the Final PLUMBBOB Tests.

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, the 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 Operation PLUMBBOB 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, Incorporated
FCDA	Federal Civil Defense Administration
HumRRO	Human Resources Research Office
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 DIABLO, JOHN, KEPLER, OWENS, STOKES, SHASTA, DOPPLER, and FRANKLIN PRIME were tests of nuclear devices conducted between 15 July and 30 August 1957 at the Nevada Test Site, the AEC continental nuclear test site northwest of Las Vegas. These shots were the eight mid-series test events of Operation PLUMBBOB, a series of 24 nuclear weapons tests and six safety experiments performed between 24 April and 7 October 1957.

The nuclear devices for seven of the eight shots were sponsored, designed, and built by AEC laboratories. The Los Alamos Scientific Laboratory (LASL) was responsible for the KEPLER, STOKES, DOPPLER, and FRANKLIN PRIME devices, while the University of California Radiation Laboratory (UCRL) was responsible for the DIABLO, OWENS, and SHASTA devices. The Department of Defense sponsored only Shot JOHN. 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, the 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. 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.

A number of other activities related to the conditions and phenomena produced bv a nuclear detonation were also conducted at these eight events. The DOD 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 l-l presents a summary of the eight mid-series PLUMBBOB tests (31).* The table provides such information as the dates of shots, the UTM coordinates+ of the points of detonation, the heights of burst, ** and explosive yields. Figure l-l displays a map of the Nevada Test Site in 1957, indicating the location of each PLUMBBOB test and highlighting the shots discussed in this volume (58).

1.1 DEPARTMENT OF DEFENSE PARTICIPATION IN NEVADA TEST ORGANIZATION ACTIVITIES AT THE EIGHT MID-SEHIES PLUMBBOB EVENTS

The Nevada Test Organization (NTO) was established to plan, coordinate, and conduct atmospheric nuclear weapons tests during

*All sources cited in the test 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.

+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 the mid-series PLUMBBOB shots were tested, is about 4,000 feet above mean sea level.

Table I-I: SUMMARY OF THE PLUMBBOB MID-SERIES SHOTS

Shot	DIABLO	JOHN	KEPLER	OWENS	STOKES	SHASTA	DOPPLER	FRANKLIN PRIME
Sponsor	UCAL	DOD	LASL	UCRL	LASL	UCRL	LASL	LASL
Planned Date	06/25/57	07/19/57	07/15/57	07/05/57	08/17/57	07/09/57	08/15/57	08/16/57
Actual Date	07/15/57	07/19/57	07/24/57	07/25/57	08/07/57	08/18/57	08/23/57	08/30/57
Local Time	0430	0700	0450	0630	0525	0500	0530	0540
NTS Location	Area 2	Area 10	Area 4	Area 9	Area 7	Area 2	Area 7	Area 7
UTM Coordinates	792118	841128	797057	852100	867047	794093	867047	867047
Type	Tower	Missile	Tower	Balloon	Balloon	Tower	Balloon	Balloon
Height of Burst (Feet)	500	20,000 *	500	500	1,500	500	1,500	750
Actual Yield (Kilotons)	17	2	10	9.7	19	17	11	4.7

*Mean Sea Level; all other heights of burst in this table indicate distance above the ground

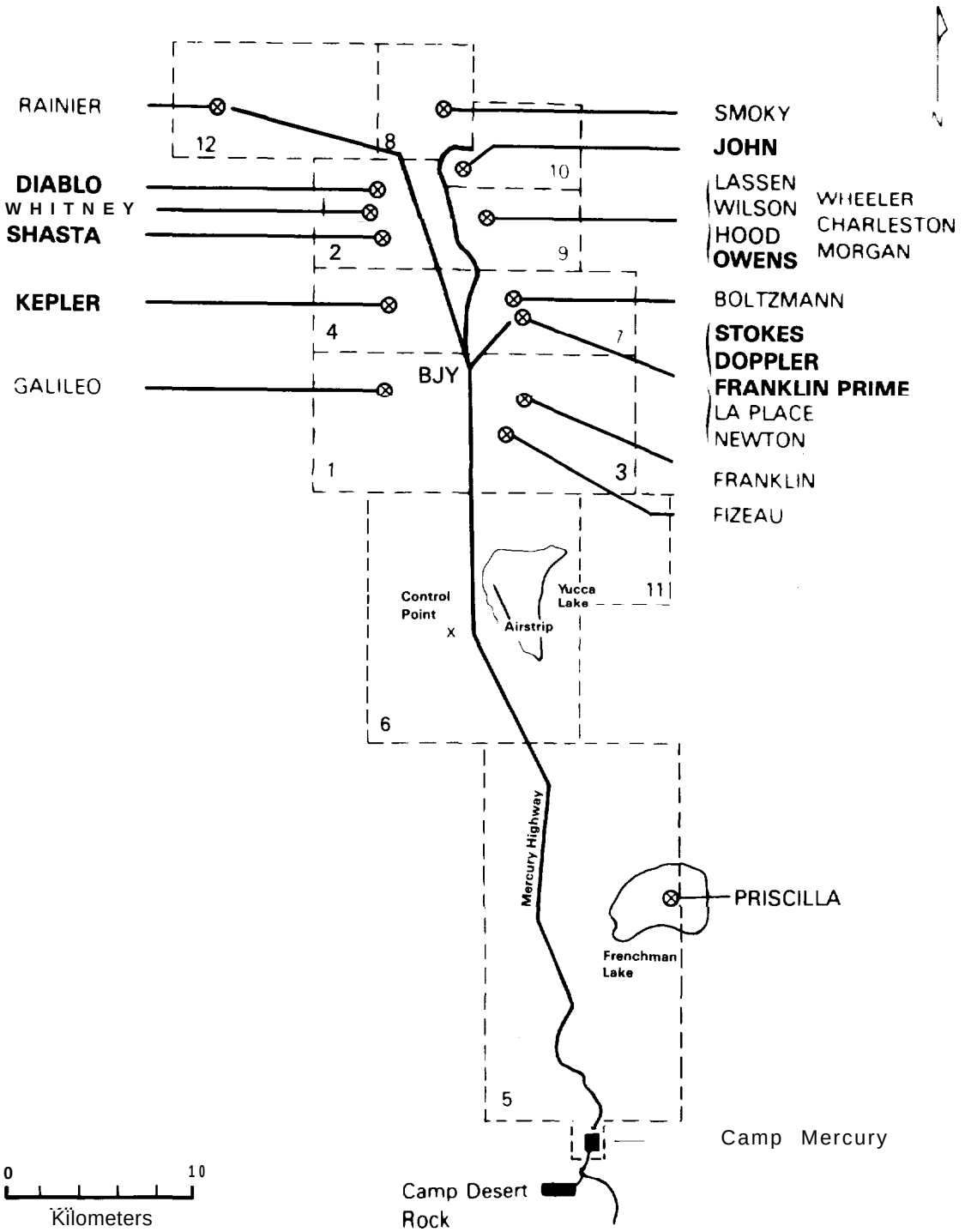


Figure I-I: LOCATION OF THE MID-SERIES PLUMBBOB SHOTS AT THE NEVADA TEST SITE IN RELATION TO OTHER SHOTS IN THE PLUMBBOB SERIES

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, who were assigned to four NTO 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 test group projects, the DOD conducted operational training projects and support activities. A major area of support activity for DOD personnel was the air operational control and air support provided by AFSWC air and ground personnel (29-31).

Overall, the largest area of DOD participation in NTO activities was in the Weapons Effects Test Group projects, designed to study yield and weapons effects characteristics in order to identify the militarily useful effects of nuclear weapons for offensive and defensive deployment (19). Personnel from DOD agencies and the four armed services participated in the experiments conducted by LASL, UCHL, and CETG, but participation was limited. Most DOD participation in these experiments was performed by the Air Force Special Weapons Center (AFSWC) 4926th Test Squadron (Sampling) in LASL and UCRL radiochemistery cloud-sampling projects (29).

The DOD operational training projects, designed to test service tactics and equipment and to train military personnel in nuclear detonation effects, were conducted at each of the eight shots. Most of the projects were conducted in aircraft and primarily involved the aircraft pilots (29).

The Air Force Special Weapons Center at Kirtland Air Force Base, New Mexico, exercised operational control over all military aircraft flying in the area of the NTS during Operation PLUMBBOB. AFSWC also provided air support to the Test Manager and to test group 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 staged from 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, courier flights, aerial surveys, and transportation services (29; 32; 76).

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 (83). 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 3 roentgens of whole-body gamma radiation for any 13-week period and 5 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 10 roentgens per hour (R/h) or greater unless they had received special permission from the Test Director (61). 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 as to the radiological situation. 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

*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.

forward area. Personnel decontamination procedures were implemented, and emergency evaucation plans were prepared for the test events (83).

The radiation protection procedures for AFSWC included the same exposure limits for aircrews and ground-crew personnel as those established for NTO personnel, with the exception of cloud sampler pilots. The Test Manager authorized these AFSWC personnel to receive a total of 7.5 roentgens of gamma radiation annually. Decontamination, including removal of anticontamination clothing and showers, was required of aircrew members after each project mission, regardless of the exposure received on the flight. Aircraft were washed or isolated until radiation intensities had decayed to acceptable levels (2; 29; 83).

1.2 EXERCISE DESERT ROCK ACTIVITIES AT THE EIGHT MID-SERIES PLUMBBOB EVENTS

Most of the DOD personnel involved in Shots DIABLO through FRANKJLIN PRIME took part in observer projects, troop tests, radiological training, and technical service experiments fielded by Exercise Desert Rock, the Army testing and training program conducted during Operation PLUMBBOB. In addition to the Desert Rock exercise troops, Camp Desert Rock support troops provided communication, transportation, traffic control, and radiological safety monitoring for Desert Rock projects at the eight shots (25; 40–48; 71). Radiological safety monitoring, for example, was conducted by soldiers from the 50th Chemical Service Platoon for Desert Rock personnel in the test area after each detonation (49).

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

project objectives. Desert Rock personnel were limited to no more than 5 roentgens of whole-body gamma radiation during any six-month period. The radiation protection procedures of Exercise Desert Rock included provisions for (40-48; 71):

- 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 equipment and personnel leaving the shot area after each detonation
- Preparing emergency evacuation plans for personnel in the forward area.

1.3 DOSIMETRY FOH 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 specific shot period, exceeded a cumulative dose of 2 roentgens. A few surviving disposition forms, specifying personnel exposures exceeding 3 roentgens, indicate that Exercise Desert Rock similarly monitored cumulative exposures. Personnel whose exposures reached 5 roentgens were prohibited from further entry into the shot area. The Operation PLUMBBOB volume summarizes dosimetry totals and overexposure information for PLUMBBOB participants (57; 63-69).

SHOT DIABLO SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	15 July 1957, 0430 hours
YIELD:	17 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 military equipment and to indoctrinate personnel in the effects of nuclear detonations
(4) To assess the effects of the nuclear detonation on civilian structures, products, and food supplies and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 23°C, and the surface wind was calm. Winds were six kpots from the south-southwest at 10,000 feet, eight knots from the west-southwest at 20,000 feet, and nine knots from the west at 30,000 feet.

Radiation Data: About an hour after the detonation, radiation intensities of 1.0 R/h or more were confined to within 750 meters of ground zero to the south and west.

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

CHAPTER 2

SHOT DIABLO

Shot DIABLO was detonated at 0430 hours Pacific Daylight Time on 15 July 1957. Fired from a cab on top of a 500-foot tower in Area 2 of the Nevada Test Site, DIABLO had a yield of 17 kilotons. After the detonation, the cloud top rose to 31,500 feet. Most of the upper portion of the cloud drifted to the northeast, although part of the upper portion followed a southeasterly course. The lower portion of the cloud and stem moved toward the north. The cloud dispersion and movement created a widespread pattern of fallout across the northeastern quadrant of Yucca Flat (31; 83).

2.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT DIABLO

Approximately 1,350 Desert Rock troops took part in projects associated with the DIABLO event: three troop observer indoctrination projects, two radiological training projects, and two technical service projects (59). Table 2-1, on the next page, identifies the Desert Rock program types, their subordinate projects, the participating units, and the estimated number of DOD participants. The table also lists 81 Camp Desert Rock support personnel who observed the detonation.

2.1.1 Troop Observer Indoctrination Projects

About 695 DOD personnel, including the 81 Camp Desert Rock support troops, participated in the troop observer indoctrination activities listed in table 2-1. They viewed Shot DIABLO from trenches 3,810 meters southeast of the shot tower at UTM coordinates 805081. Trenches were about five feet deep,

affording a minimum of two feet of overhead protection for a crouching person. Observers toured the display area that had been used for Shot HOOD on 5 July 1957 as soon as radiological safety monitors ascertained that residual radiation levels were safe (40; 42).

Table 2-1: EXERCISE DESERT ROCK PROJECTS, SHOT DIABLO

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50.2	Troop Observers	Army	588
			Navy	3
			Civilian	8
	52.2	Marine Corps Observers	Marine Corps	28
	53.3	Air Crew Observers	Air Force	9
	-		Camp Desert Rock Support Troops	81
Radiological Training	53.4	Radiological Defense Training	Radiological Defense School, Lowry AFB	46
	-	Sixth Army Chemical, Biological, and Radiological Team Training	Fort Huachuca, Arizona; Sharpe General Depot, California	14
Technical Service	50.3	Evaluation of Medium Range Detonation-detection and Cloud	Army Signal Research and Development Laboratories; Fort Huachuca, Arizona; Fort Meade, Maryland	32
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board; Army Artillery Board; Army Chemical Corps; Army Artillery and Guided Missile School; Air Weather Service	557

2.1.2 Radiological Training Projects

The two radiological training projects conducted at Shot DIABLO were Air Force Project 53.4, Radiological Defense Training, and the Sixth Army Chemical, Biological, and Radiological Team Training.

Project 53.4, Radiological Defense Training, was performed by 46 members of the Radiological Defense School of Lowry AFH,

Denver, Colorado. After the detonation, project participants proceeded along an assigned route from the observation area to their vehicles, which they had left at the Desert Rock decontamination station. Accompanied by a radiological safety monitor, the participants monitored radiation intensities at various distances from ground zero. These readings were relayed by radio to the control stations and were then plotted on a map (40; 49).

The Sixth Army Chemical, Biological, and Radiological Team Training project involved one survey team from Fort Huachuca, Arizona, and two civilians from Sharpe General Depot, California. Film badge dates for the Fort Huachuca team (CBR Team #3) extended from 11 to 18 July, while those of the two civilians were from 7 to 18 July. The purpose of the project was to train personnel from Sixth Army installations in radiological defense techniques. General procedures called for the teams to take part in the usual observer activities and then proceed into the field to conduct radiological surveys (40; 49).

2.1.3 Technical Service Projects

As indicated in table 2-1, two technical service projects were conducted at Shot DIABLO to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories; seven participants from Fort Huachuca, Arizona; and seven personnel from Fort Meade, Maryland. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and in tracking radioactive clouds, and to examine Army fallout prediction methods. Three remote radar sets were located southeast of Yucca Lake at UTM coordinates 893872, 27

kilometers from ground zero. The fallout prediction unit for this project operated from a van located next to the weather station at Camp Mercury (20; 49).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Air Defense Board, Army Artillery Board, Army Chemical Corps, Army Artillery and Guided Missile School, and Air Weather Service. The objectives were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation
- Track targets and guided missiles through the fireball or cloud resulting from a detonation
- Predict and monitor radioactive fallout.

An estimated 557 DOD personnel took part in this project. To determine the location, height of burst, and yield of the detonation, participants operated 23 onsite and offsite radar, camera, and other instrument stations located 27 to 56 kilometers from ground zero. Figure 2-l shows personnel at one of the radar locations. To determine the attenuation of the Nike Hercules missile control signals at the time of detonation, a B-26 aircraft, with a crew of at least three, positioned itself so that the cloud was between the aircraft and a Nike Hercules ground site. The aircraft was 15 miles from the shot-tower at the time of detonation and spent about 30 minutes in the area (3; 77; 79; 80). To determine the fallout pattern, three helicopters--two H-34s and one H-13--conducted aerial radiological surveys following the detonation. The helicopters, each with a crew of three, took readings up to 100 R/h at about 200 feet above the ground. Simultaneously, three ground survey teams monitored the area around ground zero up to the 5.0 R/h line (3; 49; 77; 79; 80).

Figure 2-1: PROJECT 50.8 PERSONNEL LAUNCH A WEATHER BALLOON NEAR ONE OF THE RADAR LOCATIONS

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

In addition to the Exercise Desert Rock personnel, other DOD personnel took part in test activities during Shot DIABLO that required them to enter the forward area. Table 2-2 identifies the test group projects involving DOD participants. The Air Force sponsored one operational training project during the shot. Besides the test group and the operational training projects, AFSWC and other support activities accounted for a number of other DOD participants. The Air Force Special Weapons Center supported test group projects and flew routine missions for the Test Manager (24; 29; 49; 52).

2.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted 12 projects at Shot DIABLO, as indicated in table 2-2. The personnel estimates given in this table, and 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 2.7, Radio-wave Attenuation Studies, was conducted by the Naval Research Laboratory to study the interference effects of high levels of radiation on radio transmissions and radar operations. Participants installed receivers in Building 400, located 24 kilometers from ground zero. An estimated three personnel placed scintillation detectors, as well as instruments to monitor the effects on transmitters of the electromagnetic signal generated by the detonation, at stations 830 to 1,540 meters from ground zero. After the detonation and as radiation intensities permitted, project personnel recovered the equipment (38).

Project 2.8, Evaluation of Military Radiac, was conducted by the Naval Material Laboratory to check the accuracy of several

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

Project	Title	Participants	Estimated DOD Personnel
	Weapons Effects Test Group		
2.7	Radio-wave Attenuation Studies	Naval Research Laboratory	3
2.8	Evaluation of Military Radiac	Naval Material Laboratory	5
2.10	Initial Neutron and Gamma Air-earth Interface Measurements	Air Force Special Weapons Center	5
4.2	Evaluation of Eye Protection Afforded by an Electromechanical Shutter	Tactical Air Command; Air Force School of Aviation Medicine; Navy Radiological Defense Laboratory; Wright Patterson Aero Medical Laboratory; Nellis AFB Hospital	8
5.1	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation	Navy Bureau of Aeronautics	2
5.3	In-flight Structural Response of an FJ-4 Aircraft to a Nuclear Detonation	Naval Air Special Weapons Facility	*
5.4	In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation	Navy Bureau of Aeronautics; Naval Air Special Weapons Facility: North American Aviation	*
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
6.2	Measurement of the Magnetic Component of the Electromagnetic Field near a Nuclear Detonation	Diamond Ordnance Fuze Laboratory	3
6.4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
8.3a	Performance of a High-speed Spectrographic System	Naval Radiological Defense Laboratory	4
9.1	Support Photography	AFSWP; Military Air Transport Service; EG and G	15
	Los Alamos Scientific Laboratory Test Group		
11.2	Radiochemistry Sampling	Air Force Special Weapons Center	9
	University of California Radiation Laboratory Test Group		
21.2	Radiochemistry Sampling	Air Force Special Weapons Center	9
	Civil Effects Test Group		
32.3	Evaluation of Countermeasure System Components and Operational Procedures	Naval Radiological Defense Laboratory	16
37.2	Biophysical Aspects of Fallout Phenomenology	Air Force Special Weapons Center	3
37.2a	Physical Aspects of Fallout	Air Force Special Weapons Center	3
37.6	Application of Radio-ecology Techniques	Air Force Special Weapons Center	3
39.5	Radiation Dosimetry for Human Exposures	Air Force School of Aviation Medicine	*

* Unknown

types of Navy radiac instruments in measuring radiological hazards in the field under the anticipated conditions of nuclear warfare. The experimental equipment included one masonite phantom, simulating the density and dimension of a human, loaded with selectively shielded standard depth-dose detectors and dosimeters, and other masonite phantoms containing recording ratemeters.

About one hour after the detonation, five project personnel in three vehicles left Camp Mercury to transport the phantoms into the shot area, northeast of ground zero. The trip took about one hour. Although the ratemeter reading on the hard-surface road leading toward ground zero was 5 R/h, off the road the dose rate reading was 50 R/h. As the truck transporting the equipment turned off the road to position the phantoms, it became embedded in the sand in the 50 R/h field, thus preventing both prompt retreat by the staff and removal of equipment to a field of lower radiation intensity. Personnel, therefore, unloaded and installed the equipment as rapidly as possible and radioed for assistance. They returned to the hard-surface road and were picked up there by the evacuation jeep. Recovery of equipment was accomplished in two trips, one six-and-one-half hours and the other 30 hours after the detonation (26).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, was conducted under the supervision of AFSWC. The objective was to study how the air-ground interfaces affected the radiation produced by a nuclear detonation. Integrated gamma dose and neutron readings were obtained at points on the ground and at corresponding points at heights up to approximately 500 feet on the WHITNEY and SHASTA towers, also in Area 2. Pro.ject personnel placed equipment 1,530 and 2,430 meters from the shot-tower. After the detonation and when radiation intensities permitted, five project personnel performed recovery operations (84).

Project 4.2, Evaluation of Eye Protection Afforded by an Electromechanical Shutter, was intended to evaluate the effectiveness of an electromechanical shutter device for preventing or minimizing flash blindness, a temporary condition produced by the intense light of a nuclear detonation. Test subjects were volunteers from the Tactical Air Command. The Air Force School of Aviation Medicine furnished the examiners and rabbits for the tests, and personnel from the Navy Radiological Defense Laboratory, the Wright Patterson Aero Medical Laboratory, and the Nellis Air Force Base Hospital provided technical support.

The project was conducted in a trailer 17 kilometers southeast of ground zero, at UTM cordinates 845958. The trailer was equipped with electromechanical shutters that closed one millisecond after the arrival of the intense flash of the detonation. The shutter mechanism had been changed for DIABLO to determine the effects of closure as late as one millisecond. Four volunteers and four trained examiners proceeded to the trailer four-and-one-half hours before the detonation. After the detonation, examiners tested the subjects to determine the length of time required for them to recover useful vision. Thirty minutes after the detonation, the volunteers returned to Nellis AFB for complete opthalmological evaluation. No permanent effects were discovered (34). In addition to the human subjects, project personnel evaluated chorioretinal burns received by unprotected rabbits exposed to the detonation (11; 34).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics. The objective was to measure the effects of the overpressure and wind gusts produced by a nuclear detonation on the HSS-1 helicopter. The project also studied how blast effects might limit the HSS-1 in its delivery capabilities for antisubmarine warfare weapons.

The helicopter left Indian Springs AFB at 0340, entering the test area 20 minutes later. Before the shot, the helicopter, with a crew of two, flew two practice orbits inbound at 330 degrees. It began a final run five minutes before the detonation, making a 90-degree turn 40 seconds before the detonation. At shot-time, the helicopter was positioned tail-on to the blast, at a slant range of 3,900 meters from ground zero and at an altitude of 11,000 feet. The helicopter spent approximately 60 minutes in the shot area, returning to Indian Springs AFB at 0505 (3; 82).

Project 5.3, In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation, was developed by the Navy Bureau of Aeronautics to measure the thermal and blast wave response of the FJ-4 aircraft and to determine its performance and delivery capabilities during a nuclear detonation. The Naval Air Special Weapons Facility provided the aircraft crew for this project. North American Aviation, Incorporated, supplied the test aircraft, equipped with special instruments for the project, and the personnel required to maintain the aircraft.

The FJ-4 left Indian Springs AFB at 0340. At the time of the detonation, the aircraft was at a height of 9,900 feet above the burst and at a slant range of 3,060 meters from ground zero. At the time of shock arrival, the aircraft was in a level flight pattern, tail-on to the blast, at a slant range of 3,280 meters from ground zero. Upon completing its mission, the FJ-4 returned to Indian Springs AFB, landing at 0440. During the mission, total gamma dose was recorded by film badges placed in the cockpit, ammunition bay, right drop tank, and nose-wheel well (53).

Project 5.4, In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics to measure the thermal and blast wave response of

the A4D-1 aircraft during flight and to determine its performance and delivery capabilities during a nuclear detonation. The A4D-1 aircraft was a single engine, modified delta wing, carrier-based attack jet aircraft with the capability for delivering nuclear weapons. Participants included one pilot, the ground controller, and the maintenance personnel responsible for the special painting and instrumentation of the aircraft. Nuclear radiation in the aircraft was measured by four film badges in the bottom of the nose section, six film badges in the cockpit map case, and dosimeters of various ranges located in the nose wheel door and the leg pocket of the pilot's flight suit.

The aircraft took off from Indian Springs AFB at 0346 and entered its flight pattern at 0400 hours. At shot-time, the aircraft was at a slant range of 3,300 meters from ground zero and at a height of about 9,420 feet above the burst. At the time of the first shock arrival, the A4D-1 was at a slant range of 3,000 meters from ground zero and at a height of 9,260 feet above the burst. After completing its mission, the aircraft returned to Indian Springs AFB, landing at 0442 (3; 81).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonatiun. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the project. Northrop calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center provided both the aircraft and the two-man crew. Wright Air Development Center and Northrop Aircraft together developed positioning methods and calculated the aircraft positions at detonation and shock arrival times. At 0400, the F-89D left Indian Springs AFB. It flew one complete la-minute holding pattern to position itself for the shot. At the detonation, the F-89D was approaching ground zero

at an altitude of 19,700 feet and at a slant range of 10,500 meters from the burst. When the initial shock wave arrived, the aircraft was at an altitude of 19,160 feet and at a slant range of 6,710 meters from ground zero. The F-89D returned to Indian Springs AFB at 0437. During the mission, film badges were placed in the pilot's and observer's positions (3; 74).

Project 6.2, Measurement of the Magnetic Component of the Electromagnetic Field near a Nuclear Detonation, was designed to provide a record of the strength and characteristics of the magnetic energy generated by a nuclear detonation as a function of time and distance. The project was fielded by the Diamond Ordnance Fuze Laboratory. Personnel installed a recording station about 260 meters north of ground zero. The station was not manned during the detonation. Four hours after the detonation, three men in two vehicles recovered instruments from this station. Two hours before the shot, two men in one vehicle drove to a recording station 30 kilometers southeast of ground zero, at UTM coordinates 895855. They departed one hour after the shot (11; 35).

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 a nuclear burst in order to determine the position and yield of that burst. The Indirect Bomb Damage Assessment NAROL System tested on 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 (50).

Project 8.3a, Performance of a High-speed Spectrographic System, tested equipment designed to analyze the electromagnetic energy from nuclear detonations. The equipment would eventually be used during Operation HARDTACK, a later series of atmospheric

nuclear weapons tests. At shot-time, three or four project personnel were at stations 25 kilometers from ground zero (60).

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.

Twelve men manned the camera station at the BJY, UTM coordinates 842022, from six hours before to 30 minutes after the detonation. At shot-time, two or three photographers took pictures from a C-47 aircraft operated by the Military Air Transport Service. The aircraft, which spent approximately 100 minutes in the shot area, flew a right-hand holding pattern at an altitude of 8,000 to 9,000 feet (3; 27; 40). In addition, EG and G personnel provided technical photography support to AFSWP and the AEC, operating camera stations to record fireball and cloud growth. One manned station was at the Control Point, and two unmanned stations were three to eight kilometers from ground zero (11; 27).

2.2.2 Department of Defense Participation in LASL and UCRL Test Group Projects

Of the six projects conducted by the LASL and UCHL Test Groups, only Projects 11.2 and 21.2, both entitled Radiochemistry Sampling, involved DOD participation. These projects required air support from AFSWC and are discussed in section 2.2.5.

2.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted 14 projects at DIABLO. Of these projects, the five listed in table 2-2 involved DOD participation.

Project 32.3, Evaluation of Countermeasure System Components and Operational Procedures, was fielded by the Naval Radiological Defense Laboratory. The project was conducted in two phases at a manned underground shelter within the fallout zone and beyond the region of significant blast damage. The first phase of the operation evaluated shelter performance. The second phase involved establishing a suitable staging area for testing reclamation methods.

Six hours before the detonation, 16 participants arrived in jeeps at the shelter, located at UTM coordinates 801131, 1.3 kilometers from the shot-tower. The shelter was a standard 7.5-meters-by-14.4-meters multi-plate ammunition-storage magazine. Custom-fitted with a standard Navy quick-acting, watertight door, the shelter was buried side-on to the shot area, beneath about one meter of earth. The entrance faced away from ground zero. Two M-6 collective protector air filters provided ventilation.

Thirty minutes before the detonation, the intake and exhaust vents were closed. Five minutes before the detonation, all personnel sat in the center of the floor at the rear of the shelter. Fifteen seconds before the detonation, the vent intakes were opened and the M-6 collective protector air filters were started. Between one and six minutes after the detonation, participants in the underground shelter reported dosimeter readings by radio to the Control Point. Fallout continued in the area of the shelter from seven to 20 minutes after the detonation. Twenty minutes after the detonation, the AFSWC helicopter being used to conduct aerial surveys picked up the

Director of the Civil Effects Test Group at the shelter. Surveys of exterior areas adjoining the shelter were begun 30 minutes after detonation. This first phase of the project was completed and the shelter closed by six hours after shot-time. Other personnel returned by jeep to the Control Point, where they were processed through the decontamination station.

The second phase of the project was to begin one hour after the detonation, but higher-than-expected radiation intensities on shot-day caused a postponement of two days. An unknown number of operators and their equipment, consisting of several graders, a front-end loader, and a dump-truck, were at a safe distance from the project area at shot-time. They moved to the designated area some 2,500 meters from ground zero two days after the detonation and scraped and graded the area for approximately four hours. When their assignment was completed, they returned through the decontamination station to Camp Mercury (11; 75).

The following CETG projects involved AFSWC support:

- Project 37.2, Biophysical Aspects of Fallout Phenomenology
- Project 37.2a, Physical Aspects of Fallout
- Project 37.6, Application of Radio-ecology Techniques.

For these projects, AFSWC crew members provided a single C-47 aircraft for radio relay services, as discussed in section 2.2.5.

Project 39.5, Radiation Dosimetry for Human Exposures, was conducted by the Air Force School of Aviation Medicine, along with several civilian agencies. The project collected information on the characteristics of neutron and gamma radiations at various distances from ground zero to evaluate the doses received by the survivors of Hiroshima and Nagasaki. The experiment required placing radiation detection devices approximately 450 meters from the shot-tower and recovering them soon after the detonation, as radiation intensities permitted (51).

2.2.4 Department of Defense Operational Training Projects

The primary objectives of the operational training program were to indoctrinate Air Force personnel and to test tactics and equipment. The Air Force conducted three operational training projects at Shot DIABLO:

- Project 53.1, Aerial Sampling Missions
- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.1, Aerial Sampling Missions, involved the Montana and New York Air National Guard units that flew sample missions in conjunction with LASL Project 11.2 and UCRL Project 21.2, Radiochemistry Sampling (1; 3). This activity is discussed under AFSWC operations, in the next section of this chapter.

Project 53.7, Indirect Bomb Damage Assessment, required staff from the Wright Air Development Center to install Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft from Indian Springs AFR. The F-89D, with a crew of two, flew a holding pattern at an altitude of 35,000 feet. The aircraft spent about 60 minutes in the shot area. After completing its mission, the F-89D returned to base, where it was decontaminated (1; 3).

Project 53.9, Photographic Reconnaissance Training, was intended to indoctrinate Tennessee Air National Guard Tactical Reconnaissance units in photographic missions over a nuclear target. Two RF-84 aircraft, each with a pilot and a photographer, flew a holding pattern until ten minutes after the detonation, when they made a photographic run over ground zero at 10,000 feet. Upon completion of the run, the aircraft returned to George AFB for decontamination (1; 3).

2.2.5 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling and sample courier missions for LASL and UCRL, a radio-relay for CETG, and cloud-tracking missions, security sweeps, and aerial surveys. At Shot DIABLO, AFSWC also performed a special cloud penetration study.

Cloud Sampling

Two B-57B aircraft, each operated by two crewmen, and four F-84G aircraft, each operated by a pilot, collected samples of the cloud for LASL Project 11.2, Radiochemistry Sampling, and UCRL Project 21.2, Radiochemistry Sampling. A B-57B sampler control aircraft, with a pilot and a scientific advisor, directed the cloud sampling. Pilots from the 4926th Test Squadron (Sampling) flew the aircraft. In addition, four T-33 aircraft, each with two New York and Montana Air National Guard personnel, collected cloud samples from an altitude of ab'out 30,000 feet for operational training Rroject 53.1, Aerial Sampling Missions (1; 3).

The first sampler aircraft to leave Indian Springs AFB were the T-33s, which took off 30 minutes before shot-time. The control aircraft left Indian Springs AFB 15 minutes before shot-time and was positioned by the Air Operations Center outside the testing area before shot-time. Upon reaching an altitude of 30,000 to 35,000 feet, the control aircraft began its orbit. After the detonation, the control aircraft left its orbit to view the cloud. Between 60 and 80 minutes after the detonation, the F-84G samplers took off from Indian Springs AFB. Ninety minutes after the detonation, the B-57B samplers flew from Indian Springs AFB. Guided by the control aircraft, the samplers entered the vicinity of the burst. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire the samples. After completing their sampling runs, most of the samplers left the area, and landed at Indian Springs AFB. One or more B-57Bs, with two crewmen each, flew from Indian Springs AFB .

and completed the final sampling run. The aircraft then accompanied the B-57B sampler control aircraft back to Indian Springs AFB (1; 3).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB on shot-day to transport samples to various air bases for analysis by nuclear weapons design laboratories. The 4900th Air Base Group from Kirtland AFB conducted these missions (1; 3).

Radio Relay

A C-47 aircraft provided radio relay for CETG Projects 37.2, 37.2a, and 37.6. The C-47, with a crew of three, flew a right-hand holding pattern 20 nautical miles probably northeast of ground zero. The aircraft remained aloft for three hours. Following the mission, the C-47 returned to its home base for decontamination (l-3).

Cloud Tracking

Immediately after the detonation, three aircraft flew cloud-tracking missions over and beyond the Nevada Test Site. One B-25 aircraft with three crew members and one B-29 aircraft with five crew members flew from Indian Springs AFB. One B-50 with six crew members originated from Kirtland AFB (1; 3).

Security Sweeps

Before the shot, two L-20 aircraft were dispatched from Yucca Lake airstrip near the Control Point to perform a security sweep mission over the test area. The aircraft had a crew of at least two, since the security sweep routine called for a security guard to accompany the pilot in the survey mission. The aircraft surveyed the shot area to ensure that no unauthorized personnel were in the area at shot-time (1; 3).

Helicopter Surveys

After the detonation, AFSWC pilots flew helicopter survey missions over the shot area and non-test areas to record radiation intensities. The one H-21 helicopter used had a crew of four: two AFSWC pilots and two REECo monitors. The initial survey was begun 15 minutes after the shot and completed 40 minutes later. After noting their peak reading of 45 R/h 500 feet over ground zero, the pilot was requested by the Air Operation Center to land on a pad 1680 meters north of ground zero to pick up the Director of the Civil Effects Test Group. The intensity on the pad was 2 R/h at the time. The helicopter landed as requested, delaying its return by about eight minutes, and transported the man to the Control Point. After the mission, the helicopter returned to the helicopter pad, where it was monitored and decontaminated as required (1; 3; 63).

In addition to the aerial surveys, a second H-21, piloted by an AFSWC crew of two, conducted a damage survey 15 minutes after the shot. One monitor from REECo was aboard the aircraft (1; 3; 63).

Cloud Penetration

Beginning earlier in Operation PLUMBBOB and continuing at Shot DIABLO, AFSWC conducted a study to determine whether the Air Force should monitor the accumulation of radioactive contaminants on aircraft that penetrated radioactive clouds. A T-33 from the 4926th Test Squadron, piloted by an officer from Air Support Group Headquarters, accompanied by an observer, penetrated the DIABLO cloud. The aircraft flew at an altitude of 30,000 feet and spent 20 minutes in the air. The pilot and the observer both wore lead vests instrumented with 15 to 25 film badges, and six additional film badges were taped to the ejection seats.

Upon returning to Indian Springs AFB after the flight, the aircraft was not decontaminated, but a 24-hour period was permitted for radiation decay before maintenance was performed on the aircraft. The pilot and the observer boarded and departed

from the aircraft using standard ladders, not the forklift procedure used in other AFSWC missions. However, the pilot and observer were both closely monitored and decontaminated after the flight. The aircraft was decontaminated on 25 July after performing its mission at Shot OWENS (1; 3).

2.3 RADIATION PROTECTION AT SHOT DIABLO

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 program. The available information includes NTO isointensity contour maps, monitoring data, and some NTO and Desert Rock personnel dosimetry data. Radiological safety procedures and dosimetry information are summarized in the series volume.

Dosimetry

During July 1957, the Dosimetry and Records Section issued 2,712 film badges and 595 pocket dosimeters (83). Thirteen NTO participants at DIABLO received cumulative gamma exposures greater than 2.0 roentgens, ranging from 2.01 to 3.55 roentgens (63). Seven personnel from Desert Rock Project 50.8 received 3 or more roentgens, almost all of which was accumulated at Shot DIABLO. One of these exposures was 5.1 roentgens, in excess of the Desert Rock 5 roentgens limit (57).

Logistics

For Shot DIABLO, the General Supply Section issued protective clothing to 883 persons (83). These items consisted of coveralls, shoe covers, and respirators.

Monitoring

Thirteen men in vehicles began the initial ground survey at 0440 hours. They reported the last intensity in the shot area about two hours later. The aerial helicopter survey team, consisting an AFSWC crew of two and two REECo monitors, began its initial survey 15 minutes after the shot and completed it 40 minutes later (63). Ground and aerial resurveys were conducted for several days following the detonation.

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water after Shot DIABLO (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isointensity contour maps from the radiation intensity data gathered by the ground survey teams. Figure 2-1 presents the isointensity plot developed from information gained during the initial survey. Figure 2-2 shows the data resulting from the resurveys on 15 July, 16 July, 17 July, and 18 July (83).

In addition to its other activities, the Plotting and Briefing Branch issued access permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 482 access permits during DIABLO (83).

Decontamination

During the period covering Shot DIABLO, the Vehicle and Equipment Decontamination Section decontaminated 127 vehicles (83). The SMOKY ground zero area was in the path of DIABLO fallout. During 22 to 29 July, REECo personnel decontaminated the area by bulldozing contaminated soil away from the shot tower. On 22 July, prior to decontamination, readings of 0.24 R/h were recorded at the base of the SMOKY tower (85; 86).

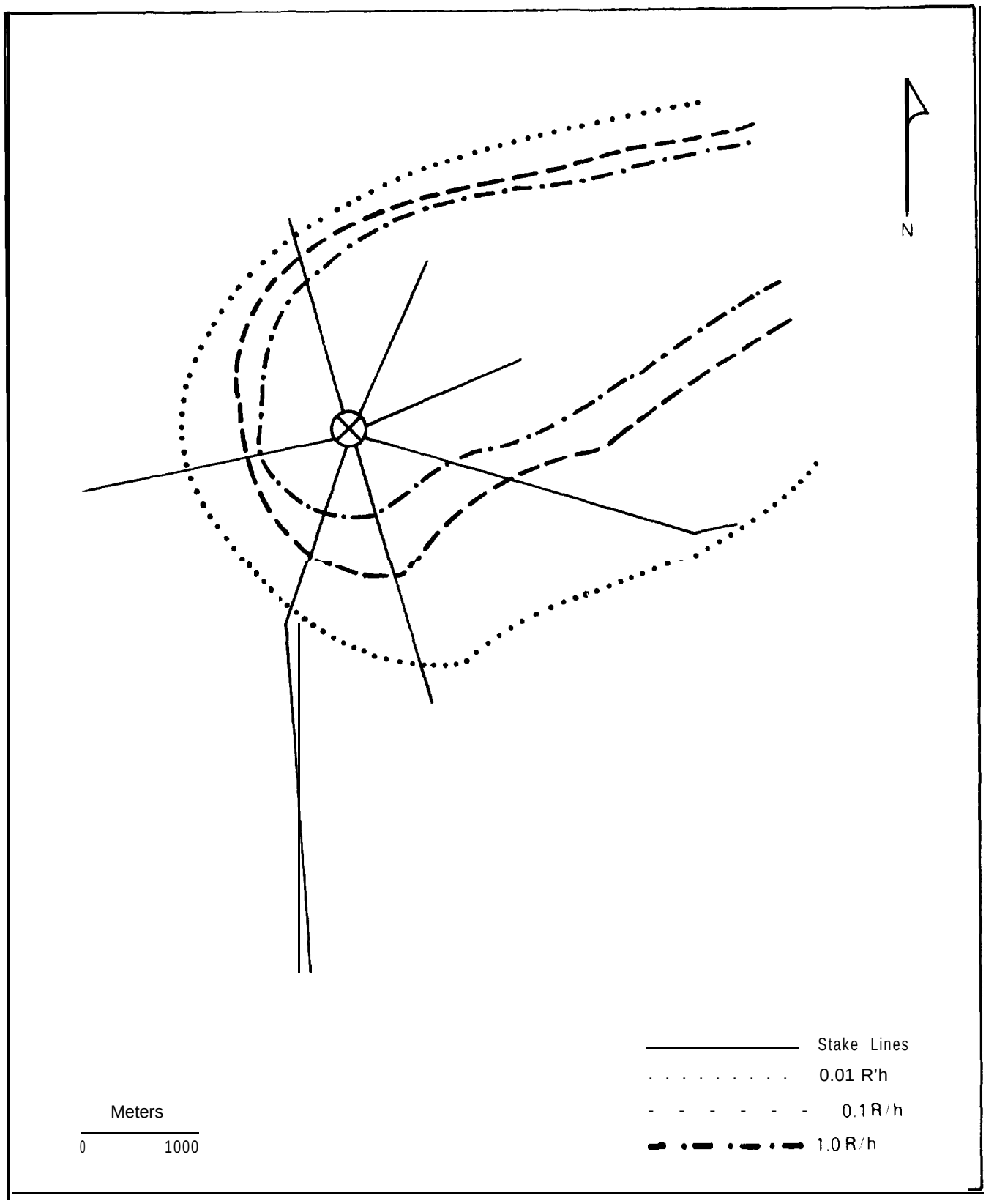
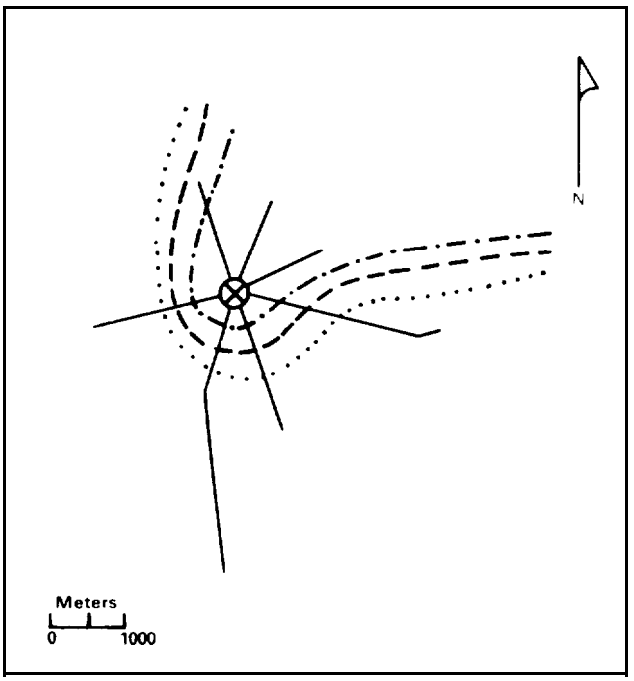
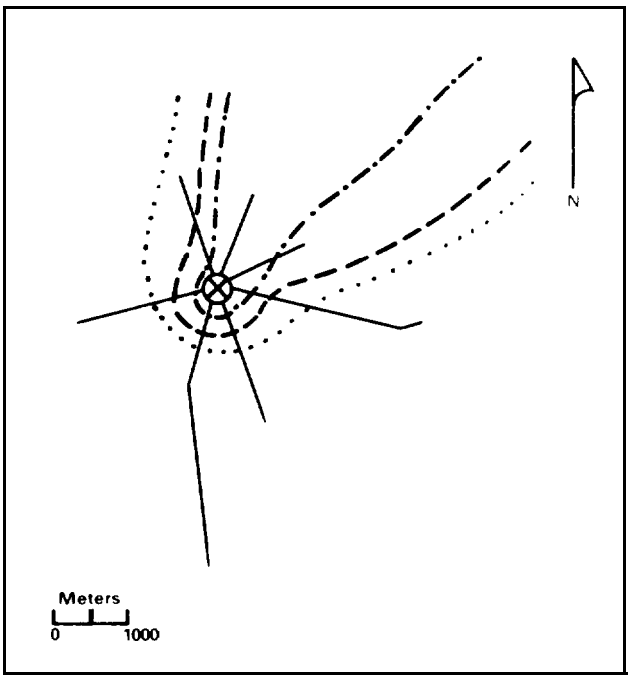


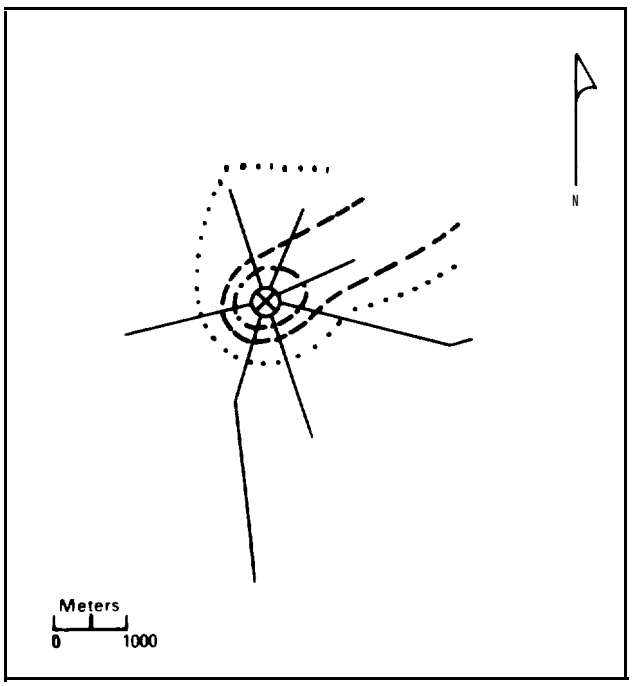
Figure 2-2: INITIAL SURVEY FOR SHOT DIABLO, 15 JULY 1957, MID-TIME 0548



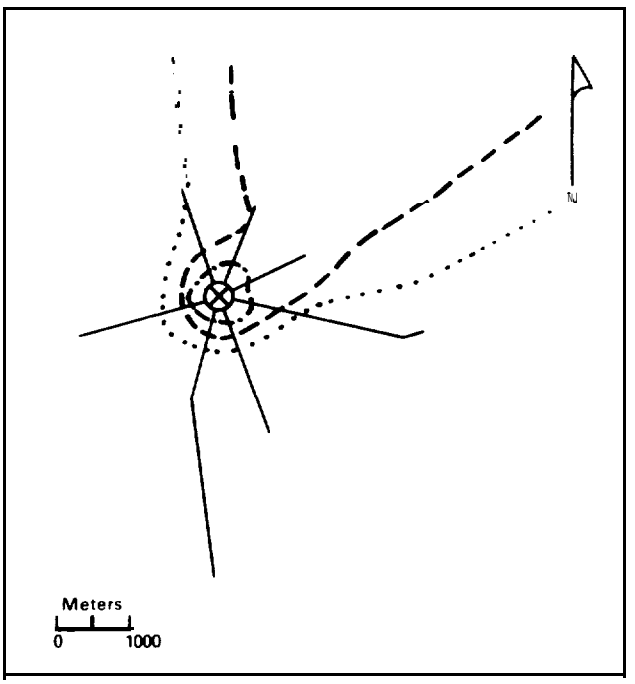
15 July 1957, Mid-Time: 1118



16 July 1957, Mid-Time: 0645



17 July 1957, Mid-Time: 0652



18 July 1957, Mid-Time: 0645

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

Figure 2-3: SUBSEQUENT SURVEYS FOR SHOT DIABLO

SHOT JOHN SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISES:	Desert Rock VII and VIII
DATE/TIME:	19 July 1957, 0700 hours
YIELD:	2 kilotons
ALTITUDE OF BURST:	20,000 feet (missile)

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 and to indoctrinate personnel in the effects of nuclear detonations.

Weather: At shot-time, the temperature was 22°C, and the surface wind was calm. Winds were 15 and 47 knots from the south-southwest at burst altitude and at the top of the cloud (44,000 feet), respectively.

Radiation Data: Because of the height of detonation, there was no onsite fallout.

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

CHAPTER 3

SHOT JOHN

Shot JOHN was conducted with a yield of two-kilotons at 0700 hours Pacific Daylight Time on 19 July 1957. The nuclear device was delivered by an air-to-air MB-1 rocket launched from an F-89J aircraft (serial number 547) flying at an altitude of about 19,000 feet. The rocket traveled 4,240 meters before it was detonated, four-and-one-half seconds after its release and about 20,000 feet above Area 10 of the NTS. There was no onsite fallout (22; 31; 74).

Wright Air Development Center personnel from Project 5.5, In-flight Structural Response of an F-89D Aircraft to a Nuclear Detonation, flew and maintained the F-89J, which departed from Indian Springs AFB at 0605 for the shot area. The F-89J, which had a crew of two, began veering left as soon as it released the rocket. At the time of the detonation, it was about 3,350 meters from the burst point. The aircraft then returned to Indian Springs AFB, landing at 0707. The delivery aircraft was accompanied by an alternate delivery F-89J aircraft. This aircraft, which had a crew of two, left Indian Springs AFB at 0620. The alternate delivery aircraft flew at an altitude of about 17,500 feet, following the same pattern as the delivery F-89J but remaining approximately 1,220 meters behind it. When the rocket was released, the alternate F-89J also veered to the left. At the time of the detonation, it was about 4,240 meters away. The alternate delivery aircraft returned to Indian Springs AFB one minute after the delivery aircraft, landing at 0708 (22; 74).

3.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT JOHN

Approximatelv 690 Desert Rock troops took part in projects associated with Shot JOHN: three troop observer indoctrination

projects and two technical service projects, as listed in table 3-1. The table also lists the 17 Camp Desert Rock support personnel who observed the detonation.

Table 3-l: EXERCISE DESERT ROCK PROJECTS, SHOT JOHN

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50.2	Troop Observers	Army Navy Civilian	30 1 2
	52.2	Marine Observers	Marine Corps	11
	53.3	Aircrew Observers	Air Force; Air Defense Command	38
	—	—	Camp Desert Rock Support Troops	17
Technical Service	50.3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Fort Huachuca, Arizona: Fort Meade, Maryland	32
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board: Army Artillery Board	557

3.1.1 Troop Observer Indoctrination Projects

About 100 DOD personnel, including the 17 Camp Desert Rock support troops, observed Shot JOHN, as indicated in table 3-l. They witnessed the detonation from open terrain, proceeding to the observer areas by convoy at 0400 hours on shot-day. One group of observers was 5,900 meters southeast of surface zero, at UTM coordinates 882085. Another group, five officers from the Air Defense Command assigned to Project 53.3, volunteered to view the air burst from ground zero. A helicopter was to return these observers to Camp Desert Rock after the shot. Because the helicopter was not sent as planned, the six observers positioned at ground zero during Shot JOHN spent an additional two hours there (43; 49).

3.1.2 Technical Service Projects

As indicated in table 3-1, two technical service projects were conducted at Shot JOHN to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Huachuca, and seven participants from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine the Army's fallout prediction methods. Three remote radar sets were located southeast of Yucca Lake at UTM coordinates 893872, about 25 kilometers from ground zero. The fallout prediction unit for this project operated from a van located next to the weather station at Camp Mercury (20; 49).

Project S0.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Air Defense Board and the Army Artillery Board. The purposes were:

- To determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation
- To predict and monitor radioactive fallout.

An estimated 557 DOD personnel took part in this project. To determine the position, height of burst, and yield of the detonation, participants operated 12 onsite and offsite radar, camera, and other instrument stations located 11 to 77 kilometers from ground zero. The control point was at UTM coordinates 768944, about 20 kilometers southwest of ground zero. Because of the burst conditions, the fallout prediction and radiation survey activities were minimal. One minute after the detonation, however, an H-13 helicopter was to lift off to measure the neutron-induced activity around ground zero (43; 49; 77; 79; 80).

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

In addition to the Exercise Desert Rock personnel, other DOD personnel took part in test activities during Shot JOHN that required them to enter the forward area. Table 3-2 identifies the test group projects involving DOD participants. The Air Force sponsored three operational training projects during the shot. Besides the test group and the training projects, AFSWC and other support activities accounted for a number of other DOD participants. AFSWC supported test group projects and flew routine missions for the Test Manager.

3.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted nine projects at Shot JOHN, as indicated in table 3-2.

Project 1.1, Basic Airblast Phenomena, was conducted by the Ballistic Research Laboratories to obtain data on overpressure and dynamic pressure at various positions near and on the ground surface at different times after the detonation. An additional objective was to evaluate modifications in gauge designs, instrument components, and measurement techniques. Before the detonation, Ballistic Research Laboratories personnel installed gauges at stations ranging from ground zero to 3,050 meters north, south, east, and west of ground zero. Project personnel were not required to be in the area of their experiments at shot-time. An estimated three project participants recovered the gauges after the detonation (21).

Project 2.3, Neutron Flux from Selected Nuclear Devices, was conducted by the Army Chemical Warfare Laboratories to measure the output of neutrons from a nuclear detonation, the energy of the neutrons, and their range in air. Small disks of selected materials that detected the neutrons in each of several energy

Table 3-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT JOHN

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
1.1	Basic Airblast Phenomena	Ballistic Research Laboratories	3
2.3	Neutron Flux from Selected Nuclear Devices	Army Chemical Warfare Laboratories	*
2.5	Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soil	Army Signal Research and Development Laboratories; Wright Air Development Center	6
2.9	Nuclear Radiation Received by Aircrews Firing the MB-l Rocket	Air Force Special Weapons Center	6
2.10	Initial Neutron and Gamma Air-earth Interface Measurements	Air Force Special Weapons Center	7
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
6.4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
8.3a	Performance of a High-speed Spectrographic System	Naval Radiological Defense Laboratory	4
9.1	Support Photography	AFSWP; Military Air Transport Service; EG and G	19
Los Alamos Scientific Laboratory Test Group			
11.2	Radiochemistry Sampling	Air Force Special Weapons Center	9

* Unknown

ranges were used to measure the number and energy of the neutrons. Because these disks were attached to Project 2.9 aircraft, Project 2.3 personnel were not in the field following the detonation (70).

Project 2.5, Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soil, was conducted by the Army Signal Research and Development Laboratories, with support from the Wright Air Development Center. The project was designed to determine initial gamma intensity versus time and distance. Personnel obtained data from three instrumented aircraft, each operated by a crew of two: the rocket delivery F-89J aircraft, the alternate F-89J delivery aircraft, and an F-89D aircraft primarily involved in Project 5.5, In-flight Structural Response of an F-89D Aircraft to a Nuclear Detonation. In the F-89Js, the instruments were mounted in the after-fuselage equipment section to the rear of the fuel tank. In the F-89D, the detectors were mounted in the rear of the forward-fuselage equipment section. The Wright Air Development Center provided the aircraft and the two-man crews for each aircraft.

The F-89D left Indian Springs AFB at 0624, about 20 minutes after the delivery aircraft. While in the test area, it flew alongside the delivery aircraft at the same altitude, about 19,000 feet. When the rocket was launched, the F-89D veered to the right instead of the left for the return trip to Indian Springs AFB. At the time of the detonation, the aircraft was about 3,350 meters from the burst, the same distance as the delivery aircraft. The F-89D returned to Indian Springs AFB at 0706 (6; 22; 74). After all three landed, the instruments were removed as part of Project 2.9.

Project 2.9, Nuclear Radiation Received by Aircrews Firing the MB-1 Rocket, was conducted by AFSWC to measure the total neutron and gamma exposures received by an aircrew delivering the

MB-l rocket. As a secondary objective, the same type of measurements were made at locations in the aircraft other than the crew compartment and in other aircraft in the delivery array.

The three aircraft involved in Project 2.5 also participated in Project 2.9. After the detonation and the return of the aircraft to Indian Springs AFB, instruments were removed at the earliest possible moment. AFSWC personnel then flew the fission-foil neutron detectors and neutron threshold detectors to the facilities set up at the NTS for Project 2.3. All of the fission foils were developed within 58 minutes of the detonation.

Since no particular time limitations existed for the other instruments, they were evaluated later. The National Bureau of Standards film packs used in the project were returned to AFSWC and were also processed on shot-day. The results from the film badges were received through the normal radiological safety channels during the afternoon of the detonation (54).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, was conducted by AFSWC to study how the air-ground interface affected the radiation produced by a nuclear detonation. Integrated gamma dose and neutron readings were obtained at points on the ground and at corresponding points in the air. A tethered balloon was used to carry the gamma dose rate equipment and other instruments for measurements in the air. Working from 2300 hours on the night before the detonation to 0400 hours on shot-day, seven personnel inflated the balloon, installed instruments in the balloon, and moored the balloon at ground zero. They returned to the shot area to recover the instruments and the balloon one hour after the detonation (13; 84).

Project 5.5; In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D in flight to the blast and

thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop calibrated, maintained, and operated the instrumentation, and later analyzed the measured data. Wright Air Development Center provided the aircraft and the two-man crew. Wright Air Development Center and Northrop Aircraft together developed positioning methods and calculated the aircraft positions at detonation and shock arrival times.

The F-89D left Indian Springs AFB at 0624. It flew one complete 12-minute holding pattern to position itself for the shot. At the detonation, the F-89D was at an altitude of 19,000 feet and 3,350 meters from the burst. When the initial shock wave arrived, the aircraft was 1,900 meters from the burst point. The aircraft was in the test area for approximately 30 minutes and then returned to Indian Springs AFB, landing at 0706. Film badges were placed in the pilot's and observer's positions (6; 74).

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 a nuclear burst in order to determine the position and yield of the burst. The Indirect Bomb Damage Assessment NAROL system tested on 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 (50).

Project 8.3a, Performance of a High-speed Spectrographic System, was conducted by the Naval Radiological Defense Laboratory. The purpose was to test high-speed spectrographic equipment designed to analyze the electromagnetic energy from a nuclear detonation. The equipment would eventually be used in Operation HARDTACK II, a later series of atmospheric nuclear

weapons tests. The project instruments were probably housed in Building 400, near the Control Point. At shot-time, three or four personnel were at their stations 25 kilometers from ground zero (13; 60).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following 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 detonations for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Working from 1500 to 2000 hours the day before the detonation, eight personnel loaded and turned on cameras at four stations. Eight other participants established and then manned a camera station at UTM coordinates 846065 on Mercury Highway from 0100 on shot-day to 30 minutes after the detonation. An additional two or three participants took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. In addition, EG and G provided technical photography support to AFSWP and the AEC. EG and G personnel operated six camera stations to record fireball and cloud growth. One manned station was at the Control Point, and five unmanned stations were three to eight kilometers from ground zero (6; 27; 43).

3.2.2 Department of Defense Participation in LASL Test Group Projects

The Los Alamos Scientific Laboratory was the only AEC weapons development laboratory conducting projects at Shot JOHN.

Of the four projects fielded by LASL, only Project 11.2, Radiochemistry Sampling, involved DOD participation. This project, which required air support from AFSWC, is discussed in section 3.2.4.

3.2.3 Department of Defense Operational Training Projects

'The primary objectives of the operational training program at Shot JOHN were to indoctrinate personnel and to test techniques and equipment. The Air Force sponsored three operational training projects at the shot:

- Project 53.2, Ground Motion Studies
- Project 53.5, Aircrew Indoctrination (Early Cloud Penetration)
- Project 53.7, Indirect Romb Damage Assessment.

Project 53.2, Ground Motion Studies, was conducted by the Air Force to collect data about the amount of energy introduced into the ground from the detonation of a nuclear device. Twelve hours after the detonation, Air Force personnel entered the forward area and spent 20 minutes traveling from the checkpoint to a point 0.8 kilometers north of ground zero and back again (1; 6; 32).

Project 53.5, Aircrew Indoctrination (Early Cloud Penetration), was designed to enable Air Defense Command aircrews and commanders to witness a nuclear detonation and penetrate its cloud. Four T-33 aircraft, one C-131 aircraft, one C-54 aircraft, and two F-89 aircraft participated in the project at Shot JOHN. The T-33 aircraft, each with a crew of two, flew at an altitude of approximately 14,000 feet in a right-hand pattern inbound west-northwest and outbound east-southeast. The slant range from the burst point was eight kilometers at the time of detonation. The C-131 and the C-54, both transport aircraft,

flew at an altitude of 14,500 feet in a right-hand pattern eight nautical miles south of air zero. The C-131 probably had four people aboard, while the C-54 may have had as many as 20. The two F-89s, each with a crew of two, flew at altitudes of 42,000 feet, 40 nautical miles northeast of air zero. Eight minutes after the detonation, the first F-89 aircraft was cleared to penetrate the cloud and, ten minutes and 30 seconds after the detonation, the second aircraft was cleared to penetrate the cloud (1; 6; 32).

Project 53.7, Indirect Bomb Damage Assessment, required staff from the Wright Air Development Center to install Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft from Indian Springs AFB. During the shot, the F-89D aircraft, with a crew of two from Indian Springs AFB, flew a right-hand holding pattern southeast of ground zero at an altitude of 35,000 feet. The aircraft spent 14 minutes in the test area. After conducting its mission, the F-89D returned to base to be decontaminated (1; 6; 32).

An additional project concerning the Air Force was performed during Shot JOHN. The Strategic Air Command conducted a photo reconnaissance mission with two RB-47 aircraft. Both RB-47 aircraft flew a 35-nautical-mile left-hand holding pattern at an altitude of 25,000 feet. The two aircraft flew in formation five nautical miles left of and behind the F-89J aircraft that delivered the nuclear device (1; 6).

3.2.4 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling and sample courier missions for LASL, cloud-tracking missions, and security sweeps.

Cloud Sampling

Four B-57B aircraft, each carrying two crewmen, collected samples of the cloud for LASL Project 11.2, Radiochemistry Sampling. A scientific advisor from LASL aboard a B-57B sampler control aircraft directed the cloud sampling. Pilots of the 4926th Test Squadron (Sampling) flew all five aircraft. Thirty minutes before the shot, the control aircraft left Indian Springs AFB. The control aircraft was positioned by air controllers of the Air Operations Center outside the testing area before shot-time. Upon reaching an altitude of between 30,000 and 35,000 feet, the sampler control aircraft began its holding pattern.

Shortly after the detonation, the control aircraft left its orbit to view the detonation. Thirty to 45 minutes after the detonation, the four sampler aircraft left Indian Springs AFB. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire the samples. These aircraft entered the sampling area and completed their sampling runs in 30 to 35 minutes. Although most of the samplers then left the area and landed at Indian Springs AFB, one or more of the B-57Bs accompanied the B-57B sampler control aircraft back to Indian Springs AFB (1; 2; 6).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB to transport samples to various air bases for analysis by AEC nuclear weapons design laboratories. The 4900th Air Base Group from Kirtland AFB conducted these courier missions (1; 2; 6).

Cloud Tracking

Immediately after the detonation, one B-29 aircraft from Indian Springs AFB flew a cloud-tracking mission over and beyond the Nevada Test Site. The aircraft carried a crew of ten (1; 6).

Security Sweeps

Prior to shot-time, one L-20 aircraft was dispatched from Yucca airstrip near Camp Mercury to perform a security sweep mission over the test area. The security sweep routine called for a security guard to accompany the pilot (1; 6).

3.3 RADIATION PROTECTION AT SHOT JOHN

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposures to ionizing radiation while accomplishing their missions. Some of the procedures described in the Operation PLUMBBOB volume resulted in records that enabled the NTO to evaluate the effectiveness of its radiation protection programs. The available information includes 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

At JOHN, the Dosimetry and Records Section issued an unknown number of film badges and 82 pocket dosimeters (83). No new NTO personnel exceeded cumulative gamma exposures of 2.0 roentgens. However, certain AFSWC personnel were exposed at this level.

Radiation exposure information has been found for aircraft and personnel involved in the Field Command Weapons Effects Test Group Project 2.9 at Shot JOHN. Table 3-3 describes the average measured exposure at locations throughout the aircraft, as well as personnel exposures (54).

Field Command Weapons Effects Test Group Project 5.5, In-flight Structural Response of an F-89D Aircraft to a Nuclear

Table 3-3: FIELD COMMAND PROJECT 2.9, EXPOSURE DATA

Aircraft	Closest Approach to Burst in Meters	Location of Instruments	Average of Measured Exposures in Roentgens	
			Rad-safe	NBS*
Delivery	2,200	Rear cockpit	1.20	0.93
		Left wing tip	3.60	2.25
		Right wing tip	3.37	2.28
		Tail section	2.87	1.88
		Pilot	1.53	1.25
		Radar observer	1.21	0.94
Alternate	2,700	Rear cockpit	0.24	0.24
		Left Wing tip	0.63	0.43
		Right wing tip	0.64	0.46
		Tail section	0.60	0.35
		Pilot	0.33	0.26
		Radar observer	0.23	0.20
Blast	1,800	Rear cockpit	1.58	1.18
		Right wing tip	5.57	3.90
		Nose section	2.84	2.10
		Tail Section	3.42	2.75
		Pilot	2.72	1.63
		Radar observer	2.19	1.43

Crew Member	Closest Approach to Burst in Meters	Average of Measured Exposure in Roentgens
Delivery Pilot	2,200	1.4
Delivery Radar Observer		1.1
Alternate Pilot	2,700	0.3
Alternate Radar Observer		0.2
Blast Effects Pilot	1,800	2.2
Blast Effects Radar Observer		1.8

*National Bureau of Standards dosimeter

Detonation, was fielded by Wright Air Development Center. For this project, **dosimeters** were **placed** in the pilot's and observer's positions. At JOHN, the dosimeters in the pilot's position measured 3.55 roentgens of gamma radiation. Those in the observer's position recorded 2.44 roentgens of gamma radiation (74).

Logistics

For Shot JOHN, the General Supply Section issued protective clothing to 41 personnel (83). These **items** included coveralls, shoe covers, and respirators.

Monitoring

Probably within 15 minutes of shot-time, the initial ground monitoring teams began their survey (83).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during JOHN (83).

Plotting and Briefing

The Plotting and Briefing Branch did not develop **isodose** contour maps after shot-time because ground survey teams detected no increase in radiation levels within the NTS.

The Plotting and Briefing Branch issued access permits to control entrv **into** radiological exclusion areas. It issued 25 access permits during JOHN (83).

SHOT KEPLER SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	24 July 1957, 0450 hours
YIELD:	10 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 military equipment and to indoctrinate personnel in the effects of nuclear detonations
(4) To access the effects of the nuclear detonation on civilian structures and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 21°C, and surface winds were calm. Winds were five knots from the south-southwest at 10,000 feet, six knots from the southwest at 20,000 feet, and 13 knots from the southwest at 28,000 feet.

Radiation Data: About two hours after the detonation, radiation intensities of 1.0 R/h or more were confined to within 800 meters from ground zero, except to the west.

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

CHAPTER 4

SHOT KEPLER

Shot KEPLER was detonated with a yield of ten kilotons at 0450 hours Pacific Daylight Time on 24 July 1957. The device was placed in a cab at the top of a 500-foot steel tower in Area 4 of the NTS. The top of the cloud resulting from the detonation reached a height of 28,000 feet, with the upper layers blown slowly to the east-northeast and the lower layers blown west-northwest. Variable winds at low levels resulted in a broad onsite fallout pattern, which extended southwesterly to northwesterly from ground zero (31; 64).

4.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT KEPLER

More than 1,450 Desert Rock troops took part in projects associated wih Shot KEPLER: three troop observer indoctrination projects, two radiological training projects, and two technical service projects, as indicated in table 4-1. The table also lists the 88 Camp Desert Rock support troops who observed the detonation.

4.1.1 Troop Observer Indoctrination Projects

Approximately 830 DOD personnel, including the 88 Camp Desert Rock support troops, observed Shot JOHN, as indicated in table 4-I. Plans had been for the troop observers to view the detonation in open terrain 5,440 meters southwest of ground zero at UTM coordinates 753025. The observers, however, evidently were positioned in trenches 3,200 meters southwest of ground zero at UTM coordinates 785030. These trenches had been used in 1955 for Shot APPLE I of Operation TEAPOT. They were cleaned out by Camp Desert Rock engineers on the day before the detonation (71).

The trenches were about five feet deep to afford a minimum of two feet of overhead protection for a crouching person. Unexpected fallout prompted an evacuation of the area. By the time the last buses had arrived and been loaded, 45 minutes had elapsed since the burst, and radiation levels had risen to 3 R/h. The fallout was described as sounding like "gravel being thrown on [participants'] helmets" (44; 72). Because of the radiation intensity, all observers and vehicles required decontamination, which was accomplished in slightly more than one hour, presumably at the Desert Rock decontamination station. Personnel brushed the fallout off one another with brooms to reduce the intensity to allowable levels (.007 R/h or less). Vehicles were sprayed with a chemical solution. It is likely that the decontamination was facilitated by the large particle size of the fallout (72).

Table 4-1: EXERCISE DESERT ROCK PROJECTS, SHOT KEPLER

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50.2	Troop Observers	Army	708
	52.2	Marine Observers	Marine Corps	5
	53.3	Aircrew Observers	Air Force	25
	-	-	Camp Desert Rock Support Troops	88
Radiological Training	53.4	Radiological Defense Training	Radiological Defense School, Lowry AFB	30
		Sixth Army Chemical, Biological, and Radiological Team Training	Fort Huachuca, Arizona; Seattle Army Terminal	25
Technical Service	59.3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Fort Huachuca, Arizona; Fort Meade, Maryland	32
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board; Army Chemical Corps; Army Artillery and Guided Missile School; Air Weather Service	557

4.1.2 Radiological Training Projects

The two radiological training projects conducted during Shot KEPLER were Air Force Project 53.4, Radiological Defense Training, and Sixth Army Chemical, Biological, and Radiological Team Training.

Project 53.4, Radiological Defense Training, was conducted by 30 personnel of the Radiological Defense School of Lowry AFB, Denver, Colorado. After taking part in the Project 50.2 observer activities, the project participants proceeded along an assigned route from the observation area to a designated area near ground zero using vehicles from the Desert Hock decontamination station. Accompanied by a radiological safety monitor, the project participants monitored radiation intensities at various distances from ground zero (49).

The Sixth Army Chemical, Biological, and Radiological Team Training involved two survey teams, one from Fort Huachuca (Team #4, 13 personnel) and one from Seattle Army Terminal (12 personnel). Film badge dates indicate that neither team was present for the KEPLER detonation; the Fort Huachuca team dates were 29 July to 8 August, and the Seattle Army Terminal team dates, 4 to 15 August. The purpose was to train personnel from Sixth Army installations in radiological defense techniques. The teams conducted surveys in the residual radiation field from KEPLER. Since they were also to observe a shot, they probably witnessed Shot STOKES (57).

4.1.3 Technical Service Projects

As indicated in table 4-1, two technical service projects were conducted at Shot KEPLER to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven participants from Fort Huachuca, and seven personnel from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. Three remote radar sets were located southeast of Yucca Lake at UTM coordinates 8933872, approximately 20 kilometers from ground zero. The fallout prediction unit for this project operated from a van located next to the weather station at Camp Mercury (20; 44; 49).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Air Defense Roard, Army Chemical Corps, Army Artillery and Guided Missile School, and Air Weather Service. The objectives were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation
- Track targets and guided missiles through a cloud or fireball
- Predict and monitor radioactive fallout.

An estimated 557 DOD personnel took part in this project. To determine the position, height of burst, and yield of the detonation, participants operated 19 onsite and offsite radar, camera, and other instrument stations located five to 70 kilometers from ground zero. The control point was at UTM coordinates 768944, 13 kilometers southwest of ground zero. One radar station 4,660 meters west of ground zero, at UTM coordinates 752048, was evacuated 14 minutes after the shot when the radiation intensity reached 2 R/h. Other personnel surveyed the blast damage to the station on the afternoon of the following day (14; 44; 77; 79; 80).

Part of Project 50.8 included a test to determine the attenuation of the Nike Hercules missile control signals. At the time of detonation, a B-26, with a crew of at least three, positioned itself so that the cloud was between the aircraft and a Nike Hercules ground site. The aircraft was 15 nautical miles from the tower at shot-time and spent 30 minutes in the area (7).

To determine the actual fallout from Shot KEPLER, both aerial and ground surveys were conducted after the detonation. One H-34 helicopter, two H-13 helicopters, and one L-20 aircraft flew at altitudes ranging from 100 to 1,000 feet and were not to exceed intensities of 100 R/h. The helicopters carried three persons each (7; 14; 77; 79; 80).

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

In addition to the Exercise Desert Hock personnel, other DOD personnel took part in test activities during Shot KEPLER that required them to enter the forward area. Table 4-2 identifies the test group projects involving DOD participants. The Air Force sponsored four operational training projects during the shot. Besides the test group and the operational training projects, AFSWC and other support activities accounted for a number of additional DOD participants. The Air Force Special Weapons Center supported the test groups and flew routine missions for the Test Manager.

4.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted ten projects at Shot KEPLER, as indicated in table 4-2.

Table 4-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT KEPLER

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
1.1	Basic Airblast Phenomena	Ballistic Research Laboratories Laboratory	*
1.2	Field Test of a System for Measuring Blast Phenomena by Airborne Gauges	Naval Ordnance Laboratory; American Machine and Foundry Company; EG and G	*
2.7	Radio-wave Attenuation Studies	Naval Research Laboratory	*
2.10	Initial Neutron and Gamma Air-earth Interface Measurements	Air Force Special Weapons Center	3
5.1	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation	Navy Bureau of Aeronautics	2
5.3	In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation	Navy Bureau of Aeronautics; Naval Air Special Weapons Facility; North American Aviation	*
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center: Northrop Aircraft	2
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	3
9.1	Support Photography	AFSWP; Military Air Transport Service; EG and G	12
Los Alamos Scientific Laboratory Test Group			
11.2	Radiochemistry Sampling	Air Force Special Weapons Center	9
Civil Effects Test Group			
37.2	Biophysical Aspects of Fallout	Air Force Special Weapons Center	3
37.2a	Physical Aspects of Fallout	Air Force Special Weapons Center	3
37.6	Application of Radio-ecology Techniques	Air Force Special Weapons Center	3
39.5	Radiation Dosimetry for Human Exposures	Air Force School of Aviation Medicine	*

* Unknown

Project 1.1, Basic Airblast Phenomena, was conducted by the Ballistic Research Laboratories to:

- Obtain data on overpressure and dynamic pressure versus time as a function of distance
- Evaluate gauge designs, instrument components, and measurement techniques.

Before the shot, Ballistic Research Laboratories personnel installed pressure-time gauges at stations 170 to 6,890 meters south of ground zero. Project personnel were not required to be in the area of their experiments at shot-time. Participants recovered the gauges when radiation levels in the area declined to permissible levels. The project personnel, who carried respirators and wore film badges and protective clothing, were accompanied in the field by a radiation monitor (21; 83).

Project 1.2, Field Test of a System for Measuring Blast Phenomena by Airborne Gauges, was conducted by the Naval Ordnance Laboratory, American Machine and Foundry Company, and Edgerton, Germeshausen, and Grier. The objectives were to:

- Field test instrumentation under development for use in two underwater shots planned for Operation HARDTACK I, a later nuclear weapons test series
- Train personnel to handle the equipment under operational conditions.

Personnel tethered a balloon instrumented to record airblast from a station at UTM coordinates 861675, 44 kilometers south of ground zero. The balloon flew at an altitude of 200 feet. To study the functioning of the balloon at the time of the shock wave, EG and G personnel photographed the experiment from a station at UTM coordinates 853678, 43 kilometers south of ground zero (37).

Project 2.7, Radio-wave Attenuation Studies, was conducted by the Naval Research Laboratory to study the interference effects of high levels of radiation on radio transmission and

radar operations. Project participants installed receivers in Building 400 at the Control Point, 19 kilometers from ground zero. Scintillation detectors were installed at stations closer to ground zero, as were instruments to monitor the effects on transmitters of the electromagnetic signal generated by the detonation. Project personnel were not required to be in the area of their experiment at shot-time. Before the detonation, participants were in the field for 18 hours at distances ranging from 830 meters to 1,540 meters from ground zero. After the detonation and as radiation intensities permitted, personnel recovered the instruments (14; 38).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, was fielded by AFSWC to study how the air-ground interface affected the radiation produced by a nuclear detonation. Integrated gamma dose and neutron readings were obtained at points on the ground and at corresponding points at heights up to approximately 500 feet on the WHITNEY and SHASTA towers. Before shot-day, two project personnel prepared equipment at locations 1,530 and 2,430 meters from the KEPLER shot-tower. Following the detonation and when radiation intensities permitted, three project personnel performed recovery operations (14; 84).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics to measure the effects of the overpressure and wind gusts produced by a nuclear detonation on the HSS-1. The project also studied how blast effects might limit the HSS-1 in its delivery capabilities for antisubmarine warfare weapons. The helicopter, with a crew of two, left Indian Springs AFB at 0416, entering the shot area about 30 minutes later. Before the detonation, the helicopter flew two practice orbits inbound at 330 degrees. It began a final inbound run five minutes before the shot, making a 90-degree turn 40 seconds before the

detonation. At shot-time, the helicopter was tail-on to the blast, at a slant range of 6,150 meters from ground zero and at an altitude of 5,990 feet. The helicopter spent approximately 60 minutes in the shot area, returning to Indian Springs AFB at 0505 (7; 82).

Project 5.3, In-flight Structural Response of an FJ-4 Aircraft to a Nuclear Detonation, was designed by the Navy Bureau of Aeronautics to measure the thermal and blast wave response of the FJ-4 aircraft and to determine its performance and delivery capabilities during a nuclear detonation. The Naval Air Special Weapons Facility provided the aircrew for this project. North American Aviation, Incorporated, provided the specially instrumented test aircraft and the personnel required to maintain the aircraft.

The FJ-4 left Indian Springs AFB at 0415. At the time of the detonation, the aircraft was at an altitude of 9,650 feet and at a slant range of 9,650 meters from ground zero. At the time of shock arrival, the aircraft was in a level flight pattern, tail-on to the blast, and at a slant range of 3,420 meters from ground zero. The FJ-4 returned to Indian Springs AFB at 0520. Total gamma dose was recorded during the mission by film badges placed in the cockpit, ammunition bay, right drop tank, and nose-wheel well (7; 53).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop Aircraft calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center provided the aircraft and the two-man crew. Wright Air Development Center and

Northrop Aircraft together developed positioning methods and calculated the aircraft positions at detonation and shock arrival times.

The F-89D left Indian Springs AFB at 0440. Before the detonation, it flew one complete 12-minute holding pattern to position itself for the shot. At the detonation, the F-89D was at an altitude of 17,690 feet and at a slant range of 10,500 meters from the burst. When the initial shock wave arrived, the aircraft was at a slant range of 6,640 meters from ground zero. The aircraft was in the test area for approximately 30 minutes, returning to Indian Springs AFB at 0517. Film badges were placed for the mission in the pilot's and observer's positions (7; 74).

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 yield of the burst. The Indirect Bomb Damage Assessment NAROL system tested on this operation consisted of nets located at Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net had two unmanned slave stations and one manned station (50).

Project 6.5, Effects of Nuclear Detonations on Nike Hercules, was conducted by personnel from the White Sands Missile Range and Bell Telephone Laboratories. The objective was to investigate the effects of a nuclear detonation on the structural and operational characteristics of components, materials, and electronic systems of the Nike Hercules guided-missile system. To accomplish this objective, personnel exposed standard vacuum-tube and experimental transistorized versions of the guidance system. Three participants manned the radar station, 3,420 meters from ground zero, and an estimated three project personnel performed postshot activities (28).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following 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 detonations for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Working from six hours before to 30 minutes after the detonation, nine personnel established and then manned a camera station located on Mercury Highway, eight kilometers from ground zero at UTM coordinates 842988. An additional two or three participants took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. The aircraft, which spent approximately 100 minutes in the shot-area, flew a right-hand holding pattern at altitudes of 8,000 to 9,000 feet. EG and G personnel provided technical photography support to AFSWP and the AEC, operating three camera stations. One manned station was near the Control Point, and two unmanned stations were three to eight kilometers from ground zero (7; 27; 44).

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

The Los Alamos Scientific Laboratory was the only AEC weapons development laboratory participating at Shot KEPLER. The LASL Test Group conducted 18 projects at the shot. Of those 18 projects, only Project 11.2, Radiochemistry Sampling, involved DOD participation. The project required air support from AFSWC and is 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 13 projects at KEPLER. Of these 13 projects, four involved DOD personnel, as shown in table 4-2. Three of the projects required AFSWC support:

- Project 37.2 Riophysical Aspects of Fallout
- Project 37.2a Physical Aspects of Fallout
- Project 37.6 Application of Radio-ecology Techniques.

One C-47 aircraft with an AFSWC crew provided radio relay services for these projects. This participation is discussed in section 4.2.5.

Project 39.5, Radiation Dosimetry for Human Exposures, was conducted by the Air Force School of Aviation Medicine, along with several civilian agencies. The project collected information on the characteristics of neutron and gamma radiations at various distances from the detonation to evaluate the doses received by the survivors of Hiroshima and Nagasaki. The experiment required placing radiation detection devices approximately 450 meters from the shot tower and recovering them soon after the detonation, as radiation intensities permitted (51).

4.2.4 Department of Defense Operational Training Projects

The primary objectives of the operational training program at Shot KEPLER were to indoctrinate personnel and to test techniques and equipment. The Air Force sponsored four operational training projects at Shot KEPLER:

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

- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.1, Aerial Sampling Missions, involved Idaho and Oregon Air National Guard units that flew sample missions in conjunction with LASL Project 11.2. This activity is discussed under AFSWC operations, in the next section of this chapter.

Project 53.5, Aircrew Indoctrination (Early Cloud Penetration), was designed to enable Air Defense Command aircrews and commanders to witness a nuclear detonation and penetrate its cloud. Five T-33 aircraft, each with a crew of two, participated at Shot KEPLER (7).

Project 53.7, Indirect Bomb Damage Assessment, required staff from the Wright Air Development Center to install Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft from Indian Springs AFB. The F-89D, with a crew of two, flew a holding pattern at an altitude of 35,000 feet. The aircraft spent approximately 60 minutes in the shot area. After completing its mission, the F-89D returned to base, where it was decontaminated (7).

Project 53.9, Photographic Reconnaissance Training, was intended to indoctrinate Tennessee Air National Guard Tactical Reconnaissance units in photographic missions over a nuclear target. Two RF-84 aircraft, each operated by one pilot and carrying a photographer, flew a holding pattern until ten minutes after detonation, when they made a photographic run over ground zero at 10,000 feet. Upon completion of the run, the aircraft returned to George AFB for decontamination (1; 2; 7).

4.2.5 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling and sample courier missions for LASL Project 11.2, a radio-relay for CETG, and cloud-tracking missions, security sweeps, and aerial surveys. AFSWC also conducted a cloud penetration study.

Cloud Sampling

Two B-57B aircraft, each operated by two crewmen, and four F-84G aircraft, each operated by one pilot, collected samples of the cloud for LASL Project 11.2, Radiochemistry Sampling. A B-37 sampler control aircraft, with a pilot and LASL scientific advisor, directed the sampling. All four aircraft were from the 4926th Test Squadron (Sampling). In addition, four T-33 aircraft, each with two Idaho and Oregon Air National Guard personnel, collected cloud samples from an altitude of about 30,000 feet for operational training Project 53.1, Aerial Sampling Missions (2; 7).

The B-57B control aircraft left Indian Springs AFB before the detonation and was positioned by air controllers of the Air Operations Center outside the testing area. Upon reaching an altitude of approximately 30,000 to 35,000 feet, the control aircraft began its holding pattern. After the detonation, the control aircraft left its pattern to view the cloud. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire the samples. Between 90 minutes and two hours after the control aircraft took off, the B-57 samplers, followed by the F-84G and the T-33 sampler aircraft, left Indian Springs AFB. Guided by the control aircraft, the samplers entered the vicinity of the burst. In 30 to 35 minutes, after completing their sampling runs, most of the samplers left the area, landing at Indian Springs AFB. One or more of the B-57Bs, after completing the final sampling,run, accompanied the B-57B sampler control aircraft back to Indian Springs AFB (2; 7).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB to transport samples to various air bases for analysis by AEC nuclear weapons development laboratories. The 4900th Air Base Group from Kirtland AFB conducted the courier missions (2).

Radio Relay

One C-47, with a crew of three, flew radio-relay missions 2(nautical miles southeast of ground zero in support of CETG Projects 37.2, 37.2a, and 37.6. The aircraft remained aloft for three hours to provide the radio relay. Following the mission, the C-47 returned to its home base, where decontamination procedures were performed (2).

Cloud Tracking

Immediately after the detonation, one B-25 aircraft from Indian Springs AFB flew a cloud-tracking mission over and beyond the NTS. The aircraft, which flew at an altitude of 22,000 feet, had a crew of four (2; 7).

Cloud Penetration

Beginning earlier in Operation PLUMBBOB and continuing at Shot KEPLER, AFSWC conducted a study to determine whether the Air Force should monitor the accumulation of radioactive contaminants on aircraft that penetrated the cloud resulting from a detonation. A T-33 from the 4926th Test Squadron, piloted by an officer from Air Support Group Headquarters and carrying one observer, penetrated the KEPLER cloud. The aircraft flew at an altitude of 30,000 feet and spent 20 minutes in the air. Both pilot and observer wore lead vests instrumented with 15 to 25 film badges. Six additional film badges were taped to the ejection seats. Upon returning to Indian Springs AFB after the

flight, the T-33 was not decontaminated, but a 24-hour period was permitted for radiation decay before maintenance was performed on the aircraft. The pilot and observer boarded and departed from the aircraft using standard ladders, not the forklift procedure used in other AFSWC missions. The pilot and observer were both closely monitored and decontaminated following the flight. The aircraft was decontaminated on 25 July after participating at Shot OWENS (1; 2; 7).

Security Sweeps.

Before the shot, two L-20 aircraft were dispatched from Yucca airstrip near Camp Mercury to perform a security sweep mission over the test area. The aircraft had a crew of at least two since the security sweep called for a security guard to accompany the pilot (7; 64).

Helicopter Surveys

After the detonation, AFSWC personnel flew helicopter survey missions over the shot area and non-test areas to record radiation intensities. One H-21 helicopter, with a crew of two AFSWC pilots and two REECo monitors, flew from the Control Point helicopter pad at 0735. After recording the final radiation intensity at 0759, the helicopter returned to the helicopter pad, where the crew was monitored and decontaminated as required (64).

4.3 RADIATION PROTECTION AT SHOT KEPLER

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposures 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 porgrams. The available information

includes NTO isointensity contour maps, monitoring data, and some Desert Rock personnel dosimetry data. Radiological safety procedures and total dose information for Operation PLUMBBOB are described in the series volume.

Dosimetry

For the detonation of KEPLER, the NTO Dosimetry and Records Section issued 222 film badges and 257 pocket dosimeters (83). Documentation does not indicate whether anyone exceeded the 2 roentgen limit at Shot KEPLER or whether any such individuals are reported for Shot OWENS, fired the day after KEPLER (64).

Several Desert Rock personnel exceeded 3 roentgens from their participation at Shot KEPLER. Two Desert Rock radiological safety personnel accrued 5.5 and 5.7 roentgens, which was over the 5-roentgen limit. Three Project 50.8 personnel manning the radar station 4660 meters from ground zero accrued exposures over 3 roentgens. Another seven Project 50.8 personnel who conducted air and ground surveys exceeded 3 roentgens; three of these were in excess of 5 roentgens. Although these individuals were barred from the forward area, one had received an additional exposure of 2.2 roentgens by the time the film badge showing more than 5 roentgens was developed. This individual's total of 8.64 roentgens was the highest exposure that can be attributed to the shots in this volume (57; 64).

Logistics

For Shot KEPLER, the General Supply Section issued anti-contamination clothing to 460 persons. The clothing included coveralls, shoe covers, and respirators (83).

Monitoring

Eleven men in vehicles began the initial ground survey at 0525 hours. They reported the last intensity in the shot area at 0654 hours. Ground resurveys were conducted for several days following the detonation. A helicopter survey, conducted by an AFSWC crew of two and two REECo monitors, began at 0735 hours and reported its final reading about 25 minutes later (83).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during KEPLER (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isointensity contour maps from the radiation intensity data gathered by the ground survey teams. Figure 4-1 presents the isointensity plot developed from information gained during the initial survey. The data resulting from the resurveys on 24 July, 25 July, 26 July, and 27 July are shown in figure 4-2 (83).

In addition to its other activities, the Plotting and Briefing Branch issued access permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 278 access permits during KEPLER (83).

Decontamination

Because of the fallout from KEPLER, all observers and 49 vehicles required decontamination, which probably took place at the Desert Rock decontamination station. Decontamination to acceptable levels was accomplished in an hour by brushing personnel with brooms and by washing vehicles. Decontamination was facilitated because, of the large fallout particles (72).

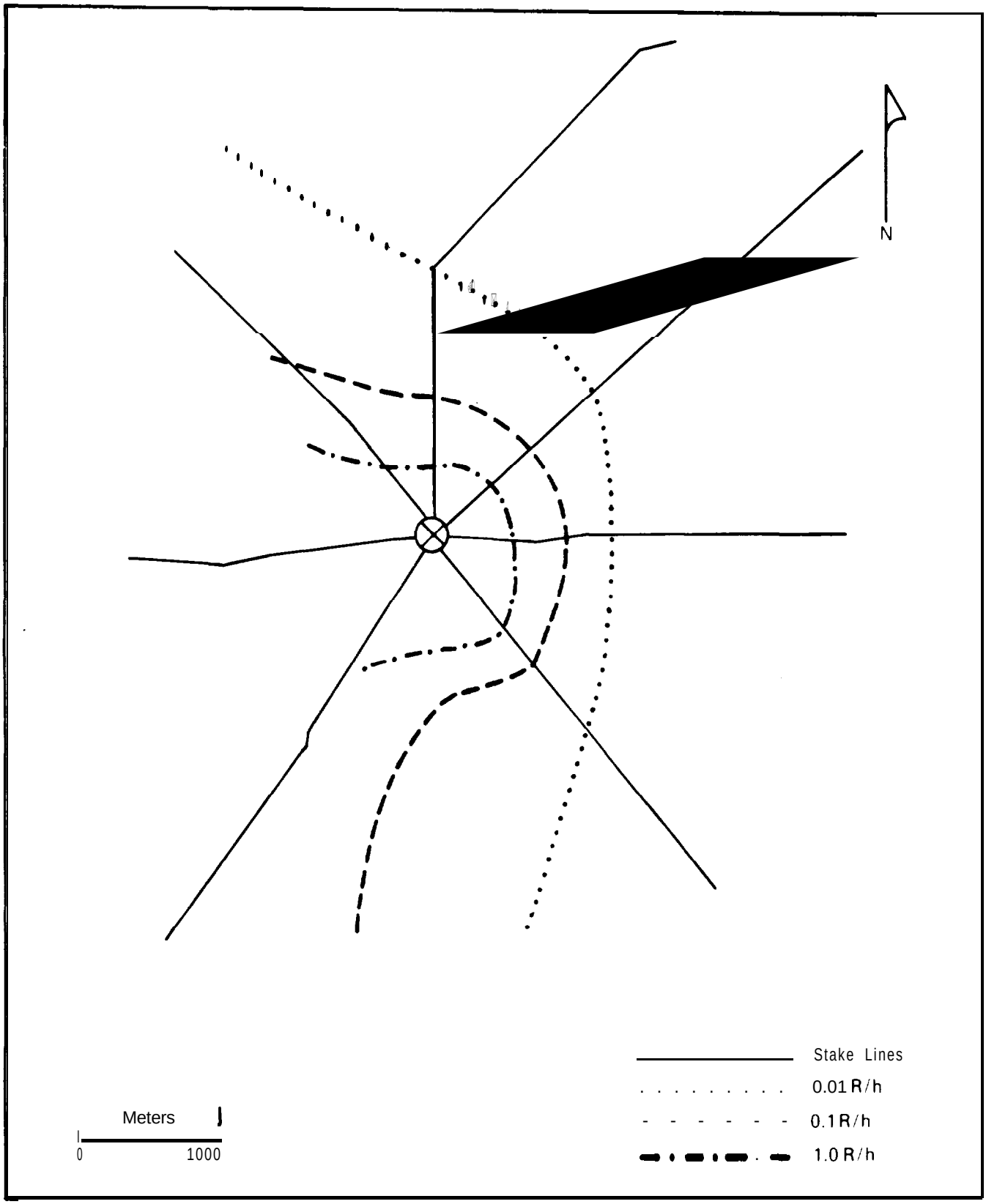
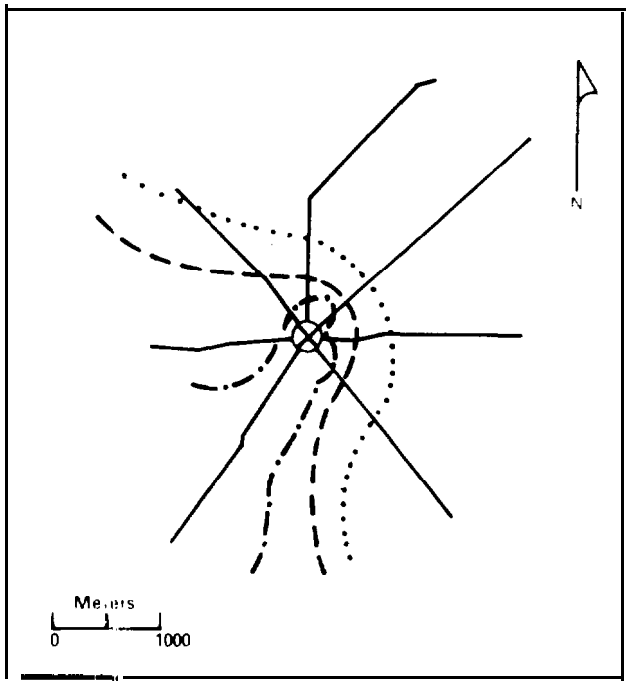
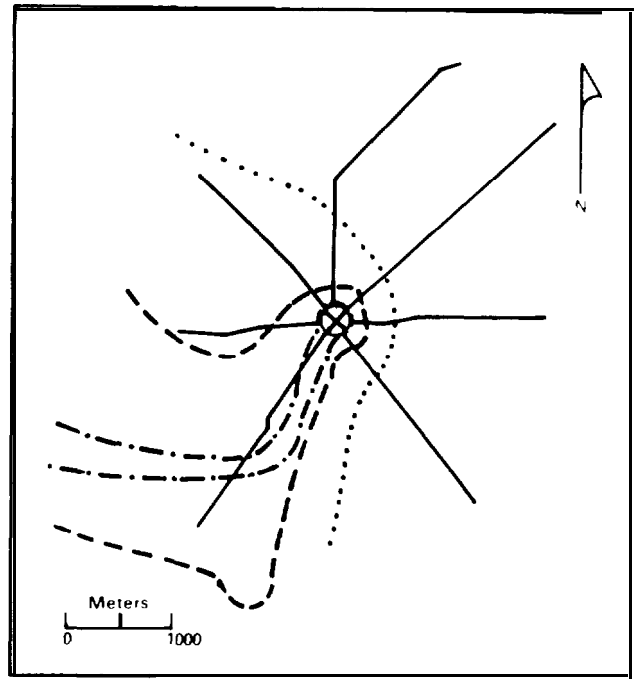


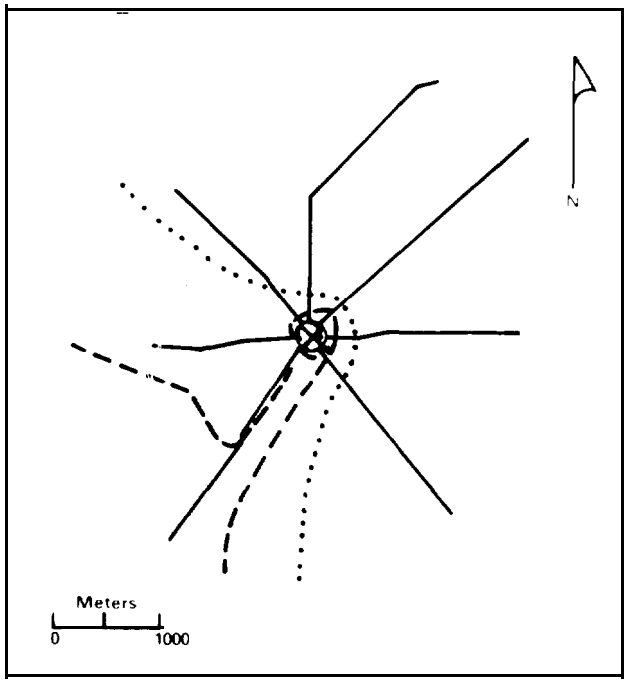
Figure 4-l: INITIAL SURVEY FOR SHOT KEPLER, 24 JULY 1957, MID-TIME 0637



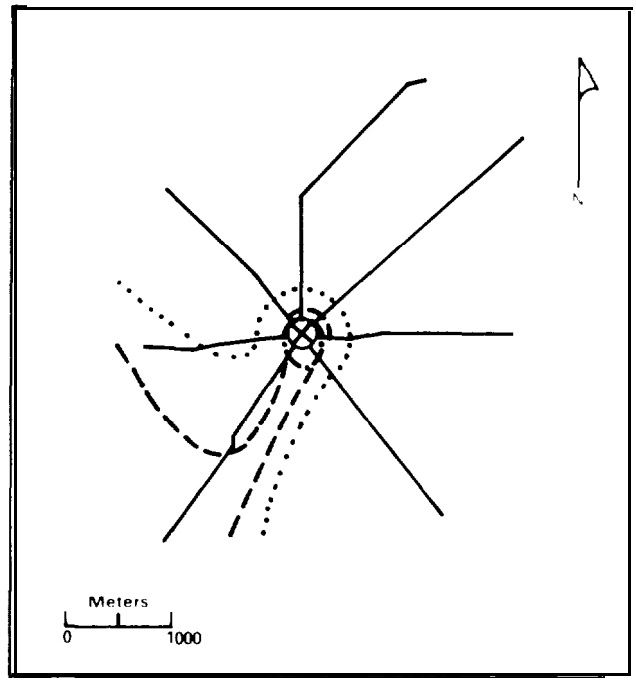
24 July 1957, Mid-Time: 1124



25 July 1957, Mid-Time: 0937



26 July 1957, Mid-Time 1057



27 July 1957, Mid-Time: 0636

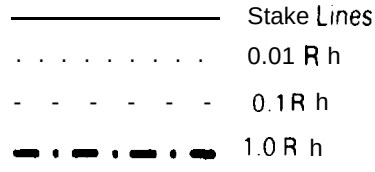


Figure 4-2: SUBSEQUENT SURVEYS FOR SHOT KEPLER

SHOT OWENS SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISES:	Desert Rock VII and VIII
DATE/TIME:	25 July 1957, 0630 hours
YIELD:	9.7 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 military equipment and tactics and to indoctrinate personnel in the effects of nuclear detonations.

Weather: At shot-time, the temperature was 20°C, and surface winds were calm. Winds were 14 knots from the south at 10,000 feet, 17 knots from the south at 20,000 feet, 30 knots from the southwest at 30,0000 feet, and 43 knots from the south-southwest at 35,000 feet.

Radiation Data: About one hour after the detonation, gamma intensities of 1.0 H/h or more were confined to within 1,500 meters of ground zero.

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 5

SHOT OWENS

Shot OWENS was detonated with a yield of 9.7 kilotons at 0630 hours Pacific Daylight Time on 25 July 1957. The device was suspended from a balloon 500 feet above the ground over Area 9 of the NTS. Moisture conditions aloft resulted in an extensive ice cap forming over the top of the radioactive cloud as it ascended. The cloud, which reached a height of 35,000 feet, broke cleanly from the stem and moved to the north-northeast (31).

5.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT OWENS

Aproximatelg 900 Desert Rock troops took part in projects associated with Shot OWENS: two troop observer indoctrination projects and two technical service projects, as indicated in table 5-l. The table also lists 210 troops from Task Force WARRIOR and the 21 Camp Desert Rock support troops who observed the detonation.

Table 5-l: EXERCISE DESERT ROCK PROJECTS, SHOT OWENS

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50.2	Troop Observers	Army	77
			Civilian	*
	53.3	Aircrew Observers	Air Force	1
	—	—	Task Force WARRIOR	210
	—		Camp Desert Rock Support Troops	21
Technical Service	50.3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Fort Huachuca, Arizona; Fort Meade, Maryland	32
	58.8	Detection of Atomic Burst and Radioactive Fallout	495th'Antiaircraft Artillery Missile Battalion; Army Air Defense Board; Army Artillery Board; Army Artillery and Guided Missile School; Air Weather Service	557

* Unknown

5.1.1 Troop Observer Indoctrination Projects

Four groups of observers participated at Shot OWENS, as indicated in table 5-l. The 210 Task Force WARRIOR troops observed the detonation as part of their rehearsal for Shot SMOKY, conducted on 31 August 1957. The OWENS observers viewed the detonation from the Desert Rock decontamination station at IJTM coordinates 843895, about 20 kilometers south of ground zero (41).

5.1.2 Technical Service Projects

As indicated in table 5-1, two technical service projects were conducted at Shot OWENS to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Pro.ject 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Huachuca., and seven participants from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. Three remote radar sets were located southeast of Yucca Lake, approximately 25 kilometers from ground zero. The fallout prediction unit for this project operated from a van located next to the weather station at Camp Mercury (20; 41; 49).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Air Defense Board, Army Artillery Board, Army Artillery and Guided Missile School, and Air Weather Service. The objectives were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of an atomic detonation

- Track targets and guided missiles through a nuclear cloud or fireball.

An estimated 557 DOD personnel took part in this project. To determine the position, height of burst, and yield of the detonation, participants operated 24 onsite and offsite radar, camera, and other instrument stations located 24 to 70 kilometers from ground zero. The control point was at UTM coordinates 829900, 21 kilometers southwest of ground zero. To test the attenuation of the Nike Hercules missile control signal, a B-26 aircraft, with a crew of three, positioned itself so that the cloud was between the aircraft and a Nike Hercules ground site. The aircraft was 15 miles from the balloon at the time of the detonation and spent about 30 minutes in the area (12; 41; 49; 77; 79; 80).

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

In addition to the Exercise Desert Rock personnel, other DOD personnel took part in test activities during Shot OWENS that required them to enter the forward area. Table 5-2 identifies the test group projects involving DOD participants. The Air Force sponsored three operational training projects during the shot. Besides the test group and the operational training projects, AFSWC and other support activities accounted for a number of DOD participants. The Air Force Special Weapons Center supported one test group project and flew routine missions for the Test Manager.

5.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted 15 projects at Shot OWENS, as listed in table 5-2.

Table 5-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT OWENS

Project	Title	Participants	Estimated DOD Personnel
	Weapons Effects Test Group		
1.1	Basic Airbiast Phenomena	Ballistic Research Laboratories Laboratory	*
1.2	Field Test of a System for Measuring Blast Phenomena by Airborne Gauges	Naval Ordnance Laboratory; American Machine and Foundry Company; EG and G	10
2.1	Soil Activation by Neutrons	Army Chemical Warfare Laboratories	6
2.2	Neutron-induced Activity in Soil Elements	Naval Radiological Defense Laboratory	16
2.3	Neutron Flux from Selected Nuclear Devices	Army Chemical Warfare Laboratories	6
2.4	Neutron and Initial-gamma Shielding	Army Chemical Warfare Laboratories; Evans Signal Laboratory	*
2.5	Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soils	Army Chemical Warfare Laboratories	5
2.7	Radio-wave Attenuation Studies	Naval Research Laboratory	11
2.10	Initial Neutron and Gamma Air-earth Interface Measurements	Air Force Special Weapons Center	8
5.1	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation	Navy Bureau of Aeronautics	2
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
6.2	Measurement of the Magnetic Component of the Electromagnetic Field near a Nuclear Detonation	Diamond Ordnance Fuze Laboratories	3
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	14
9.1	Support Photography	AFSWP; Military Air Transport Service; EG and G	11
	University of California Radiation Laboratory Test Group		
21.2	Radiochemistry Sampling	Air Force Special Weapons Center	9

* Unknown

Project 1.1, Basic Airblast Phenomena, was conducted by the Ballistic Research Laboratories to:

- Obtain data on overpressure and dynamic pressure versus time as a function of distance
- Evaluate gauge designs, instrument components, and measurement techniques.

Before the shot, participants installed pressure-time gauges at stations 600 to 6,600 meters due south of ground zero. Personnel recovered the gauges when radiation levels in the area had declined to permissible levels (21).

Project 1.2, Field Test of a System for Measuring Blast Phenomena by Airborne Gauges, was conducted by the Naval Ordnance Laboratory, American Machine and Foundry Company, and EG and G. The project was to (37):

- Field test instrumentation under development for use in two underwater shots planned for Operation HARDTACK I, a subsequent nuclear weapons test series
- Train personnel to handle the equipment under operational conditions.

From 1800 to 2200 hours on the day before the detonation, ten project participants prepared three instrumented rockets, which were later fired to record airblast from a station 4,610 meters southwest of ground zero. To determine the actual launching time of each rocket with respect to the time of detonation, EG and G personnel erected camera stations 41, 43, 44, and 45 kilometers south of ground zero. They loaded the cameras between 1800 and 2200 hours on the day before the shot (12; 37).

Project 2.1, Soil Activation by Neutrons, was conducted by the Army Chemical Warfare Laboratories to measure neutron-induced radioactivity in the soil. The data were to be used to predict the radiological hazard to people from such soil activation. Six

personnel installed soil samples south-southwest of ground zero from 1900 to 2300 hours the night before the detonation. Three personnel also manned a station near RJY, 7,620 meters south of ground zero at UTM coordinates 853033. They remained there from five hours before to five minutes after the detonation, at which time they started a sample recovery mission lasting 15 minutes. Five minutes after the detonation, two additional personnel proceeded by helicopter to Area 9 and initiated an aerial survey of points 460, 370, 270, and 180 meters from ground zero (12; 55).

Project 2.2, Neutron-induced Activity in Soil Elements, was conducted by the Naval Radiological Defense Laboratory to measure the neutron-induced radioactivity in soils of varying types and composition. Three personnel spent two hours on the day before shot-day removing plastic covers from four soil stations. An additional 13 personnel proceeded to a manned station near BJY, 7,620 meters south of ground zero at UTM coordinates 853033. They remained there from 2030 hours on the night before the shot until four hours after the detonation, at which time they were replaced by personnel who manned the station through 1200 hours two days after the detonation. Personnel left the manned station after the detonation to retrieve canister samples from the other stations. One party of three retrieved samples from a station 460 meters from ground zero (Cooklean). Another party of five recovered samples one hour after the detonation. In addition, a helicopter with four personnel recovered samples three minutes after the detonation (12; 23).

Project 2.3, Neutron Flux from Selected Nuclear Devices, was conducted by the Army Chemical Warfare Laboratories to measure the output of neutrons from the detonation and to determine the energy of the neutrons and the distances they traveled in the air. Neutron measurements were made as a function of distance from the point of detonation. The measurements involved the use of small disks of selected materials that detected the neutrons in each of several energv ranges.

Since neutron-induced radiation decays rapidly, it was essential to return the detectors to the laboratory for analysis as soon after the shot as possible. To aid in this prompt retrieval, the five or six different types of neutron detectors were attached to a cable laid along the ground, starting 90 meters northwest of the shot balloon and extending to 920 meters from the balloon. A few minutes after the detonation, two project personnel and a radiation monitor, all clothed in radiation protection gear, drove a pickup truck to the far end of the cable. While the monitor measured the radiation and clocked their time in the area, the project personnel quickly secured the end of the cable to the back of the pickup truck. Then all three climbed back aboard the truck and drove out of the area, dragging out the neutron-detection arrays. Once beyond the radiation zone, they stopped the truck, detached the detectors from the cable, and put them in sealed storage containers in the truck. After proceeding through decontamination, they took the samples to the laboratory at Camp Mercury for analysis (70).

In support of the project, six personnel manned the station at UTM coordinates 853033, located near BJY, 7,620 meters south of ground zero. They were at the station from four hours before to five minutes after the detonation. At that time, they pulled the instrument cable to a low radiation area. They spent about 30 minutes in the shot area (12; 70).

Project 2.4, Neutron and Initial-gamma Shielding, was conducted by the Army Chemical Warfare Laboratories and Evans Signal Laboratorv to perform neutron- and gamma-attenuation studies in soil to obtain the variation of gamma dose, neutron dose, and neutron spectrum with depth. Project personnel packed three three-foot steel cubes with soil from Area 7, Yucca Flat. The soil was prepared by Project 2.1 personnel. The cubes were then set in the ground, tops flush with the surface, at distances of 180, 200, and 360 meters from ground zero, adjacent to the

Project 2.1 stations. Neutron and gamma detectors were arranged in each box to eliminate mutual shielding of the detectors in the line of sight to the shot. The detectors were attached to cables for rapid recovery. Personnel manned the station at UTM coordinates 853033 from four-and-one-half hours before until three minutes after the detonation. They then proceeded to an area 910 meters southwest of ground zero to pull out the instrument cable (12; 78).

Project 2.5, Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soils, was conducted by the Army Chemical Warfare Laboratories to:

- Determine initial gamma intensity versus time and distance, both on the ground and in the air
- Measure the neutron-induced gamma radiation as a function of time.

For the first objective, five personnel connected instruments to Project 2.10 balloons from 1800 hours on the day before the detonation to 0330 hours on shot-day (50). For the second objective, measurements were made at seven stations, 460 to 3,270 meters northeast of ground zero, from one minute to eight hours after the detonation. The measurements were done in support of Project 2.1, Soil Activation by Neutrons, to test various theories for predicting gamma radiation from neutron-induced activity in soils (12; 22).

Project 2.7, Radio-wave Attenuation Studies, was developed by the Naval Research Laboratory to studv the interference effects of high levels of radiation on radio transmission and radar operations. Project participants installed receivers in Building 400 at the Control Point, about 20 kilometers from ground zero. Scintillation detectors were installed at two stations closer to ground zero, as were instruments to monitor

the effects on transmitters of the electromagnetic signal generated by the detonation. Two parties of seven and four personnel prepared equipment at the two stations from 2200 hours on the day before the detonation until 0230 on shot-day. A party of nine recovered film data from the stations beginning eight hours after the detonation (12; 38).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, was fielded by AFSWC to study how the air-ground interface affected the radiation produced by a nuclear detonation. This objective was accomplished with two measurements. Integrated gamma dose and neutron readings were obtained at points on the ground and at corresponding points at heights up to approximately 500 feet on the WHITNEY and SHASTA towers. Working from 1800 to 2400 hours on the day before the detonation, eight personnel inflated balloons, installed instruments, and moored balloons at four stations in Area 9. They recovered the instruments and balloons from two to four hours after the detonation (12; 84).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics to measure the the effects of overpressure and wind gusts produced by a nuclear detonation on the HSS-1 helicopter. The project also studied how blast effects might limit the HSS-1 in its delivery capabilities for antisubmarine warfare weapons.

The helicopter, with a crew of two, left Indian Springs AFB at 0536, entering the shot area about 30 minutes later. The HSS-1 then flew two practice orbits inbound at 330 degrees. It began a final run five minutes before the detonation, making a 90-degree turn 40 seconds before the detonation. At shot-time, the helicopter was tail-on to the detonation, at a slant range of 6,425 meters from ground zero and at an altitude of 7,290 feet.

The helicopter spent approximately 60 minutes in the shot area, returning to Indian Springs APB at 0405 (8; 82).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop Aircraft calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center provided both the aircraft and the two-man crew. Wright Air Development Center and Northrop Aircraft together developed positioning methods and calculated the aircraft positions at detonation and shock arrival times.

The aircraft left Indian Springs AFB at 0600. Before the detonation, it flew one complete 12-minute pattern to position itself for the shot. At the detonation, the F-89D was at a slant range of 10,080 meters from the burst. When the initial shock wave arrived, the aircraft was at a slant range of 6,315 meters from ground zero. The aircraft was in the test area for approximately 30 minutes, returning to Indian Springs AFB at 0636 hours. During the mission, film badges were placed in the pilot's and observer's positions (8; 74).

Project 6.2, Measurement of the Magnetic Component of the Electromagnetic Field near a Nuclear Detonation, was conducted by the Diamond Ordnance Fuze Laboratories. The project determined the characteristics of the electromagnetic pulse from a nuclear detonation as a function of time and distance. This study used five self-powered recording stations located at intervals of about 250 to 3,000 meters from ground zero.

Before the detonation, project personnel installed sensors and recording devices at each station. They buried the devices in holes lined with concrete and then covered with sandbags. Recovery operations began about four hours after the detonation and involved three men, who spent ten minutes in the shot area (12; 35).

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 yield of the burst. The Indirect Bomb Damage Assessment NAHOL system tested on 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 (50).

Project 6.5, Effects of Nuclear Detonations on Nike Hercules, investigated the effects of radiation produced by a nuclear detonation on the structural and operational characteristics of components, materials, and electronic systems of the Nike Hercules guided-missile system. To accomplish this objective, standard vacuum-tube and experimental transistorized versions of the guidance system were exposed at three sites, one of which was 590 feet below the point of detonation. The furthest site was 670 meters from ground zero. A manned radar station was 3,420 meters from ground zero, at UTM coordinates 765031.

Six personnel checked equipment at the exposure sites from 1800 to 2200 hours on the night before the detonation. At 2300 hours on the same night, 14 personnel proceeded to the manned station, where they remained until two hours after shot-time. A party of five personnel then proceeded to Area 9 to recover equipment and instrumentation (12; 28).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following 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 detonations for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Eight men proceeded to the station at the BJY, UTM coordinates 843022, six hours before the detonation and established a manned station, from which they took pictures at shot-time and until 30 minutes after the detonation. Two or three personnel took pictures from a C-47 aircraft operated bv personnel from the Military Air Transport Service. The aircraft, which spent approximately 100 minutes in the shot area, flew a right-hand holding pattern at an altitude of 8,000 to 9,000 feet. EG and G personnel provided technical photography support to AFSWP and the AEC, operating five camera stations to record fireball and cloud growth. One manned camera station was near the Control Point, and four unmanned stations were three to eight kilometers from ground zero. In addition to these tasks, project personnel provided technical photographic support for Projects 1.2, 2.10, and 6.3 (8; 12; 27; 41).

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

The University of California Radiation Laboratory was the onlv AEC weapons development laboratory that involved DOD

personnel in its activities at Shot OWENS. The four projects fielded by the Los Alamos Scientific Laboratory Test Group did not include DOD participation. Among the six UCRL projects, only Project 21.2, Radiochemistry Sampling, engaged DOD personnel. The project required air support from AFSWC and is discussed in section 5.2.4.

5.2.3 Department of Defense Operational Training Projects

The primary objectives of the operational training program were to indoctrinate personnel and to test techniques and equipment. The Air Force sponsored three operational training projects at Shot OWENS:

- Project 53.1, Aerial Sampling Mission
- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.1, Aerial Sampling Missions, involved Idaho and Oregon Air National Guard units that flew sample missions in conjunction with UCRL Project 21.2. This activity is discussed under AFSWC operations, in the next section of this chapter.

Project 53.7, Indirect Bomb Damage Assessment, required staff from the Wright Air Development Center to install Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft (serial number 412) from Indian Springs AFB. The F-89D, with a crew of two, left Indian Springs AFB at 0537 hours and then flew a right-hand pattern at an altitude of 35,000 feet, 70 nautical miles east of ground zero. The aircraft spent approximately 60 minutes in the shot area and then returned to Indian Springs AFB, landing at 0647 (8).

Project 53.9, Photographic Mission, indoctrinated Air National Guard Tactical Reconnaissance units in conducting photographic missions over a nuclear target. Two RF-84 aircraft, each operated by one pilot and carrying one photographer from the Tennessee Air National Guard, flew holding patterns until ten minutes after the detonation, when the aircraft made photographic runs over ground zero at 10,000 feet. Upon completion of the run, the aircraft returned to George AFH for decontamination (2; 8).

S.2.4 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling and sample courier missions for UCRL Project 21.2, and cloud-tracking missions, security sweeps, and aerial surveys. In addition, AFSWC performed one mission of its own, a cloud-penetration study.

Cloud Sampling

One H-57R aircraft, operated by two crewmen, and six F-84G aircraft, each operated by one pilot, collected samples of the cloud for UCRL Project 21.2, Radiochemistry Sampling. A B-57B sampler control aircraft (serial number 501), operated by a pilot and carrying a UCRL scientific advisor, directed the sampling. Pilots of the 4926th Test Squadron (Sampling) flew the aircraft. In addition, four T-33 aircraft, each with two Idaho and Oregon Air National Guard personnel, collected cloud samples at an altitude of about 30,000 feet for Project 53.1, Aerial Sampling Missions (8).

The control aircraft left Indian Springs at 0610 and was positioned by air controllers of the Air Operations Center outside the testing area. At 0625 hours, upon reaching an altitude of approximately 30,000 to 35,000 feet, the control aircraft began its orbit pattern. After the detonation, the control aircraft left its orbit to view the cloud. Within 80

minutes after the detonation, the B-57 sampler aircraft, followed by the six F-84G and four T-33 sampler aircraft, left Indian Springs AFB. Guided by the control aircraft, the samplers entered the OWENS cloud area. The scientific advisor aboard the control aircraft then directed the samplers to penetrate the cloud as necessary to acquire the samples. After completing the sampling mission, the samplers left the area, landing at Indian Springs AFB between 0810 and 0840 (1; 2; 8).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB on shot-day to transport samples to various air bases for analysis by AEC nuclear weapons design laboratories. The 4901st Air Base Wing from Kirtland AFB conducted these courier missions (2).

Cloud Tracking

Immediately after the detonation, one B-25 aircraft (serial number 532) from Indian Springs AFB flew a cloud-tracking mission over and beyond the Nevada Test Site. The aircraft, which flew at an altitude of 15,000 feet, had a crew of ten (8).

Security Sweeps

Before the shot, two L-20 aircraft were dispatched from Yucca airstrip near Camp Mercury to perform a security sweep mission over the test area. The aircraft had a crew of at least two since the security sweep called for a security guard to accompany the pilot (65).

Helicopter Surveys

After the detonation, AFSWC flew helicopter survey missions over the shot area and non-test areas to record radiation intensities. Two H-21 helicopters were used, each with a crew of two pilots and three REECo monitors. The initial survey began

about three hours after the detonation. The highest intensity recorded was 23 R/h, encountered 500 feet above ground zero. Resurveys were conducted one, two, and three days after the shot. In addition to the radiation surveys, one H-21 helicopter, with an AFSWC crew of two and three REECo personnel, including a monitor, conducted a damage survey, beginning 15 minutes after the detonation and lasting about 40 minutes (65).

Cloud Penetration

Beginning earlier in Operation PLUMBBOB and continuing at Shot OWENS, AFSWC conducted a study to determine whether the Air Force should monitor the accumulation of radioactive contaminants on cloud-penetrating aircraft. A T-33 (serial number 105) from the 4926th Test Squadron, piloted bv an officer from Air Support Group Headquarters and carrying one observer, left Indian Springs AFB at 0725 hours and then penetrated the OWENS cloud. The aircraft flew at an altitude of 30,000 feet and spent about 30 minutes in the shot area. Both pilot and observer wore lead vests instrumented with 15 to 25 film badges. Six additional film badges were taped to the ejection seats. Upon returning to Indian Springs AFB at 0810 hours, the aircraft was not decontaminated, but a 24-hour period was permitted for radiation decay before maintenance was performed on the T-33. The pilot and observer boarded and departed from the aircraft using standard ladders, not the forklift procedure used in other AFSWC missions. The pilot and observer were both closely monitored and decontaminated following the flight, and the aircraft was decontaminated sometime after the OWENS shot (1; 2; 8).

5.3 RADIATION PROTECTION AT SHOT OWENS

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

During the period covering the 25 July detonation of OWENS, the Dosimetry and Records Section issued 5,230 film badges and 1,196 pocket dosimeters. Dosimetry readings indicate that 29 DOD participants received cumulative gamma exposures greater the 2.0 roentgens. Five of these had exposures over 3.0 roentgens, from 3.14 to 4.04 roentgens. Those over 3.0 roentgens were personnel from the Chemical Weapons Laboratory and Naval Radiological Defense Laboratory who had been involved in very early recovery operations for Program 2. Of these, two Naval Radiological Defense Laboratory participants performed recovery operations in an area with an intensity of more than 10 R/h without the Test Director's permission. The two Chemical Weapons Laboratory personnel failed to shield samples properly during their return to Camp Mercury. Sixteen of the rest were AFSWC participants, including ten cloud samplers and aerial survey helicopter pilots. The remaining eight personnel came from the Ballistic Research Laboratories, the Diamond Ordnance Fuse Laboratory, and AFSWP (61; 65; 83).

Logistics

For Shot OWENS, the General Supply Section issued protective clothing to 3,020 people. The clothing included coveralls, shoe covers, and respirators, (83).

Monitoring

Twelve men in vehicles began the initial ground survey at 0645 hours. They reported the last intensity in the shot area at 0736 hours. Two H-21 helicopters, each with two AFSWC pilots and three REECo personnel, conducted aerial surveys. Ground and aerial resurveys were conducted for several days following the detonation (65).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during the OWENS event (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isointensity contour maps from the radiation intensity data gathered by the ground survey teams. Figure 5-l presents the isointensity plot developed from information gained during the initial survey. The data resulting from the resurveys on 25 July, 26 July, 27 July, and 28 July are shown in figure 5-2 (83).

In addition to its other activities, the Plotting and Briefing Branch issued access permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 3,003 access permits during OWENS (83).

Decontamination

During the period covering Shot OWENS, the Vehicle and Equipment Decontamination Section decontaminated 210 vehicles (83).

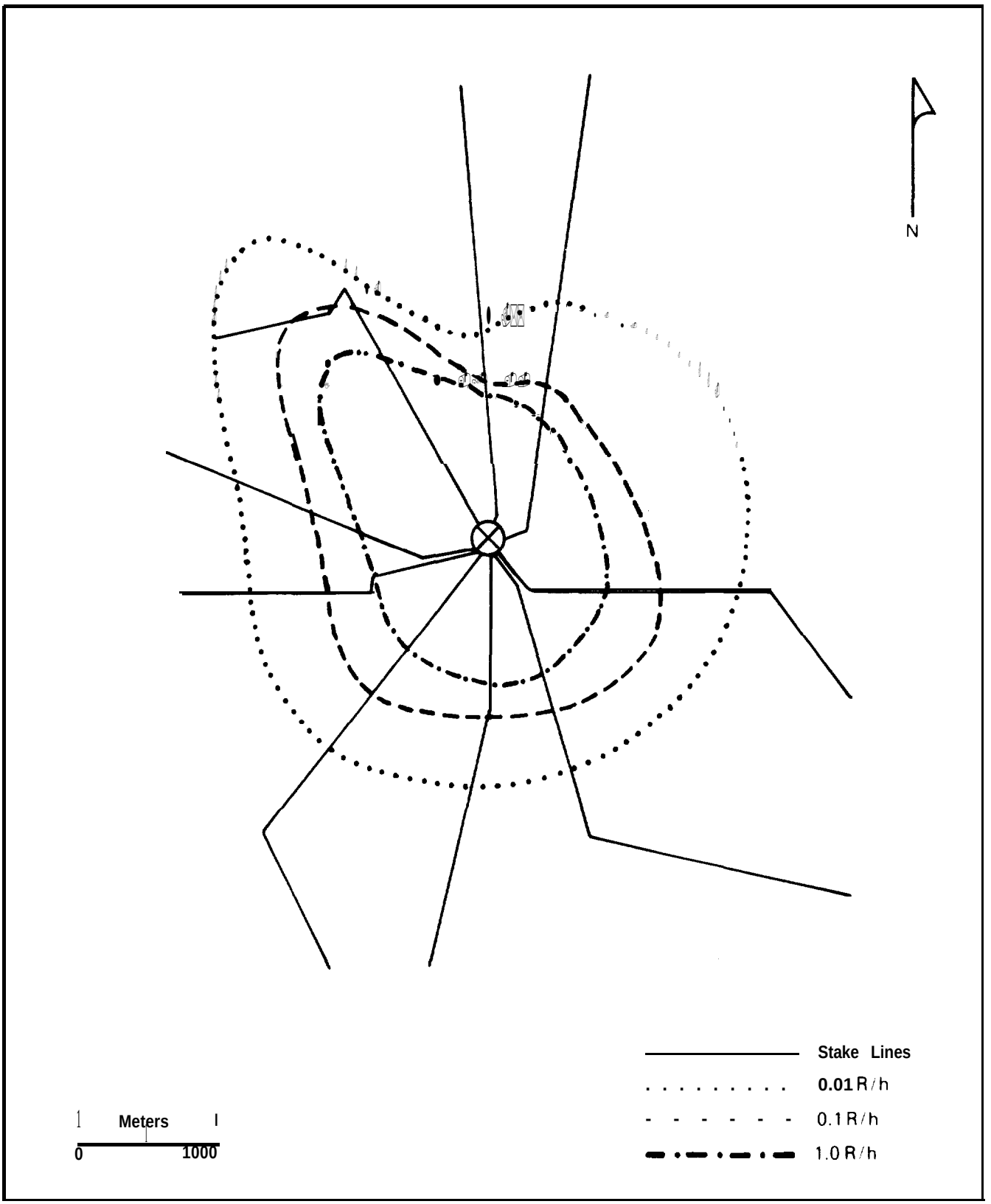
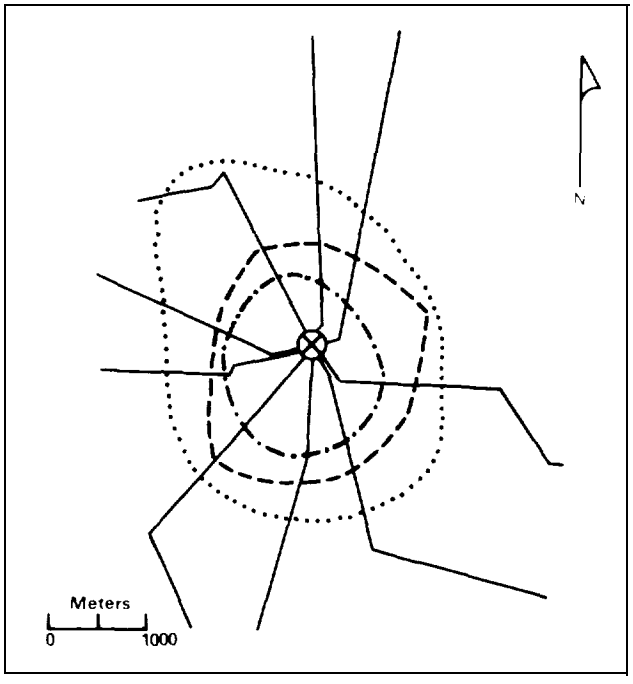
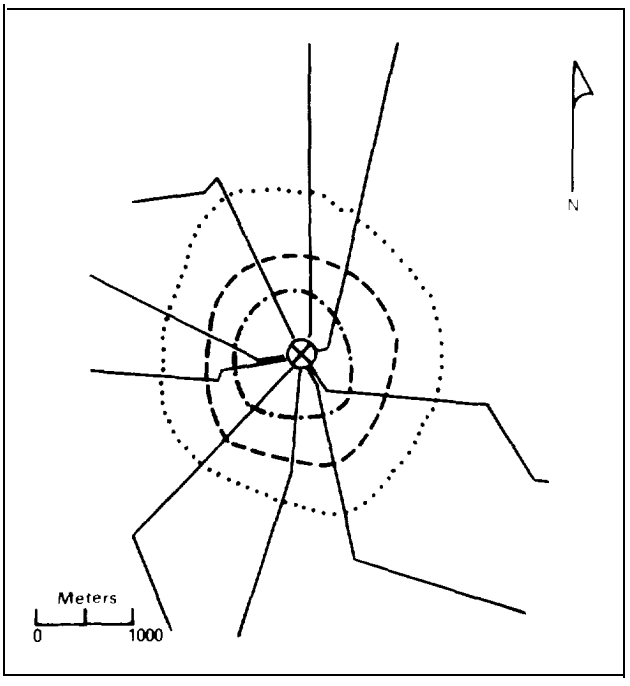


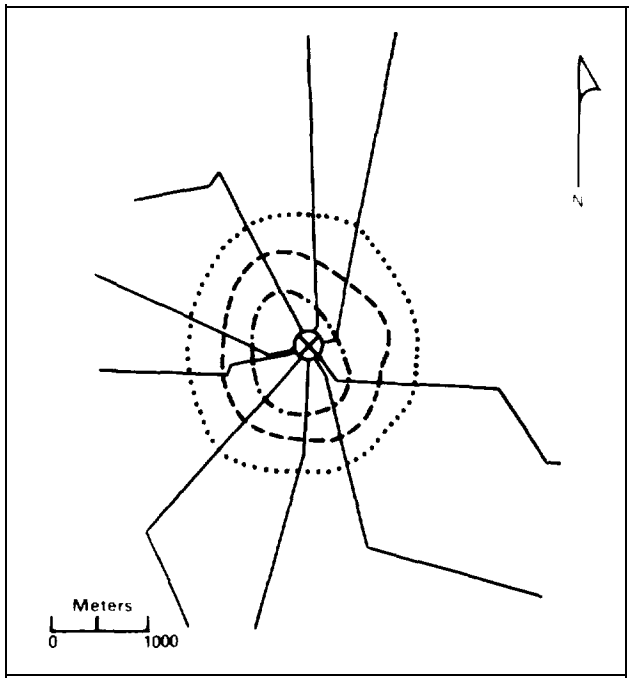
Figure 5-I: INITIAL SURVEY FOR SHOT OWENS, 25 JULY 1957, MID-TIME 0726



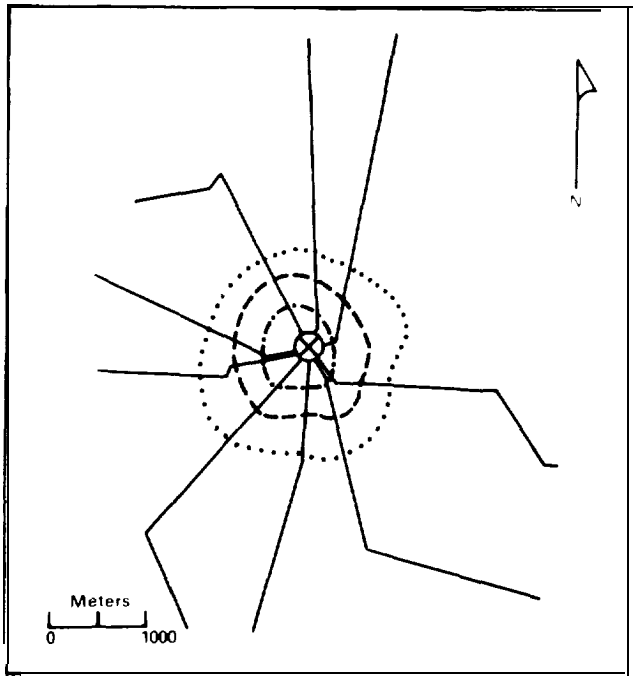
25 July 1957, Mid-Time: 1233



26 July 1957, Mid-Time: 0750



27 July 1957, Mid-Time: 0637



28 July 1957, Mid-Time: 0745

Stake Lines
0.01 R/h
0.1 R/h
1.0 *Rih*

Figure 5-2: SUBSEQUENT SURVEYS FOR SHOT OWENS

SHOT STOKES SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXEHCISE:	Desert Rock VII and VIII
DATE/TIME:	7 August 1957, 0525 hours
YIELD:	19 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 and tactics and to indoctrinate personnel in the effects of nuclear detonations.

Weather: At shot-time, the temperature was 17°C, and surface winds were calm. Winds were eight knots from the south-southeast at 10,000 feet, 41 knots from the south at 20,000 feet, 66 knots from the south-southwest at 30,000 feet, and 73 knots from the south-southwest at 37,000 feet.

Radiation Data: About 30 minutes after the detonation, radiation intensities of 1.0 R/h or more were confined to within about 1,000 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, other contractors.

CHAPTER 6

SHOT STOKES

Shot STOKES was detonated with a yield of 19 kilotons at 0525 hours Pacific Daylight Time on 7 August 1957. The device was suspended from a balloon 1,500 feet above Area 7 of the NTS. The cloud resulting from the detonation rose to a height of 37,000 feet and was blown generally north-northeast. Fallout resulted offsite to the north. Onsite radiation was in the form of neutron-induced activity around ground zero (31). Figure 6-1 shows a view of Shot STOKES from News Nob.

6.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT STOKES

An estimated 1,310 Desert Rock troops took part in projects associated with Shot STOKES: one troop observer indoctrination project, one radiological training project, and two technical service projects. Table 6-1 identifies these projects. It also lists Task Force WARRIOR observers and Camp Desert Rock support troops who witnessed the detonation.

6.1.1 Troop Observer Indoctrination Projects

Three groups of observers participated at Shot STOKES, as listed in table 6-l. The 499 troops from Task Force WARRIOR observed the detonation as part of their rehearsal for Shot SMOKY. The observers witnessed the shot from the observation area at News Nob, 16 kilometers south of ground zero. Figure 6-2 shows Desert Rock observers shielding their eves from the glare of the detonation (49).

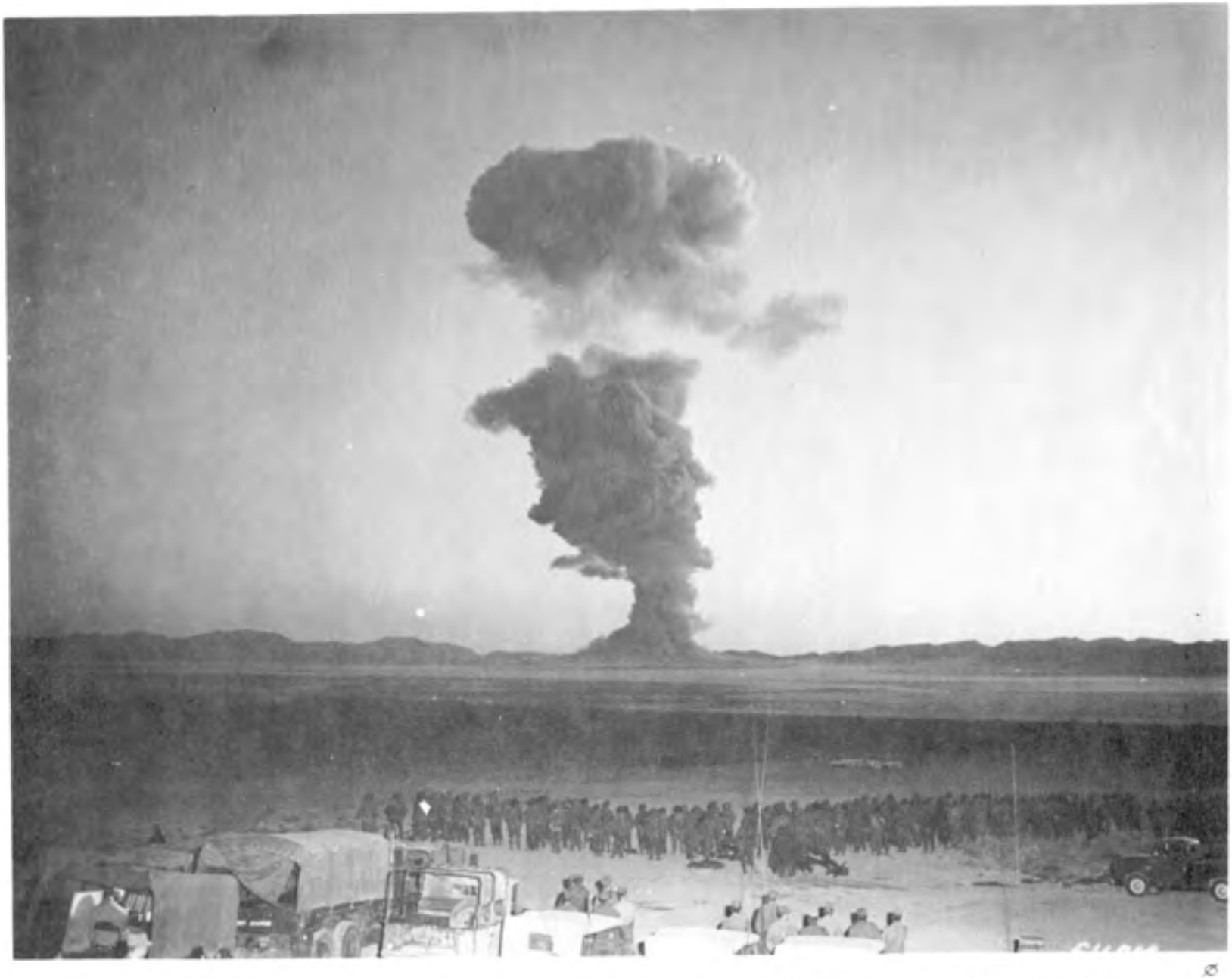


Figure 6-1: THE CLOUD OF SHOT STOKES WITH OBSERVERS IN THE FOREGROUND

Figure 6-2: DESERT ROCK OBSERVERS SHIELD THEIR EYES FROM THE GLARE OF SHOT STOKES

Table 6-1: EXERCISE DESERT ROCK PROJECTS, SHOT STOKES

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50.2	Troop Observers	Army	95
	-	-	Task Force WARRIOR	499
	-	-	Camp Desert Rock Support Troops	99
Radiological Training	53.4	Radiological Defense Training	Radiological Defense School, Lowry AFB	35
Technical Service	50.3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Army Electronic Proving Ground; Fort Huachuca, Arizona; Fort Meade, Maryland	32
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board; Army Artillery Board; Army Chemical Corps; Army Artillery and Guided Missile School; Air Weather Service	557

6.1.2 Radiological Training Project

Project 53.4, Radiological Defense Training, was the one radiological training project conducted at STOKES. The project was performed by about 35 members of the Radiological Defense School of Lowry AFB, Denver, Colorado. After the detonation, the project participants proceeded along an assigned route from the observation area to their vehicles, which they had left at the Desert Rock decontamination station. Accompanied by a radiological safety monitor, the participants monitored radiation intensities at various distances from ground zero. These readings were relayed by radio to the control stations and were then plotted on a map (46; 49).

6.1.3 Technical Service Projects

As indicated in table 6-1, two technical service projects were conducted at Shot STOKES to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Huachuca, and seven personnel from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. Two remote radar sets were 18 kilometers from ground zero. A third radar site was six kilometers from ground zero. A fallout prediction unit for this project operated from a van located next to the weather station at Camp Mercury. A second fallout prediction team, consisting of personnel from the Army Electronic Proving Ground, Fort Huachuca, Arizona, operated near Alamo, Nevada, 88 kilometers northeast of Yucca Lake (20; 46; 493).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Air Defense Board, Army Artillery Board, Army Chemical Corps, Army Artillery and Guided Missile School, and Air Weather Station. The objectives were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of an atomic detonation.
- Track targets and guided missiles through a nuclear cloud or fireball.

An estimated 557 DOD personnel participated in this project. To determine the location, height of burst, and yield of the detonation, participants operated 17 onsite radar, camera, and other instrument stations located nine to 30 kilometers from ground zero. The control point was at UTM coordinates 768942, 15 kilometers southwest of ground zero. To determine the

attenuation of the Nike Hercules missile control signals, a B-26 aircraft, with a crew of at least three, positioned itself so that the cloud was between the aircraft and a Nike ground site at the time of detonation. The B-26 was about 20 kilometers northeast of ground zero at the time of detonation and spent about 30 minutes in the area (16; 28; 46; 49; 77; 79; 80).

6.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT STOKES

In addition to the Exercise Desert Rock personnel, other DOD personnel took part in test activities during Shot STOKES that required them to enter the forward area. Table 6-2 identifies the test group projects involving DOD participants. The Air Force sponsored one operational training project during the shot. Besides the test group and the operational training projects, AFSWC and other support activities accounted for a number of DOD participants. The Air Force Special Weapons Center supported one test group project and flew routine missions for the Test Manager.

6.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted seven projects at Shot STOKES, as indicated in table 6-2.

Project 1.1, Basic Airblast Phenomena, was conducted by the Ballistic Research Laboratories to:

- Obtain data on overpressure and dynamic pressure versus time as a function of distance
- Evaluate gauge designs, instrument components, and measurement techniques.

Before the shot, participants installed two very low pressure gauges at the airstrip on Yucca Lake, approximately 16 kilometers from ground zero. Personnel recovered the gauges the day after the shot (21).

Table 6-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT STOKES

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
1.1	Basic Airblast Phenomena	Ballistic Research Laboratories	*
1.9	Spectra of Ground Shocks Produced by Nuclear Detonations	Air Research and Development Command; Ramo-Woolridge Corporation	*
5.1	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation	Navy Bureau of Aeronautics	2
5.2	Structural Response and Gas Dynamics of an Airship Exposed to a Nuclear Detonation	Navy Bureau of Aeronautics; Aeronautical Structures Laboratory; Naval Air Material Center	54
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
6.4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
9.1	Support Photography	AFSWP; Military Air Transport Service; EG and G	10
Los Alamos Scientific Laboratory Test Group			
11.2	Radiochemistry Sampling	Air Force Special Weapons Center	10

* Unknown

Project 1.9, Spectra of Ground Shocks Produced by Nuclear Detonations, was conducted by the Air Research and Development Command and the Ramo-Woolridge Corporation to measure and analyze the velocity and movement of the ground shock wave produced by a nuclear detonation. Four self-contained mechanical reed shock gauges were placed inside cylindrical canisters 0.6 meters in diameter and 0.6 meters long. Before the shot, personnel placed the canisters in the ground 50 meters east of ground zero. Participants recovered the gauges after the area was declared radiologically safe (36).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted by the Navy

Bureau of Aeronautics to measure the effects of overpressure and wind gusts produced by a nuclear detonation on the HSS-1 helicopter. The project also studied how blast effects might limit the HSS-1 in its delivery capabilities for antisubmarine warfare weapons.

The helicopter left Indian Springs AFB at 0431, entering the shot area 30 minutes later. Before the detonation, the helicopter, with a crew of two, flew two practice orbits inbound at 330 degrees. It began a final run five minutes before the detonation, making a 90-degree turn 40 seconds before shot-time. At the time of the detonation, the helicopter was tail-on to the shot, at a slant range of about 1,000 meters from ground zero and at an altitude of 8,430 feet. The helicopter spent approximately 60 minutes in the shot area, returning to Indian Springs AFB at 0555 (10; 82).

Project 5.2, Structural Response and Gas Dynamics of an Airship Exposed to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics, the Aeronautical Structures Laboratory, and the Naval Air Material Center. The objective was to determine the response characteristics of the Model ZSG-3 airship to a nuclear detonation to establish criteria for safe escape distances for airship delivery of antisubmarine warfare special weapons.

Two airships were scheduled to be tested at Shot STOKES. One airship was destroyed before the detonation when it was torn from its mooring mast at Yucca Lake by a dust storm. The mooring lines holding the other airship were released about 20 seconds before the shock arrival to obtain free-body response data. Immediately after shock arrival, the envelope ruptured forward of the car and the airship crashed but did not burn. The project exposed the structural vulnerability of an airship when subjected to a nuclear detonation.

At 2000 hours on the night before the detonation, 17 personnel worked to position the airship and secure the mountings. An additional 37 participants joined these personnel at 0025 on shot-day. They later recovered the test instruments from the wrecked airship (16; 33).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop Aircraft calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center provided both the aircraft and the two-man crew. Wright Air Development Center and Northrop Aircraft together developed positioning methods and calculated the aircraft positions at the detonation and shock arrival times.-

The F-89 aircraft left Indian Springs AFB at 0455. Before the detonation, it flew one complete 12-minute holding pattern at 15,000 feet to position itself for the shot. At the detonation, the F-89D was at a slant range of 3,400 meters from the burst. It was at a slant range of 4,115 meters from ground zero when the initial shock wave arrived. The aircraft was in the test area for approximately 30 minutes, returning to Indian Springs AFB at 0531. During the mission, film badges were placed in the pilot's and observer's positions (16; 74).

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 yield of that burst. The Indirect Bomb Damage Assessment NAROL system tested on 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 (50).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following 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 detonations for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Working from six hours before until 30 minutes after the detonation, seven personnel established and then manned a photo station at UTM coordinates 844963. An additional two or three personnel took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. The aircraft, which spent approximately 100 minutes in the shot-area, flew a right-hand holding pattern at an altitude of 8,000 to 9,000 feet. EG and G personnel provided technical photography support to AFSWP and the AEC, operating five camera stations to record fireball and cloud growth. One unmanned station was near the Control Point, and four unmanned stations were three to eight kilometers from ground zero. In addition to documenting the shot, Project 9.1 also provided camera instrumentation for Project 5.2 (10; 16; 27).

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

The Los Alamos Scientific Laboratory was the only AEC weapons design laboratory participating at Shot STOKES. Of the 14 projects conducted by the LASL Test Group, only Project 11.2, Hadiochemistry Sampling, involved DOD personnel. This project required air support from AFSWC and is discussed in section 6.2.4.

6.2.3 Department of Defense Operational Training Project

The Air Force sponsored one operational training project at STOKES, Project 53.9, Photographic Reconnaissance Training. Project 53.9 was intended to indoctrinate Tennessee Air National Guard Tactical Reconnaissance units in conducting photographic missions over a nuclear target. Two RF-84 aircraft, each operated by one pilot and carrying one photographer, took off from Luke AFB, Arizona, and began orbiting off the NTS at 0520 hours. Ten minutes before the detonation, the aircraft made a photographic run over ground zero at 10,000 feet. Upon completion of their mission, at about 0540 hours, the aircraft left the shot area for Luke AFB (2; 10).

6.2.4 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support at Shot STOKES consisted of cloud-sampling and sample courier missions for LASL Project 11.2, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Two B-57B aircraft, each operated by two crewmen, and five F-84G aircraft, each with one pilot, collected samples of the cloud for LASL Project 11.2, Radiochemistry Sampling. A B-57B

sampler control aircraft (serial number 500), with a pilot and a LASL scientific advisor, directed the sampling. Pilots of the 4926th Test Squadron (Sampling) flew the nine aircraft.

The control aircraft left Indian Springs AFB at about 0505 and was positioned by air controllers of the Air Operations Center at 0520 hours. Upon reaching an altitude of 30,000 to 35,000 feet, the control aircraft began its orbit. After the detonation, the control aircraft left its orbit to view the cloud. The B-57B sampler aircraft, followed by the F-84G sampler aircraft, left Indian Springs AFB within one and two hours after the detonation. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire samples. After completing the final sampling run, the samplers left the area and landed at Indian Springs AFB between 0720 and 0815 hours (1; 2; 10).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB on shot-day to transport samples to various air bases for analysis by AEC nuclear weapons design laboratories. The 4901st Air Base Wing from Kirtland AFB conducted these courier missions (2).

Cloud Tracking

Immediately after the detonation, one B-25 aircraft from Indian Springs AFB and one B-50 from Kirtland AFB flew cloud-tracking missions over and beyond the Nevada Test Site. The B-25 flew at 27,000 feet, and the B-50 at 25,000 feet (10).

Security Sweeps

Before the shot, two L-20 aircraft were dispatched from Yucca airstrip near Camp Mercury to perform a security sweep over the test area. Each aircraft had a crew of at least two,

since the security sweep called for a security guard to accompany the pilot (2; 66).

Helicopter Surveys

After the detonation, AFSWC flew helicopter survey missions over the shot area and non-test areas to record radiation intensities. The one participating H-21 helicopter had a crew of four: two AFSWC pilots and two REECo monitors. After the mission, the helicopter returned to the helicopter pad and was monitored and decontaminated as required. In addition, AFSWC flew damage effects surveys (66).

6.3 RADIATION PROTECTION AT SHOT STOKES

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

During the period covering the 7 August detonation of STOKES, the Dosimetrv and Records Section issued 2,855 film badges and 405 pocket dosimeters. Forty-nine NTO personnel received cumulative gamma exposures ranging from 2.0 to 2.5 roentgens. Two of the 49 were DOD personnel, one of whom was from the Ballistic Research Laboratories and the other from AFSWP (66; 83).

Logistics

For Shot STOKES, the General Supply Section issued anticontamination clothing to 8,240 persons. The clothing included coveralls, shoe covers, and respirators (83).

Monitoring

Eleven men in vehicles began the initial ground survey at 0530 hours. They reported the last intensity in the shot area at 0605 hours. The initial helicopter survey team, consisting of an AFSWC crew-of two and two REECo monitors, left the Control Point helicopter pad at 0700, 95 minutes after the detonation. The highest radiation was 10 R/h, encountered 200 feet above ground zero at 0720. An aerial resurvey was conducted one day after the shot. Ground surveys were conducted for several days following the detonation (66).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during STOKES (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isointensity contour maps from the radiation intensity data gathered by the ground survey teams. Figure 6-3 presents the isointensity plot developed from information gained during the initial survey. The data resulting from the resurveys on 7 August, 9 August, 10 August, and 12 August are shown in figure 6-4 (83).

In addition to its other activities, the Plotting and Briefing Branch issued access permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 2,285 access permits during STOKES (83).

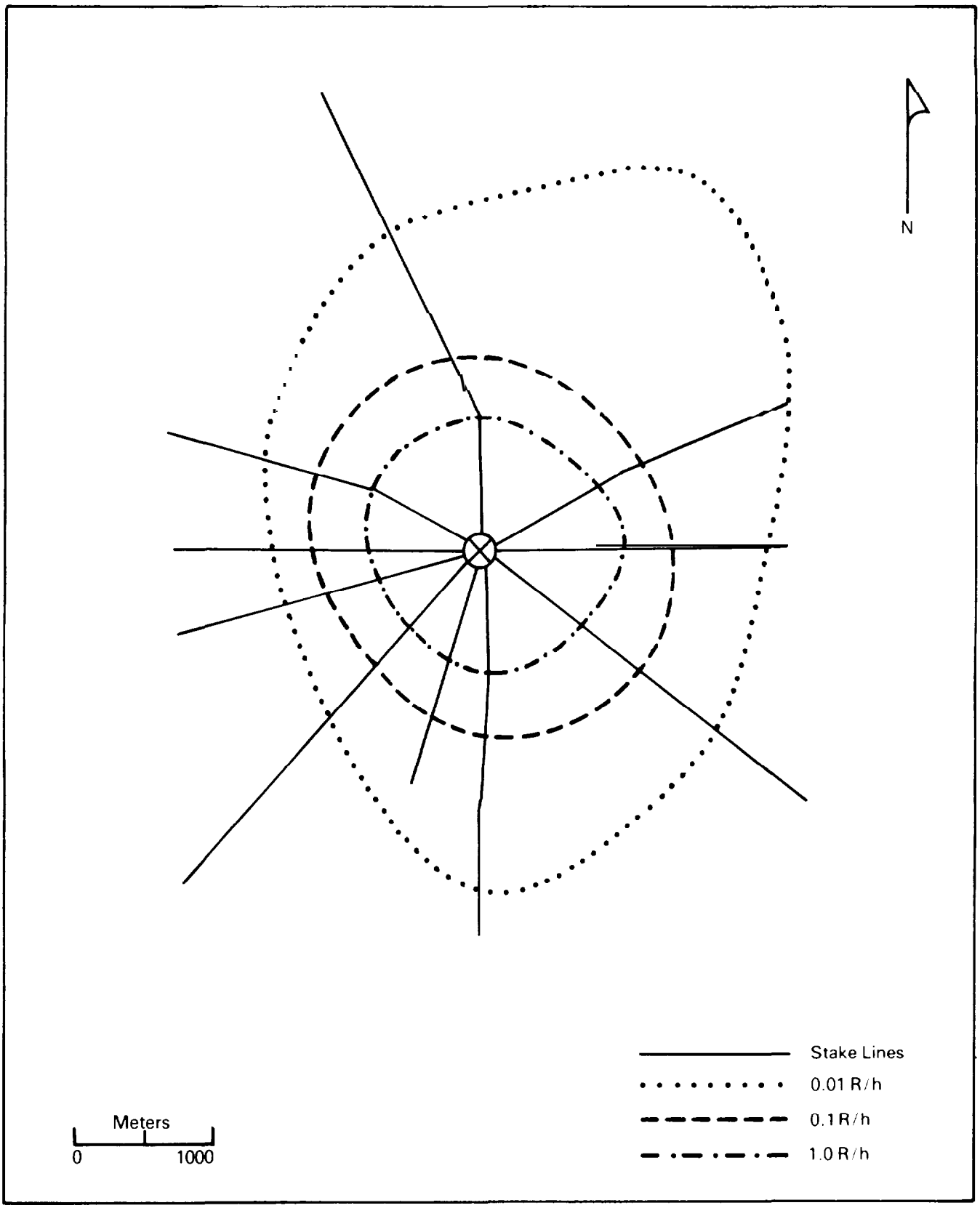
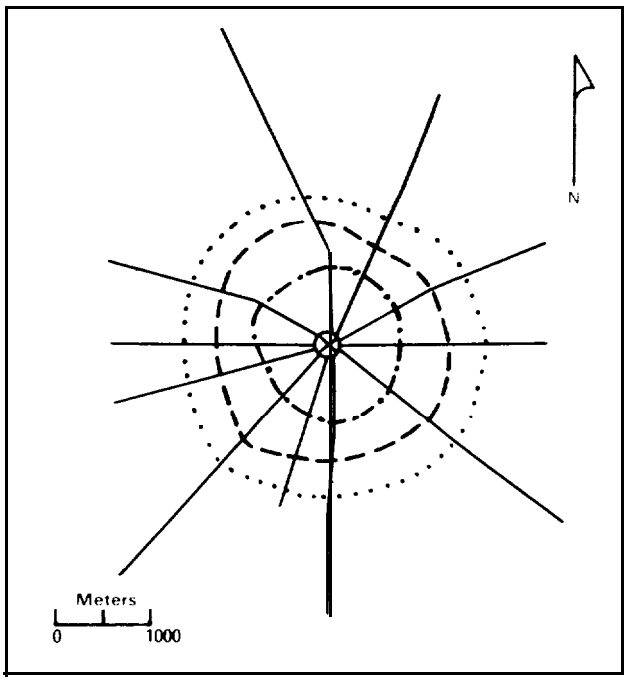
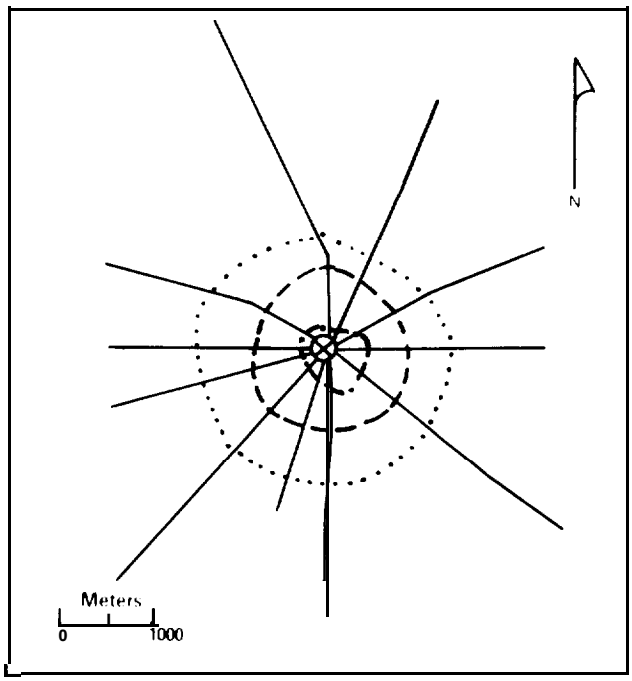


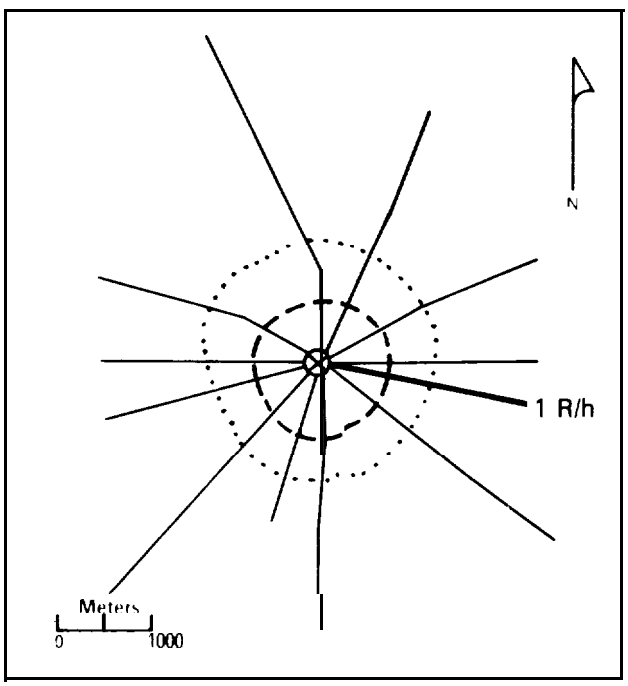
Figure 6-3: INITIAL SURVEY FOR SHOT STOKES, 7 AUGUST 1957, MID-TIME 0555



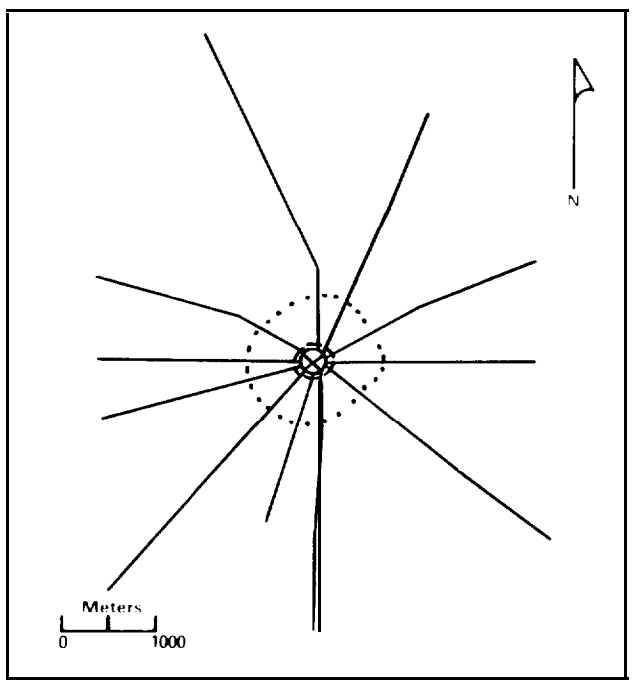
7 August 1957, Mid-Time: 1133



9 August 1957, Mid-Time: 0548



10 August 1957, Mid-Time: 0620



12 August 1957, Mid-Time: 0552

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

Figure 6-4: SUBSEQUENT SURVEYS FOR SHOT STOKES

Decontamination

During the period covering Shot STOKES, the Vehicle and Equipment Decontamination Section decontaminated 132 vehicles (83).

SHOT SHASTA SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXEHCISE:	Desert Rock VII and VIII
DATE/TIME:	18 August 1957, 0500 hours
YIELD:	17 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 indoctrinate personnel in the effects of nuclear detonations
(4) To assess the effects of a nuclear detonation on civilian structures and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 26°C, and surface winds were calm. Winds were 11 knots from the southwest at 10,000 feet, ten knots from the southeast at 20,000 feet, and nine knots from the west at 30,000 feet.

Radiation Data: About three hours after the detonation, radiation intensities of 1.0 R/h or more were confined to within about 900 meters of ground zero, except to the north through the northeast.

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 SHASTA

Shot SHASTA was detonated with a yield of 17 kilotons at 0500 hours Pacific Daylight Time on 18 August 1957. The device was positioned in a cab on top of a 500-foot steel tower in Area 2 of the NTS. The SHASTA cloud top rose to 32,000 feet and moved east, while the middle section moved northwest, and the lower section drifted northeast from the point of detonation. Fallout fell generally to the north of ground zero (31).

7.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT SHASTA

More than 600 Desert Rock troops took part in projects associated with the SHASTA event: one troop observer indoctrination project, one radiological training project, and two technical service projects. Table 7-1 identifies these projects and lists the nine Camp Desert Rock support troops who also witnessed the detonation.

7.1.1 Troop Observer Indoctrination Projects

As indicated in table 7-1, an estimated 20 DOD personnel took part in troop observer indoctrination activities. These observers probably witnessed SHASTA from News Nob, 20 kilometers south of ground zero.

Several personnel of the Human Resources Research Office (HumRRO) team, consisting of civilians, witnessed SHASTA from a hill at the south end of Yucca Flat, 20 kilometers from ground zero and near News Nob. The observation area had 12 rows of

wooden benches. The observers wore steel helmets and protective field masks. One observer described the detonation as follows:

> Dimly visible in the first morning light the golden fireball boiled and churned like a genie from a bottle, cooled to orange splotched with deep dirty brown, cooled to heavy violet and as it cooled, its shimmering blue corona contracted and glowed around it....I didn't know whether to expect [a shock wave,] a crack, or a roar, or what. Then I heard what sounded exactly like a long line of freight cars "bumping" in the distance, a low quickly punctuated rumble that lasted three or four seconds and faded away (19).

The experiences of the HumRRO observer were similar to those described by other observers.

Table 7-1: EXERCISE DESERT ROCK PROJECTS, SHOT SHASTA

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination		Troop Observers	Armv	11
	-	-	Camp Desert Rock Support Troops	9
Radiological Training		Sixth Army Chemical, Biological, and Radiological Team Training	Sierra Ordnance Depot; Fort Huachuca	21
Technical Service	*50.3*	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Fort Huachuca, Arizona: Fort Meade, Maryland	*32*
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board; Army Chemical Corps; Army Artillery and Guided Missile School; Air Weather Service	*557*

7.1.2 Radiological Training Project

The one radiological training project conducted during Shot SHASTA was the Sixth Army Chemical, Biological, and Radiological Team Training. The project was designed to train personnel from Sixth Army installations in radiological defense techniques. Two survey teams, one of nine civilians and one military participant

from the Sierra Ordnance Depot and the other of 11 military personnel. from Fort Huachuca, were at the NTS from 14 to 23 August and from 18 to 29 August, respectively. The teams received practical instruction and field experience in conducting radiological surveys. General procedures called for the teams to participate as observers and then survey the residual radiation field. From the dates of attendance, it is possible that the teams also observed the DOPPLER detonation (45; 49; 57).

7.1.3 Technical Service Projects

As indicated in table 7-1, two technical service projects were.conducted at Shot SHASTA to evaluate diagnostic instrumentation and techniques for military use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Huachuca, and seven personnel from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. Three radar sets were located 23 kilometers southeast of ground zero. The fallout prediction unit for this project operated from a van located next to the weather station at Camp Mercury (20; 45; 49).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Air Defense Board, Army

Chemical Corps, Army Artillery and Guided Missile School, and Air Weather Service. The purposes of the pro.ject were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and vield of a nuclear detonation
- Track targets and guided missiles through a cloud or fireball
- Predict and monitor radioactive fallout.

An estimated 557 DOD personnel took part in this project. To determine the location, height of burst, and yield of the detonation, participants operated 18 onsite and offsite radar, camera, and other instrument stations located 14 to 70 kilometers from ground zero. The control point was at UTM coordinates 768944, 14 kilometers southwest of ground zero. To test the attenuation of an aircraft's missile control signals, a B-26, with a crew of at least three, positioned itself so that the cloud was between the aircraft and a Nike Hercules ground site. In another part of the project, two H-34 helicopters, two H-13 helicopters, and one L-21 aircraft conducted aerial radiological surveys after the detonation to determine the actual fallout pattern. The aircraft flew at altitudes ranging from 100 to 1,000 feet and landed at several points in fallout areas downwind of ground zero to gather ground readings. Each of the helicopters had a crew of three, while the L-20 had a crew of two (15; 28; 45; 49; 77; 79; 80).

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

In addition to the Exercise Desert Rock personnel, other DOD personnel took part in test activities during Shot SHASTA that required them to enter the forward area. Table 7-2 identifies the test group projects involving DOD participants. The Air Force sponsored two operational training projects during the shot. In addition to the test group and the operational training

Table 7-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT SHASTA

Project	Title	Participants	Estimated DOD Personnel
	Weapons Effects Test Group		
1.1	Basic Airblast Phenomena	Ballistic Research Laboratories	*
5.3	In-flight Structural Response of the FJ4 Aircraft to a Nuclear Detonation	Navy Bureau of Aeronautics; Naval Air Special Weapons Facility; North American Aviation	*
5.4	In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation	Navy Bureau of Aeronautics; Douglas Aircraft	*
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
9.1	Support Photography	AFSWP; Military Air Transport Service: EG and G	12
	University of California Radiation Laboratory Test Group		
21.2	Radiochemistry Sampling	Air Force Special Weapons Center	9
	Civil Effects Test Group		
32.3	Evaluation of Countermeasure System Components and Operational Procedures	Naval Radiological Defense Laboratory	5
36.4	Aerial Monitoring Operations Development	Federal Civil Defense Administration: Civil Air Patrol	6
37.2	Biophysical Aspects of Fallout	Air Force Special Weapons Center	3
37.2a	Physical Aspects of Fallout	Air Force Special Weapons Center	3
37.6	Application of Radio-ecological Techniques	Air Force Special Weapons Center	3

* Unknown

projects, AFSWC and other support activities accounted for a number of DOD participants. The Air Force Special Weapons Center supported one test group project and flew routine missions for the Test Manager.

7.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted five projects at Shot SHASTA, as listed in table 7-2. In conducting these projects, personnel sometimes entered the shot area after the detonation. Recovery hour was declared at 0800, three hours after the detonation.

Project 1.1, Basic Airblast Phenomena, was conducted by the Ballistic Research Laboratories to:

- Obtain data on overpressure and dynamic pressure versus time as a function of distance
- Evaluate gauge designs, instrument components, and measurement techniques.

Before the shot, personnel installed pressure-time gauges at stations 165 to 6,785 meters south of ground zero. Participants recovered the gauges when radiation levels in the area had declined to permissible levels (21).

Project 5.3, In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation, was designed by the Navy Bureau of Aeronautics to measure the thermal and blast wave response of the FJ-4 aircraft and to determine its performance and delivery capabilities during a nuclear detonation. The Naval Air Special Weapons Facility provided the aircrew for this project. North American Aviation, Incorporated, supplied the specially instrumented test aircraft and the personnel required to maintain the aircraft. The FJ-4 left Indian Springs AFB at 0405. At the time of burst, the aircraft was at an altitude of about 7,090 feet and at a slant range of 7,600 meters from ground zero. At

the time of shock arrival, the aircraft was in a level flight pattern, tail-on to the detonation, and was at a slant range of 3,500 meters from ground zero. The aircraft returned to Indian Springs AFB at 0510 (9; 53).

Project 5.4, In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation, was to measure the thermal and blast wave response of the A4D-1 aircraft during flight and to determine its performance and delivery capabilities during a nuclear detonation. The A4D-1 was a single engine, modified delta wing, carrier-based jet attack aircraft with the capability to deliver special weapons covering a wide range of weapon yields. Project personnel, who were from the Navy Bureau of Aeronautics and Douglas Aircraft, included the pilot, the ground controller, and the maintenance personnel responsible for the special painting and instrumentation of the aircraft.

The aircraft left Indian Springs AFB at 0421. At shot-time, it was at a slant range of 3,060 meters from ground zero and at a height of 8,860 feet above the burst. At the time of the first shock arrival, the A4D-1 was at a slant range of 2,730 meters from ground zero and at a height of 9,090 feet above the burst. The aircraft was piloted and flown on a straight and level course directly above ground zero. The A4D-1 returned to base at 0515 (9; 81).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop Aircraft calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center provided the aircraft and the two-man crew. Wright Air Development Center and

Northrop Aircraft together developed positioning methods and calculated the aircraft positions at the detonation and shock arrival times.

The aircraft left Indian Springs AFB at 0430. Before the shot, it flew one complete la-minute holding pattern to position itself for the detonation. At the time of the detonation, the F-89D was at a slant range of 7,570 meters from the burst. The aircraft was in the test area for approximately 30 minutes, returning to Indian Springs AFB at 0507. During the mission, film badges were placed in the pilot's and observer's positions (9; 74).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following 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 detonations for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Working from six hours before to 30 minutes after the detonation, nine personnel established and then manned a camera station at the BJY, UTM coordinates 842022. An additional two or three participants took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. 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 (9; 15; 27).

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

The University of California Radiation Laboratory was the only AEC weapons development laboratory conducting a project involving DOD personnel at SHASTA. The Los Alamos Scientific Laboratory performed five projects at the shot, but none of these activities included DOD participants. Of the eight UCRL projects, Project 21.2, Radiochemistry Sampling, required air support from AFSWC and is discussed in section 7.2.5.

7.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted 19 projects at SHASTA. Of these 19 projects, five involved DOD personnel, as listed in table 7-2.

Project 32.3, Evaluation of Countermeasure System Components and Operational Procedures, was fielded by the Naval Radiological Defense Laboratory to evaluate the performance of a manned underground shelter located within the fallout zone and beyond the region of significant blast damage.

Ninety minutes before the detonation, five personnel arrived by jeep at the shelter, four kilometers from ground zero. The shelter was a standard 7.5-meters-by-14-meters multi-plate ammunition-storage magazine. It was custom-fitted with a standard Navy quick-acting, watertight door and was buried side-on to the shot area beneath 0.9 meters of earth. The entrance faced away from ground zero. Two M-6 collective protector air filters provided ventilation.

Thirty minutes before the detonation, the intake and exhaust vents were closed. Five minutes before the detonation, all personnel sat in the center of the floor at the rear of the

shelter. Fifteen seconds before the detonation, the vent intakes were opened and the M-6 collective protector air filter was started. Retween one and six minutes after the detonation, participants in the underground shelter reported dosimetry readings to the Control Point by radio. Fallout continued in the area of the shelter from seven minutes to 20 minutes after the detonation. Surveys of exterior areas adjoining the shelter were begun 30 minutes after the detonation. The surveys were completed and the shelter closed by six hours after shot-time. Personnel returned to the Control Point by jeep, where they were processed through the decontamination station (75).

Project 36.4, Aerial Monitoring Operations Development was conducted by the Federal Civil Defense Administration and the Civil Air Patrol. Its objectives were to develop correlation factors for a survey meter used by the Federal Civil Defense Administration, to continue the study of aerial-monitoring techniques begun at Operation TEAPOT, and to develop instructional material for radiological defense manuals for Civil Air Patrol or other aerial-survey units. The project consisted of three phases (62):

- Concurrent aerial, automotive, and ground surveys of the NTS fallout areas
- Development of an isointensity fallout plot by aerial monitoring of a fallout pattern along three different routes
- Development of a radiological plot by using a training exercise involving air-to-ground communications and radiation-measuring equpment.

Military participation in this project was confined to the aerial surveys. The aerial survey aircraft, a Cessna-170 and a PA-18 Piper Cub, and four pilots came from the Milwaukee Group, Wisconsin Wing of the Civil Air Patrol. The Test Director also provided an H-21 helicopter, piloted by two AFSWC pilots, for aerial monitoring.

Both air and ground project personnel assembled at the civil defense center at the Yucca Lake airstrip before the declaration of recovery hour. When recovery hour was announced at 0800, the ground and aerial survey teams of phase one proceeded to the fallout area, entering it one hour later. The Cessna-170, flying in a clover-leaf pattern at heights ranging from 300 to 1,000 feet, monitored the fallout area at 0900 and 1300. The aircraft covered the area twice for each survey. While the Cessna-170 conducted its survey, the H-21 helicopter hovered over the terminal points of the aerial-survey pattern to take radiation readings for developing correlation factors.

Phase two began at 0900, when the PA-18 Piper Cub aircraft at a height of 500 feet monitored three designated routes marked along Mercury Highway at BJY and along the road leading north and south of the SHASTA ground zero. The survey was repeated at 1300, but the eastern leg of Mercury Highway north of BJY was not monitored because the aircraft had found no measurable fallout there during the earlier survey. Concurrently with these surveys, the Piper Cub conducted phase three. Personnel aboard the aircraft used an aerial-monitoring instrument to record radiation intensities. The readings were then relayed by radio to the Civil Defense Control Center (62).

The following CETG projects involved AFSWC support:

- Project 37.2 Biophysical Aspects of Fallout
- Project 37.2a Physical Aspects of Fallout
- Project 37.6 Application of Radio-ecology Techniques.

At each project, AFSWC crew members provided a single C-47 aircraft for radio relay services, as described in section 7.2.5 (56).

7.2.4 Department of Defense Operational Training Projects

The primary purposes of the operational training program were to test equipment and techniques and to indoctrinate personnel. The Air Force sponsored two operational training projects at Shot SHASTA:

- Project 53.1 Aerial Sampling Missions
- Project 53.7 Indirect Bomb Damage Assessment.

Project 53.1, Aerial Sampling Missions, involved California Air National Guard units that flew sample missions in conjunction with UCRL Project 21.2. This activity is discussed under AFSWC operations in the next section of this chapter.

Project 53.7, Indirect Bomb Damage Assessment, required staff from the Wright Air Development Center to install Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft from Indian Springs AFB. The F-89D, with a crew of two, flew a right-hand holding pattern at an altitude of 35,000 feet. The aircraft spent approximately 60 minutes in the shot area. After completing its mission, the F-89D returned to base, where it was decontaminated (2; 9).

7.2.5 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling and sample courier missions for UCRL Project 21.2, a radio-relay for three CETG projects, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Two B-57B aircraft, each operated by two crewmen, and four F-84G aircraft, each operated by one pilot, collected samples of the cloud for UCRL Project 21.2, Radiochemistry Sampling. One B-57B sampler control aircraft, with an AFSWC pilot and a UCRL

scientific advisor, directed the cloud sampling. Pilots of the 4926th Test Squadron (Sampling) flew the eight aircraft. In addition, two T-33 aircraft, each with two California Air National Guard personnel, collected cloud samples at an altitude of about 30,000 feet for the operational training Project 53.1, Aerial Sampling Missions.

The sampler control aircraft flew from Indian Springs AFB ten minutes before shot-time. Upon reaching an altitude of 30,000 to 35,000 feet, the control aircraft began its holding pattern. After the detonation, the control aircraft left its holding pattern to view the cloud. The F-84G and the T-33 samplers left Indian Springs AFB between 60 and 90 minutes after the detonation. Within two hours after the detonation, the B-57B sampler aircraft left Indian Springs AFB. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire the samples. In 30 to 35 minutes, after completing their sampling runs, the samplers left the area for Indian Springs AFB, landing between 0635 and 0750 (1; 2; 9).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB on shot-day to transport samples to various air bases for analysis by AEC nuclear weapons design laboratories. The 4901st Air Base Wing from Kirtland AFB conducted these missions (2).

Radio Relay

One C-47 aircraft performed a radio relay for CETG Projects 37.2, 37.2a, and 37.6. For each project, the C-47, with three crew members, flew a right-hand holding pattern 20 nautical miles southeast of ground zero. The aircraft remained aloft for three hours. After the mission, the C-47 returned to its home base for decontamination (2).

Cloud Tracking

Immediately after the detonation, one B-25 aircraft and one B-29 aircraft from Indian Springs AFB and one B-50 from Kirtland AFB flew cloud-tracking missions over and beyond the Nevada Test Site. The B-25 flew at 15,000 feet, the B-29 flew at 22,000 feet, and the B-50 flew at 75,000 feet. The B-25 had a crew of nine, and both the B-29 and the B-50 had crews of about ten (2; 9).

Security Sweeps

Before the shot, two L-20 aircraft were dispatched from Yucca airstrip near Camp Mercury to perform a security sweep over the test area. The aircraft each had crews of at least two, since the security sweep called for a security guard to accompany the pilot (67).

Helicopter Surveys

After the detonation, AFSWC personnel flew helicopter surveys in the shot area and non-test areas to record radiation intensities and to determine damage effects. H-21 helicopters were used, each with a crew of four: two AFSWC pilots and two REECo monitors. The surveys, each of which lasted about 40 minutes, were planned for 15 minutes, six hours, and one, two, and three days after the detonation. The initial survey did not begin, however, until 0715. The highest radiation intensity was 2 R/h, encountered 200 feet above the DIABLO ground zero, three kilometers north of the SHASTA ground zero. Following the mission, helicopters returned to the helicopter pad and were monitored and decontaminated as required (67).

7.3 RADIATION PROTECTION AT SHOT SHASTA

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that participants would avoid unnecessary exposure to ionizing radiation while accom-

plishing 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 programs. The available data include NTO isointensity contour maps, monitoring information, and some dosimetry data for NTO and Desert Rock personnel.

Dosimetrv

During the period covering the 18 August detonation of SHASTA, the NTO Dosimetry and Records Section issued 1,304 film badges and 202 pocket dosimeters. Five NTO/DOD personnel, three of whom were from the Ballistic Research Laboratories, two from the Naval Radiological Defense Laboratory, and one from AFSWC, received cumulative gamma exposures exceeding 2.0 roentgens. These exposures ranged from 2.03 to 2.32 roentgens. Three Desert Rock personnel exceeded 3.0 roentgens of cumulative gamma exposure at Shot SHASTA. They were Project 50.8 survey personnel, two of whom had their most significant exposures at Shot DIABLO (57; 67; 73).

Logistics

For Shot SHASTA, the General Supply Section issued anticontamination clothing to 1,153 persons (83). These supplies consisted of coveralls, shoe covers, respirators, and other protective equipment.

Monitoring

Ground surveys were to begin at 0505 but were evidently delayed, since the teams reported no measurements until 0707. Most of the data were collected during the next hour, although some were reported until 0904. The initial helicopter survey, planned to begin 15 minutes after the shot, was also delayed, as the team of AFSWC and REECo personnel flew from the Control Point helicopter pad at 0715 (67).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during SHASTA (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isodose contour maps from the radiation intensity data gathered by the ground survey teams. Figure 7-1 presents the isointensity plot developed from information gained during the initial survey. Figure 7-2 shows the data resulting from the resurveys on 18 August through 21 August (83).

In addition to its other activities, the Plotting and Briefing Branch issued *access* permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 1,232 access permits during SHASTA (83).

Decontamination

During the period covering Shot SHASTA, the Vehicle and Equipment Decontamination Section decontaminated 72 vehicles (83).

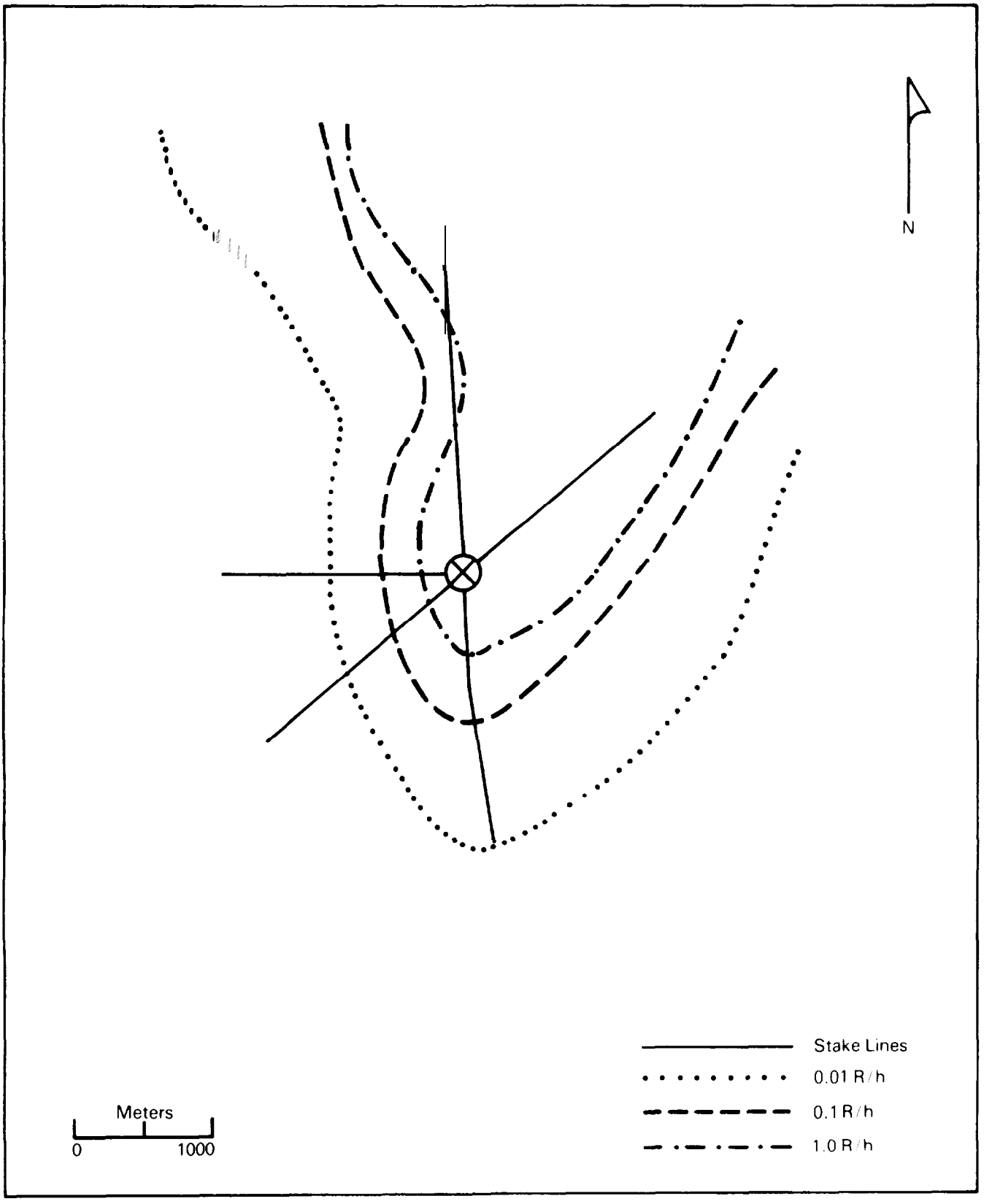
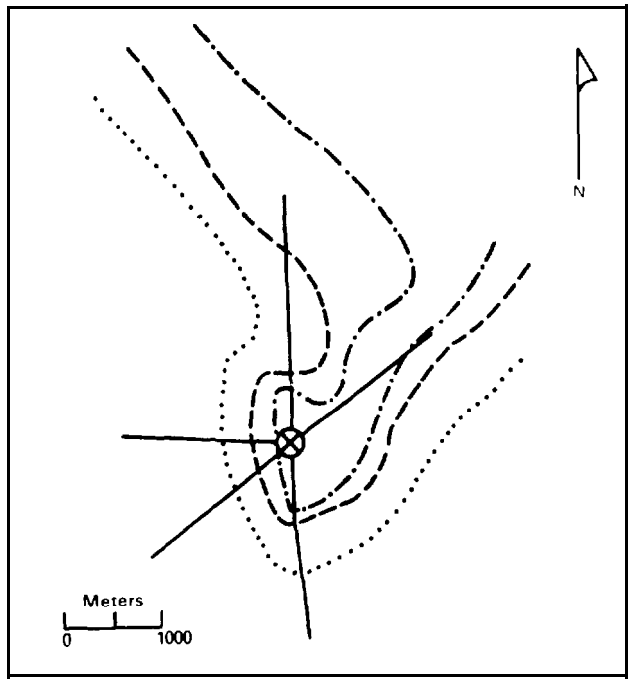
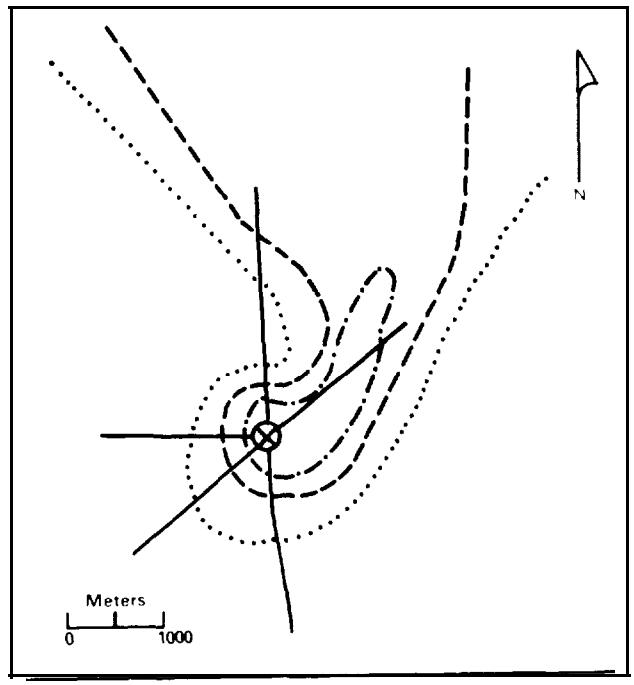


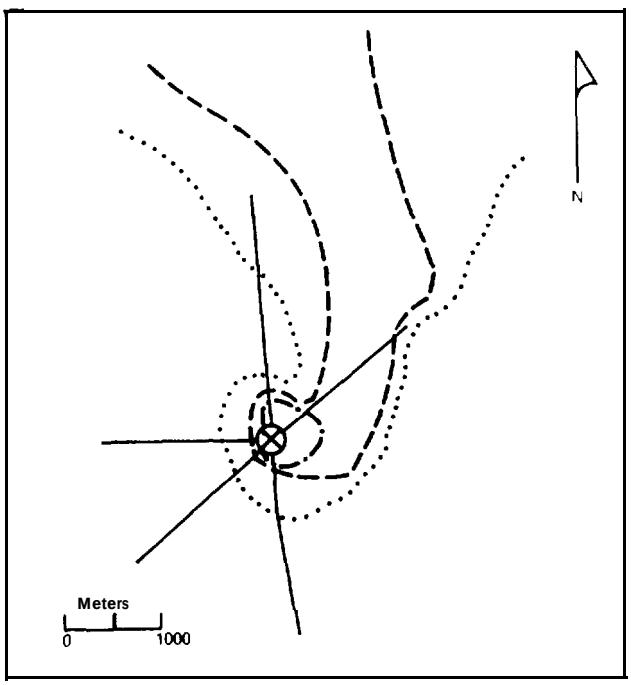
Figure 7-I: INITIAL SURVEY FOR SHOT SHASTA, 18 AUGUST 1957, MID-TIME 0740



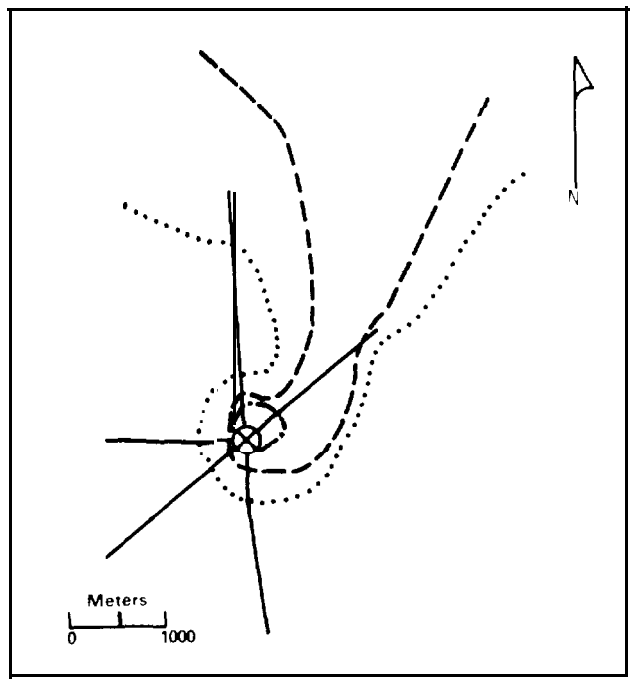
18 August 1957, Mid-Time: 1124



19 August 1957, Mid-Time: 0729



20 August 1957, Mid-Time: 0650



21 August 1957, Mid-Time: 0625

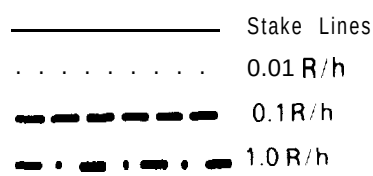


Figure 7-2: SUBSEQUENT SURVEYS FOR SHOT SHASTA

SHOT DOPPLER SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISES:	Desert Rock VII and VIII
DATE/TIME:	23 August 1957, 0530 hours
YIELD:	11 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 and tactics and to indoctrinate personnel in the effects of nuclear detonations
(4) To assess the effects of the nuclear detonation on civilian structures and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 21°C, and surface winds were calm. Winds were 14 knots from the south-southeast at 10,000 feet, six knots from the south-southwest at 20,000 feet, 44 knots from the southwest at 30,000 feet, and 53 knots from the south-southwest at 38,000 feet (the top of the cloud).

Radiation Data: About 40 minutes after the detonation, radiation levels of 1.0 R/h were limited to within 1,400 meters of ground zero.

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 8

SHOT DOPPLER

Shot DOPPLER was conducted with a yield of 11 kilotons at 0530 hours Pacific Daylight Time on 23 August 1957. The device was suspended from a balloon 1,500 feet above the ground over Area 7 of the NTS. Onsite radiation was mostly neutron-induced activity around ground zero. Most fallout occurred well offsite in far eastern Nevada and adjoining Utah (31).

8.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT DOPPLER

Approximately 1,200 Desert Rock troops took part in projects associated with Shot DOPPLER: two troop observer indoctrination projects, one radiological training project, and two technical service projects. Table 8-1 identifies these projects. It also lists Task Force WARRIOR observers and Camp Desert Rock support troops who witnessed the detonation.

8.1.1 Troop Observer Indoctrination Projects

Four groups of observers participated at Shot DOPPLER, as indicated in table 8-I. The 492 troops from Task Force WARRIOR observed the detonation as part of their rehearsal for Shot SMOKY. The observers viewed the detonation from trenches 2,900 meters southwest ground zero at UTM coordinates 847029. Trenches were about five feet deep, affording a minimum of two feet of overhead protection for a crouching person. Camp Desert Rock engineers dug the trenches about one week before the detonation (48; 49; 71).

A member of the Human Resources Research Office team observed DOPPLER from the trenches. He described his experience in the following passages:

> At H minus three minutes we put on our gas masks and helmets, faced half-right in the trenches and crouched, eyes closed, arm tightly against the goggles of the mask. The three minutes seemed interminable, breathless in every sense; then came the silent, brilliant white flash.
>
> I could feel the heat of the fireball reflecting from the wall of the trench about me. I peeked, but quickly shielded my eyes again. It was still furnace bright. The ground wave caught me unaware, three distinct shocks, seeming to raise me about a foot each time, with the terrible sensation of being detached from anything solid or reliable and thoroughly shaken, as in an earthquake (19).

The experiences of the HumRRO observer, who wore a steel helmet and a protective face mask, were similar to those described by other observers.

Table 8-1: EXERCISE DESERT ROCK PROJECTS, SHOT DOPPLER

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	56.2	Troop Observers	Army	9
	53.3	Aircrew Observers	Air Force	2
	-	-	Task Force WARRIOR	492
	-	-	Camp Desert Rock Support Troops	66
Radiological Training	53.4	Radiological Defense Training	Radiological Defense School, Lowry AFB	56
Technical Service	50.3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Fort Huachuca, Arizona; Fort Meade, Maryland	32
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board	557

8.1.2 Radiological Training Project

Project 53.4, Radiological Defense Training, was the one radiological training project conducted at DOPPLER. Conducted by the Radiological Defense School of Lowry AFB, Denver, Colorado, the project involved 56 Air Force personnel. After the detonation, these participants proceeded along an assigned route from the observation area to their vehicles, which they had left at the Desert Rock decontamination station. Accompanied by a radiological safety monitor, the participants monitored radiation intensities at various distances from ground zero. These readings were relayed by radio to the control stations and were then plotted on a map (48; 49).

8.1.3 Technical Service Projects

As indicated in **table 8-1,** two technical service projects were conducted at Shot DOPPLER to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Huachuca, and seven personnel from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. The project required a radar section to activate remote radar sets located approximately six kilometers from ground zero, 20 kilometers from ground zero, and at a third, unspecified distance. In addition, a fallout prediction team, operating out of an M-109 mobile van next to the weather station at Camp Mercury, participated in the project (20; 48; 49).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery

Missile Battalion, along with the Army Air Defense Board. The objectives were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation
- Track targets and guided missiles through a nuclear cloud or fireball.

An estimated 557 DOD personnel took part in this project. To determine the location, height of burst, and yield of the detonation, participants operated 15 onsite and offsite radar, camera, and other instrument stations located nine to 70 kilometers from ground zero. The control point was at UTM coordinates 768942, 15 kilometers southwest of ground zero. To test the attenuation of the Nike Hercules missile control signal, a B-26 aircraft, with a crew of three, positioned itself so that the cloud was between the aircraft and a Nike Hercules ground site about 20 kilometers northeast of ground zero. The B-26 spent about 30 minutes in the area (18; 28; 48; 49; 77; 79; 80).

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

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

Table 8-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT DOPPLER

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
5.3	In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation	Navy Bureau of Aeronautics; Naval Air Special Weapons Facility; North American Aviation	*
5.4	In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation	Navy Bureau of Aeronautics	*
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
6.4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
9.1	Support Photography	AFSWP; Military Air Transport Service; EG and G	12
University of California Radiation Laboratory Test Group			
21.2	Radiochemistry Sampling	Air Force Special Weapons Center	9
Civil Effects Test Group			
39.5	Radiation Dosimetry for Human Exposures	Air Force School of Aviation Medicine	4

* Unknown

8.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted five projects at Shot DOPPLER, as indicated in table 8-2.

Project 5.3, In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation, was designed by the Navy Bureau of Aeronautics to measure the thermal and blast wave response of the FJ-4 aircraft and to determine its performance and delivery capabilities during a nuclear detonation. The Naval Air Special Weapons Facility provided the aircrew for this project. North American Aviation, Incorporated, supplied the specially instrumented test aircraft and the personnel required to maintain the

aircraft. The FJ-4 aircraft flew from Indian Springs AFB at 0435. At the time of the detonation, the aircraft was at a height of 10,910 feet above the burst and at a slant range of 3,480 meters from ground zero. At the time of shock arrival, the aircraft was in a level flight pattern, tail-on to the blast, at a slant range of 3,360 meters from ground zero. The aircraft returned to Indian Springs AFB at 0542. To determine pilot safetv, total gamma dose was recorded during the mission by film badges placed in the cockpit, ammunition bay, right drop tank, and nose-wheel well (53).

Project 5.4, In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation, was designed to measure the thermal and blast wave response of the A4D-1 aircraft during flight and to determine its performance and delivery capabilities during a nuclear detonation. The A4D-1 was a single engine, modified delta wing, carrier-based jet attack aircraft with capability for delivery of special weapons covering a wide range of weapon yields. Project personnel, who were from the Navy Bureau of Aeronautics, included one pilot, the ground controller, and the maintenance personnel responsible for the special painting and instrumentation of the aircraft.

Two A4D-1 aircraft participated in the project. At shot-time and at the first shock arrival, the aircraft positions were as follows:

Aircraft #1	Shot Time	First Shock Arrival
Slant range from burst	2,910 meters	3,960 meters
Height above burst	9,610 feet	9,620 feet
Height above ground	11,110 feet	11,120 feet

Aircraft #2

Slant range from burst	2,940 meters	4,050 meters
Height above burst	9,710 feet	9,720 feet
Height above ground	11,210 feet	11,210 feet

The two aircraft were piloted and flown on a straight and level course directly above ground zero. The flight consisted of takeoff from Indian Springs AFB at 0451, pattern entry 30 minutes before the detonation, and landing at Indian Springs AFB at 0545 (4; 81).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop Aircraft calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center supplied the F-89D aircraft and the two-man crew. Wright Air Development Center and Northrop Aircraft together developed positioning methods and calculated the aircraft positions at the detonation and shock arrival times.

The F-89D aircraft flew from Indian Springs AFB at 0500. Before the shot, the aircraft positioned itself by flying one complete 12-minute holding pattern. At shot-time, the aircraft was at a slant range of 4,010 meters from the burst and at a slant range of 4,130 meters when the initial shock wave arrived. The aircraft was in the test area for approximately 30 minutes, returning to Indian Springs AFB at 0536. During the mission, film badges were placed in the pilot's and observer's positions (4; 74).

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LOKAN) system in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and yield of that burst. The Indirect Bomb Damage Assessment NAROL system tested on this operation consisted of nets located in Albuquerque, New Mexico; Vale, Oregon; Rapid City, South Dakota. Each NAROL net had two unmanned slave stations and one manned station (50).

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

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

Working from five hours before to 30 minutes after the detonation, nine personnel established and then manned a camera station on Mercury Highway at UTM coordinates 843963. An additional two or three personnel took pictures from a C-47 aircraft operated by participants from the Military Air Transport Service. EG and G personnel provided technical photography support to AFSWP and the AEC, operating five camera stations to record fireball and cloud growth. One manned station was near the Control Point, and four unmanned stations were three to eight kilometers from ground zero (4; 18; 27; 48).

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

The University of California Radiation Laboratory was the only AEC nuclear weapons development laboratory conducting a project at DOPPLER involving DOD personnel. The Los Alamos Scientific Laboratory fielded 11 projects, but none had DOD involvement. Of the two projects fielded by the UCRL Test Group, only Project 21.2, Radiochemistry Sampling, engaged DOD personnel. The project required air support from AFSWC and 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 conducted two projects at DOPPLER. Only Project 39.5, Radiation Dosimetry for Human Exposures, involved DOD personnel, as listed in table S-2. Project 39.5 was conducted by the Air Force School of Aviation Medicine, along with several civilian agencies. The project was designed to collect information on the characteristics of neutron and gamma radiations at various distances from ground zero in order to evaluate the doses received by the survivors of Hiroshima and Nagasaki. Five minutes after the detonation, 15 personnel recovered radiation detectors that had been placed 550 to 1,370 meters from ground zero. They spent about 30 minutes in the field. One hour after detonation, five men began recovering gamma collimators, film badges, chemical dosimeters, and phantoms 690 to 1,100 meters from ground zero, a process that took about 40 minutes. These participants received permission from the Test Director to enter areas with intensities up to 20 R/h. At least two of the project participants were DOD personnel who collected the gamma collimators. Two other DOD personnel were radiological safety monitors from the 1st Radiation Safety Support Unit (18; 51; 52; 61).

8.2.4 Department of Defense Operational Training Projects

The one operational training project conducted at DOPPLER was Project 53.7, Indirect Bomb Damage Assessment. Staff from the Wright Air Development Center installed Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft (serial number 412) from Indian Springs AFB. The F-89D, with two crew members from Indian Springs AFB, left base at 0445 hours and then flew a right-hand holding pattern at an altitude of 35,000 feet, 125 nautical miles east of ground zero. The aircraft spent about 45 minutes in the shot area. After completing its mission, the F-89D landed at Indian Springs AFB at 0554 hours (2; 4).

X.2.5 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support at DOPPLER consisted of cloud-sampling and sample courier missions for UCRL Project 21.2, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Two B-57B aircraft, each with a crew of two, and four F-84G aircraft, each with a crew of one, collected samples of the cloud for UCRL Project 21.2, Radiochemistry Sampling. A B-57B sampler control aircraft, with a pilot and a UCRL scientific advisor, directed the sampling. Pilots of the 4926th Test Squadron (Sampling) flew the eight aircraft.

The control aircraft left Indian Springs AFB 15 minutes before the detonation and was positioned by air controllers of the Air Operations Center outside the testing area. Upon reaching an altitude of 30,000 to 35,000 feet, the control aircraft began its holding pattern. After the detonation, the control aircraft left its orbit to view the cloud. Around 90 minutes after the detonation, the B-57B sampler aircraft,

followed by the F-84G sampler aircraft, left Indian Springs AFB. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire the samples. In 30 to 35 minutes, after completing their sampling runs, most of the aircraft left the area for Indian Springs AFB. One or more of the B-57Rs accompanied the B-57B sampler control aircraft back to Indian Springs AFB (1; 2; 4).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with an estimated crew of three, left Indian Springs AFB on shot-day to transport samples to various air bases for analysis by AEC nuclear weapons design laboratories. The 4901st Air Base Wing from Kirtland AFB conducted these courier missions (2).

Cloud Tracking

Immediately after the detonation, one B-25 aircraft and one B-29 aircraft from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Test Site. The B-25 flew at 15,000 feet, while the B-29 flew at 22,000 feet. The B-25 had a crew of four, and the B-29 had a crew of ten (2; 4).

Security Sweeps

Before the shot, one L-20 aircraft was dispatched from Yucca airstrip near Camp Mercury to perform a security sweep mission over the test area. The aircraft had a crew of at least two since the security sweep called for a security guard to accompany the pilot (2; 68).

Helicopter Surveys

The Test Director's radiological safety advisor canceled two H-21 helicopter surveys to record radiation intensities over the shot area because they were not needed (52; 68).

8.3 RADIATION PROTECTION AT SHOT DOPPLER

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

During the period covering the 23 August detonation of DOPPLER, the Dosimetry and Records Section issued 2,987 film badges and 180 pocket dosimeters. Fourteen NTO/DOD personnel received cumulative gamma exposures exceeding 2.0 roentgens. Four of these exposures were greater than 3.0 roentgens, ranging from 3.3 to 4.9 roentgens. Among the 14 personnel, three were from the Ballistic Research Laboratories, one from AFSWP, and ten from AFSWC, including five cloud-sampling pilots and one helicopter pilot (57; 68; 73).

Logistics

For Shot DOPPLER, the General Supply Section issued anti-contamination clothing to 1,260 people (83). These items consisted of coveralls, shoe covers, respirators, and other protective equipment.

Monitoring

Eleven men in vehicles proceeded toward the shot area ten minutes after the detonation to begin the initial ground survey

of the area. They reported the last intensity in the shot area at 0625 hours. Six men in vehicles also conducted ground surveys in areas adjacent to the shot area. The survey began at 0543, and the last radiation intensity was reported at 0646 hours. The highest gamma intensity encountered was 0.012 R/h. Ground resurveys were conducted for several days after the detonation. All aerial surveys were canceled at 0800 hours on shot-day (68; 83).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during DOPPLER (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isointensity contour maps from the radiation intensity data gathered by the ground survey teams. Figure 8-l presents the isointensity plot developed from information gained during the initial survey. Figure 8-2 shows the data resulting from the resurveys on 23 August through 26 August (83).

In addition to its other activities, the Plotting and Briefing Branch issued access permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 1,419 access permits during DOPPLER (83).

Decontamination

During the period covering Shot DOPPLER, the Vehicle and Equipment Decontamination Section decontaminated 69 vehicles (83).

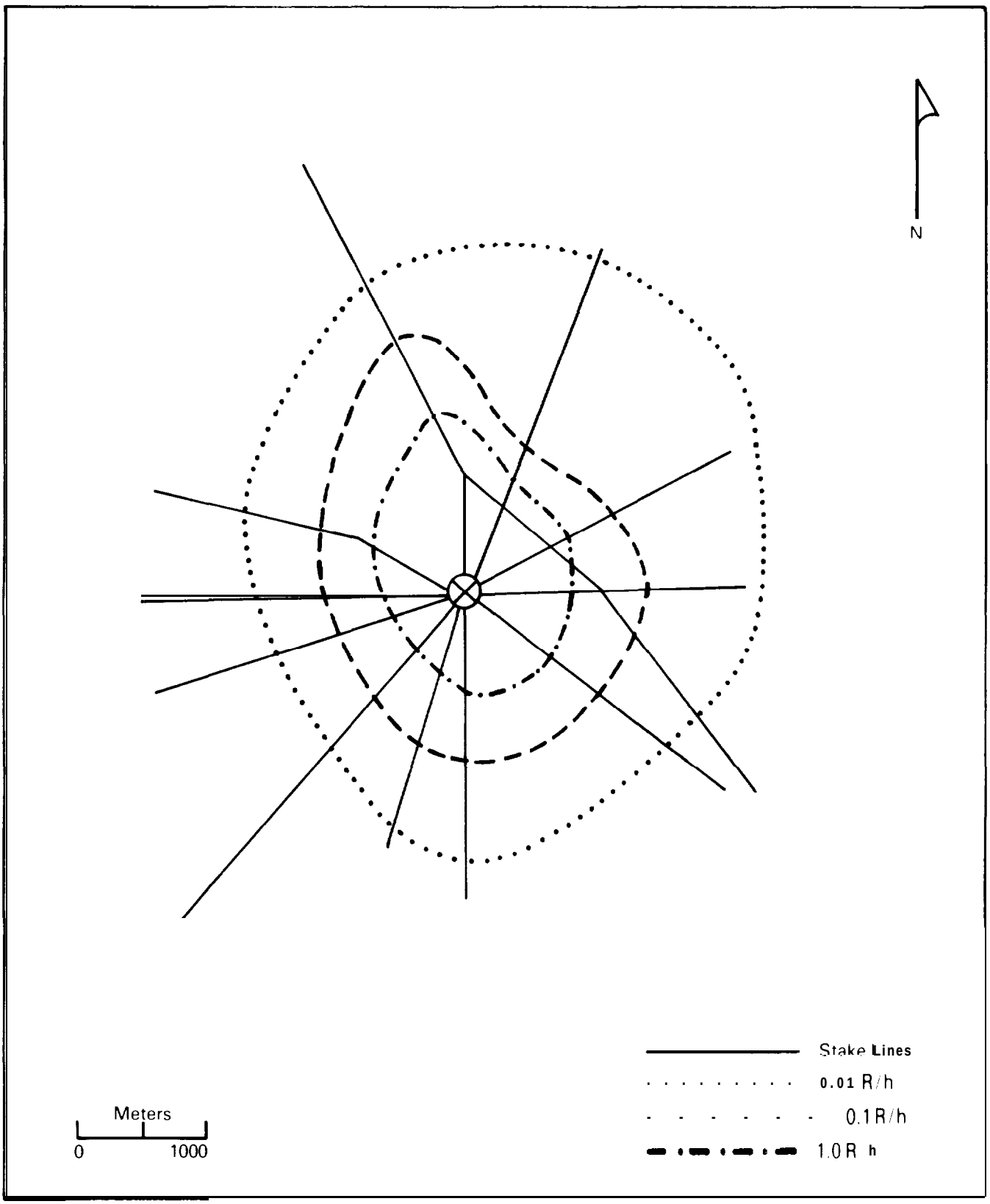
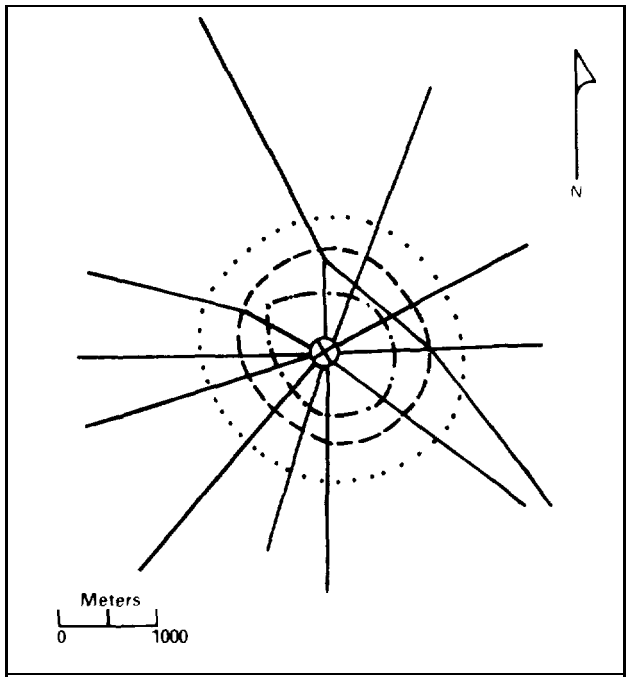
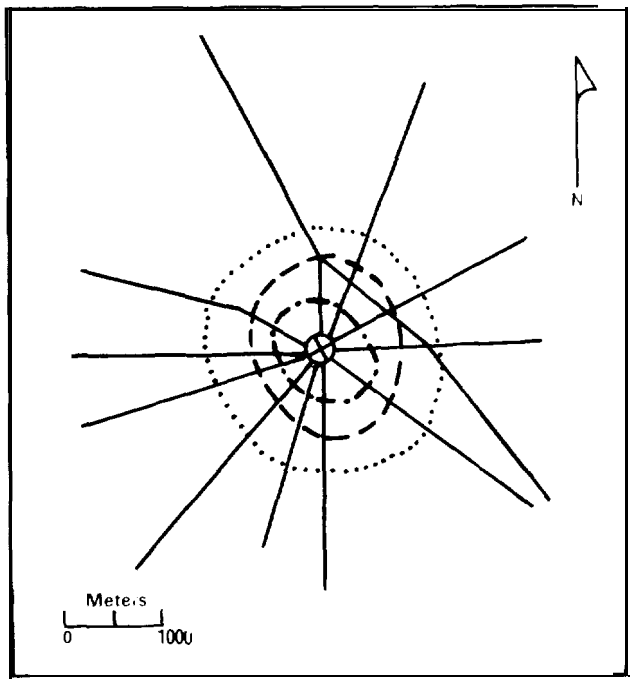


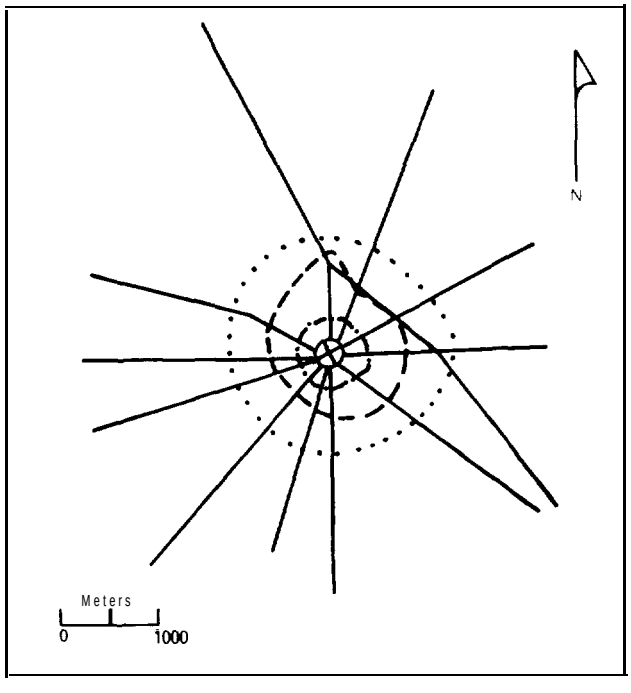
Figure 8-I: INITIAL SURVEY FOR SHOT DOPPLER, 23 AUGUST 1957, MID-TIME 0611



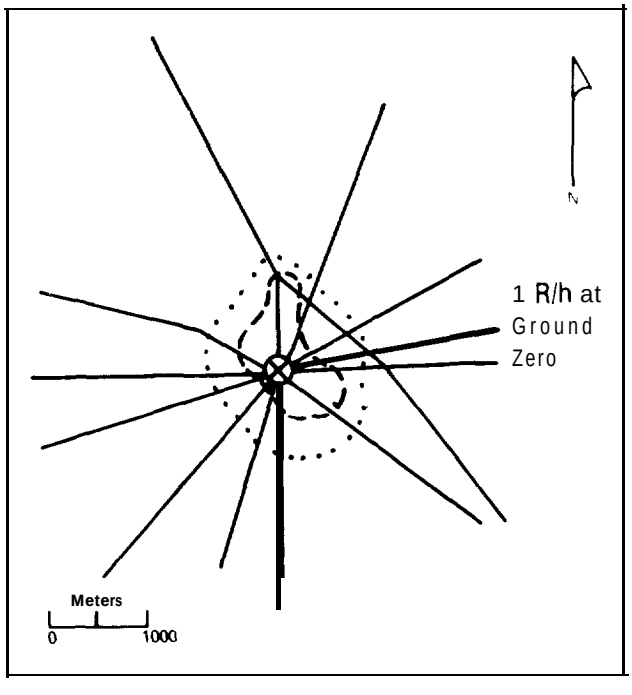
23 August 1957, Mid-Time: 1142



24 August 1957, Mid-Time: 0602



25 August 1957, Mid-Time: 0606



26 August 1957, Mid-Time: 0612

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

Figure 8-2': SUBSEQUENT SURVEYS FOR SHOT DOPPLER

SHOT FRANKLIN PRIME SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	30 August 1957, 0540 hours
YIELD:	4.7 kilotons
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 effectiveness of military equipment and tactics and to indoctrinate personnel in the effects of nuclear detonations.

Weather: At shot-time, the temperature was 11°C, and surface winds were calm. Winds were 14 knots from the south-southeast at 10,000 feet, 31 knots from the south-southwest at 20,000 feet, and 40 knots from the southwest at 30,000 feet.

Radiation Data: About 45 minutes after the detonation, radiation intensities of 1.0 R/h or more were confined to within about 800 meters of ground zero.

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 9

SHOT FRANKLIN PRIME

Shot FRANKLIN PRIME was detonated with a yield of 4.7 kilotons at 0540 hours Pacific Daylight Time on 30 August 1957. The device was suspended from a balloon 750 feet above the ground over Area 7 of the NTS. The cloud top, which reached 32,000 feet, traveled northeast from Yucca Flat, while the stem of the cloud drifted somewhat west of north. Although there was some fallout to the north of ground zero, most onsite radiation was from neutron activation of the soil around ground zero (31).

9.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT FRANKLIN PRIME

Approximately 1,200 Desert Rock troops took part in projects associated with Shot FRANKLIN PRIME: three troop observer indoctrination projects, one radiological training project, and two technical service pro.jects. Table 9-l identifies these projects. It also lists the troops from Task Force BIG BANG and Task Force WARRIOR and the Camp Desert Rock support troops who witnessed the detonation.

9.1.1 Troop Observer Indoctrination Projects

Five groups of observers participated at Shot FRANKLIN PRIME, as indicated in table 9-l. Of these observers, 67 were from a provisional company of the 82nd Airborne Division assigned to Task Force BIG BANG for Shot GALILEO, and 50 were assigned to Task Force WARRIOR for Shot SMOKY. The observer area was at UTM coordinates 849859, 16 kilometers southwest of the shot balloon. Because of the distance, the observers were not in trenches (47; 49).

Table 9-1: EXERCISE DESERT ROCK PROJECTS, SHOT FRANKLIN PRIME

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50.2	Troop Observers	Army	384
			Navy	3
	52.2	Marine Observers	Marine Corps	9
	53.3	Aircrew Observers	Air Force	15
	-		Task Force BIG BANG; Task Force WARRIOR	117
			Camp Desert Rock Support Troops	49
Radiological Training	53.4	Radiological Defense Training	Radiological Defense School, Lowry AFB	48
Technical S[redacted]	50.3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories; Fort Huachuca. Arizona; Furt Meade, Maryland	32
	50.8	Detection of Atomic Burst and Radioactive Fallout	495th Antiaircraft Artillery Missile Battalion; Army Air Defense Board	557

9.1.2 Radiological Training Project

Project 53.4, Radiological Defense Training, was the one radiological training project conducted during FRANKLIN PRIME. Conducted by the Radiological Defense School of Lowry AFH, Denver, Colorado, the project involved 48 Air Force personnel. After the detonation, the participants proceeded along an assigned route from the observation area to a designated area near ground zero using vehicles from the Desert Rock Decontamination Station. Accompanied bv a radiological safety monitor, the project personnel monitored radiation intensities at various distances from ground zero. These readings were relayed by radio to the control stations and were then plotted on a map (47; 493).

9.1.3 Technical Service Projects

As indicated in table 9-1, two technical service projects were conducted at Shot FRANKLIN PRIME to evaluate diagnostic instrumentation and techniques for use in a nuclear environment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Huachuca, and seven personnel from Fort Meade. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine the Army fallout prediction methods. The project required a radar section to activate remote radar sets located approximately five kilometers from ground zero and 64 kilometers east of the NTS. A fallout prediction team also participated, operating out of an M-109 mobile van next to the weather station at Camp Mercury (20; 47; 49).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the 495th Antiaircraft Artillery Missile Battalion, along with the Army Chemical Corps. The objectives were to:

- Determine how well equipment found in a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation
- Track targets and guided missiles through a nuclear cloud or fireball
- Predict and monitor radioactive fallout.

The project involved an estimated 557 DOD personnel. To determine the location, height of burst, and yield of the detonation, participants operated 15 onsite and offsite radar, camera, and other instrument stations located nine to 70 kilometers from ground zero. The control point was at UTM coordinates 768942, 15 kilometers southwest of ground zero. To test the attenuation of the aircraft missile control signals, a B-26, with a pilot only,

was positioned between the cloud and a Nike Hercules ground site 20 kilometers northeast of ground zero. The aircraft spent about 30 minutes in the area. In another part of the project, two H-34 helicopters, two H-13 helicopters, and an L-21 aircraft conducted aerial radiological surveys following the detonation. The aircraft flew at altitudes ranging from 100 to 1,000 feet. Each H-34 and the H-13 carried three and two persons, respectively (17; 28; 47; 49; 77; 79; 80).

9.2 DEPARTMENT OF DEFENSE PARTICIPATION IN TEST GROUP, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT FRANKLIN PRIME

In addition to the Exercise Desert Rock personnel, other DOD personnel took part in test activities during Shot FRANKLIN PRIME that required them to enter the forward area. Table 9-2 identifies the test group projects involving DOD participants. The Air Force sponsored three operational training projects during the shot. In addition to the test group and the operational training projects, AFSWC and other support activities accounted for a number of other DOD participants. The Air Force Special Weapons Center supported UCRL Project 21.2 and flew routine missions for the Test Manager.

9.2.1 Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted three projects at Shot FRANKLIN PRIME, as indicated in table 9-2.

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft, Incorporated, was contracted to assist the Wright Air Development Center in planning and conducting the test. Northrop Aircraft

calibrated, maintained, and operated the instrumentation, and correlated the data. Wright Air Development Center provided the F-89D aircraft and the two-man crew. Wright Air Development Center and Northrop Aircraft together developed positioning methods and calculated the aircraft positions at the detonation and shock arrival times.

Table 9-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT FRANKLIN PRIME

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center; Northrop Aircraft	2
6.4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
9.1	Support Photography	AFSWP; Military Air Transport Service	10
University of California Radiation Laboratory Test Group			
21.2	Radiochemistry Sampling	Air Force Special Weapons Center	4

* Unknown

The aircraft left Indian Springs AFB at 0510. Before the shot, it flew one complete 12-minute holding pattern to position itself. At shot-time, the aircraft was at a slant range of 2,500 meters from the burst. When the initial shock wave arrived, the aircraft was a slant range of 3,350 meters from the burst. The aircraft was in the test area for approximately 30 minutes, returning to Indian Springs AFB at 0545. During the mission, film badges were placed in the pilot's and observer's positions (5; 74).

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 yield of that burst. The Indirect Bomb Damage Assessment NAROL system tested on 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 (50).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following 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 detonations for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Working from five hours before to 30 minutes after the detonation, seven personnel established and then manned a camera station at UTM coordinates 842004. An additional two or three participants took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. EG and G personnel provided technical photography support to AFSWP and the AEC, operating five camera stations to record fireball and cloud growth. One manned camera station was near the Control Point, and four unmanned stations were three to eight kilometers from ground zero (5; 17; 27; 47).

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

The University of California Radiation Laboratory was the only AEC nuclear weapons development laboratory conducting a

project at FRANKLIN PRIME involving DOD personnel. The Los Alamos Scientific Laboratory fielded nine projects, but none had DOD involvement. Of the two projects fielded by the UCRL Test Group, only Project 21.2, Radiochemistry Sampling, engaged DOD personnel. The project required air support from AFSWC and is discussed in section 9.2.4.

9.2.3 Department of Defense Operational Training Projects

The primary objectives of the operational training program were to indoctrinate personnel and to test equipment and techniques. The Air Force sponsored three operational training projects at Shot FRANKLIN PRIME to indoctrinate personnel in the effects of a nuclear detonation and to test equipment:

- Project 53.1, Aerial Sampling Missions
- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.1, Aerial Sampling Missions, involved Wisconsin and Delaware Air National Guard units that flew sample missions in conjunction with UCRL Project 21.2, Radiochemistry Sampling. This activity is discussed under AFSWC operations, in the next section of this chapter.

Project 53.7, Indirect Bomb Damage Assessment, required staff from the Wright Air Development Center to install Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft from Indian Springs AFB. The F-89D, with a crew of two, flew a holding pattern at an altitude of 35,000 feet. The aircraft spent approximately 60 minutes in the shot area. After completing its mission, the F-89D returned to base for decontamination (2; 5).

Project 53.9, Photographic Mission, was intended to indoctrinate Tennessee Air National Guard Tactical Reconnaissance units in photographic missions over a nuclear target. Two RF-84 aircraft, each operated by one pilot, flew holding patterns until ten minutes after the detonation, when the aircraft made photographic runs over ground zero at 10,000 feet. Upon completion of the run, the aircraft returned to base for decontamination (2; 5).

9.2.4 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support at Shot FRANKLIN PRIME consisted of cloud-sampling and sample courier missions for UCRL Project 21.2, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Three F-84G aircraft, each operated by one pilot, collected samples of the cloud for UCRL Project 21.2, Radiochemistry Sampling. One B-57B sampler control aircraft, with a pilot and a UCRL scientific advisor, directed the sampling. Pilots from the 4926th Test Squadron (Sampling) flew all four aircraft.

The control aircraft left Indian Springs AFB 15 minutes before the detonation and was positioned by air controllers of the Air Operations Center outside the testing area. Upon reaching an altitude of 30,000 to 35,000 feet, the control aircraft began its orbit pattern.

Within 90 minutes after the control plane took off, the three F-84G sampler aircraft left Indian Springs AFB. Guided by the control aircraft, the samplers entered the vicinity of the burst. After the detonation, the control aircraft left its orbit to view the cloud. The scientific advisor then directed the samplers to penetrate the cloud as necessary to acquire the

samples. One of the F-84s had to abort its mission because of communications difficulties. After completing their sampling runs, the samplers left the area and landed at Indian Springs AFB, followed by the control aircraft (1; 2; 5).

Courier Missions

After the sampling missions were completed, three C-47 aircraft, each with a crew of three, left Indian Springs AFB on shot-day to transport samples to various air bases for analysis by AEC nuclear weapons design laboratories. The 4901st Air Base Wing from Kirtland AFB conducted these courier missions (2).

Cloud Tracking

Immediately after the detonation, one B-25 aircraft from Indian Springs AFB flew a cloud-tracking mission over and beyond the Nevada Test Site. The B-25, which flew at 15,000 feet, carried a crew of nine (2; 5).

Security Sweeps

Before the shot, one L-20 aircraft was dispatched from Yucca airstrip near Camp Mercury to perform a security sweep mission over the test area. The aircraft had a crew of at least two since the security sweep called for a security guard to accompany the pilot (69).

Helicopter Surveys

After the detonation, AFSWC used one H-21 helicopter to fly survey missions over the shot area and non-test areas to record radiation intensities. The helicopter had a crew of four: two AFSWC pilots and two REECo monitors. The surveys were conducted 70 minutes and six hours after the detonation. Additional aerial resurveys were not conducted because sufficient information could be obtained from the ground surveys. After th,e mission, helicopters returned to the helicopter pad and were monitored and decontaminated as required (69).

9.3 RADIATION PROTECTION AT SHOT FRANKLIN PRIME

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 dosimetrv data. Radiological safety procedures and dosimetry information for Desert Rock are described in the Operation PLUMBBOB volume.

Dosimetry

During the period covering the 30 August detonation of FRANKLIN PRIME, the Dosimetry and Records Section issued 909 film badges and 79 pocket dosimeters. With the possible exception of some AFSWC personnel, no NTO/DOD personnel exceeded cumulative gamma exposures at FRANKLIN PRIME of 2.0 roentgens. Some data indicate exposures at FHANKLIN PRIME exceeding 2.0 roentgens. Field Command Weapons Effects Test Group Project 5.5, Inflight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was fielded by Wright Air Development Center. For this project, dosimeters were placed in the pilot's and observer's positions. The dosimeters in the pilot's position recorded 2.44 roentgens, and the dosimeters in the observer's position measured 2.05 roentgens of gamma radiation (74).

Logistics

The General Supply Section issued anticontamination clothing to 140 people at FRANKLIN PRIME (83). This clothing included respirators, coveralls, and shoe covers.

Monitoring

Eleven men in vehicles proceeded toward the shot area ten minutes after the detonation to begin the initial ground survey. They reported the last intensity in the shot area at 0635 hours. Six men in vehicles also conducted ground surveys in areas adjacent to the shot area, beginning at 0549 and reporting a last reading at 0628 hours. Radiation intensities encountered were the same as before the FRANKLIN PRIME detonation. Ground resurveys were conducted for several days following the detonation. Aerial helicopter surveys, conducted by AFSWC and REECo personnel, were begun 70 minutes and six hours after the detonation (69).

The Special Assignments Branch monitored radiation levels in living and working areas and found no evidence of increased radioactivity in either well or drinking water during FRANKLIN PRIME (83).

Plotting and Briefing

The Plotting and Briefing Branch developed isodose contour maps from the radiation intensity data gathered by the ground survey teams. Figure 9-1 presents the isointensity plot developed from information gained during the initial survey. Figure 9-2 shows data resulting from the resurveys on 30 August, 1 September, and 2 September. The 0.01 H/h line shown for the September surveys includes a contribution from Shot SMOKY, fired on 31 August (83).

In addition to its other activities, the Plotting and Briefing Branch issued access permits to control entry into radiological exclusion areas. The Plotting and Briefing Branch issued 237 access permits during FRANKLIN PRIME (83).

Decontamination

During the period covering Shot FRANKLIN PRIME, the Vehicle and Equipment Decontamination Section decontaminated ten vehicles (83).

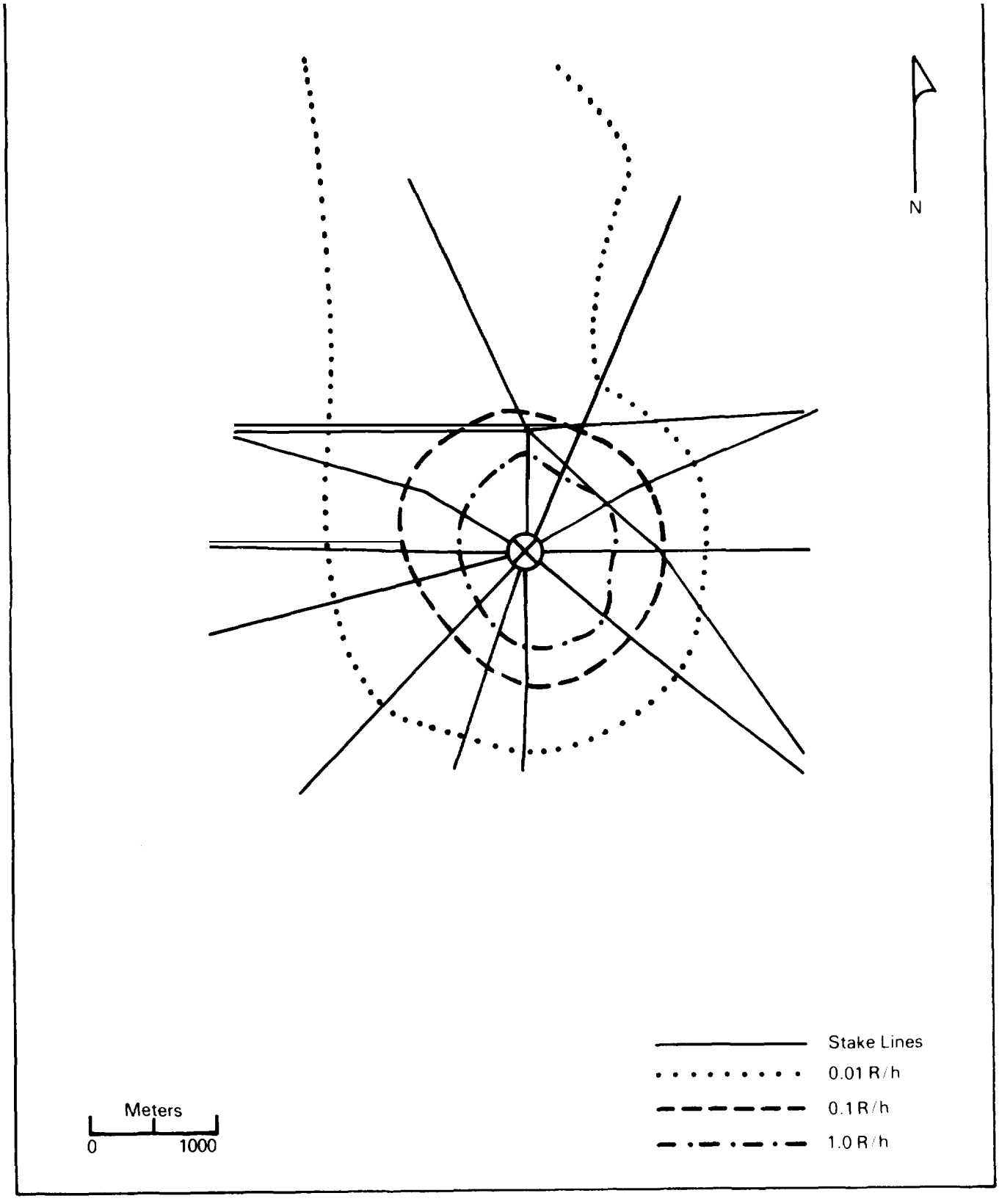
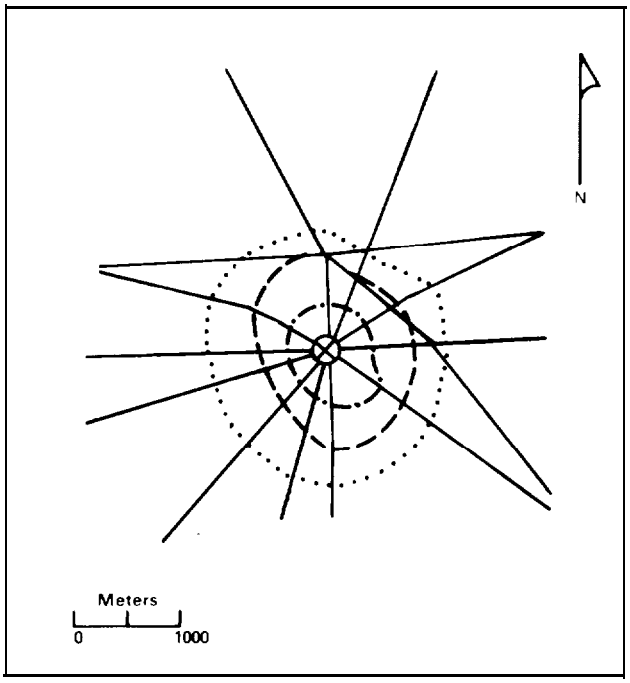
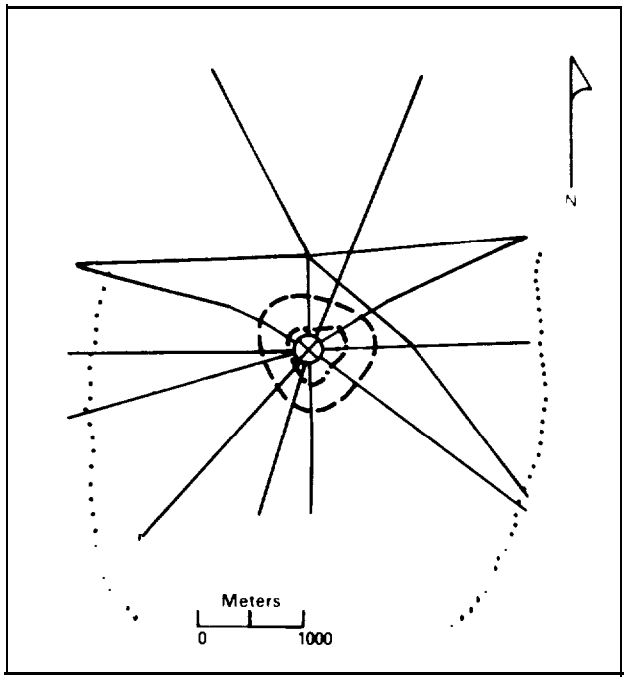


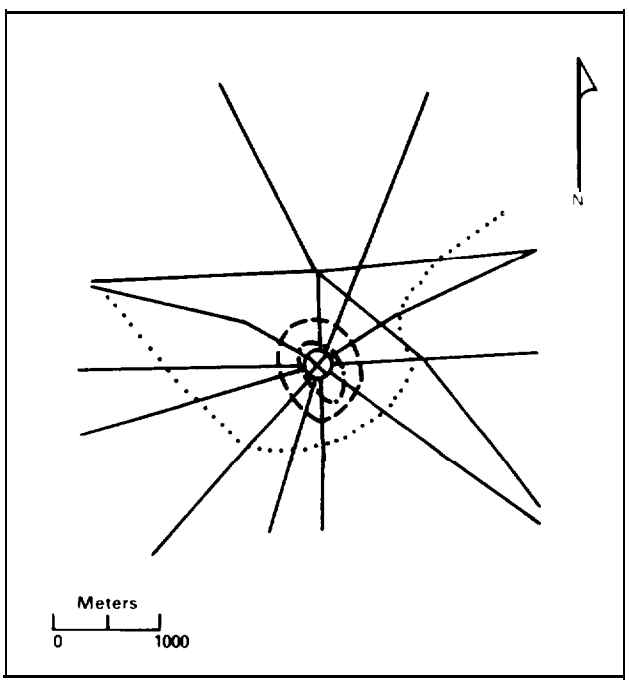
Figure 9-1: INITIAL SURVEY FOR SHOT FRANKLIN PRIME, 30 AUGUST 1957, MID-TIME 0525



30 August 1957, Mid Time: 1153



1 September 1957, Mid-Time: 0621



2 September 1957, Mid-Time: 0901

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

Figure 9-2: SUBSEQUENT SURVEYS FOR SHOT FRANKLIN PRIME

REFERENCE LIST

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

The DIABLO through FRANKLIN PRIME volume was completed after the publication of the series volume. References 2, 4, 11, 12, 14, 16-18, 25, 27, 39, 57, 59, 62-69, 71, 72, 80, 85, and 86 do not appear in the PLUMBBOB Series bibliography.

AVAILABILITY INFORMATION

An availability statement has been included at the end of the reference citation for those readers who wish to read or obtain copies of source documents. The following addresses are being provided for that purpose.

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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: DLCS Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
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)

Manchester City Library
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Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
ATTN: Librn

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

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

Miami Dade Community College
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
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Michigan State University Library
ATTN: Librn

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)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
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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 cf Emergency Svcs
ATTN: Librn

OTHER (Continued)

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Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
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Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

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

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
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 Oocs

University of Oklahoma
ATTN: Docs Div

Old Dominion University
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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
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Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN: Librn

Portland Public Library
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Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN: Librn

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN: Librn

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College 'Library
ATTN: Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
RTTN: 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
ATTN: Librn

Riverside Public Library
ATTN: Librn

University of Rochester Library
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University of Rutgers Camden Library
ATTN: Librn

State University of Rutgers
ATTN: Librn

Rutgers University
ATTN: Dir of Libraries (Reg)

Rutgers University Law Library
ATTN: Fed Docs Dept

Salem College Library
ATTN: Librn

Samford University
ATTN: Librn

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

San Diego Public Library
ATTN: Librn

San Diego State University Library
ATTN: Gov Pubs Dept

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 Librarv
ATTN: Librn

Seattle Public Library
ATTN: Ref Docs Asst

OTHER (Continued1

Selby Public Library
ATTN: Librn

Shawnee Library System
ATTN: Librn

Shreve Memorial Library
ATTN: Librn

Silas Bronson Public Library
ATTN: Librn

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

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
ATTN: Librn

Southeastern Massachusetts University Library
ATTN: Docs Sec

University of Southern Alabama
ATTN: Librn

Southern California University Library
ATTN: Docs Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librn

Southern Illinois University
ATTN: Docs Ctr

Southern Methodist University
ATTN: Librn

University of Southern Mississippi
ATTN: Library

OTHER (Continued)

Southern Oregon College
ATTN: Library

Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN: Librn

St Louis Public Library
ATTN. Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN. Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
ATTN: Librn

State University of New York
ATTN: Librn

Stetson University
ATTN: Librn

University of Steubenville
ATTN: Librn

Stockton & San Joaquin Public Library
ATTN: Librn

Stockton State College Library
ATTN. Librn

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 Deut

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 Call

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 Oreno
ATTN: Librn

University of Northern Iowa
ATTN: Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN: Librn

University of Utah
ATTN: Special Collections

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

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
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librn

Wright State University Library
ATTN: Gov Docs Librn

Wyoming State Library
ATTN: Librn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Librn

Yuma City County Library
ATTN: Librn

Simon Schwob Mem Lib, Columbus Col
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS

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ATTN: DASIAC
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Science Applications, Inc
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