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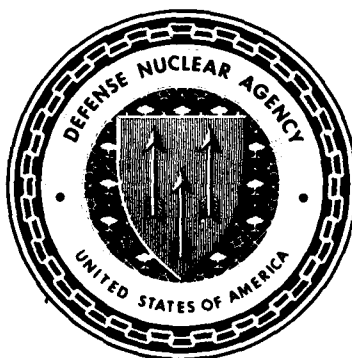
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OPERATION DOMINIC II

Shots LITTLE FELLER II,
JOHNIE BOY, SMALL BOY,
LITTLE FELLER I
7 JULY-17 JULY 1962



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United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

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Fact Sheet



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

Subject: Operation DOMINIC II

Operation DOMINIC II was conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS) from 7 July through 17 July 1962. The operation consisted of four low-yield shots, three of which were near-surface detonations and one a tower shot. One of the near-surface shots was fired from a DAVY CROCKETT rocket launcher as part of Exercise IVY FLATS, the only military training exercise conducted at DOMINIC II. An estimated 3,000 Department of Defense (DOD) personnel participated in Exercise IVY FLATS, scientific and diagnostic tests, and support activities. The series was intended to provide information on weapons effects and to test the effectiveness of the DAVY CROCKETT weapons system under simulated tactical conditions. Also known by the DOD code name of Operation SUNBEAM, DOMINIC II was the continental phase of DOMINIC I, the nuclear test series conducted at the Pacific Proving Ground from April to November 1962.

Department of Defense Involvement

Approximately 1,000 Sixth Army military personnel at Operation DOMINIC II participated in Exercise IVY FLATS, which was sponsored by the Department of the Army and conducted at Shot LITTLE FELLER I. The remaining DOD personnel took part in scientific tests, air support activities, or administrative support activities for DOMINIC II.

Among the Sixth Army participants in Exercise IVY FLATS were approximately 550 maneuver troops drawn primarily from the 4th Infantry Division and approximately 210 Sixth Army personnel who provided support services. Also present were about 400 military and civilian observers. Other military participants included approximately 80 members of the Control, Safety, and Evaluation Group. Some of these personnel accompanied the task force on its maneuver, while others monitored the maneuver from the command post.

The scientific tests at DOMINIC II were supervised by the Defense Atomic Support Agency (DASA) Weapons Effects Test Group. These tests were designed to collect information on weapons effects, such as the electromagnetic pulse, prompt and residual radiation, and thermal radiation. The experiments also tested the effects of low-yield detonations on structures and on aircraft in flight.

Personnel from the following organizations participated in these tests:

- Air Force Special Weapons Center
- Army Engineer Research and Development Laboratories
- Army Engineer Waterways Experiment Station
- Army Nuclear Defense Laboratory
- Army Signal Research and Development Laboratories
- Ballistic Research Laboratories (Army)
- David Taylor Model Basin (Navy)
- Harry Diamond Laboratories
- Naval Missile Center.

Air support activities at DOMINIC II included cloud sampling, courier missions, aerial surveys of terrain, and cloud tracking. The Air Force Special Weapons Center (AFSWC) provided most of these air support services. Specific AFSWC units participating were the AFSWC Nuclear Test Directorate, the Special Projects Division, and the 4900th Air Base Group. The following other Air Force units provided support to AFSWC:

- The 1211th Test Squadron (Sampling), Military Air Transport Service, performed cloud sampling.
- The 4520th Combat Crew Training Wing, Tactical Air Command, provided support services at Indian Springs Air Force Base and Nellis Air Force Base.
- The 55th Weather Reconnaissance Squadron supplied an aircraft and crew for high-altitude cloud tracking.
- The Aeronautical Systems Division, Air Force Systems Command, provided air support for technical projects.

Most of the air support activities were staged from Indian Springs Air Force Base, 30 kilometers east of Camp Mercury, the Nevada Test Site base camp.

Department of Defense personnel also assisted the AEC Test Manager in planning, coordinating, and executing the DOMINIC II test events. These personnel were responsible for overseeing DOD technical and military planning objectives in the operation.

Summaries of DOMINIC II Nuclear Events

The four DOMINIC II events are summarized in the accompanying table. The accompanying figure shows the ground zeros of the four shots.

The event involving the largest number of DOD participants was Shot LITTLE FELLER I, the fourth DOMINIC II test. LITTLE FELLER I was a stockpile DAVY CROCKETT tactical weapon, fired as part of Exercise IVY FLATS. This training exercise consisted of an observer program and a troop maneuver. Observers in bleachers about 3.5 kilometers southwest of ground zero wore protective goggles while they watched the detonation. Maneuver troops forward of the observation site were in trenches during the detonation. Five personnel from the IVY FLATS maneuver task force launched the weapon from a rocket launcher mounted on an armored personnel carrier. LITTLE FELLER I detonated on target, 2,853 meters from the firing position. After the initial radiation surveys were completed, the IVY FLATS troops entered their vehicles and moved into the shot area, where they spent about 50 minutes conducting maneuvers.

Military personnel at Shot LITTLE FELLER I also participated in weapons effects tests, collecting data on blast, shock, and fallout effects, and in air support activities, including cloud sampling and cloud tracking.

The Operation DOMINIC II event involving the largest number of DOD projects was Shot SMALL BOY. Originally scheduled for 31 DOD projects, the shot ultimately included 63 DOD projects, as well as four Civil Effects and 31 AEC projects.

Shot SMALL BOY had initially been planned as the one detonation of Operation DOMINIC II. The primary purpose of the detonation was to provide information on electromagnetic pulse effects. Headquarters, DASA, consequently assigned Harry Diamond Laboratories, which had collected electromagnetic pulse data at Operation PLUMBBOB (1957), to provide overall technical direction for DOD programs. Program 6, Electromagnetic Effects, was given priority over the other programs, which were conducted according to strict guidelines designed to assure noninterference with Program 6 objectives.

Besides participating in the 63 DOD projects, military personnel took part in air-support activities. As at the other Operation DOMINIC II shots, these activities included cloud-sampling and cloud-tracking missions.

Safety Standards and Procedures

The Atomic Energy Commission was responsible for onsite and offsite radiological safety during Operation DOMINIC II. The AEC recommended a gamma exposure limit of 3 rem per 13-week period for most participants but authorized the pilots conducting cloud-sampling missions to receive up to 3.9 rem per 13-week period because their mission required them to penetrate the clouds.

The Test Manager was responsible for implementing the radiological safety procedures for the test organization, which included the Weapons Effects Test Group, AFSWC, and, at Shot LITTLE FELLER I, the IVY FLATS organization. Personnel from the Reynolds Electrical and Engineering Company (REECo) performed the radiological safety activities onsite and at Indian Springs AFB. These activities included:

- Monitoring radiation areas and controlling access into these areas
- Plotting isointensity maps of the shot areas
- Issuing radiation detection instruments and anti-contamination clothing and equipment to personnel entering radiation areas
- Providing film badges and maintaining exposure records for all personnel
- Decontaminating personnel, vehicles, and equipment.

At Shot LITTLE FELLER I, personnel from the IVY FLATS Radiological Safety Control Section, working within the REECo radiological safety program, conducted similar activities for Exercise IVY FLATS participants.

U.S. Public Health Service (USPHS) personnel performed offsite monitoring under the supervision of the Offsite Radiological Control Officer. Their activities included:

- Assessing offsite radiation
- Collecting data on fallout patterns
- Monitoring air, water, and milk
- Preparing reports, maps, and records that described the results of the monitoring and data collection.

In addition to these ground monitoring activities, the USPHS conducted aerial surveys of offsite areas.

Air Force personnel from the 1211th Test Squadron (Sampling) assisted REECo in monitoring and, as necessary, decontaminating aircrews and aircraft participating in cloud-sampling missions at DOMINIC II. These activities took place at Indian Springs AFB.

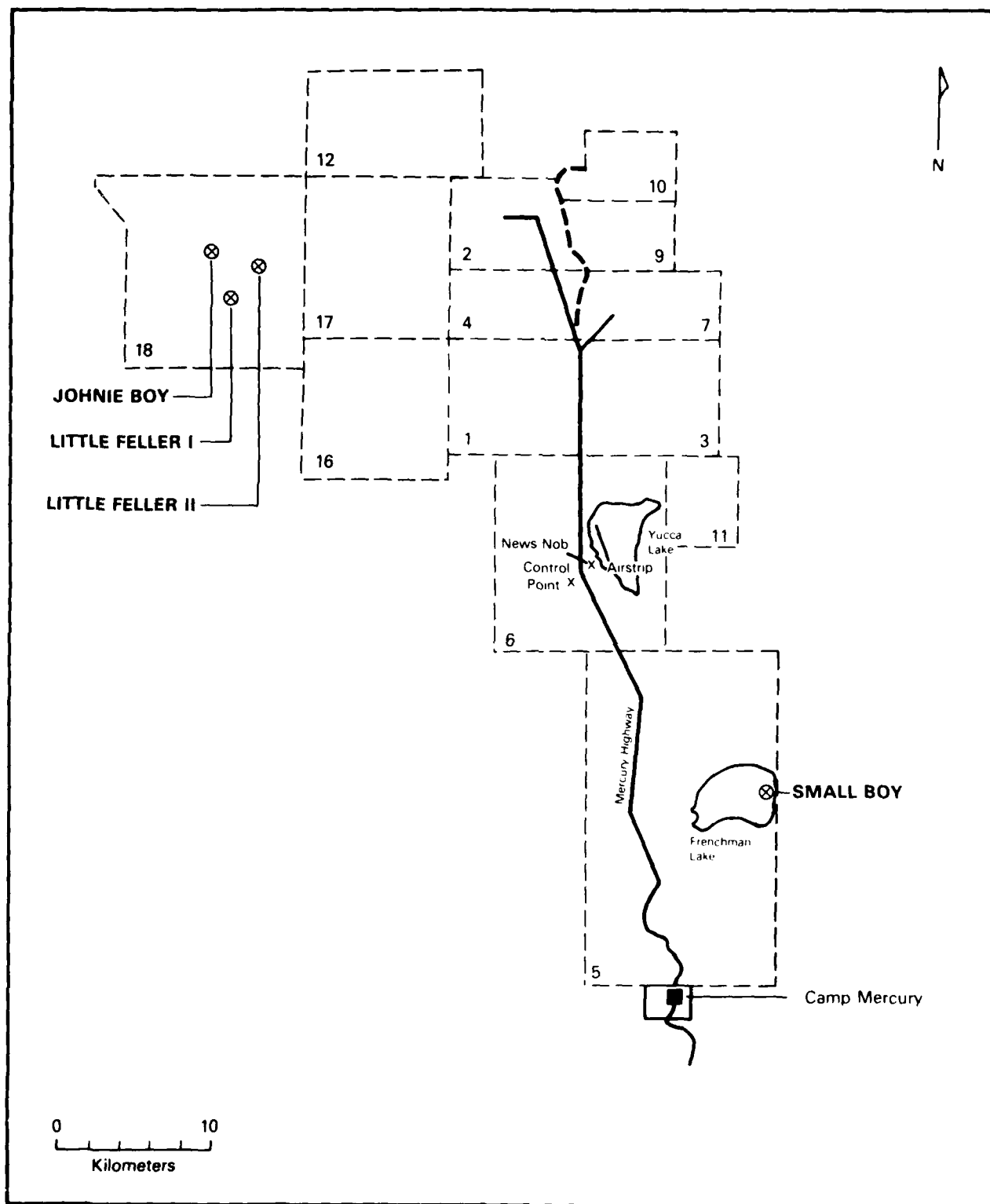
Radiation Exposures

As of December 1982, the military services had identified 1,738 participants by name. Available film badge data are shown in the table "Summary of Dosimetry for Operation DOMINIC II."

SUMMARY OF OPERATION DOMINIC II EVENTS (1962)

| Shot | LITTLE FELLER II | JOHNIE BOY | SMALL BOY | LITTLE FELLER I |
|------------------------|---------------------|-----------------|--------------------|--------------------|
| Sponsor | DOD | DOD | DOD | DOD |
| Date | 7 July | 11 July | 14 July | 17 July |
| Local Time* | 1200 | 0945 | 1130 | 1000 |
| NTS Location | Area 18 | Area 18 | Area 5 | Area 18 |
| Type of Detonation | Near Surface | Near Surface | Surface (Tower) | Near Surface |
| Height of Burst (Feet) | 3 | -2 | 10 | 3 |
| Yield (Kiloton) | Low | 0.5 | Low | Low |

*Pacific Daylight Time



**LOCATIONS OF DOMINIC II NUCLEAR TEST EVENTS
AT THE NEVADA TEST SITE**

**SUMMARY OF DOSIMETRY FOR OPERATION
DOMINIC II AS OF DECEMBER 1982**

| Service | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Gamma Exposure (rem) | | | | | Number of Personnel with Zero Gamma Exposure* | Average Gamma Exposure (rem) | Maximum Gamma Exposure (rem) |
|---|------------------------------------|---|----------------------|------------|-----------|----------|----------|---|---------------------------------------|---------------------------------------|
| | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0 + | | | |
| Army | 57 | 5 | 3 | 2 | 0 | 0 | 0 | 1 | 0.093 | 0.3 |
| Navy | 81 | 59 | 8 | 22 | 28 | 0 | 1 | 5 | 1.013 | 5.8 |
| Marine Corps | 89 | 58 | 18 | 24 | 15 | 1 | 0 | 10 | 0.573 | 4.3 |
| Air Force | 150 | 135 | 59 | 69 | 7 | 0 | 0 | 18 | 0.278 | 1.9 |
| Scientific Personnel, Contractors, and Affiliates | 1361 | 1361 | 1272 | 74 | 15 | 0 | 0 | 303 | 0.039 | 2.9 |
| TOTAL | 1738 | 1618 | 1360 | 191 | 65 | 1 | 1 | 337 | 0.114 | |

* The number of personnel in this column is also represented in the <.1 Gamma Exposure column.

PREFACE

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

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

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

- Identify DOD personnel who had taken part in the atmospheric nuclear weapons tests
- Determine the extent of the participants' exposure to ionizing radiation

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

- Provide public disclosure of information concerning participation by DOD personnel in the atmospheric nuclear weapons tests.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report on Operation DOMINIC II is based on the military and technical documents associated with the atmospheric nuclear weapons tests. These records, most of which were developed by individuals and organizations participating in DOMINIC II, are kept in over three dozen document repositories throughout the United States. In many cases, the documentation addresses test specifications and technical information, rather than personnel data. Moreover, the documents sometimes have inconsistencies in vital facts. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader.

For some of the projects discussed in this volume, the only records available are various plans and operations orders. These sources detail the plans developed by DOD and AEC personnel before DOMINIC II; they do not necessarily describe operations as they were actually conducted at the NTS. The project officer reports (also called weapons test reports) for the Defense Atomic Support Agency (DASA), on the other hand, summarize experiments performed by test groups during DOMINIC II, but these reports usually do not provide information about personnel activities. Because achieving the DOMINIC II objectives required detailed planning and adherence to operations orders, plans and operations orders should provide a reasonably accurate account of personnel activities.

This volume uses the project titles and agency designations that appear in the project officer reports for each project. Information on dates and yields of the detonations, fallout patterns, meteorological conditions, and cloud dimensions is taken from volume 1 of the General Electric Company-TEMPO's

Compilation of Local Fallout Data from Test Detonations
1945-1962, Extracted from DASA 1251 (75),* except in instances
where more specific information is available elsewhere.

ORGANIZATION OF THIS VOLUME

The following chapters detail DOD participation in Operation DOMINIC II. Chapter 1 provides background information about the operation, including summaries of the four nuclear test events and the activities of DOD participants. Chapter 2 outlines the Nevada Test Site Organization and the IVY FLATS organization, the two groups with major DOD participation. Chapter 3 describes the radiological criteria and procedures in effect for each of the DOD groups with significant participation. Chapter 4 discusses the results of the radiation protection program during DOMINIC II, including an analysis of film badge readings for DOD personnel.

Chapters 5 through 8 address each of the four shots in turn. Each chapter describes the specific setting and characteristics of the detonation, details DOD personnel activities at the shot, and discusses the radiation protection procedures used to minimize the potential for unauthorized exposures to ionizing radiation.

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

*All sources cited in the text are listed alphabetically and numbered in the Reference List at the end of this volume.

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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 |
| CTO | Continental Test Organization |
| DASA | Defense Atomic Support Agency |
| DOD | Department of Defense |
| EG&G | Edgerton, Germeshausen, & Grier, Incorporated |
| LASL | Los Alamos Scientific Laboratory |
| NTS | Nevada Test Site |
| NTSO | Nevada Test Site Organization |
| REECo | Reynolds Electrical and Engineering Company |
| rem | roentgen equivalent man |
| R/h | Roentgens per hour |
| UCLA | University of California at Los Angeles |
| USPHS | United States Public Health Service |
| UTM | Universal Transverse Mercator |

CHAPTER 1

INTRODUCTION

Operation DOMINIC II, the eighth peacetime series of nuclear weapons tests conducted within the continental United States, consisted of four nuclear detonations. Conducted from 7 July through 17 July 1962, the operation involved about 3,000 Department of Defense personnel participating in a military training exercise, scientific and diagnostic studies, and support activities. The series was intended to develop and test nuclear weapons for possible inclusion in the defense arsenal.

The purpose of this volume is to summarize information on organizations, procedures, and activities of DOD personnel in DOMINIC II. This chapter introduces the operation with background information, including:

- A discussion of the historical background and the establishment of Operation DOMINIC II
- A description of the NTS
- A synopsis of the four nuclear events
- An overview of DOD participation in this test series.

The information provides a basis for understanding the nature and extent of DOD participation in specific shots, as discussed in subsequent chapters.

1.1 HISTORICAL BACKGROUND AND THE ESTABLISHMENT OF OPERATION DOMINIC II

The development of a nuclear weapon became a high priority for the United States during the early years of World War II. As the war effort intensified, and as reports circulated concerning

German nuclear weapons research, the United States and Great Britain began collaborating in 1942 on a project to construct a nuclear weapon before the Germans did. The Army Corps of Engineers supervised the effort, code-named the Manhattan Project. On 16 July 1945, the Manhattan Project successfully detonated TRINITY, the first nuclear device ever tested. One month later, the United States detonated a nuclear device over Hiroshima and then another over Nagasaki, thereby bringing an end to World War II.

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

During the early 1950s, the United States reevaluated its military defense policy. The Soviet Union had detonated its first nuclear device in 1949, well ahead of American expectations. One year later, the United States committed ground forces to the Korean peninsula. To reduce the necessity of a large standing army and to minimize the likelihood of a surprise Soviet attack, the United States developed a nuclear arsenal capable of inflicting massive destruction on critical targets in the Soviet Union. Research continued on strategic nuclear weapons for arming international ballistic missiles and Strategic Air Command aircraft. The United States also explored the potential of smaller nuclear devices for tactical battlefield use (26; 90; 100).

The U.S. defense policy during the 1950s rested largely on America's ability to deter attack and general war by threatening

a major aggressor with nuclear retaliation. Consequently, the U.S. Government conducted an extensive nuclear weapons development program. From 1951 to 1958, the AEC and DOD conducted 14 nuclear weapons test series. Seven of the series were within the continental United States: RANGER (1951), BUSTER-JANGLE (1951), TUMBLER-SNAPPER (1952), UPSHOT-KNOTHOLE (1953), TEAPOT (1955), PLUMBBOB (1957), and HARDTACK II (1958). Six of the series were in the Pacific: GREENHOUSE (1951), IVY (1952), CASTLE (1954), WIGWAM (1955), REDWING (1956), and HARDTACK I (1958). One series, ARGUS (1958), was conducted in the Atlantic. During Operation IVY, the United States tested the first thermonuclear device, Shot MIKE, which had a yield of 10.4 megatons (26; 100).

Concern about nuclear proliferation existed throughout the 1950s. A movement toward limiting or banning atmospheric nuclear tests gained momentum in 1954, when natives of the Marshall Islands and the crew of a Japanese fishing boat were exposed to high levels of radiation from Shot BRAVO of Operation CASTLE. Public pressure on the nuclear power to reach an agreement limiting testing resulted in the U.S. Government's proposing an international conference to study the problems of monitoring a test ban. After this conference, held in Geneva during July and August 1958, the United States unilaterally proposed a test moratorium, which began on 1 November 1958, declaring a cessation in nuclear testing if the Soviet Union also refrained (24).

The moratorium on atmospheric nuclear weapons testing lasted almost three years, during which time the United States, the Soviet Union, and the United Kingdom participated in several international conferences on a nuclear test ban agreement. On 1 September 1961, the Soviet Union resumed atmospheric nuclear weapons testing. During the next eight months, it conducted about 30 nuclear tests, including one with a yield of 60 megatons. The United States resumed nuclear weapons testing on 15 September 1961 and, from that date to 25 June 1963, conducted

136 nuclear tests. These tests were part of Operations NOUGAT, STORAX, DOMINIC I, and DOMINIC II. Operation NOUGAT began on 15 September 1961 and ended on 30 June 1962. Operation STORAX was conducted from 6 July 1962 to 25 June 1963. Operation DOMINIC II, consisting of Shots LITTLE FELLER II, JOHNIE BOY, SMALL BOY, and LITTLE FELLER I, was conducted during the period of Operation STORAX. Operation DOMINIC II was the continental phase of DOMINIC I, the nuclear test series conducted at the Pacific Proving Ground from April through November 1962. The AEC used the designation DOMINIC II, while the DOD called the series Operation SUNBEAM (5; 24; 31).

In June 1963, President Kennedy announced that the United States, the Soviet Union, and the United Kingdom would resume discussions in Moscow concerning a test ban agreement. The discussions resulted in the Moscow Treaty or Partial Nuclear Test Ban Treaty, signed on 5 August 1963. This treaty, which became effective on 10 October 1963, banned nuclear weapons tests in the atmosphere, in outer space, and underwater. The treaty did not prohibit underground nuclear testing, as long as the detonations did not cause radioactive debris to leave the territorial borders of the testing nation (24).

1.2 THE NEVADA TEST SITE

The NTS, originally established by the AEC in December 1950, is located in the southeastern part of Nevada, 100 kilometers* northwest of Las Vegas, as shown in figure 1-1. The NTS, parts of which are depicted in figure 1-2, is an area of high desert and mountain terrain encompassing approximately 3,500 square

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

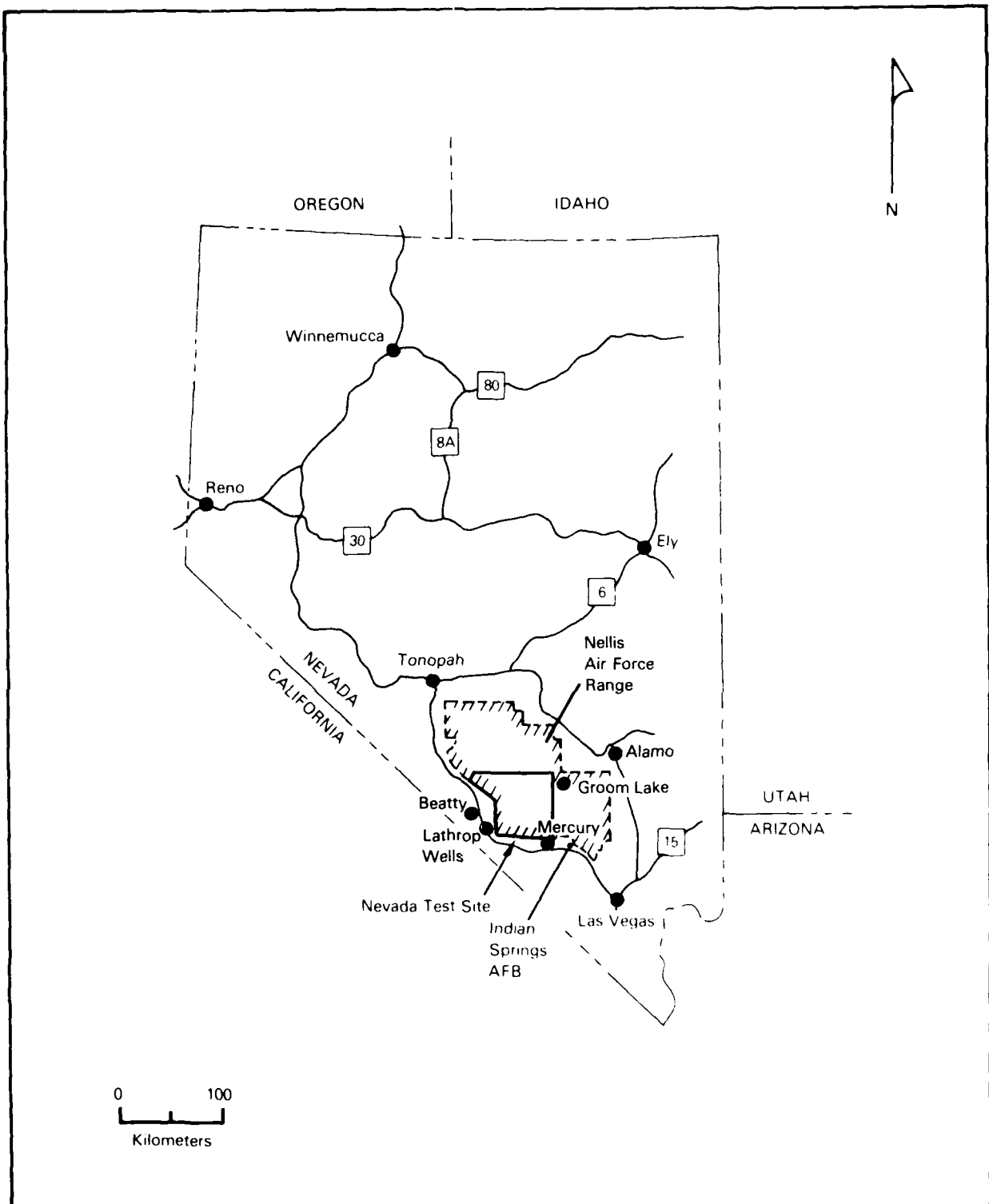


Figure 1-1: LOCATION OF NEVADA TEST SITE

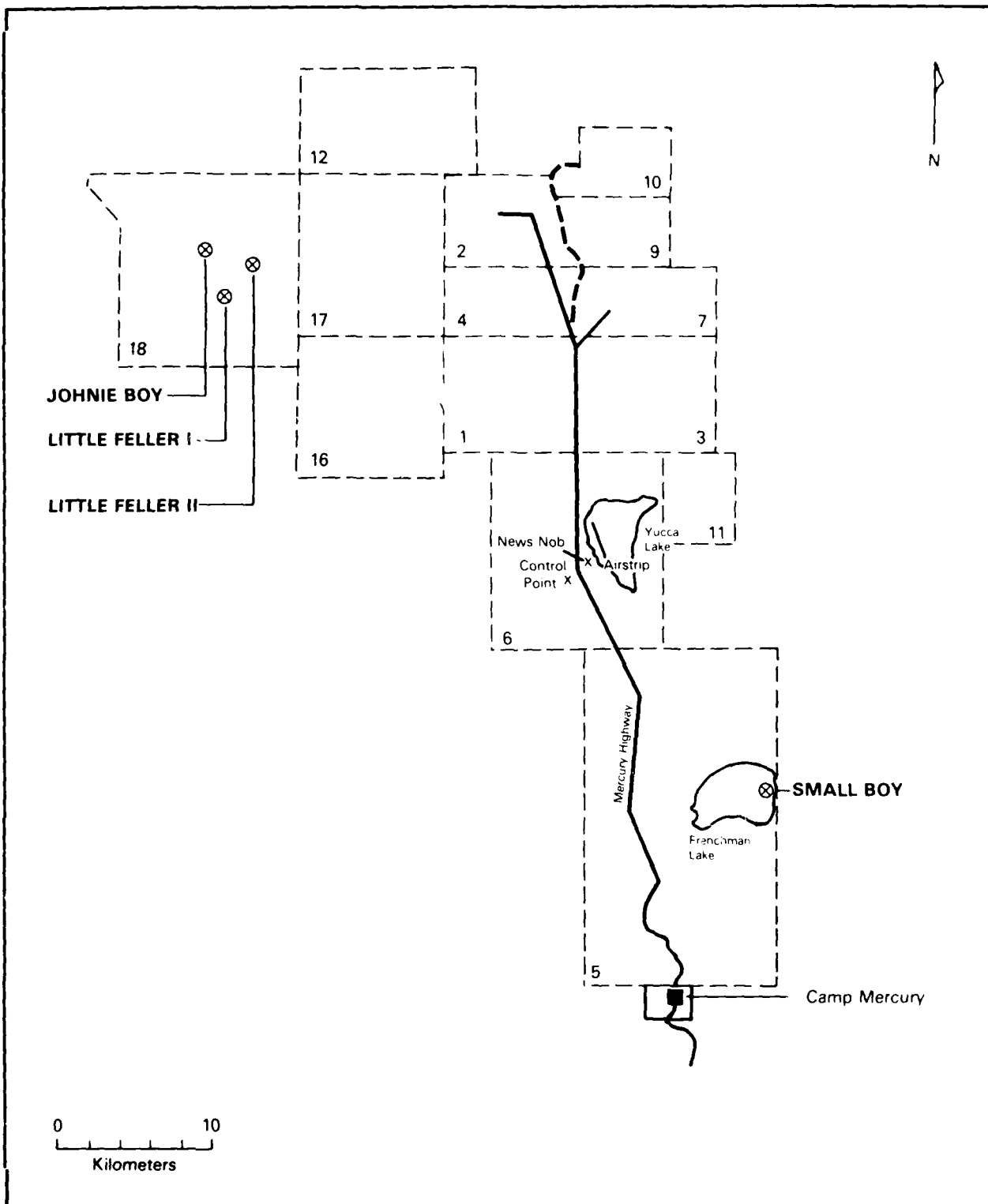


Figure 1-2: LOCATIONS OF DOMINIC II NUCLEAR TEST EVENTS AT THE NEVADA TEST SITE

kilometers in Nye, Lincoln, and Clark counties. On its eastern, northern, and western boundaries, the NTS adjoins the Nellis Air Force Range, of which it was originally a part. The NTS has been the location for most of the nuclear weapons tests conducted within the continental United States from 1951 to the present.

The nuclear weapons tests of Operation DOMINIC II were conducted in Area 18 and Area 5. Area 18, situated in the northwestern part of the NTS, consists of desert valley and mountains. Area 5, located in the southeastern part of the NTS, includes a 22-square-kilometer dry lake, known as Frenchman Lake. Yucca Pass is the site of the Control Point. Consisting of several permanent buildings, the Control Point is on the west side of Yucca Pass. Power, timing, and firing cables led from the control building to test locations in Area 5. Area 18 tests were fired from the forward command post in the area. The Air Operations Center, which controlled all aircraft conducting test support missions over the NTS, was located at the Control Point (5; 31).

Camp Mercury, at the southern boundary of the NTS, was the base of DOMINIC II management, the Nevada Test Site Organization (NTSO). Camp Mercury provided office and living quarters, as well as laboratory facilities and warehouses, for some test participants.

Indian Springs Air Force Base (AFB), 30 kilometers east of Camp Mercury, served as the principal staging and decontamination area for Air Force aircraft participating in DOMINIC II.

1.3 SUMMARY OF OPERATION DOMINIC II EVENTS

The Operation DOMINIC II nuclear tests were conducted within a ten-day period, as shown in table 1-1.* Shots LITTLE FELLER II, JOHNIE BOY, and LITTLE FELLER I were fired in Area 18. A primary concern with these shots was that the fallout from one detonation would not overlap with fallout from another event, thus confusing the data received from each detonation. This consideration was not so relevant for SMALL BOY, the one DOMINIC II shot fired in Area 5, which includes Frenchman Flat (31). All the shots had low yields, defined as less than 20 kilotons (35). One of the shots, LITTLE FELLER I, was fired as part of a military maneuver. All shots were DOD weapons effects tests and engaged large numbers of DOD project participants.

1.4 DEPARTMENT OF DEFENSE PARTICIPATION AT OPERATION DOMINIC II

An estimated 3,000 military and civilian DOD personnel participated at Operation DOMINIC II. They took part in three general areas: Nevada Test Site Organization activities, air support, and the Exercise IVY FLATS military training maneuvers.

1.4.1 Nevada Test Site Organization Activities

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

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

Table 1-1: SUMMARY OF OPERATION DOMINIC II EVENTS (1962)

| Shot | LITTLE FELLER II | JOHNIE BOY | SMALL BOY | LITTLE FELLER I |
|------------------------|---------------------|-----------------|--------------------|--------------------|
| Sponsor | DOD | DOD | DOD | DOD |
| Date | 7 July | 11 July | 14 July | 17 July |
| Local Time* | 1200 | 0945 | 1130 | 1000 |
| NTS Location | Area 18 | Area 18 | Area 5 | Area 18 |
| UTM Coordinates | 619081 | 593084 | 959733 | 606069 |
| Type | Near Surface | Near Surface | Surface (Tower) | Near Surface |
| Height of Burst (Feet) | 3 | -2 | 10 | 3 |
| Yield (Kiloton) | Low | 0.5 | Low | Low |

*Pacific Daylight Time

DOD personnel also took part in scientific projects conducted by the Weapons Effects Test Group of the Defense Atomic Support Agency. These projects were part of eight programs investigating nuclear weapons effects. Table 1-2 lists the programs and projects conducted at each DOMINIC II shot (28-31).

In addition, DOD personnel participated in three VELA UNIFORM projects: Project 1.7 at Shot JOHNIE BOY and Projects 8.1 and 8.4 at Shot SMALL BOY. Concern over the ability of foreign powers to conduct nuclear weapons tests undetected led to the establishment of VELA, the research and development program directed toward improving the U.S. ability to detect and identify underground and high-altitude nuclear detonations. The VELA UNIFORM program consisted of continuing research, systems development, and an experimental field program conducted by various research agencies.

Because of the moratorium on nuclear testing and the consequent restrictions on planning for new tests, the time was insufficient for distinct planning and operational phases for DOMINIC II. Numerous changes were made to the projects even after the Programs Division had received program plans that in previous nuclear test series would have been considered essentially complete. Some activities were deleted, and many others were added, especially at SMALL BOY. All projects required some modification to integrate them with other test activities and field conditions (31).

1.4.2 Air Support Activities

The Air Force played a major support role in many of the Operation DOMINIC II projects. The Air Force Special Weapons Center (AFSWC) was the primary support organization, but other Air Force organizations also contributed personnel or aircraft to

Table 1-2: WEAPONS EFFECTS TEST GROUP PROGRAMS INDICATING PARTICIPATION BY SHOT

| Program \ Shot | LITTLE FELLER II | JOHNIE BOY | SMALL BOY | LITTLE FELLER I |
|--|--|--|--|------------------------------|
| Program 1 Blast, Shock, and Ground Motion Requirements | 1.1 1.3 1.5 1.9 | 1.1 1.12 1.2 1.13 1.5 1.9 1.11 | 1.1 1.6 1.2 1.7 1.3 1.8 1.4 1.9 1.5 | 1.1 |
| Program 2 Prompt and Residual Nuclear Radiation | 2.3 2.20 2.4 2.8 2.16 2.17 | 2.3 2.16 2.4 2.20 2.8 2.9 2.13 | 2.1 2.8 2.13 2.2 2.9 2.14 2.3 2.10 2.15 2.4 2.11 2.7 2.12 | 2.3 2.4 2.8 |
| Program 3 Effects on Structures | | | 3.1 3.2 3.3 3.4 | |
| Program 4 Biomedical Effects | 4.1 | | | 4.1 |
| Program 6 Electromagnetic Phenomena | 6.6 6.6b | 6.6 6.6b | 6.1 6.6 6.11 6.2 6.6.1 6.12 6.3 6.7 6.13 6.4 6.8 6.5 6.9 | 6.6 6.6b |
| Program 7 Miscellaneous Studies of Specific Interest to a Particular Service | 7.16 7.17 | 7.17 | 7.1 7.2 7.8.1 7.14 7.1.1 7.5 7.9 7.15 7.1.2 7.6 7.10 7.16 7.1.3 7.6.1 7.12 7.17 7.1.4 7.8 7.13 | 7.17 |
| Program 8 Thermal Radiation | 8.2 | | | 8.1 8.2 |
| Program 9 Technical Support | 9.2 9.6 9.3 9.7 9.4 9.5 | 9.2 9.6 9.3 9.7 9.4 9.5 | 9.1 9.5 9.2 9.6 9.3 9.7 9.4 9.10 | 9.2 9.7 9.4 9.5 9.6 |

security sweep, cloud-sampling, radio relay, courier, and cloud-tracking missions. The following description of these activities is based on the AFSWC "Operation Plan 8-62" for Shot SMALL BOY, the only document found describing air support activities at DOMINIC II. It is probable that air support at the other DOMINIC II shots was similar to the activities at SMALL BOY (44).

Security Sweeps

The 4520th Combat Crew Training Wing of the Tactical Air Command provided one L-20 aircraft and the crew for security sweeps. In these missions, the pilot flew around the test area perimeter at low altitudes from three hours to 30 minutes before the detonation. A security officer on board surveyed the area to ensure that no unauthorized personnel were entering the area. The security sweeps were staged from Indian Springs AFB (44).

Cloud Sampling

Pilots from the 1211th Test Squadron (Sampling), Military Air Transport Service, flew missions to collect samples of fission products from each nuclear detonation. Personnel from the Los Alamos Scientific Laboratory (LASL) later analyzed these samples to determine the yield and efficiency of the nuclear device (44).

One week before the first scheduled shot, the 1211th Test Squadron sent several B-57 aircraft, with crews and support personnel, to Indian Springs AFB. Before each detonation, the Chief, Special Projects Division (AFSWC), and a LASL scientific controller briefed the aircrews on flight procedures, communication procedures, and the scientific aspects of the sampling mission (44).

The Nuclear Applications Section of the 1211th Test Squadron instrumented and equipped the B-57 samplers. These aircraft had specially modified wing-tip tanks. From inside the aircraft, the

pilot could open a valve that allowed air to pass through the tank, where filter paper would trap radioactive particles from the airstream. A cockpit instrument, connected to an ion chamber in the wing-tip tank, indicated the radioactivity of the sample collected (44).

The B-57, with a pilot and the LASL scientific controller, who directed all sampling missions, left Indian Springs AFB and established an orbiting pattern over the shot area about 15 minutes before the detonation. The pilot maintained radio-communications with the Air Operations Center. At shot-time, the B-57 was to be in a holding pattern on a northerly heading (44).

After the detonation, the B-57 aircraft followed and observed the formation and dissipation of the cloud resulting from the detonation. Meanwhile, the scientific controller evaluated the cloud structure and determined the areas from which samples should be collected. If necessary, the controller requested other B-57 samplers, on alert at Indian Springs AFB, to take part in the sampling mission (44).

The aircraft returned to Indian Springs AFB after completing the cloud sampling. There, ground crews removed the filter papers and packaged them for delivery by air courier to LASL.

The crew of the sampler aircraft underwent decontamination by personnel from Reynolds Electrical and Engineering Company (REECo) at Indian Springs AFB. Personnel from the Nuclear Applications Section supervised the decontamination of the sampler aircraft (44).

Radio Relay and Sample Courier Missions

The 4900th Air Base Group provided C-47 aircraft, which staged from Indian Springs AFB, for radio relay and courier missions. For radio relay missions, flown at the Test Manager's

request, the C-47 aircraft was usually positioned between the Air Operations Center and support aircraft. The aircraft relayed information to the Air Operations Center about the location, direction of travel, size, and radiation intensity of the cloud (44).

The courier flights delivered samples and data from DOMINIC II research projects to LASL and other laboratories for analysis. The C-47 aircraft used for courier service were ready to depart with samples about four hours after each shot. The courier aircraft usually followed normal air routes, unless specifically authorized to do otherwise by the 4900th Air Base Group at Kirtland AFB, New Mexico (38; 44).

Cloud Tracking

The objective of cloud tracking at DOMINIC II was to chart the path of the cloud and monitor its radiation intensity in order to divert commercial aircraft from the cloud path if necessary. This mission was conducted with one AFSWC U3A aircraft for low-altitude tracking; one L-20 backup aircraft from the 4520th Combat Crew Training Wing; and one WB-50 aircraft for high-altitude tracking, provided by the 55th Weather Reconnaissance Squadron. The aircraft were at Indian Springs AFB the day before the detonation so that aircrews could receive preflight briefings. The Chief, Special Projects Division, had operational control of these aircraft (44).

Before shot-time, the U3A and the L-20, if necessary, left Indian Springs AFB with U.S. Public Health Service (USPHS) representatives aboard. Ten minutes before the detonation, the WB-50 aircraft established an east-west holding pattern about 10,000 feet above Indian Springs AFB (44).

After the cloud-sampling mission was complete, the Air Operations Center cleared each tracking aircraft to begin its

mission. The cloud-tracking aircraft approached the edge of the cloud until a radiation intensity of 0.005 roentgens per hour (R/h) was encountered. The aircraft then turned away from the cloud to avoid contact. By repeating this procedure throughout the mission, the cloud trackers determined the extent and progress of the cloud. As the visible cloud dissipated, the radiation monitor onboard used instrument readings to direct the aircraft to the cloud. Close coordination between pilots and monitors on each cloud-tracking aircraft was needed to prevent losing track of the cloud and also to prevent the aircraft from inadvertently entering the cloud (44).

The tracking aircraft maintained constant radio contact with the Air Operations Center at the Control Point. Usually aircrews informed the Air Operations Center of the time, location of the aircraft in relation to ground zero, altitude, and radiation readings. The Air Operations Center relayed this information to the Chief, Special Projects Division, who advised the onsite and offsite radiological safety monitors and AEC officials of the cloud movement. The cloud was tracked either until it dissipated or until AEC administrators directed the trackers to stop. The aircraft then returned to Indian Springs AFB (44).

1.4.3 Exercise IVY FLATS

About 1,000 military personnel from various Sixth Army installations were involved in Exercise IVY FLATS, a training maneuver conducted in conjunction with LITTLE FELLER I. IVY FLATS was the only military maneuver in Operation DOMINIC II. The exercise was designed to test a nuclear weapons system under simulated tactical conditions. The activities of the Sixth Army personnel in the maneuver are discussed in chapter 8, on Shot LITTLE FELLER I (45; 46).

CHAPTER 2

OPERATION DOMINIC II ORGANIZATION

The Nevada Test Site Organization planned, managed, and conducted Operation STORAX, a series of tests conducted from 1 July 1962 to 30 June 1963. The four weapons effects tests of Operation DOMINIC II were conducted during the period of Operation STORAX but were not a part of STORAX. The responsibilities of the NTSO included conducting the nuclear tests and coordinating the military effects, diagnostic, and technical projects that constituted STORAX and Operation DOMINIC II. The chief Government agencies represented in the NTSO were the Atomic Energy Commission and the Department of Defense. Other participants included Federal agencies involved in support work, research laboratories, and private firms under contract to the Government. DOD personnel participated in the activities of many of these agencies (5).

The Director of the AEC Division of Military Application supervised nuclear test operations from the AEC headquarters in Washington, D.C. Responsibility for test preparations at the Nevada Test Site was delegated to the Manager of the AEC Nevada Operations Office in Las Vegas. This responsibility included assigning the chief officials to direct the nuclear test series and supervising the activities of the various test participants. Figure 2-1 shows the lines of authority from the President through the AEC and the DOD to the test organization.

The principal DOD agency coordinating the military nuclear test requirements was the Defense Atomic Support Agency. The Chief, DASA, assigned responsibility for the DOD test preparations to the Commander, Field Command, DASA, in Albuquerque, New Mexico. This responsibility included the planning and

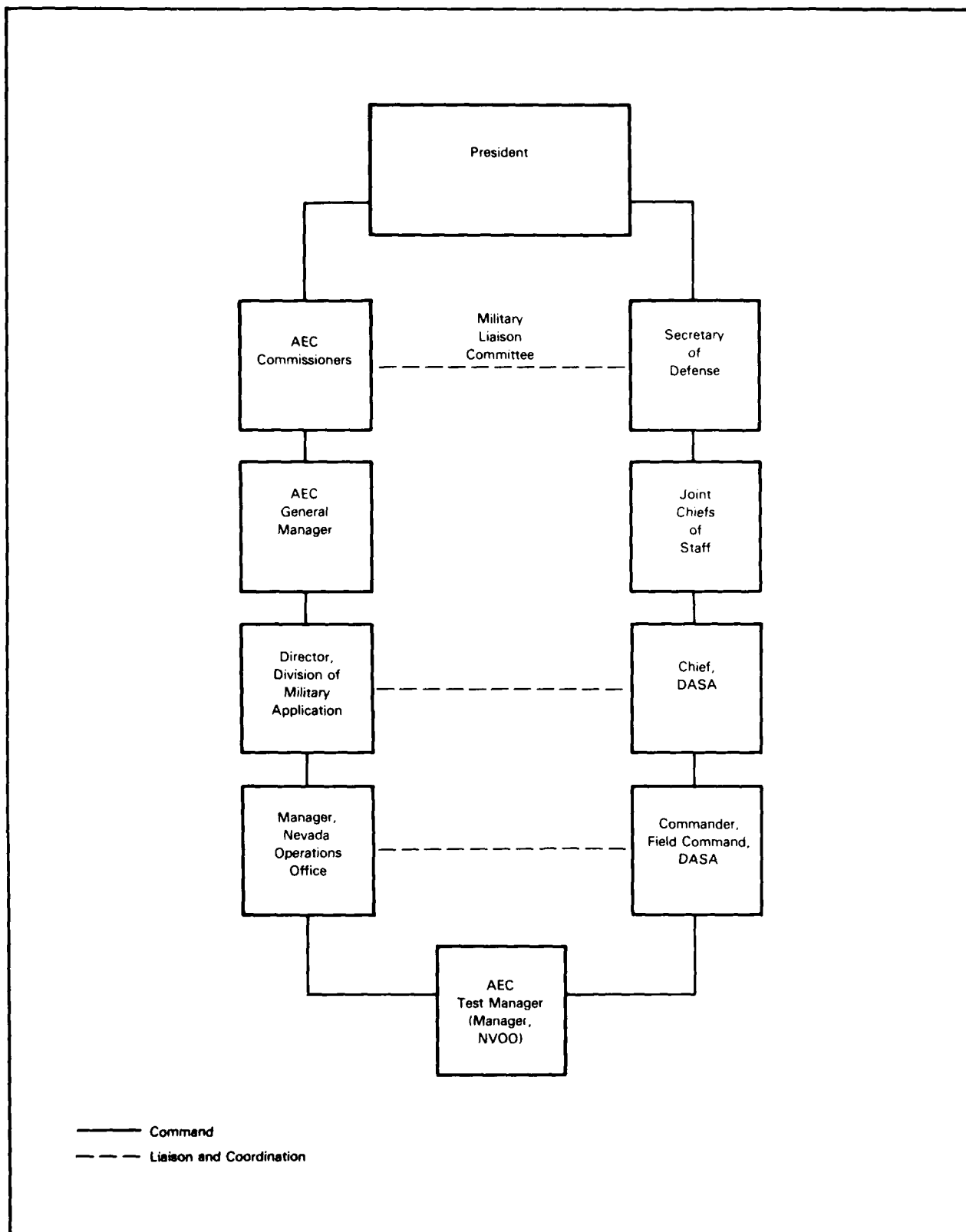


Figure 2-1: FEDERAL GOVERNMENT STRUCTURE FOR CONTINENTAL NUCLEAR TESTS

funding of DOD test activities and the assignment of DOD personnel to the NTSO (1-3).

The relationship between the AEC and DASA was originally formalized on 16 February 1953 in a memorandum signed by the field officers of the AEC Santa Fe Operations Office (relocated to the Albuquerque Operations Office after the 1955 TEAPOT Series) and Field Command, Armed Forces Special Weapons Project (AFSWP) (renamed DASA in 1959). This memorandum stated that, in matters relating to military participation at the NTS, the Test Manager, who was the senior AEC official, was responsible to the Commander, Field Command, AFSWP. For non-military matters, the Test Manager was to report to his AEC headquarters superior, the Director of the Division of Military Application (31).

In January 1961, a memorandum negotiated between the Manager of the Albuquerque Operations Office and the Commander, Field Command, DASA, affirmed an organizational policy first implemented at Operation HARDTACK II in 1958. Although the AEC, through the Test Manager, remained the ultimate authority at the NTS, greater independence was given to DASA, other Government agencies, and contractors involved in the nuclear testing series. According to the 1961 agreement, the NTSO was "so conceived . . . to provide the user organization [e.g., DASA] with a maximum latitude to conduct their activities to their best interests while, at the same time, providing the most efficient support services with minimum control consistent with economical and safe use of the test site and its facilities" (31). DASA and the other series participants were allowed to develop their own test group structures and to plan the technical portions of their projects without interference by the NTSO. The principal stipulations were that the Test Manager be informed of all activities and that the Test Manager reserve the right to veto projects conflicting with the primary function of the series, which was to conduct nuclear weapons tests (31).

2.1 NEVADA TEST SITE ORGANIZATION

On 17 September 1962, a letter from the General Manager of AEC Headquarters in Washington, D.C., to the Manager of the AEC Nevada Operations Office stated approval and identified responsibilities and policies for the conduct of Operation STORAX and the other CONUS tests conducted during the STORAX period. The letter directed that the Manager of the Nevada Operations Office serve as the Test Manager for the NTSO. The Test Manager was responsible for the overall direction of the test series. This responsibility included deciding whether or not to proceed with a shot as planned, coordinating the agencies involved in the testing, and supervising the units that performed support functions for the test participants. To fulfill his duties, the Test Manager required the large and diversified organization shown in figure 2-2 (31). The NTSO consisted of civilian and military personnel from the AEC, DOD, and Government contractors. The Test Manager was assisted by a Deputy Test Manager and a Military Deputy. The Military Deputy, who was in charge of all DOD activities, was also the Assistant Deputy Chief of Staff, Field Command Weapons Effects Test Group. DOD participation in the NTSO was primarily restricted to the DOD Coordination Staff, the DOD Support Division, and the Continental Test Organization (CTO).

The NTS Planning Board, the consultants, and the Advisory Panel advised the Director of the Division of Military Application and the Test Manager on matters relating to overall planning for the nuclear testing. After the laboratories submitted a list of weapons tests for approval by the Division of Military Application, the Planning Board developed a schedule of events for the series and made recommendations to the Test Manager detailing the scope of the operation and the level of effort required to conduct the tests. The panel of consultants included members of the National Academy of Sciences who were

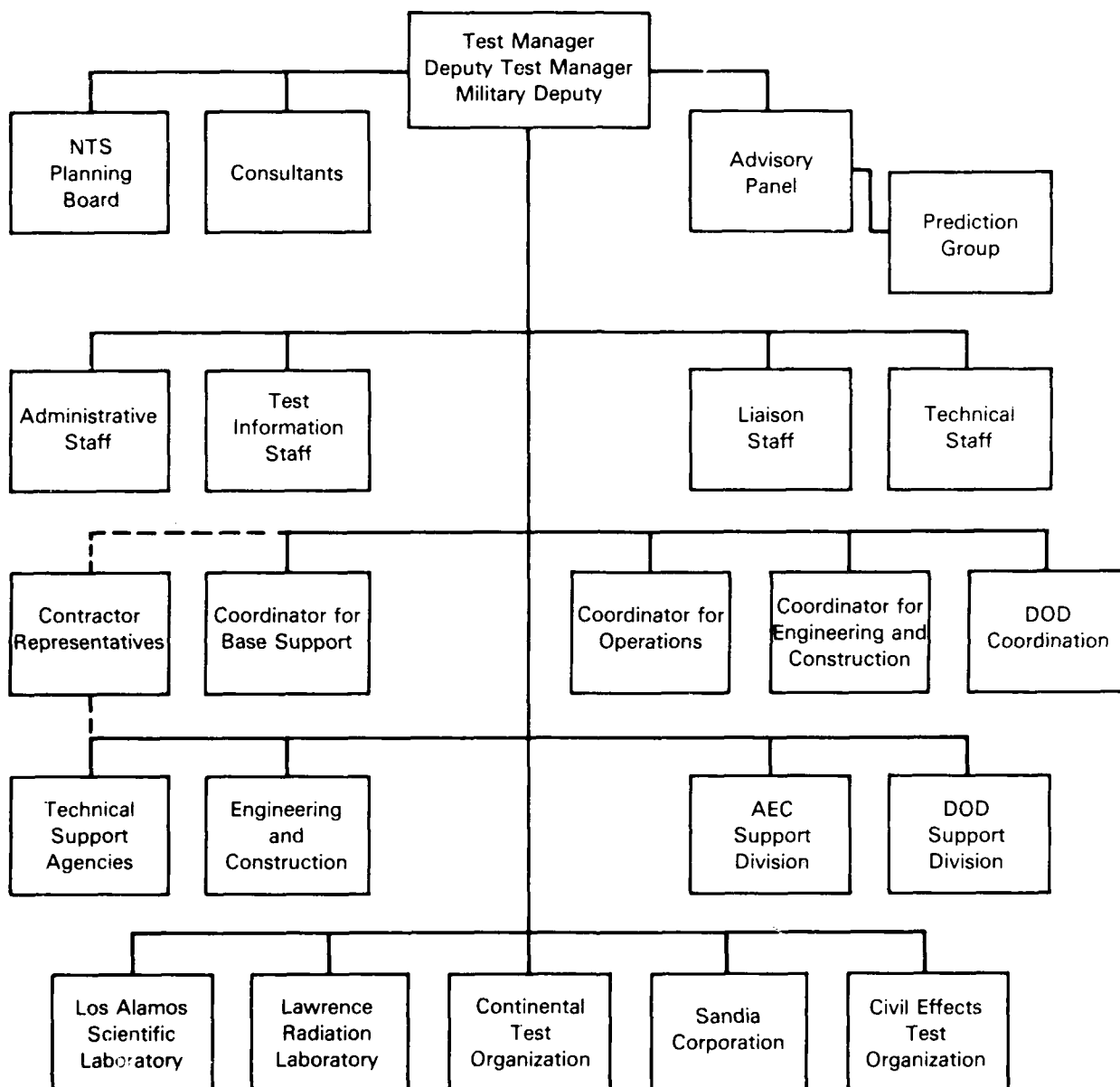


Figure 2-2: NEVADA TEST SITE ORGANIZATION

— Command
 - - - Liaison and Coordination

recognized experts in engineering and physical sciences. The panel discussed the proposed weapons test program and recommended maximum size limitations for single events at the NTS. The Advisory Panel advised the Test Manager on the feasibility of proceeding with a scheduled nuclear event. The Advisory Panel evaluated information from the Prediction Group, particularly the weather expected on the scheduled shot-day and the fallout and blast that could result from the detonation. The Advisory Panel then discussed with the Test Manager whether or not the detonation should occur as planned.

Four staffs assisted the Test Manager (31):

- Administrative Staff
- Test Information Staff
- Liaison Staff
- Technical Staff.

The Administrative Staff consisted of AEC personnel who handled clerical and administrative matters for the Test Manager. The Test Information Staff coordinated the activities of the NTSO Office of Test Information. The office informed the public of activities at the NTS and processed media representatives for entry into the NTS to observe certain nuclear detonations. The Liaison Staff, consisting of personnel from the Division of Military Application and the Division of Biology and Medicine, was charged with maintaining contact between the NTSO and Federal agencies, Government contractors, and the weapons development laboratories. The Technical Staff, consisting of AEC and contractor employees, was primarily responsible for the safety of participants, including onsite radiological safety. The Technical Staff also maintained contact with the Civil Aeronautics Administration to ensure that commercial and private aircraft were rerouted to avoid radioactive clouds outside the NTS (5; 31).

The Test Manager appointed coordinators for contractors, base support services, operations, engineering and construction, and the DOD. The DOD Coordination Staff was under the direction of the Military Deputy. Staffed by personnel from the Field Command Weapons Effects Test Group, its function was to coordinate DOD activities with the AEC. This included integrating the Sixth Army's Exercise IVY FLATS into Operation DOMINIC II (5; 31).

The Technical Support Agencies, the Engineering and Construction Group, the AEC Support Division, and the DOD Support Division provided logistical support to the test groups conducting the scientific experiments. The DOD Support Division, headed by a director appointed by the Military Deputy, provided support, including housing and messing, for all DOD participants at the NTS. The DOD Support Division arranged for assistance to be provided by the Technical Support Agencies, such as radiological safety, and by the Engineering and Construction Division (5; 31).

The test groups, sponsored by LASL, the Lawrence Radiation Laboratory, the Continental Test Organization, the Sandia Corporation, and the Civil Effects Test Organization, were responsible for planning and implementing the scientific, technical, and diagnostic programs (5; 31).

The Continental Test Organization, outlined in figure 2-3, was the DASA test group within the NTSO. During Operation DOMINIC II, the CTO was located at Camp Mercury, the AEC base camp in the southeastern corner of the NTS. The CTO planned and implemented the scientific programs for DASA participation in DOMINIC II. The Director of the CTO was the Assistant Deputy Chief of Staff, Weapons Effects Tests. This individual was also the Military Deputy to the Test Manager. The Assistant Deputy Chief of Staff was assisted by the Technical Advisor. At Shot

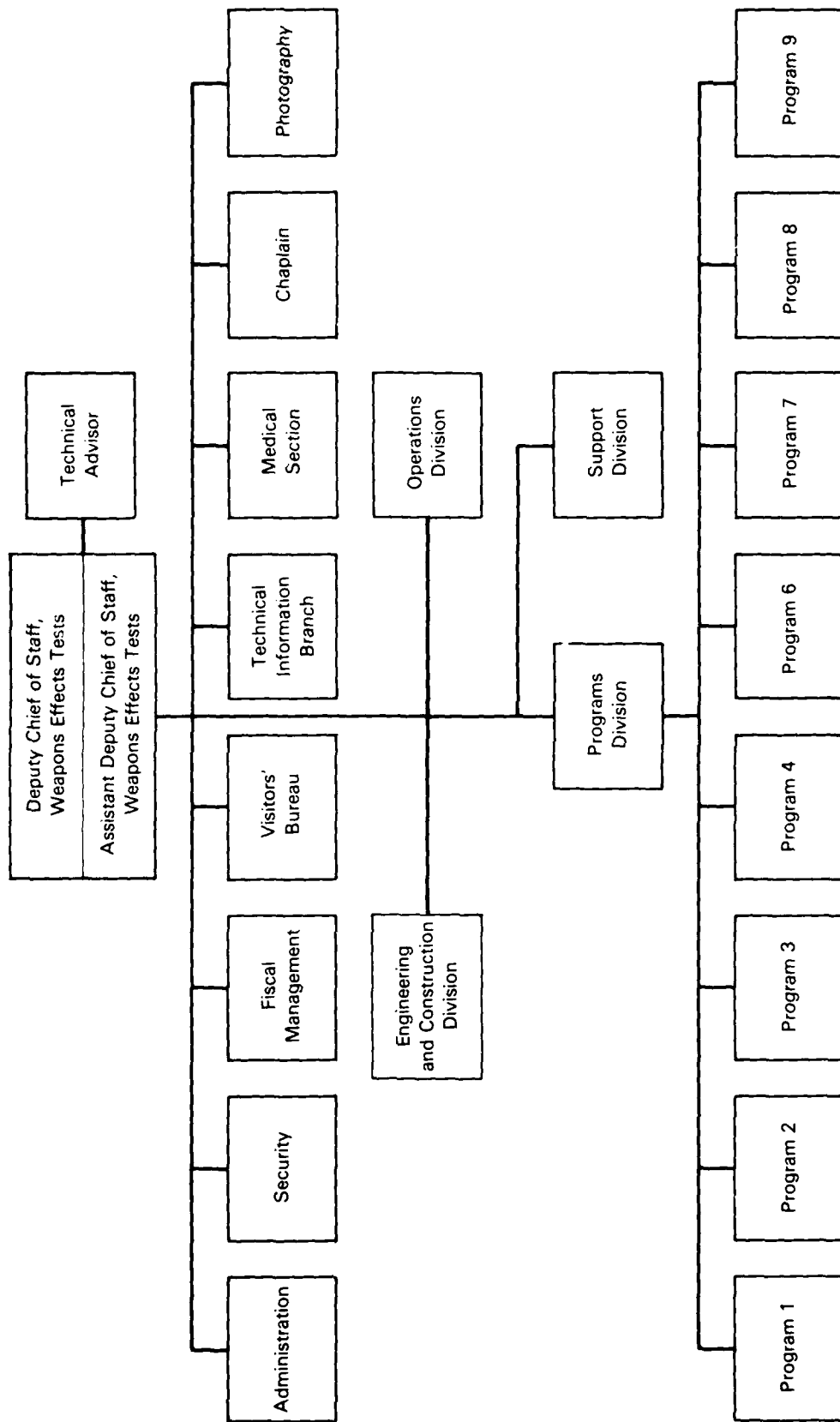


Figure 2-3: CONTINENTAL TEST ORGANIZATION

SMALL BOY, originally planned as the only detonation to be conducted at Operation DOMINIC II, Harry Diamond Laboratories provided the technical direction (31; 101).

Most CTO participants were assigned to the Weapons Effects Test Group. Many of these participants were on temporary duty from other DOD units and laboratories, many of which conducted projects under DASA supervision. The number of CTO personnel fluctuated during Operation DOMINIC II. Because of the atmospheric nuclear test moratorium, which began in November 1958, the CTO staff had been cut to a minimum. When the announcement came in January 1962 that atmospheric testing would resume in April 1962, the CTO had 89 personnel, two of whom were civilian DOD employees. By 1 June 1962, the number had increased to 202: 60 officers, 140 enlisted men, and two civilians. The largest number of CTO personnel during DOMINIC II, in July 1962, was 465 participants (158 officers, 298 enlisted men, and nine DOD civilians). By August, the number of personnel had decreased to 150, with 52 officers and 98 enlisted men (31).

The Administrative Branch of the CTO, which had two officers and seven enlisted men during July, was responsible for financial affairs, record keeping, publications and memos, mail, and routine administrative support (31).

The Security Branch was in charge of the clearance and badging of personnel and the classification of documents and photographs. In July, three individuals from the 901st Intelligence Corps Detachment, Sandia Base, New Mexico, were assigned to the CTO Security Branch. Other than two guard posts at the DOD compound in Camp Mercury, physical security at the NTS was managed by an AEC contractor, Federal Services, Incorporated (31).

The Fiscal Management Office carried out the budgeting and funding functions for both the NTS and Pacific test activities. Its main office was at Field Command, DASA, in Albuquerque, but it also had a branch office at Camp Mercury (31).

The Visitors' Bureau was established in September 1961 under the supervision of the Field Command Public Information Office to provide orientation, quarters, and transportation for DOD visitors. The staff consisted of one officer and two enlisted men, who were augmented as required by escort officers and drivers. The escort officers were primarily from Field Command, DASA. The main office of the Visitors' Bureau was at Camp Mercury. During DOMINIC II operations, the bureau maintained an office at the Las Vegas Municipal Airport (31).

The Technical Information Branch provided drafting and typing assistance for CTO projects, edited and processed the project reports, and prepared briefing charts for CTO personnel. In July, its total strength was two officers, ten enlisted men, and one DOD civilian (31).

The Medical Section Branch, with one officer and six enlisted men, operated from the Camp Mercury dispensary. Its primary responsibility was to give medical care to DOD personnel, but it also treated AEC and contractor employees in a joint effort with REECo medical personnel. Military patients needing hospitalization were sent to Nellis AFB near Las Vegas (31).

The Chaplain Section provided religious services and counseling for DOD personnel (31).

The Photography Branch provided the CTO with technical photography, documentary still photography, documentary motion pictures, and film processing. The photography support was

provided either through DASA facilities or by the following: Army Pictorial Center, the Air Force Lookout Mountain Laboratory, and Edgerton, Germeshausen, and Grier, Incorporated (EG&G) (31).

The Operations Division, consisting in July of 12 officers and six enlisted men, was responsible for preparing technical and operations plans and coordinating air support with AFSWC, the Tactical Air Command, and the AEC. It also maintained radiation exposure records for CTO personnel (31).

The Engineering and Construction Division directed and coordinated all field construction in support of DOD test activities. Manned by approximately ten engineer officers, this office coordinated all phases of project construction and contracted for labor, equipment, and other materials for projects in the field (31).

The Engineering and Construction Division had difficulties because of the relatively short period in which DOMINIC II activities were planned and conducted. Frequently, construction began before plans for the scientific projects had been finalized. This complicated the coordination of activities, caused frequent changes of plans in the field, and increased the cost. The shortness of time also required the use of a number of inexperienced personnel, which resulted in decreased efficiency and further increases in cost. Other problems hampering construction included "strong dust-laden winds" that caused a cessation in field activities and extremes in temperatures, which ranged from below zero to over 38 degrees Celsius (31).

The Programs Division was responsible for the scientific, technical, and diagnostic programs conducted by the CTO. The division consisted of eight program groups, each supervised by a program director (31).

The Support Division provided the CTO with supply and procurement services, transportation, food, and housing in the DOD compound at Camp Mercury (31).

2.2 AIR FORCE SPECIAL WEAPONS CENTER ORGANIZATION

The Air Force Special Weapons Center was the primary support organization during Operation DOMINIC II. AFSWC units providing support to the Nevada Test Site Organization included (44):

- Nuclear Test Directorate
- Special Projects Division
- 4900th Air Base Group.

Field Command, Defense Atomic Support Agency, asked AFSWC to provide air support to the AEC Test Manager during DOMINIC II. The Commander of AFSWC delegated responsibility for these missions to the Director, Nuclear Test Directorate, who coordinated and directed overall AFSWC activities, appointed an Air Operations Advisor to the Test Manager, and exercised operational control over all aircraft participating in the test events. The Air Operations Advisor, at the NTS Air Operations Center during the DOMINIC II shots, was the liaison with the DOD test agencies. The Air Operations Center was responsible for aircraft clearances at the NTS and for coordination of air traffic over the NTS during rehearsals for shot-day activities and on shot-day. Air Operations Center personnel coordinated and plotted the cloud-sampling and cloud-tracking information received through radio communications with the sampling and tracking aircraft.

Elements of the AFSWC 4900th Air Base Group provided C-47 air-shuttle service between Kirtland AFB and Indian Springs AFB. They also provided U3A aircraft and crews to perform low-altitude cloud tracking and C-47 aircraft and crews for radio relay and courier missions (44).

Other Air Force organizations participating in Operation DOMINIC II placed personnel and equipment under AFSWC operational control on a temporary basis. These units were (44):

- 1211th Test Squadron (Sampling), Military Air Transport Service, McClellan AFB, California
- 4520th Combat Crew Training Wing, Tactical Air Command, Nellis AFB, Nevada
- 55th Weather Reconnaissance Squadron, Military Air Transport Service, McClellan AFB
- Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson AFB, Ohio.

Elements of the 1211th Test Squadron (Sampling) were attached to Indian Springs for ten days for each nuclear event. Their primary task was cloud sampling, which included conducting the sampling mission, removing the cloud samples, and packaging and loading the samples onto courier aircraft. Personnel from this unit also assisted REECO in implementing radiological safety procedures and decontaminating aircraft, crews, and equipment at Indian Springs AFB (44).

Elements of the 4520th Combat Crew Training Wing provided support functions, such as housing, food, and logistics, to the units operating from Indian Springs AFB and Nellis AFB. In addition, they provided security sweep aircraft, control tower operations, fire-fighting, and crash rescue services at Indian Springs AFB. They also maintained and provided equipment for the helicopter pad at the NTS Control Point (44).

The 55th Weather Reconnaissance Squadron supplied one WB-50 aircraft and crew to perform high-altitude cloud tracking (44).

The Aeronautical Systems Division, Air Force Systems Command, provided the aircraft and crews to perform technical

projects. This command notified AFSWC of all support requirements prior to each test event (44).

AFSWC underwent considerable reorganization to ready itself for the resumption of nuclear testing in 1961. During the nuclear test moratorium, much of AFSWC had been disbanded. The 4926th Test Squadron (Sampling) had been transferred to the Military Air Transport Service and assigned to the 9th Weather Reconnaissance Group at McClellan AFB. On 16 August 1961, the squadron was redesignated the 1211th Test Squadron (Sampling) to conform to the numbering system of the Military Air Transport Service. The 4935th Air Base Squadron had been deactivated on 1 April 1961. Also during the spring of 1961, Indian Springs AFB had been transferred to the Tactical Air Command under the auspices of the 4520th Combat Crew Training Wing at Nellis AFB. To prepare for a resumption of nuclear weapons testing within the continental United States, arrangements had to be made with the 4520th for support at Indian Springs AFB, and AFSWC units had to be reconstituted in a very short time (44).

2.3 EXERCISE IVY FLATS ORGANIZATION

Exercise IVY FLATS, the one troop maneuver conducted during Operation DOMINIC II, was sponsored by the Department of the Army. It involved an estimated 1,000 participants at Shot LITTLE FELLER I (45; 46).

The initial stage of the exercise began on 8 May 1962, when the Department of the Army directed Headquarters, Continental Army Command, to begin planning for a troop maneuver. The Commander, Continental Army Command, appointed the Commanding General of the Sixth Army as Orientation Director. The Orientation Director supervised the Army's planning and execution of the exercise. During the planning phase, he conferred with

representatives from the AEC, DASA, and the Sixth Army to ensure that IVY FLATS activities were coordinated with the activities being conducted at the NTS by other agencies (45; 46).

The Orientation Director's staff is shown in figure 2-4. On 11 June 1962, the Commander of the Continental Army Command appointed the Commanding General of the 4th Infantry Division at Fort Lewis, Washington, as the Deputy Orientation Director. The Deputy Orientation Director coordinated Army planning of the maneuver. He was assisted by a Chief of Staff and his deputy. During the planning phases, the Deputy Orientation Director maintained headquarters for the exercise at Fort Lewis. On 26 June 1962, he moved his headquarters to Camp Mercury, where it remained throughout the maneuver (45; 46).

The Information Section, consisting of one officer and six enlisted men from Fort Lewis, was originally to provide information concerning IVY FLATS activities to public news media. A press area was planned at the shot. Very little press information was released by this section, however, and no news media coverage was allowed (45; 46).

The G-1, Administration, was responsible for military personnel management. Duties included obtaining and processing the military personnel required for administrative duties, for participation in the maneuver, and for activities supporting the maneuver. This staff section had two officers and three enlisted men (45; 46).

The G-2, Intelligence, obtained security clearances for IVY FLATS participants, coordinated the security badging of Army personnel for entry into the NTS, and ensured that proper and adequate security safeguards had been arranged for classified material. This staff section consisted of two officers and three enlisted men (45; 46).

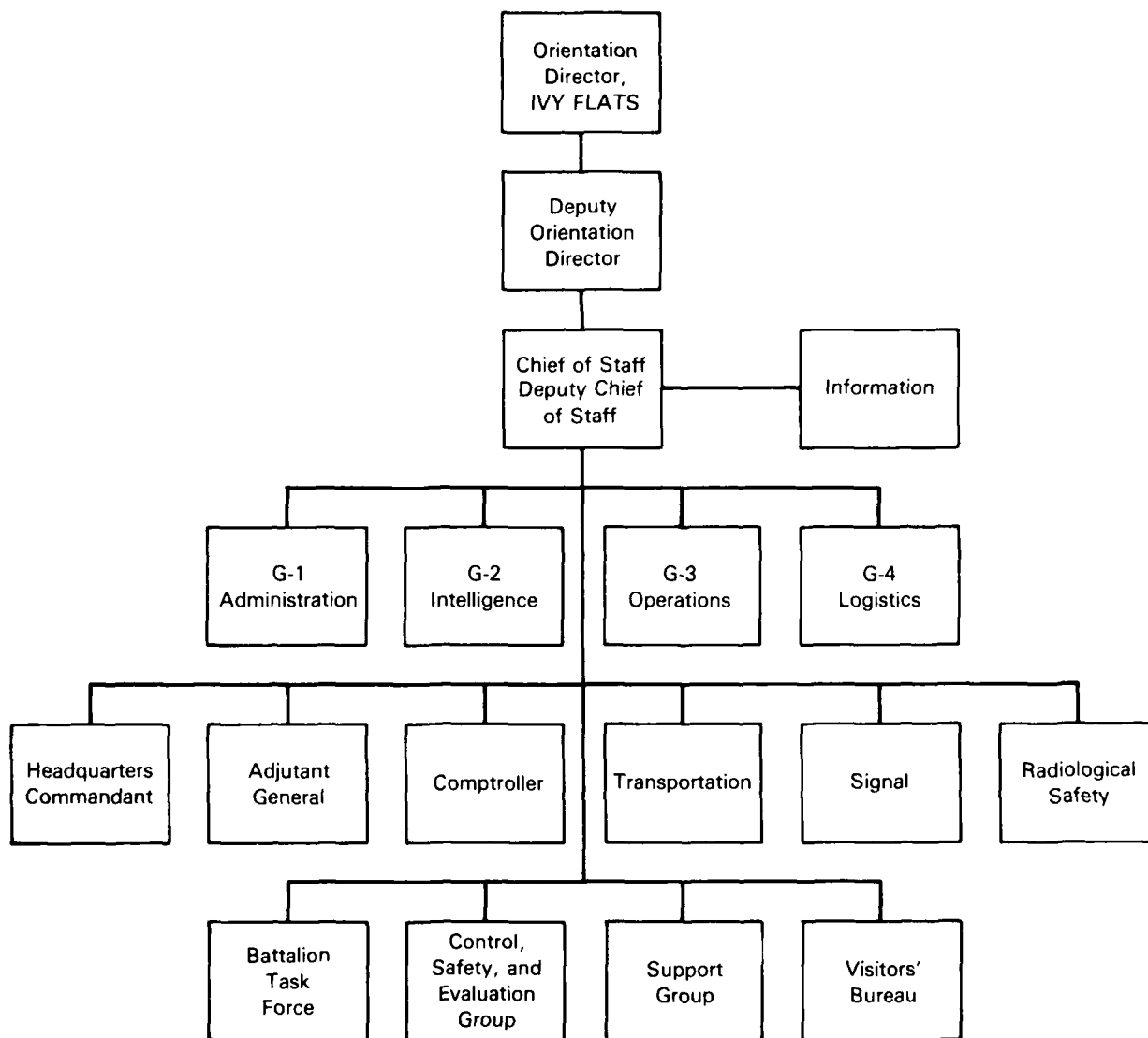


Figure 2-4: IVY FLATS ORGANIZATION

The G-3, Operations, coordinated and executed the IVY FLATS maneuver. The section consisted of five officers and nine enlisted men (45; 46).

The G-4, Logistics, provided support services to units participating in IVY FLATS. The section had three officers and five enlisted men (45; 46).

The Headquarters Commandant and his staff of two enlisted men supervised and administered the billeting, supply, messing, and other housekeeping duties.

The Adjutant General Section was responsible for the management of military personnel and for record keeping. This section, consisting of one warrant officer and four enlisted men, worked closely with the G-1 Section (45; 46).

The Comptroller managed the budget and funding for the maneuver.

The Transportation Section provided transportation and logistical support to participants and observers at the rehearsal of IVY FLATS and during the maneuver. The section consisted of one officer and one enlisted man (45; 46).

The Signal Section was responsible for planning, coordinating, and supervising communications and pictorial requirements for the maneuver. This included establishing radio systems for the forward area and setting up timing and firing signals during the official shot countdown. The section consisted of one officer and three enlisted men. Motion picture and still photography camera teams provided photographic support of the exercises. These teams consisted of three officers and four enlisted men from Field Command, DASA, and one officer and five enlisted men from Headquarters, Continental Army Command (45; 46).

The Radiological Safety Section, with two officers and four enlisted men, performed radiological safety activities and operations as required by the AEC Test Manager through the DASA radiation-safety liaison offices. This section performed radiological safety exercises during the maneuver. REECo assisted in these activities. This section was responsible for:

- Ensuring that radiac instruments were operational and calibrated
- Collecting, consolidating, and evaluating survey readings and total dose computations from radiological monitors
- Coordinating their data with information obtained by medical personnel
- Advising on dosimetry and dosimetry reporting (46).

The Battalion Task Force conducted the maneuver. This task force consisted of about 540 personnel from the 1st Mechanized Infantry Battalion, 12th Infantry, 4th Infantry Division of Fort Lewis. On 22 May 1962, the Sixth Army had directed the 4th Infantry Division to provide the troops for participation in IVY FLATS (45; 46).

The Control, Safety, and Evaluation Group, with 29 officers and 41 enlisted men, also participated in the operational phase of the maneuver. This group was to ensure that IVY FLATS was conducted safely and that its objectives were met (45; 46).

The Support Group provided logistical aid to the Battalion Task Force and to the Control, Safety, and Evaluation Group. This group consisted of 38 officers, one warrant officer, and 165 enlisted men from Fort Lewis and other bases throughout the country (46).

The Visitors' Bureau was organized to process the numerous observers and distinguished visitors at Operation IVY FLATS. Its

responsibilities included receiving, billeting, messing, and transporting 396 official observers at Shot LITTLE FELLER I and IVY FLATS. The bureau, which started operations at the NTS on 29 June 1962, consisted of 28 officers, who served as escorts for observers, and 22 enlisted men, who served as drivers (46).

The activities of the IVY FLATS organization are described in more detail in the discussion of Shot LITTLE FELLER I, in chapter 8.

CHAPTER 3

RADIATION PROTECTION

To minimize personnel exposure to the ionizing radiation produced by a nuclear detonation, a radiological safety program was developed. The Test Manager oversaw this program. Personnel from Reynolds Electrical and Engineering Company conducted radiological safety activities for the Nevada Test Site Organization, Air Force Special Weapons Center, and Exercise IVY FLATS. These activities included (46; 52; 73):

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

The following sections discuss radiological safety activities during Operation DOMINIC II, addressing maximum permissible levels of exposure, the structure of the radiological safety organizations, and the procedures used by each organization to control individual exposures to ionizing radiation.

3.1 RADIATION PROTECTION AT EXERCISE IVY FLATS

The Test Manager was responsible for the radiological safety of personnel participating in the IVY FLATS exercise. He assigned this responsibility to the Radiological Safety Officer,

who directed the activities of the IVY FLATS Radiological Safety Control Section. The Control Section, which provided monitoring during the military maneuver, consisted of troop monitors trained by REECO personnel prior to the operation. REECO radiological safety personnel also operated decontamination facilities for IVY FLATS personnel and vehicles. The IVY FLATS radiological safety activities are detailed in chapter 8 (45; 46).

3.2 RADIATION PROTECTION FOR THE NEVADA TEST SITE ORGANIZATION

The Test Manager was responsible for the radiological safety of NTSO participants involved in onsite and offsite activities during Operation DOMINIC II. Operational responsibility was delegated to the Test Group Director for a designated period before and after each test event. The REECO Radiological Safety Division performed onsite radiological activities. Operational responsibility for offsite radiological safety was assigned to the Offsite Radiological Safety Officer. USPHS personnel conducted offsite radiological monitoring, under the direction of the Offsite Radiological Safety Officer (31; 69; 73).

The NTSO Radiological Safety Division worked within exposure guidelines recommended by the AEC Division of Biology and Medicine. With certain exceptions, individual exposures were limited to 3 rem of gamma and neutron radiation for a 13-week period and not more than 5 rem annually. This was the occupational exposure limit recommended by the National Council on Radiation Protection and Measurements (5). Higher exposure limits were permitted for participants in Projects 2.3/2.4, 2.9, 2.11, and 7.15. A total of 5 rem was authorized for Project 2.3/2.4 personnel for all events. Project 2.9 and 2.11 personnel could receive gamma exposures up to 6 rem, while participants in Project 7.15 could receive 20 rem (31).

3.2.1 Onsite Operations

The REECO Radiological Safety Division was responsible for onsite radiological safety support at DOMINIC II. Members of the Radiological Safety Division had responsibility for several activities and functions, including (5):

- Training radiological safety monitors, including troop monitors
- Monitoring radiation areas and controlling access into these areas
- Plotting isointensity contour maps of the shot areas and providing radiation information to personnel entering the areas
- Issuing anticontamination clothing and equipment to personnel entering radiation areas
- Issuing, exchanging, developing, and evaluating film badges
- Maintaining film badge records to determine cumulative exposures of each participant to gamma and neutron radiation
- Monitoring and decontaminating personnel, vehicles, and equipment leaving radiation areas
- Providing all of the above radiological safety support for AFSWC personnel at Indian Springs AFB.

Access Control

Forty-eight hours before each shot, security personnel cleared the shot area and closed all roads leading into the area. They established check stations along these roads to ensure that personnel entering the test area to conduct preshot activities had the proper identification badges. All personnel except the arming party were cleared from the area about two hours before the detonation.

After the detonation, Radiological Safety Division personnel established and operated a base station and a mobile check

station along the main access road to prevent unauthorized entry. To enter the shot area, personnel had to pass through one of these stations, where radiological safety personnel checked each group of entering personnel for an access permit. This permit, which had to be authorized by the Test Manager, gave such information as the names and number of those permitted to enter, the purpose of their mission, and the estimated time required to complete the mission. Radiological safety personnel also checked to ensure that each individual was wearing appropriate anti-contamination clothing, a film badge, and a pocket dosimeter (5; 73).

Monitoring

Monitoring activities of the Radiological Safety Division included (5):

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

Before each detonation, the Radiological Safety Officer briefed the initial radiological survey teams on the expected fallout pattern. Four teams of two men each usually conducted the initial surveys. They entered the shot area as early as possible after each detonation. The teams used vehicle odometers to determine how far intensities of 0.01, 0.1, and 1 R/h were from previously established reference stakes. They radioed this information to radiological safety personnel in the base station, where the isointensity lines were plotted and mapped. The maps were then made available to project personnel planning to enter the radiation areas to retrieve their experiments. Survey teams posted the test areas with radiation warning signs, and traffic

was routed so that it would pass by either the base station or the mobile check station.

Teams resurveyed the shot area five hours and one, two, three, five, and seven days after the detonation. They moved the warning signs and barricades after each resurvey to indicate the current radiation intensity lines.

A radiological safety monitor accompanied groups entering areas with radiation intensities greater than 0.1 R/h. Project teams were generally required to provide their own certified monitors. However, if project monitors were not available, the Radiological Safety Division supplied them from personnel stationed at the base station or at the mobile check station (5).

Personnel Dosimetry

Personnel from the Radiological Safety Division provided dosimetry service and kept cumulative exposure records for all test organization personnel, both civilian and military. Each individual entering the NTS received a film badge, and each individual entering a radiation area received a pocket dosimeter. The film badge was attached to the security badge, while the pocket dosimeter was clipped to the shirt pocket. The film badges were marked with colored tape indicating the month of issue. Cards, numbered to match the number on the film badge, were stamped with the participants' identification information. At the end of each month, or whenever participants with a suspected exposure of 0.1 roentgen or more left a radiation area, radiological safety personnel exchanged the film badges. The film badges were developed and the optical densities measured with an Eberline FD-11 densitometer. Film badge readings for each participant were then included in a daily exposure report prepared by Radiological Safety Division personnel (5; 31; 73).

Upon entry into radiation areas, each participant's cumulative exposure from the daily report was listed on the Area Access Register. Upon exit from the radiation area, each person's pocket dosimeter reading was entered in the register. If the dosimeter reading was 0.1 rem or more, the person's film badge was exchanged. The dosimeter reading was added to the cumulative exposure until the next day's exposure report was received, which reflected the actual film badge reading for each participant in the new cumulative exposure total (5; 73).

The FEECo Radiological Safety Division also issued and processed film badges for participants at Indian Springs AFB and for the offsite radiological safety personnel. Radiological Safety Division personnel collected and processed the badges for the offsite organization at the end of the series (5).

Protective Equipment

Radiological Safety Division personnel at base stations issued radiation detection instruments, which had been checked and calibrated for field use, to certified project monitors entering radiation areas. They also issued the participants respirators and anticontamination clothing, such as coveralls, shoe covers, gloves, surgeon's caps, socks, and underclothing. The following is a list of the respirators and anticontamination clothing issued during the four shots (73):

| | |
|----------------|-------|
| Coveralls | 4,882 |
| Gloves (pairs) | 4,729 |
| Boots (pairs) | 4,288 |
| Dosimeters | 4,466 |
| Respirators | 2,956 |

Upon leaving radiation areas, participants removed their anti-contamination clothing and equipment and turned the items in to Radiological Safety Division personnel (73).

Decontamination

Radiological Safety Division personnel monitored personnel, vehicles, aircraft, and equipment leaving radiation areas. Decontamination was required if radioactivity exceeded the following limits:

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

Decontamination facilities were located at the base station for each shot. For Shot SMALL BOY, radiological safety personnel also used decontamination facilities at Building 2 of the Control Point (5; 73; 76).

The first step for personnel returning from a radiation area was to remove booties. Personnel then turned in film badges and pocket dosimeters, removed coveralls and gloves, and finally removed respirators and caps. Radiological safety personnel then monitored each individual. If the radioactivity readings exceeded the limit, the person was required to remove the suspect clothing and, if the readings were still too high, wash the specific skin areas or take a shower. Radiological safety personnel monitored these individuals again after washing or showering. When radiation readings were less than 0.001 R/h on the surface of the skin, the individuals were released. If personal clothing was contaminated, personnel were issued Government clothing for temporary use. Contaminated clothing was laundered, or radioactivity on the clothing was allowed to decay to the release limits.

Vehicles returning from radiation areas were parked in designated areas adjacent to base stations. Members of the

Radiological Safety Division monitored the vehicles. If they recorded readings of 0.007 R/h or greater within three centimeters of the vehicle surface, the vehicles had to be decontaminated. Radiological safety personnel first vacuumed all surfaces, including running boards, floorboards, and the under-sides of fenders. They then resurveyed the vehicles and, if the vehicles were still contaminated, steam cleaned them or washed them with a liquid detergent and rinsed them with water. When measured radiation intensities were less than 0.007 R/h, the vehicles were returned to service. Some vehicles and equipment were decontaminated at Building 6 of the Control Point (5; 73; 76).

3.2.2 Offsite Operations

The Test Manager was responsible for offsite radiological safety, but the Offsite Radiological Safety Officer had operational control of the program. Personnel from the USPHS provided operational support services, and REECo provided film badges and radiation detection equipment.

The objectives of the offsite radiological safety program were to:

- Assess the offsite radiation associated with each detonation
- Collect data on fallout patterns
- Conduct environmental monitoring of air, water, and milk
- Produce reports, maps, and records that described the findings of this monitoring and data collection
- Establish and maintain public relations activities.

Before each detonation, monitoring teams in radio-equipped vehicles were dispatched to selected offsite areas within 320 kilometers of the Control Point. These teams were then in

position to perform ground surveys as the cloud formed by the detonation drifted over their locations. In addition, the USPHS performed aerial monitoring for each shot in a U3A aircraft with an Air Force crew (5; 69).

3.3 RADIATION PROTECTION FOR THE AIR FORCE SPECIAL WEAPONS CENTER

During Operation DOMINIC II, AFSWC had responsibility for conducting all aerial support missions, including cloud sampling, cloud tracking, and aerial surveys of onsite and offsite areas. Because of the special nature of their activities, personnel involved with cloud sampling were authorized by the Test Manager to receive gamma exposures of up to 12 rem annually (44).

The Radiological Safety Division of REECo provided radiological safety support for Air Force personnel at Indian Springs AFB, as stated previously. Personnel from the 4520th Combat Crew Training Wing attached to AFSWC at DOMINIC II assisted REECo radiological safety personnel in performing monitoring, decontaminating personnel and aircraft, and maintaining the film badge program at Indian Springs AFB (31; 44; 73).

Air Force personnel were also responsible for other operational activities at Indian Springs AFB. The Director, Nuclear Test Directorate, had operational control of all aircraft activities. The 1211th Test Squadron (Sampling), also attached to AFSWC at DOMINIC II, provided aircraft and crews for cloud sampling. The 4900th Air Base Group provided aircraft and crews for cloud tracking (44).

Personnel Dosimetry

AFSWC participants were required to wear film badges while on cloud-sampling and cloud-tracking missions. In addition, each

aircraft had a radiation survey meter on board. REECo issued, exchanged, processed, and evaluated all film badges worn by Air Force personnel at Indian Springs AFB, including personnel involved with cloud sampling and cloud tracking. The film badge results were to be sent to the Chief, Special Projects Division, who was to forward them to the appropriate organizations for inclusion in the individual's personnel file (44). Not all records were, however, posted to the organizations and included in individual files.

Decontamination and Sample Removal

Aircraft returning from cloud-sampling or cloud-tracking missions were parked in the designated decontamination area at Indian Springs AFB. The engines were shut down and the canopies remained closed and latched until ground personnel removed the samples from the aircraft. The crews stayed within the enclosed cockpits and on full oxygen while the samples were removed. Personnel from the sample removal team used long-handled tools to remove the sample filter papers from each wing pod and place them in shielded containers.

After the samples were removed and placed in containers, the pilots shut down their oxygen supply and opened their canopies. The crew members stepped from the cockpit onto a platform on a forklift so they would not touch the outer surfaces of the aircraft. They were taken in pickup trucks to the decontamination station. The trucks then returned to the aircraft where they were loaded with the samples, which they transported to the waiting courier aircraft. The courier aircraft left from Indian Springs AFB to deliver the samples to laboratories for analysis.

At the decontamination station, Radiological Safety Division personnel monitored the cloud-sampling pilots and crews. The

pilots and crews were required to go through complete decontamination procedures. This involved removing flight suits and undergarments, showering, and receiving a fresh change of laundered clothes. Showering was continued until radioactivity on the surface of the skin was less than 0.001 R/h (5; 44).

Personnel from the 4520th Combat Crew Training Wing assisted radiological safety personnel in decontaminating the sampling aircraft. They used firehoses to spray and wash the outside of the aircraft with water. Streams of water from fire hoses were directed through running B-57 jet engines to decontaminate these most highly contaminated aircraft locations. The personnel then opened the canopy and the cockpit and wiped the inside of the canopy. Cloud-tracking aircraft returned to Indian Springs AFB, where they were monitored for radioactivity and, if necessary, decontaminated (5; 44).

CHAPTER 4

DOSIMETRY FOR DEPARTMENT OF DEFENSE PERSONNEL AT OPERATION DOMINIC II

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

4.1 PARTICIPATION DATA

The identity of participants was determined from several sources:

- Final Report of Exercise IVY FLATS provided information on unit participation and activities of IVY FLAT organizations (46).
- Weapons test reports for DASA and other scientific projects often identified personnel, units, and organizations that participated in the operation.
- After-action reports, security rosters, and vehicle-loading rosters related to the military exercises identified some participants.
- Morning reports, unit diaries, and muster rolls provided identification data on personnel assigned to participating units, absent from their home unit, or in transient status for the purpose of participating in a nuclear weapons test.
- Discharge records, maintained by all services, aided in identification.
- Records maintained by REECe listed many participants by name and organization (77).
- Military personnel records from some of the services provided information about individuals' assignments to participating units or attendance in transient status at the nuclear weapons tests.

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

4.2 SOURCES OF DOSIMETRY DATA

Dosimetry data for Operation DOMINIC II were derived from film badge records. The film badge was the primary device used to measure the radiation dose received by individual participants. Normally worn at chest level on the outside of clothing, the film badge was designed to measure the wearer's exposure to gamma radiation from external sources. The film badge was not designed to measure neutron radiation or the amount of radioactive material that may have been inhaled or ingested.

The REECO Radiological Safety Division was responsible for issuing, receiving, developing, and interpreting film badges worn by personnel of the NTSO, Exercise IVY FLATS, and Air Force units stationed at Indian Springs AFB. As described in chapter 3, REECO radiological safety personnel recorded film badge data for participants on daily exposure reports as part of the dosimetry records system (5; 73). In this manner, a record was maintained of the individual's exposure history.

At the conclusion of DOMINIC II, film badge records were compiled into the aggregate exposure data included in the Report of the Test Manager, Operation STORAX (5) and the Final Report, [Exercise] IVY FLATS (46). The film badge data summarized in this chapter come from dosimetry records in the historical files of REECO and from military records (22; 77).

4.3 DOSIMETRY DATA FOR OPERATION DOMINIC II

As stated in chapter 3, the gamma exposure limit for participants at DOMINIC II was 3 rem. A total of 5 rem was authorized

for Projects 2.3/2.4 personnel. Projects 2.9 and 2.11 personnel could receive gamma exposures up to 6 rem. Personnel participating in Project 7.15 were authorized to receive 20 rem (31).

The gamma exposures available from film badge records for DOD participants in Operation DOMINIC II are indicated in tables 4-1 through 4-6. Table 4-1 summarizes gamma exposure data for personnel by affiliation. Tables 4-2 through 4-6 provide information about the gamma exposures of participants for the Army; Navy; Marine Corps; Air Force; and scientific personnel, contractors, and observers, respectively. Distributions and averages are given by unit (22).

Available dosimetry records show that two DOMINIC II participants received gamma exposures greater than 3 rem. One of the participants was from the Navy and the other from the Marine Corps, but both were affiliated with the Naval Radiological Defense Laboratory. Their exposures were 5.8 and 4.3 rem, respectively (22). The second individual participated in Projects 2.9 and 2.11, which were authorized a 6 rem limit (104). Three additional personnel received gamma exposures of 3.065, 3.295, and 3.610. At this time, their affiliations and project assignments are unavailable; hence, they were not included in the dosimetry tables (77).

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

| Service | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|--|------------------------------|--|------------------------------|----------------------|---------|---------|---------|------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0+ |
| Army | 57 | 5 | 0.093 | 3 | 2 | 0 | 0 | 0 |
| Navy | 81 | 59 | 1.013 | 8 | 22 | 28 | 0 | 1 |
| Marine Corps | 89 | 58 | 0.573 | 18 | 24 | 15 | 1 | 0 |
| Air Force | 150 | 135 | 0.278 | 59 | 69 | 7 | 0 | 0 |
| Scientific Personnel, Contractors, and Observers | 1361 | 1361 | 0.039 | 1272 | 74 | 15 | 0 | 0 |
| Total | 1738 | 1618 | 0.114 | 1360 | 191 | 65 | 1 | 1 |

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

| Units | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|--|------------------------------|--|------------------------------|----------------------|---------|---------|---------|------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0+ |
| Camp Desert Rock, NV | 42 | 0 | | | | | | |
| DASA at Mercury, NV | 1 | 0 | | | | | | |
| Engineer Research and Development Laboratories, Fort Belvoir, VA | 1 | 1 | 0.270 | 0 | 1 | 0 | 0 | 0 |
| Field Command DASA, U.S. Army Element Kirtland AFB, NM | 2 | 2 | 0.070 | 1 | 1 | 0 | 0 | 0 |
| Fourth Infantry Division, Fort Lewis, WA | 1 | 0 | | | | | | |
| Headquarters Ivy Flats, CA | 1 | 1 | 0.035 | 1 | | | | |
| Photographic Unit (sic)* | 1 | 0 | | | | | | |
| Signal Corps (sic) | 1 | 0 | | | | | | |
| U.S. Army Intelligence School Fort Holabird, MD | 1 | 0 | | | | | | |
| Third Army, Ft. McPherson, GA | 1 | 1 | 0.021 | 1 | 0 | 0 | 0 | 0 |
| 52nd Artillery Regiment, 6th Artillery Group Fort Bliss, TX | 1 | 0 | | | | | | |
| 116th Military Intelligence Group Washington, D.C. | 1 | 0 | | | | | | |
| 524th Military Police Company, 3rd Platoon Fort Shafter, HI | 1 | 0 | | | | | | |
| Unit Unknown** | 2 | 0 | | | | | | |
| Total | 57 | 5 | 0.093 | 3 | 2 | 0 | 0 | 0 |

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

** Unit information unavailable.

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

| Units | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|---|------------------------------|--|------------------------------|----------------------|---------|---------|---------|-------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0 + |
| Armed Forces Special Weapons Project (sic) * | 2 | 0 | | | | | | |
| Construction Battalion Center, Port Hueneme, CA | 1 | 1 | 0.120 | 0 | 1 | 0 | 0 | 0 |
| Director, Weapons Effects Test | 1 | 0 | | | | | | |
| Naval Administrative Unit, Sandia Base | 7 | 5 | 0.044 | 4 | 1 | 0 | 0 | 0 |
| Naval Mobile Construction Battalion-ELEVEN | 21 | 21 | 0.923 | 3 | 6 | 12 | 0 | 0 |
| Naval Radiological Defense Laboratory | 44 | 32 | 1.253 | 1 | 14 | 16 | 0 | 1 |
| University of California Radiation Laboratory | 4 | 0 | | | | | | |
| Unit Unknown** | 1 | 0 | | | | | | |
| Total | 81 | 59 | 1.013 | 8 | 22 | 28 | 0 | 1 |

* "Sic" indicates that the table entry for the organization appears as it was listed in source documentation.

** Unit information unavailable.

Table 4-4: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR MARINE CORPS PERSONNEL AND AFFILIATES, OPERATION DOMINIC II

| Units | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|---|------------------------------|--|------------------------------|----------------------|---------|---------|---------|------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0+ |
| Marine Medium Helicopter Squadron - 363 Marine Air Group - 36, 3d Marine Air Wing FMF Pacific | 58 | 29 | 0.717 | 3 | 13 | 13 | 0 | 0 |
| Naval Radiological Defense Laboratory | 29 | 28 | 0.416 | 15 | 10 | 2 | 1 | 0 |
| Observer, Field Command DASA, Sandia Base | 1 | 1 | 0.800 | 0 | 1 | 0 | 0 | 0 |
| Observer, Joint Chiefs of Staff | 1 | 0 | | | | | | |
| Total | 89 | 58 | 0.573 | 18 | 24 | 15 | 1 | 0 |

Table 4-5: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR AIR FORCE PERSONNEL AND AFFILIATES, OPERATION DOMINIC II

| Units | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|---|------------------------------|--|------------------------------|----------------------|---------|---------|---------|------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0+ |
| Aerospace Audio Visual Service Washington, D.C. | 11 | 11 | 0.014 | 4 | 7 | 0 | 0 | 0 |
| Air Force Flight Testing Center Edwards AFB, CA | 10 | 10 | 0.192 | 3 | 7 | 0 | 0 | 0 |
| Air Force Missile Development Center Holloman AFB, NM | 6 | 6 | 0.356 | 0 | 6 | 0 | 0 | 0 |
| Air Force Special Weapons Center Kirtland AFB, NM | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| Air Force Weapons Laboratory Kirtland AFB, NM | 58 | 58 | 0.305 | 27 | 27 | 4 | 0 | 0 |
| Defense Atomic Support Agency | 4 | 4 | 0.028 | 4 | 0 | 0 | 0 | 0 |
| Headquarters, U.S. Air Force Washington, D.C. | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Space Systems Division, Los Angeles, CA | 11 | 11 | 0.557 | 2 | 8 | 1 | 0 | 0 |
| 56th Weather Reconnaissance Squadron Hickman AFB, HI | 1 | 0 | | | | | | |
| 728th Aircraft Control and Warning Squadron Cannon AFB, NM | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1136th Special Activity Squadron | 7 | 7 | 0.315 | 3 | 3 | 1 | 0 | 0 |
| 1090th Special Reporting Wing Kirtland AFB, NM | 3 | 3 | 0.241 | 2 | 1 | 0 | 0 | 0 |
| 1211th Test Squadron (Sampling) McClellan AFB, CA | 2 | 0 | | | | | | |
| 1352nd Photographic Group Lookout Mt. Laboratory, CA | 1 | 1 | 1.010 | 0 | 0 | 1 | 0 | 0 |
| 1942nd Communication Squadron Homestead, FL | 1 | 0 | | | | | | |
| 3245th Operational Group L.G. Hanscom AFB, MA | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4520th Air Base Group, Nellis AFB, NV | 1 | 0 | | | | | | |
| 4900th Air Base Group, Kirtland AFB, NM | 1 | 0 | | | | | | |
| Unit Unknown* | 28 | 19 | 0.289 | 9 | 10 | 0 | 0 | 0 |
| Total | 150 | 135 | 0.278 | 59 | 69 | 7 | 0 | 0 |

* Unit information is unavailable.

Table 4-6: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR SCIENTIFIC PERSONNEL, CONTRACTORS, AND OBSERVERS, OPERATION DOMINIC II

| Units | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|--|------------------------------|--|------------------------------|----------------------|---------|---------|---------|------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0+ |
| Al A. Martin Associates (sic)* | 1 | 1 | 0.000 | 1 | 0 | 0 | 0 | 0 |
| Allied Research Associates, Inc. | 9 | 9 | 0.555 | 2 | 6 | 1 | 0 | 0 |
| American Telephone and Telegraph | 1 | 1 | 0.390 | 0 | 1 | 0 | 0 | 0 |
| American Sci. & Engr., Inc. (sic) | 6 | 6 | 0.536 | 1 | 5 | 0 | 0 | 0 |
| Armour Research Foundation | 7 | 7 | 0.202 | 6 | 0 | 1 | 0 | 0 |
| Assistant Chief of Staff Intelligence [Department of Army] Washington, D.C. | 1 | 1 | 0.050 | 1 | 0 | 0 | 0 | 0 |
| Bendix Aircraft Corporation | 2 | 2 | 0.000 | 2 | 0 | 0 | 0 | 0 |
| Boeing Aircraft Company | 15 | 15 | 0.874 | 2 | 9 | 4 | 0 | 0 |
| Canada, Headquarters, NBCW | 1 | 1 | 0.285 | 0 | 1 | 0 | 0 | 0 |
| Chance Vought | 9 | 9 | 0.000 | 9 | 0 | 0 | 0 | 0 |
| DASA, Clarksville Base (Ft. Campbell, KY), TN | 4 | 4 | 0.165 | 3 | 1 | 0 | 0 | 0 |
| DASA, Lakemead Base, NV | 9 | 9 | 0.000 | 9 | 0 | 0 | 0 | 0 |
| DASA, Manzano Base, NM | 4 | 4 | 0.000 | 4 | 0 | 0 | 0 | 0 |
| DASA Field Command (Civilians), Kirtland AFB | 10 | 10 | 0.054 | 8 | 2 | 0 | 0 | 0 |
| DASA Field Command Miscellaneous | 252 | 252 | 0.000 | 252 | 0 | 0 | 0 | 0 |
| DASA Field Command NTS Detachment | 30 | 30 | 0.017 | 29 | 1 | 0 | 0 | 0 |
| DASA Headquarters, Washington, D.C. | 86 | 86 | 0.028 | 81 | 4 | 1 | 0 | 0 |
| General Precision, NJ | 1 | 1 | 0.135 | 0 | 1 | 0 | 0 | 0 |
| Hospital, Sandia Base (sic) | 1 | 1 | 0.220 | 0 | 1 | 0 | 0 | 0 |
| Hughes Aircraft Company | 9 | 9 | 0.267 | 5 | 3 | 1 | 0 | 0 |
| JER Pro Res Co (sic) | 1 | 1 | 0.000 | 1 | 0 | 0 | 0 | 0 |
| Lockhead Missiles & Space Company, Inc. | 21 | 21 | 0.198 | 13 | 7 | 1 | 0 | 0 |
| Marquardt Aircraft (sic) | 10 | 10 | 0.000 | 10 | 0 | 0 | 0 | 0 |
| Martsat (sic) | 3 | 3 | 0.081 | 2 | 1 | 0 | 0 | 0 |
| Massachusetts Institute of Technology | 2 | 2 | 0.000 | 2 | 0 | 0 | 0 | 0 |
| MHD Research | 3 | 3 | 0.120 | 0 | 3 | 0 | 0 | 0 |
| Motorola (Inc.) Systems Laboratory | 1 | 1 | 0.000 | 1 | 0 | 0 | 0 | 0 |
| North American Aircraft, Inc. | 2 | 2 | 0.000 | 2 | 0 | 0 | 0 | 0 |

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

Table 4-6: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR SCIENTIFIC PERSONNEL, CONTRACTORS, AND OBSERVERS, OPERATION DOMINIC II (Continued)

| Units | Personnel Identified by Name | Personnel Identified by Name and by Film Badge | Average Gamma Exposure (rem) | Gamma Exposure (rem) | | | | |
|------------------------------------|------------------------------|--|------------------------------|----------------------|---------|---------|---------|-------|
| | | | | <0.1 | 0.1-1.0 | 1.0-3.0 | 3.0-5.0 | 5.0 + |
| Northrop Corporation | 6 | 6 | 0.168 | 2 | 4 | 0 | 0 | 0 |
| Office of the Secretary of Defense | 2 | 2 | 0.000 | 2 | 0 | 0 | 0 | 0 |
| Ralph Parson, Inc. | 6 | 6 | 0.000 | 6 | 0 | 0 | 0 | 0 |
| Raytheon Company, Missiles Systems | 1 | 1 | 0.065 | 1 | 0 | 0 | 0 | 0 |
| Seaspace Systems, Inc. | 1 | 1 | 0.040 | 1 | 0 | 0 | 0 | 0 |
| Shannon & Wilson | 6 | 6 | 0.120 | 4 | 2 | 0 | 0 | 0 |
| Stanford Research Institute | 50 | 50 | 0.125 | 35 | 14 | 1 | 0 | 0 |
| Struble International | 1 | 1 | 0.065 | 1 | 0 | 0 | 0 | 0 |
| System Science & Software (sic) | 2 | 2 | 0.000 | 2 | 0 | 0 | 0 | 0 |
| Texas Instruments | 4 | 4 | 0.026 | 4 | 0 | 0 | 0 | 0 |
| Unit Name Unknown* | 760 | 760 | 0.003 | 754 | 6 | 0 | 0 | 0 |
| Universities | 18 | 18 | 0.341 | 13 | 1 | 4 | 0 | 0 |
| Weston Hydraulics Ltd. | 3 | 3 | 0.553 | 1 | 1 | 1 | 0 | 0 |
| Total | 1361 | 1361 | 0.039 | 1272 | 74 | 15 | 0 | 0 |

* Unit information is unavailable.

LITTLE FELLER II

SHOT SYNOPSIS

AEC TEST SERIES: DOMINIC II
DATE/TIME: 7 July 1962, 1200 hours
YIELD: Low
HEIGHT OF BURST: Three feet above ground

Purpose of Test: Weapons effects test designed to:
(1) Collect data on the effects of a detonation of low yield

(2) Gather information for use in Shot LITTLE FELLER I.

Weather: At shot-time, the temperature was 35.5 degrees Celsius. Winds were seven knots from the south at surface level and ten knots from the south at 10,000 feet.

Radiation Data: A radiation level of 1 R/h or more was confined to within 200 meters of ground zero except to the north, where this level extended to about 2,300 meters. Intensities greater than 10 R/h were registered at ground zero at the time of the initial survey (mid-time 1315). By three days after the detonation, the radiation level at ground zero had decreased to 1 R/h, and the area with radiation intensities of 0.01 R/h or more was confined within 180 meters of ground zero.

Participants: Army Engineer Waterways Experiment Station; Army Engineer Research and Development Laboratories; Army Ballistic Research Laboratories; Army Nuclear Defense Laboratory; Northrop Corporation; Air Force Weapons Laboratory; Air Force Special Weapons Center; Naval Missile Center; Army Electronics Research and Development Laboratory; Los Alamos Scientific Laboratory; AEC civilians; other contractors.

CHAPTER 5

SHOT LITTLE FELLER II

Shot LITTLE FELLER II was detonated on 7 July 1962 at 1200 hours Pacific Daylight Time in Area 18* of the Nevada Test Site, UTM coordinates 619081. Figure 5-1 shows the LITTLE FELLER II event ten seconds after the detonation (29). Sponsored by the Department of Defense, the test involved the detonation of a stockpile DAVY CROCKETT warhead intended as a companion shot for LITTLE FELLER I. The device, positioned three feet above the ground by a cable suspended between two posts, detonated with a low yield (5; 29; 31).

At shot-time, the temperature at the surface was 35.5 degrees Celsius. Winds were seven knots from the south at the surface and ten knots from the south at 10,000 feet.⁺ The top of the cloud resulting from the detonation reached 11,000 feet and moved to the north (35).

Shot LITTLE FELLER II, like LITTLE FELLER I, was planned and executed within a 70-day period. Three Little Feller shots were originally considered. One was to be three feet above ground and the second 40 feet above ground. The third was to be launched tactically after having been set to fire at a height of 40 feet. A military exercise was scheduled for this third shot. As plans developed, the third shot was canceled, and the second shot, which became LITTLE FELLER I, was changed to a three-foot shot to be launched in connection with a tactical maneuver (31).

*Ground zeros in Area 18 are about 5,000 feet above sea level.

⁺Altitudes are measured from sea level, unless otherwise noted.



**Figure 5-1: SHOT LITTLE FELLER II TEN SECONDS AFTER THE DETONATION, WITH
PROJECT 1.1 INSTRUMENTED BALLOON TO LEFT OF CLOUD TOP**

5.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT LITTLE FELLER II

Department of Defense personnel took part in a number of scientific projects conducted by the Weapons Effects Test Group. Table 5-1 lists these projects by number and title and identifies the participants. DOD personnel also took part in AFSWC activities providing support to test group projects and to the Test Manager.

5.1.1 Weapons Effects Tests

The Weapons Effects Test Group projects were designed to collect data on the blast, shock, cratering, prompt nuclear radiation, and fallout effects of a low-yield nuclear detonation. These projects were also intended to gather information for use in Exercise IVY FLATS, to be conducted at Shot LITTLE FELLER I (29; 31). In conducting these projects, participants spent several weeks before the detonation placing and calibrating various types of instruments and gauges in the shot area. Project personnel accompanied by a radiological safety monitor reentered the shot area at various times from 15 minutes up to 18 days after the detonation to retrieve data and instruments (5; 29; 31).

Project 1.1, Airblast Phenomena from Small Yield Devices, was conducted by the Army Ballistic Research Laboratories to:

- Measure the free-field overpressures and dynamic pressure versus time resulting from the detonation of a DAVY CROCKETT weapon
- Measure the free-air overpressure versus time resulting from the detonation of a DAVY CROCKETT weapon
- Integrate the results with existing subkiloton nuclear and multiton high-explosive data

Table 5-1: WEAPONS EFFECTS TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT LITTLE FELLER II

| Project/ Program | Title | Participants |
|---------------------|--|---|
| 1.1 | Airblast Phenomena from Small Yield Devices | Army Ballistic Research Laboratories |
| 1.3 | Blast Effects on Simple Objects and Military Vehicles | Army Ballistic Research Laboratories; EG&G |
| 1.5 | Debris Throwout | Army Engineer Research and Development Laboratories |
| 1.9 | Crater Size and Shape | Army Engineer Waterways Experiment Station; American Aerial Surveys |
| 2.3 | Neutron Flux Measurements | Army Nuclear Defense Laboratory |
| 2.4 | Integrated Gamma Dose Measurements | Army Nuclear Defense Laboratory |
| 2.8 | Radiological Surveys | Army Nuclear Defense Laboratory |
| 2.16 | Residual Radiation in the Crater and Crater-lip Area of Low-yield Nuclear Devices | Army Engineer Research and Development Laboratories; Army Nuclear Defense Laboratory |
| 2.17 | Transient Radiation Effects Measurements—Guidance Systems Circuits and Piece Parts | Nuclear Sciences Group of the Northrop Corporation |
| 2.20 | Transit Radiation Dose Rate | Army Nuclear Defense Laboratory |
| 4.1 | Tissue Dosimetry | Air Force Weapons Laboratory; Army Signal Research and Development Laboratory; Los Alamos Scientific Laboratory |
| 6.6 | Initial Gamma Rate Measurements | Air Force Special Weapons Center |
| 6.6b | Electromagnetic Measurements | Air Force Special Weapons Center; Sandia Corporation |
| 7.16 | Airborne E-Field Radiation Measurements of Electromagnetic Pulse Phenomena | Naval Missile Center |
| 7.17 | Radiological Water Decontamination Study | Army Engineer Research and Development Laboratories |
| 8.2 | Fallout Hazard Determination by Fireball Spectroscopy | Army Electronics Research and Development Laboratory |
| 9.2 | Documentary Photography | Field Command, DASA |
| 9.3 | Technical Photography | Field Command, DASA; EG&G |
| 9.4 | Weapon Test Reports | Field Command, DASA |
| 9.5 | Communications | Field Command, DASA |
| 9.6 | General DOD Support | Field Command, DASA |
| 9.7 | Engineering and Field Operations | Field Command, DASA; Holmes and Narver; REEC |

- Provide supporting free-field measurements of blast parameters to other projects as required.

To obtain surface measurements, project personnel placed 15 electronic pressure gauges and 17 self-recording gauges along a line four to 5,130 meters south-southwest of ground zero. They also tethered an instrumented balloon 640 meters away from and 1,275 feet above ground zero. In this phase of the project, an instrumented tethered balloon was used to measure pressure versus time in free air. The balloon test was unsuccessful, however, because of technical difficulties (65).

Project 1.3, Blast Effects on Simple Objects and Military Vehicles, was conducted by the Army Ballistic Research Laboratories, with assistance from EG&G. The objectives were to:

- Study the response of simple objects to the blast from a nuclear detonation
- Determine how damage to tanks varies with distance from a low-yield detonation
- Measure the radiation doses at crew positions within the tanks
- Investigate the effectiveness of protective cover over equipment.

To study blast response, project participants placed two spheres and four cubes made of wood and aluminum on steel bars anchored to concrete pads about 40 meters southwest of ground zero. Project personnel installed pressure gauges in the ground near the mounted objects to measure the blast pressure at shot-time. EG&G personnel filmed the effects of the blast wave on these objects with remotely operated cameras they had installed before the shot in a bunker about 15 meters from the objects.

For the second and third objectives, personnel from the Army Tank - Automotive Center placed five M-46 tanks, which had been

used at Operation HARDTACK, at distances ranging from 15 to 45 meters in different directions from ground zero. Project 1.3 personnel installed radiation detectors within the tanks at crew positions and also outside the tanks. The detectors inside the tanks were connected to a heavy pull cord located near the tank hatches. This made it possible for personnel to recover the detectors immediately after the detonation without having to enter the tanks.

To achieve the fourth objective, project personnel placed two 1/4-ton trucks 30 meters southeast of ground zero in four-foot deep revetments and covered the trucks with canvas. They also installed a gauge on the floor of the revetment under each truck to measure blast overpressure. Sometime after the detonation, project participants reentered the area to recover the instruments, and EG&G personnel retrieved their film from the camera bunker (27).

Project 1.5, Debris Throwout, was conducted by the Army Engineer Research and Development Laboratories. The objective was to collect data on the range and dispersion of blast-driven surface debris in order to assess the significance of surface missiles from very low-yield surface detonations as a casualty-producing source. Before the detonation, project personnel placed an assortment of test objects, including tree branches and various building materials, along 20 radial lines extending from ground zero out to a distance of 60 meters. Personnel searched for test objects up to 300 meters from ground zero on the day following the detonation. They made a final survey after the radiation levels in the area had decreased (58).

Project 1.9, Crater Size and Shape, was conducted by the Army Engineer Waterways Experiment Station, with the assistance of American Aerial Surveys, a civilian subcontractor of Holmes and Narver, Incorporated. The objectives were to:

- Measure the crater formed by the shot
- Measure the permanent earth deformation occurring within the plastic response zone.

Before the shot, project personnel placed eight colored sand columns, 18 centimeters in diameter and varying from five to 15 feet in depth, on a radius 18 meters from ground zero.

American Aerial Surveys personnel took aerial photographs of the test area two days before the detonation. The morning after the shot, American Aerial Surveys personnel repeated the aerial photography, subsequently measuring the crater through the use of stereoscopes. They conducted their mission in an aircraft flying at a speed of 70 knots and at heights of 1,200 and 1,500 feet above the ground. Project personnel continued to conduct ground surveys of the crater until about four months after the detonation. The excavating and measuring of the sand columns went on for about eight months after the shot (81).

Project 2.3, Neutron Flux Measurements, was conducted by the Army Nuclear Defense Laboratory. The objective was to document neutron flux versus ground range. Project personnel installed neutron flux detectors nine to 460 meters northwest of ground zero and five to 730 meters southwest of ground zero. They attached most of the detectors to cables. Immediately after the detonation, project personnel, assisted by Project 1.3 participants, entered the shot area in an M-88 tank retriever to drag the cables out of the area. They transported the detectors to the Project 2.3 mobile laboratory at the Control Point (80).

Project 2.4, Integrated Gamma Dose Measurements, was conducted by the Army Nuclear Defense Laboratory.

gamma dose versus ground range. Before the detonation, project personnel installed gamma detectors along two lines south-southwest of ground zero and one line west-northwest of ground zero. These detectors, which project personnel attached to four recovery cables, were ten to 730 meters from ground zero. After the detonation, Project 2.4 and 2.3 participants pulled the cables out of the radiation field. They completed recovery within one hour after the detonation. The gamma detectors were then sent for analysis to the Army Nuclear Defense Laboratory and the Army Signal Corps Research and Development Laboratory.

In addition to their field activities, project personnel provided 25 gamma detectors to Project 1.1 personnel. They also supplied Project 2.20 personnel with 50 film badges for their study of gamma dose (79).

Project 2.8, Radiological Surveys, was conducted by the Army Nuclear Defense Laboratory. The objectives were to determine:

- Residual radiation patterns and decay rates resulting from a low-yield detonation
- Gamma exposure rates and decay rates in and around the crater resulting from the detonation.

To obtain data, ground-survey teams and helicopter-to-ground units surveyed radiation areas. In addition, personnel obtained information from radiation-detecting instruments placed in and near the crater resulting from the detonation and from film badges positioned throughout the region of expected fallout (8).

To conduct ground surveys, monitors used the same procedures for each DOMINIC II shot. Two-man teams in four-wheel-drive vehicles performed the surveys. Each team drove nine to 15 meters from a particular onsite station to be monitored. They then stopped the vehicle, and the monitor walked to the station. Holding a dose-rate meter before him at a three-foot height, the

monitor then rotated 360 degrees and recorded the highest reading obtained. He and all other personnel working in the area were required to report by radio their dosimeter readings and locations every 15 minutes. To facilitate the preparation of isointensity maps, they also reported the location of .01 R/h, 0.1 R/h, 1 R/h, and 10 R/h readings. On the day of detonation for LITTLE FELLER II, as well as for JOHNIE BOY and SMALL BOY, monitors made two complete surveys and selected station resurveys (8).

To enable cross-country travel in the mountainous terrain of Area 18, bulldozers were used to make a network of roads, along which ground-survey stations were established. For Shot LITTLE FELLER II, stakes were placed at intervals of 30 to 300 meters on downwind roads 70 to 400 meters north of ground zero. In addition, stakes were placed at 30-meter intervals on three upwind roads up to 610 meters southeast to southwest of ground zero (8).

Twelve minutes after the detonation, four monitoring teams entered the test area to survey, according to documentation, "the ground zero radial lines and the lines within 400 feet downwind of ground zero" (8). The teams did not proceed into areas with a higher intensity than 10 R/h. Twenty-eight minutes after the detonation, additional teams proceeded into the area to survey stations at greater distances downwind. By 40 minutes after the detonation, 14 monitoring teams, the total number designated for Shot LITTLE FELLER II, were conducting initial surveys in radiation areas. Following conclusion of the complete survey of the area, monitors resurveyed selected stations. They finished a second complete survey of the area just before dark (8).

Monitors conducted a complete resurvey of the area one day after the detonation. They resurveyed selected stations on the second, third, fourth, and ninth days after the shot. During the

survey on 10 July 1982, monitors recovered all film badges in the area (8).

Project 2.8 aerial operations consisted of the following types of activities:

- Placing radiation-measuring instruments in and near ground zero to determine radiation intensities and decay rates
- Lowering a radiation-detecting probe from helicopters to determine ground radiation intensities in areas exceeding 10 R/h
- Landing a helicopter in areas geographically inaccessible by ground travel in order to determine radiation intensities.

The helicopter and crews participating in these activities were from the Marine Corps. Chemical Corps officers from Headquarters, Continental Army Command, Fort Monroe, Virginia, conducted the measurements made from the helicopter (8).

Thirteen minutes after the detonation, one helicopter flew at an altitude of 1,000 feet over ground zero to determine radiation intensities. A second helicopter flew as a "safety rescue" aircraft. The readings obtained by the first helicopter were less than 10 R/h. Consequently, a third helicopter was directed to hover over the crater while a radiation-recording instrument was lowered by rope to a position about 10 meters southeast of ground zero. Because this instrument was turned over while being released from the rope, another identical instrument was placed 10 meters northwest of ground zero 50 minutes after the detonation. In addition, two helicopters flew missions over the shot area beginning 29 minutes after the detonation. Radiation-detecting probes were lowered from these aircraft to the ground zero area and to stations close to ground zero (8).

The helicopters were permitted to land at selected sites when intensities measured within the aircraft did not exceed 1 R/h. Approximately four hours after the detonation and again one day after the shot, aircraft landed on the high mesa north of Area 18. There, monitors left the helicopters to conduct radiological surveys in the area (8).

Project 2.16, Residual Radiation in the Crater and Crater-lip Area of Low-yield Nuclear Devices, was conducted by the Army Engineer Research and Development Laboratories, with assistance from Army Nuclear Defense Laboratory personnel. The objectives were to:

- Determine the residual radiation environment in and near the nuclear crater
- Obtain information on gamma intensity versus time and gamma activity versus soil depth.

Project personnel put instruments to measure and record gamma intensities on a remote-controlled D7 bulldozer. Shortly after the detonation, two parties, one of four and the other of two personnel, drove into the shot area approximately three kilometers south of ground zero. The two-person party proceeded to a station about 1.5 kilometers from ground zero, where they remained until about eight hours after the detonation. The four-person team used a flatbed truck to transport the bulldozer to a position about 600 meters from ground zero. They then directed the bulldozer by remote control into the desired location within the crater area. After spending about 45 minutes in the shot area, these four participants then returned to the Control Point, where they received data from instruments on the bulldozer from 85 minutes to 40 hours after the detonation (74). Five days after the shot, project personnel returned to the crater area and obtained soil samples from five locations ten to 25 meters from ground zero. They sent the samples for analysis to the Army Nuclear Defense Laboratory (66; 74).

Project 2.17, Transient Radiation Effects Measurements-- Guidance Systems Circuits and Piece Parts, was conducted by the Nuclear Sciences Group of the Northrop Corporation, Newbury Park, California. The objectives of this project were to:

- Determine the electronic response of typical semiconductor parts and electronic circuits exposed to the prompt gamma pulse from a near-surface nuclear detonation
- Correlate the responses from the detonation with the responses from experiments simulated in the laboratory.

Project participants placed the various electronic circuits and components to be tested on four concrete pads, two of which were 110 meters south-southwest, another 450 meters southwest, and the other 240 meters west of ground zero. After the area was cleared for recovery activities, two two-person parties spent one hour in the test area retrieving instruments (39; 74).

Project 2.20, Transit Radiation Dose Rate, was conducted by the Army Nuclear Defense Laboratory. The objective was to determine the extent and significance of transit radiation from passage of the cloud from surface and subsurface detonations. Two days before the detonation, project personnel placed 48 gamma radiation detectors, recorders, and film badges in and around 18 foxholes to the north and six foxholes to the south of ground zero. The foxholes, in groups of six, were 275 to 910 meters from ground zero. The gamma detectors and recorders had a recording range of zero to 10,000 R/h. Personnel turned on the instruments four hours before the detonation. They recovered the instruments the day after the detonation (86).

Project 4.1, Tissue Dosimetry, was conducted by the Air Force Weapons Laboratory, with assistance from the Army Signal Research and Development Laboratory and the Los Alamos Scientific Laboratory. Objectives were to:

- Measure initial levels of neutron and gamma radiation in the shot area
- Measure and compare radiation levels in the air with radiation levels at various depths in animal tissue and in synthetic materials equivalent in density to animal tissue
- Evaluate the performance of various types of dosimeters in field conditions.

Project personnel placed gamma and neutron dosimeters on stakes, inside sheep carcasses, and inside synthetic tissue materials. They located these test specimens 300, 335, 400, 520, and 600 meters from ground zero. Seventy-five minutes after the detonation, three participants in two vehicles returned to the shot area and recovered the dosimeters. Personnel began their analysis five hours after the detonation and continued it until the next day (20; 74).

Project 6.6, Initial Gamma Rate Measurements, was conducted by the Air Force Special Weapons Center. The objective was to measure the gamma dose rate as a function of time from shot-time to 1,000 microseconds after the detonation. Project personnel constructed a bunker from a five-meter section of a metal pipe three meters in diameter, the ends of which were closed with steel plates. Participants transported the bunker to the shot area in a flatbed truck. They then placed the bunker in a hole 80 meters southwest of ground zero and put gamma detectors and automatic cameras inside the bunker. Four hours before the detonation, personnel entered the shot area to check the instruments and secure the bunker. For the first 30 seconds after the detonation, the instruments in the bunker automatically collected data. Project personnel returned to the shot area to recover

film and other recorded data four hours after the shot. They brought the film for processing to the EG&G photography trailer near the Control Point (63).

Project 6.6b, Electromagnetic Measurements, was conducted by the Air Force Special Weapons Center and the Sandia Corporation. The main objective was to obtain and correlate data concerning gamma radiation rates from a nuclear detonation, the resultant electromagnetic field, and field-induced currents in various cable configurations. Project personnel extended two copper wires from the southeast to within 15 meters of ground zero at a depth of one foot. They instrumented the wires for dynamic current measurements 60 and 300 meters from ground zero and for passive current measurements at various other distances along the cables. Signals from these instruments were carried by wire to the recording station, where the information was recorded on magnetic tape (48).

Project 7.16, Airborne E-Field Radiation Measurements of Electromagnetic Pulse Phenomena, was conducted by the Naval Missile Center. The objective was to measure, from the air, the vertical electric field of the radiated electromagnetic pulse from the detonation. Project personnel placed electromagnetic pulse detection and recording equipment, including vertical whip antennas, magnetic tape recorders, and oscilloscopes, on one C-131F aircraft, provided by the Naval Missile Center, which flew over the shot area. At shot-time, the aircraft was at an altitude of 9,960 feet directly above ground zero, with an air speed of 155 knots and a heading of 164 degrees. After the detonation, the aircraft landed at Indian Springs AFB for radiation monitoring before returning to Nellis AFB (13).

Project 7.17, Radiological Water Decontamination Study, was conducted by the Army Engineer Research and Development Laboratories. The objectives were to:

- Study the effect of acidity or alkalinity, temperature, and time of contact upon the solubility of radioactive soil and debris in water
- Evaluate emergency methods of removing radioactive materials from water
- Evaluate Army and Civil Defense field methods of determining the concentration of radioactive materials in water
- Evaluate a proposed decontamination method for removing radioactivity from water.

Five days after the detonation, project participants took soil samples from the center of the crater. They removed the samples from the shot area and determined the specific activity of each sample. They then delivered the samples to a laboratory near the Control Point for analysis. There, personnel conducted solubility studies, tested instruments for detection of radioactivity in water, and tested Civil Defense and Army water decontamination techniques (61).

Project 8.2, Fallout Hazard Determination by Fireball Spectroscopy, was conducted by the Army Electronics Research and Development Laboratory. The objective was to determine the feasibility of using spectroscopic analysis to predict the fallout hazard from a surface detonation. Project personnel placed two spectrometers connected to 35-millimeter movie cameras in the open with no special protection. The instruments, approximately 90 meters east of the forward control point, were about 5,280 meters from ground zero. The cameras, started three seconds before shot-time, operated for approximately 18 seconds, as planned. The film was sent for development and analysis to the Army Electronics Research and Development Laboratory (9).

Projects 9.2, 9.3, 9.4, 9.5, 9.6, and 9.7 were support projects conducted by Field Command, DASA, with the assistance of other DOD agencies and contractors. Much of the work done by these projects involved aerial and ground photography performed by the Army Pictorial Center; the Air Force Lookout Mountain Laboratories; EG&G, Incorporated; and the Sandia Corporation. Depending on project requirements, the number of personnel directly involved numbered from one officer and seven enlisted men to four officers, 17 enlisted men, and four civilians (31).

Specific information is available on Project 9.2, Documentary Photography, and Project 9.3, Technical Photography. On the day before the detonation, two project participants entered the shot area in one vehicle to take preshot photographs of ground zero. Two hours before the detonation, 12 participants drove into the shot area in three vehicles to establish a manned photography station 1.8 kilometers from ground zero. These personnel took still and motion pictures of the detonation. An aerial team also took part in the projects. From 30 minutes before to 45 minutes after the detonation, three participants in one H-21 helicopter orbited south of ground zero and took documentary photographs (74).

5.1.2 Air Force Special Weapons Center Activities

Personnel from AFSWC and other Air Force units performed security, photography, cloud-sampling, courier, and cloud-tracking missions during Shot LITTLE FELLER II.

Security Sweep

Before the detonation, one L-20 aircraft, with one pilot and one security officer, flew over the shot area and around the perimeter to ensure that all personnel had left the area and that no unauthorized vehicles were in the vicinity (31).

Photography

One H-21 helicopter, probably with a crew of five, conducted a photography mission during the shot (31).

Cloud Sampling

A B-57 aircraft, with a pilot and a technical advisor, flew a cloud-sampling mission to obtain samples of cloud particulate for analysis (31).

Cloud Tracking

A U3A aircraft conducted a cloud-tracking mission (31).

5.2 RADIATION PROTECTION AT SHOT LITTLE FELLER II

The information available for Shot LITTLE FELLER II concerns results of onsite monitoring, the procedures used by radiological safety personnel to control reentry into the shot area, and radiological safety procedures at Indian Springs AFB.

Monitoring

From the time of detonation until the time when the initial monitoring teams were permitted to enter the shot area, REECO personnel obtained data on gamma and beta radiation from remote radiation detection stations. These stations were in a clockwise pattern northeast to northwest 15 to 730 meters from ground zero (73).

Ten minutes after the detonation, the initial monitoring party, consisting of two two-man teams in two radio-equipped vehicles, entered the shot area on opposite sides of the fallout pattern. After surveying the shot area, they radioed their data to personnel at plotting facilities in the forward area and at the Control Point. Radiological safety personnel then plotted

isointensity maps showing the 0.01, 0.1, and 1 R/h radiation contours. They also measured an intensity of 10 R/h near ground zero (73; 74). Figure 5-2 presents results of the initial survey.

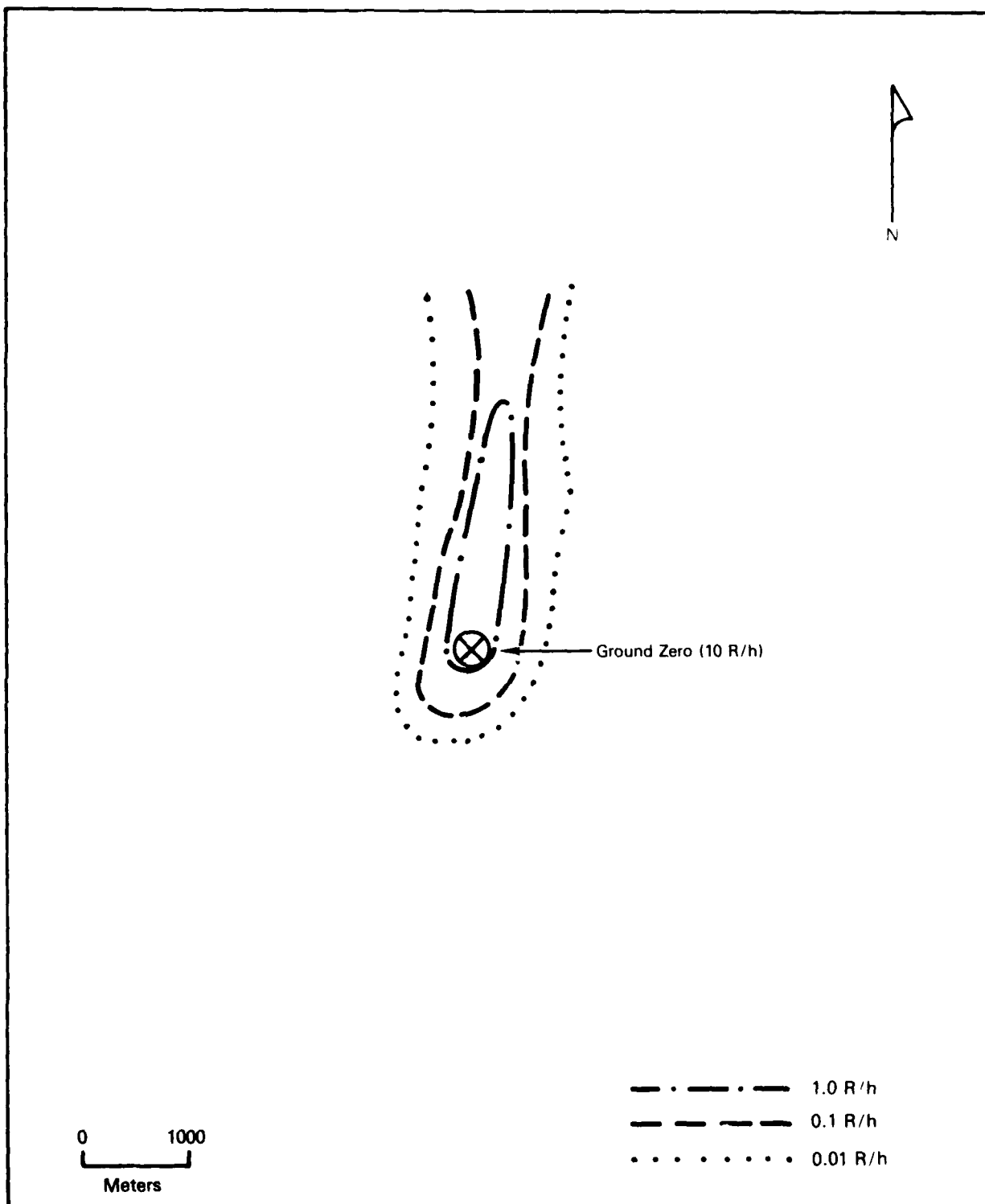
The monitoring teams surveyed the shot area daily for three days after the detonation. The day after Shot LITTLE FELLER II, the 0.01 R/h area was confined to within about 350 meters of ground zero except to the north-northwest, where it extended beyond 1,100 meters. Three days after the detonation, the gamma intensity near ground zero had decreased to 1 R/h, and the 0.01 R/h area was confined to within 180 meters of ground zero (73; 74).

Personnel from the USPHS, supported by REECo radiological safety personnel, conducted offsite monitoring (69).

Reentry Procedures

Once the initial onsite ground survey was completed, the Test Manager opened the shot area for recovery operations. Roads leading into the shot area had been barricaded, and radiological safety personnel from REECo reestablished a base station and a mobile check station along the main access road to prevent unauthorized entry into the shot area. The mobile check station was three kilometers southwest of ground zero and about 600 meters north of the base station. Personnel entering the shot area had to pass through both of these stations. There, radiological safety personnel checked to ensure that entering personnel had access permits and were wearing anticontamination clothing, film badges, and pocket dosimeters (5; 73; 76).

Reentry of project personnel began about 15 minutes after the detonation and continued in the daylight hours until 18 days after the detonation. The operations were interrupted on 10 July 1962 for Shot JOHNIE BOY and then continued intermittently until



**Figure 5-2: ISOINTENSITY MAP FOR SHOT LITTLE FELLER II
ABOUT ONE HOUR AFTER DETONATION**

the detonation of Shot LITTLE FELLER I on 17 July 1962. The reentry parties generally consisted of from two to four men. They were larger only when laborers were needed to provide access to instruments in bunkers. Each reentry party was required to be accompanied by a radiological safety monitor (31).

Decontamination

Radiological safety personnel operated a monitoring and decontamination facility at the base station for personnel and vehicles leaving the shot area (5; 73; 74).

Radiological safety personnel from REECO also maintained a facility at Indian Springs AFB for monitoring and decontaminating personnel and aircraft involved with cloud sampling. Radiological monitors found a maximum gamma reading of 4 R/h on the right wing of the cloud-sampling aircraft. Decontamination reduced the radioactivity to an acceptable level (31; 44; 52).

JOHNIE BOY

SHOT SYNOPSIS

AEC TEST SERIES: DOMINIC II
DATE/TIME: 11 July 1962, 0945 hours
YIELD: 0.5 kiloton
HEIGHT OF BURST: 23 inches below ground

Purpose of Test: Weapons effects test designed to explore the cratering effects of a subkiloton nuclear device detonated in a shallow emplacement.

Weather: At shot-time, the temperature was 24.3 degrees Celsius. Winds were seven knots from the south-southwest at surface level, 15 knots from the south at 10,000 feet, and 23 knots from the south-southwest at 20,000 feet.

Radiation Data: About one hour after the detonation, radiation intensities of 0.1 R/h and greater were confined within 1,000 meters of ground zero except for a broad area to the north, where they extended beyond five kilometers. By seven days after the detonation, the area with radiation intensities of 1 R/h or greater did not extend beyond 980 meters north of ground zero.

Participants: Army Ballistic Research Laboratories; Army Engineer Waterways Experiment Station; Stanford Research Institute; Air Force Special Weapons Center; Army Nuclear Defense Laboratory; Naval Radiological Defense Laboratory; Air Force Weapons Laboratory; Army Engineer Research and Development Laboratories; Sandia Corporation; Los Alamos Scientific Laboratory; AEC civilians; other contractors.

CHAPTER 6

SHOT JOHNIE BOY

Shot JOHNIE BOY was detonated on 11 July 1962 at 0945 hours Pacific Daylight Time in Area 18 of Yucca Flat, UTM coordinates 593084. Plans for this shot were not made until May 1962. Originally scheduled for 12 July 1962, the date was advanced to 10 July to enable an earlier conclusion of the test series. The event was then postponed until 0830 hours on 11 July because of unfavorable wind conditions. It was rescheduled to 0945 on 11 July because unauthorized personnel were in the control area (31).

Sponsored by the Department of Defense, JOHNIE BOY was designed to explore the cratering effects of a subkiloton nuclear device detonated in a shallow emplacement. It was part of a planned series of shots to determine various cratering effects of a detonation. JOHNIE BOY was fired about two feet below the surface, and it had a yield of 0.5 kilotons (5; 28; 31).

At shot-time, the temperature at the surface was 24.3 degrees Celsius. Winds were seven knots from the south-southwest at the surface, 15 knots from the south at 10,000 feet, and 23 knots from the south-southwest at 20,000 feet. The top of the cloud resulting from the shot reached 17,000 feet and moved north from the point of detonation (35).

6.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT JOHNIE BOY

Department of Defense personnel participated in a number of scientific projects conducted by the Weapons Effects Test Group

at Shot JOHNIE BOY. Table 6-1 lists these projects by number and title and identifies the participants. DOD personnel also took part in AFSWC activities providing support to some of the test group projects and to the Test Manager.

6.1.1 Weapons Effects Tests

The Weapons Effects Test Group projects, identified in table 6-1, were designed to collect data on the effects of a shallow, underground detonation with a low yield. In conducting these experiments, project participants spent several weeks before the detonation placing and calibrating various types of instruments and gauges in the shot area. Project personnel accompanied by a radiological safety monitor reentered the shot area at various times after the officially declared reentry hour to recover data and instruments (5; 28; 31).

Project 1.1, Free-air and Free-field Blast Phenomena from a Small Yield Device, was conducted by the Army Ballistic Research Laboratories. The objectives were to measure the:

- Overpressure and dynamic pressure versus time along the surface from 13 stations 20 to 4,900 meters from ground zero
- Overpressure versus time in free-air.

During the week before the detonation, project personnel placed 16 self-recording gauges at 11 stations ranging 40 to 4,900 meters from ground zero. They also positioned 14 electronic gauges at eight stations 20 to 170 meters from ground zero. Two days before the detonation, participants launched a tethered balloon carrying self-recording and electronic gauges. The instruments attached to the balloon, anchored 100 meters from ground zero, were to record free-air measurements. However, this part of the experiment was canceled the day before the shot because of technical difficulties. After the detonation,

Table 6-1: WEAPONS EFFECTS TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT JOHNIE BOY

| Project/ Program | Title | Participants |
|---------------------|--|---|
| 1.1 | Free-air and Free-field Blast Phenomena from a Small Yield Device | Army Ballistic Research Laboratories |
| 1.2 | Earth Motion Measurements | Army Engineer Waterways Experiment Station |
| 1.5 | Mass Distribution Measurements | Army Engineer Waterways Experiment Station |
| 1.9 | Crater Size and Shape | Army Engineer Waterways Experiment Station |
| 1.11 | Soils Survey | Army Engineer Waterways Experiment Station |
| 1.12 | Measurement of Permanent Ground Displacement and Rotation | Stanford Research Institute; Holmes and Narver |
| 1.13 | Measurement of Permanent Ground Movements with Depth | Air Force Special Weapons Center; Army Engineer Waterways Experiment Station; Army Ballistic Research Laboratories; Holmes and Narver |
| 2.3 | Neutron Flux Measurements | Army Nuclear Defense Laboratory |
| 2.4 | Integrated Gamma Dose Measurements | Army Nuclear Defense Laboratory |
| 2.8 | Radiological Surveys | Army Nuclear Defense Laboratory |
| 2.9 | Fallout Sampling and Analysis: Radiation Dose Rate and Dose History at 16 Locations | Naval Radiological Defense Laboratory; 1st Marine Division and Force Troops, Fleet Marine Force Pacific; 3rd Marine Aircraft Wing |
| 2.13 | Radioisotope Fractionation and Particle Size Characteristics of a Low-yield Surface Nuclear Detonation | Air Force Weapons Laboratory |
| 2.16 | Residual Radiation in the Crater and Crater-lip Area of Low-yield Nuclear Devices | Army Engineer Research and Development Laboratories; Army Nuclear Defense Laboratory |
| 2.20 | Transit Radiation Dose Rate | Army Nuclear Defense Laboratory |
| 6.6 | Initial Gamma Rate Measurements | Air Force Special Weapons Center |
| 6.6b | Electromagnetic Measurements | Air Force Special Weapons Center; Sandia Corporation |
| 7.17 | Radiological Water Decontamination Study | Army Engineer Research and Development Laboratories |
| 9.2 | Documentary Photography | Field Command, DASA |
| 9.3 | Film Reports | Field Command, DASA |
| 9.4 | Weapon Test Reports | Field Command, DASA |
| 9.5 | Communications | Field Command, DASA |
| 9.6 | General DOD Support | Field Command, DASA |
| 9.7 | Engineering and Field Operations | Field Command, DASA; Holmes and Narver; REEC |

three parties totaling 11 individuals entered the shot area to retrieve the gauges (55; 75).

Project 1.2, Earth Motion Measurements, was conducted by the Army Engineer Waterways Experiment Station. The main purpose was to study the crater and the ground shock motions resulting from a detonation like Shot JOHNIE BOY. To determine ground motions, project personnel placed 32 horizontally and vertically oriented accelerometers and velocity gauges in a line 45 to 150 meters south of ground zero. They positioned an additional gauge 90 meters either east or west of ground zero. All of these gauges were buried at depths ranging from one to ten feet. A van, located 1,220 meters southeast of ground zero in a bunker of timber and sandbags, housed the electronic recording equipment. After the detonation, three personnel recovered data from the van (68; 75).

Project 1.5, Mass Distribution Measurements, was conducted by the Army Engineer Waterways Experiment Station. The purpose was to determine the type and distribution of soil and rock debris thrown from the crater resulting from a low-yield near-surface detonation. Project personnel arranged 168 collector pads of sheet metal on the surface in seven concentric rings ranging 50 to 600 meters from ground zero. Debris from the detonation fell onto the collector pads, which were secured to the surface of the ground by large spikes. On 12 July, project personnel began recovering the collector pads, an activity continued intermittently through 26 July. They sealed samples from each pad in marked metal containers. The sealed samples were transported to the Radiological Safety Office of REEC in Control Point Building 2 and then forwarded to other laboratories for analysis (83).

Project 1.9, Crater Size and Shape, was conducted by the Army Engineer Waterways Experiment Station to:

- Measure the crater formed by the shot
- Measure the permanent earth deformation occurring within the crater.

Project personnel placed 14 vertical colored sand columns in holes drilled along the diameter of the predicted crater, anticipated to be 24 feet deep with a radius of 20 meters. The actual crater was 37 feet deep with a radius of 20 meters. The columns were 15 to 18 centimeters wide and ten to 15 feet deep, and they extended 60 meters radially from ground zero. Participants used aerial photography to make early postshot measurements of the visible crater. When the area was opened for recovery operations, personnel conducted a ground survey of the test area. Then they excavated and mapped the crater lip and most of the sand columns (81).

Project 1.11, Soils Survey, was conducted by the Army Engineer Waterways Experiment Station. The objectives were to:

- Obtain preshot data on the physical properties of the soil in the vicinity of ground zero to a depth of 80 feet
- Drill and instrument shafts for use in Projects 1.2, 1.5, 1.9, 1.13, and 9.1.

On 27 June 1962, project personnel entered the shot area to begin field operations. They took soil samples 1.5 meters to 150 meters from ground zero. The soil samples were analyzed at a laboratory at Camp Mercury and at the Army Engineer Waterways Experiment Station. Also in the weeks before the detonation, project personnel drilled instrument shafts for the projects identified above. They then placed blast recording instruments in many of the shafts before backfilling them (38).

Project 1.12, Measurement of Permanent Ground Displacement and Rotation, was conducted by the Stanford Research Institute, a DOD contractor, with assistance from Holmes and Narver, an AEC site support contractor. The objective was to measure permanent horizontal soil displacement resulting from the detonation. Before the shot, project personnel installed ground displacement measuring instruments at various distances and directions from ground zero. Following the detonation, they surveyed the instrument area and noted ground displacement phenomena.

Postshot surveys were not done immediately after the detonation because of high levels of radioactivity within the crater. By 24 July 1962, however, the radiation had decreased sufficiently so that a survey could be made up to 45 meters south-southwest of ground zero. On 8 and 9 August 1962, further decreases in radiation levels made possible additional measurements from 45 to 150 meters south-southwest of ground zero. Because of high radiation levels north of the crater, project personnel could not measure ground displacement in that area until 9 January 1963 (53).

Project 1.13, Measurement of Permanent Ground Movements with Depth, was conducted by the Air Force Special Weapons Center, with assistance from the Army Engineer Waterways Experiment Station, Army Ballistic Research Laboratories, and Holmes and Narver. The objective was to measure permanent ground deformation with depth resulting from a surface nuclear burst. Before the detonation, Project 1.11 personnel drilled six holes 75 feet deep and 45 to 65 meters from ground zero. Project 1.13 participants then placed plastic pipes in these holes. Holmes and Narver personnel conducted preshot surveys of the holes and pipes for ground motion comparisons after the burst. Following the detonation, these personnel entered the shot area to measure displacement of the pipes (12).

Project 2.3, Neutron Flux Measurements, was conducted by the Army Nuclear Defense Laboratory. The objective was to document neutron flux versus ground range. Project personnel installed neutron flux detectors 30 to 910 meters southwest of ground zero. They attached most of the detectors to cables. Immediately after the detonation, project personnel, assisted by Project 7.2 participants, entered the shot area in an M-88 tank retriever to drag the cables out of the area. They retrieved most of the detectors within one hour after the detonation. They transported the detectors to the Project 2.3 mobile laboratory at the Control Point (80).

Project 2.4, Integrated Gamma Dose Measurements, was conducted by the Army Nuclear Defense Laboratory to document gamma dose versus ground range. Before the detonation, project personnel installed gamma detectors along a line 30 to 910 meters south-southwest of ground zero. They attached these detectors to a recovery line. After the detonation, personnel from Projects 2.4 and 2.3 pulled the recovery line out of the radiation field. They retrieved most of the detectors within one hour after shot-time. The gamma detectors were then sent for analysis to the Army Nuclear Defense Laboratory and the Army Signal Research and Development Laboratory. In addition to their field activities, Project 2.4 personnel supplied 58 film badges to Project 2.20 personnel for their measurements of gamma dose (79).

Project 2.8, Radiological Surveys, was conducted by the Army Nuclear Defense Laboratory. The objectives were to determine:

- Residual radiation patterns and decay rates resulting from a low-yield detonation
- Gamma exposure rates and decay rates in and around the crater resulting from the detonation.

To obtain data, ground-survey teams and helicopter-to-ground units surveyed radiation areas. In addition, personnel obtained information from radiation-detecting instruments placed in and near the crater resulting from the detonation and from film badges positioned throughout the region of expected fallout (8). The ground-survey teams followed the general procedures identified in the Project 2.8 description for Shot LITTLE FELLER II.

Project personnel located ground-survey stations on the same site as that used for Shot LITTLE FELLER II. However, roads for stake lines were 150 to 1,200 meters from ground zero. Additional stake lines were established southeast to southwest of ground zero (8).

Fifteen minutes after the detonation, four two-man teams entered the area upwind of ground zero to conduct an initial survey. They resurveyed this area six hours after the detonation. Thirty and 45 minutes after the detonation, additional teams entered the area to survey stations close to ground zero. To obtain field decay data, they resurveyed selected of these stations on the first, second, fifth, seventh, ninth, and tenth days after the detonation. They encountered high winds during the survey on 12 July 1962. They recovered film badges on 16 July 1962 (8).

Two hours after the detonation, three teams proceeded to areas beyond the mountains north of ground zero to conduct a survey. They took readings at stations within this area from five to eight hours after the detonation. The region was resurveyed one day after the detonation, at which time the monitors encountered rain. The monitors resurveyed selected stations in the area four days after the detonation, during which time film badges were retrieved (8).

Monitors surveyed all roads northwest of stations close to ground zero on the day after the detonation. During the same day, the first complete survey was conducted of roads in the vicinity of the mountains. These roads could not be entered on the day of detonation because of high radiation intensities. Access to other parts of the mountainous terrain was impossible because there were no roads (8).

The helicopter missions had the same objectives as those described for Project 2.8 at LITTLE FELLER II. The participating helicopters and crews were from the Marine Corps. Chemical Corps officers from Headquarters, Continental Army Command, Fort Monroe, Virginia, conducted the measurements made from the aircraft (8).

Thirteen minutes after the detonation, one helicopter flying toward ground zero at an altitude of 1,000 feet found that the 10 R/h line extended 270 meters south of ground zero. After repeated readings, an attempt was made about 90 minutes after the detonation to lower radiation-detecting instruments into the crater. The effort was unsuccessful, in that the instruments were left overturned in the crater. Approximately 95 minutes after the detonation, instruments were successfully positioned about 10 meters northeast of the crater (8).

Throughout the day of detonation, helicopters were used to conduct surveys with radiation-detecting probes dropped at downwind ground stations. According to documentation, "the crater was too hot for such surveys" on the day of the shot (8).

The helicopters were permitted to land when intensities within the aircraft did not exceed 1 R/h. About 100 minutes after the detonation, aircraft landed on the high mesa north of Area 18. There, monitors disembarked to conduct radiological surveys in the area. Such measurements were not allowed on

subsequent days "because of the potential risk to the helicopter crews when operating in such inaccessible regions" (8).

Between the first and the fifth days after the detonation, helicopters were not used for surveys of the JOHNNIE BOY ground zero. Contributing factors were troop exercises in Area 18 and preparations being made for Shot SMALL BOY, conducted three days after JOHNNIE BOY. Later, helicopter surveys for SMALL BOY were given precedence over radiation measurements made for the other DOMINIC II shots, including JOHNNIE BOY. Nevertheless, helicopter surveys of the JOHNNIE BOY ground zero were begun on the fifth and continued through the eighth day following the detonation (8).

Project 2.9, Fallout Sampling and Analysis: Radiation Dose Rate and Dose History at 16 Locations, was conducted by the Naval Radiological Defense Laboratory. Assigned to the Naval Radiological Defense Laboratory for this project were 11 personnel from the 1st Marine Division, Fleet Marine Force Pacific; 13 personnel from Force Troops, Fleet Marine Force Pacific; and three personnel from 3d Marine Aircraft Wing. Objectives were to:

- Collect data on fallout (mass per unit area, ionization decay rate, and size-activity relationships)
- Compare properties of environmental surface material and fallout material
- Measure radiation dose rate and accumulated integrated dose during fallout.

Two days before the detonation, project personnel installed platforms, fallout collector trays, and a gamma intensity time recorder at each of 16 stations located 370 to 1,950 meters from ground zero. Between 0400 and 0600 hours on shot-day, they relocated three of the stations east of the other stations to correspond with the wind direction predicted for shot-time. Between 0300 and 0600 hours on shot-day, project personnel checked and armed the gamma recorders.

Personnel entered the radiation area at a point 860 meters west of ground zero at 1600 hours on shot-day. They recovered sample trays from locations 860 to 1,220 meters west of ground zero before they had to leave the area in order to remain within the prescribed radiation dose limits. Later on shot-day, other recovery teams collected sample trays 370 to 1,950 meters from ground zero. The day after the detonation, personnel collected trays between 660 and 1,440 meters from ground zero. However, the radiation level of the samples, which was over 4,000,000 counts per minute, was too high for immediate gross counting. Also on the day following detonation, personnel collected the gamma intensity recorders from all but three stations located 410, 660, and 860 meters from ground zero. Six days after the detonation, participants recovered the remaining gamma recorders and the sample trays located 410 meters from ground zero. The samples and gamma recorders were sent to laboratories set up at the Control Point for immediate analysis.

In conjunction with these field operations, the Naval Radiological Defense Laboratory arranged with LASL to receive cloud samples from the B-57 cloud-sampling aircraft of the 1211th Test Squadron, which operated out of Indian Springs AFB. Laboratory personnel performed radiochemical analyses on cloud samples obtained 20 minutes after the detonation at altitudes of 11,000 and 14,000 feet. They conducted particle studies of samples taken 48 minutes after the shot at an altitude of 12,000 feet and samples taken 54 minutes after the shot at an altitude of 13,700 feet (18).

Project 2.13, Radioisotope Fractionation and Particle Size Characteristics of a Low-yield Surface Nuclear Detonation, was conducted by the Air Force Weapons Laboratory to:

- Define the radiochemical and physical characteristics of the cloud in a three-dimensional sense

- Relate these characteristics to those found in prompt radiation samples.

Twenty to 54 minutes after the detonation, three B-57 aircraft equipped with wing-tip tank samplers penetrated the cloud at five levels. The length of time they spent in the cloud ranged from ten to 83 seconds. The highest average gamma intensity measured was 75 R/h, on the left tip tank of one aircraft. The same aircraft measured the highest maximum gamma intensity, 200 R/h, also on the left tip tank.

Project personnel also collected samples using cake pans, which they placed in the anticipated fallout area 460 to 1,370 meters from ground zero. After the detonation, they recovered the samples and sent them with the cloud samples to the Air Force Weapons Laboratory for analysis (84).

Project 2.16, Residual Radiation in the Crater and Crater-lip Area of Low-yield Nuclear Devices, was conducted by the Army Engineer Research and Development Laboratories, with assistance from Army Nuclear Defense Laboratory personnel. The objectives were to:

- Determine the residual radiation environment in and near the nuclear crater
- Obtain information on gamma intensity versus time and the change in mean gamma energy level with time.

Before Shot LITTLE FELLER II, project personnel had instrumented a remote-controlled D7 bulldozer with an ionization chamber and a scintillometer to record gamma intensities. Shortly after Shot JOHNNIE BOY, they used a flatbed truck to transport the bulldozer to the shot area. They then attached a cable to the bulldozer to assist in locating it by remote control within the crater area. In directing the bulldozer into the area, however, project personnel misjudged distances, and the bulldozer fell into the crater. Thirty hours after the detonation, participants drove an

instrumented van into the shot area and connected a signal cable to instruments on the bulldozer. They were unsuccessful in their attempt to obtain data from these instruments (66).

Project 2.20, Transit Radiation Dose Rate, was conducted by the Army Nuclear Defense Laboratory. The objective was to determine the extent and significance of transit radiation from passage of the cloud resulting from a subsurface detonation. Project personnel placed 60 gamma recorders and film badges in and around 24 foxholes north and northwest and six foxholes south of ground zero. The foxholes, in groups of six, were 460 to 1,370 meters from ground zero. The gamma detectors and recorders had a recording range of zero to 10,000 R/h. Participants recovered most of the instruments and film badges the day after the detonation. They retrieved the remaining instruments four days after the detonation (86).

Project 6.6, Initial Gamma Rate Measurements, was conducted by the Air Force Special Weapons Center. Objectives were to:

- Measure the gamma dose rate as a function of time from time zero to 1,000 microseconds after the detonation
- Determine the feasibility of moving a fully instrumented bunker from one shot area to another.

Project personnel constructed a bunker from a five-meter section of a metal pipe three meters in diameter, the ends of which were closed with steel plates. After the LITTLE FELLER II detonation, they used a flatbed truck to transport the material to the JOHNNIE BOY shot area. They placed the bunker in a hole 280 meters southwest of ground zero and put gamma detectors and automatic cameras inside the bunker. Four hours before the detonation, participants entered the shot area to check the instruments and secure the bunker.

For the first 30 seconds after the burst, the instruments in the bunker automatically collected data. Project personnel returned to the shot area 24 hours after the shot to recover film and other recorded data. They brought the film for processing to the EG&G photography trailer near the Control Point (63).

Project 6.61, Electromagnetic Measurements, was conducted by the Air Force Special Weapons Center and the Sandia Corporation. The main objective was to collect and correlate data concerning gamma radiation rates, time to burst, detonation, the resultant electromagnetic field, and induced currents in various cable configurations. Project 6.61 personnel extended two copper wires from the southeast to within 10 meters of ground zero at a depth of one foot. They instrumented the wire for dynamic current measurements at 60 and 300 meters from ground zero and for passive current measurements at various other distances along the cables. In addition, Project 6.5 personnel buried a long cable loop around ground zero. They instrumented this cable to measure induced currents at numerous locations. Signals from these instruments were carried by wire to the recording station, where the information was recorded on magnetic tape (48).

Project 7.17, Radiological Water Decontamination Study, was conducted by the Army Engineer Research and Development Laboratories. The objectives were to:

- Study the effect of acidity or alkalinity, temperature, and time of contact upon the solubility of radioactive soil and debris in water
- Evaluate emergency methods of removing radioactive materials from water
- Evaluate Army and Civil Defense field methods of determining the concentration of radioactive materials in water
- Evaluate a proposed decontamination method for removing radioactivity from water.

One day after the detonation, project participants took soil samples from the surface at the 10 R/h line. They removed the samples from the shot area and determined the specific activity of each sample. They then delivered the samples to a laboratory near the Control Point for analysis. After the soil samples were leached with water, personnel conducted solubility studies, tested instruments for detection of radioactivity in water, and tested Civil Defense and Army water decontamination techniques (61).

Projects 9.2, 9.3, 9.4, 9.5, 9.6, and 9.7 were support projects conducted by Field Command, DASA, with the assistance of other DOD agencies and contractors. Much of the work done by these projects involved aerial and ground photography performed by the Army Pictorial Center; the Air Force Lookout Mountain Laboratories; EG&G, Incorporated; and the Sandia Corporation. Depending on project requirements, the number of personnel directly involved numbered from one officer and seven enlisted men to four officers, 17 enlisted men, and four civilians (31).

Project 1.7, Shock Spectra Measurements, was conducted for DASA by the TRW Space Technology Laboratories as part of the VELA UNIFORM series of projects. VELA UNIFORM was directed toward improving U.S. ability to detect and identify underground nuclear detonations. The project objective was to measure the displacement shock spectra at various distances from an underground nuclear explosion. Participants placed measuring gauges 45 to 60 meters northeast of ground zero. After reentry into the shot area was permitted, personnel retrieved the gauges (105).

6.1.2 Air Force Special Weapons Center Activities

Personnel from AFSWC and other Air Force units performed security, photography, cloud-sampling, courier, and cloud-tracking missions during Shot JOHNIE BOY.

Security Sweep

Before the detonation, one L-20 aircraft, with one pilot and one security officer, conducted a low-altitude security check to ensure that all personnel had left the area and that no unauthorized vehicles were in the vicinity (31).

Photography

One H-21 helicopter, probably with a crew of five, photographed the detonation (31).

Cloud Sampling

A B-57 aircraft, with a pilot and a radiological safety monitor, flew a cloud-sampling mission to obtain particulate cloud debris for analysis. This aircraft was also used in Project 2.13 (31).

Cloud Tracking

One B-50 and one U3A aircraft each performed a high-and-low-altitude cloud-tracking mission. These aircraft tracked the cloud out to 320 kilometers from ground zero (31).

6.2 RADIATION PROTECTION AT SHOT JOHNIE BOY

The information available for Shot JOHNIE BOY consists of the results of onsite and offsite monitoring, the procedures used by radiological safety personnel to control reentry into the shot area, and the radiological safety procedures used at Indian Springs AFB.

Monitoring

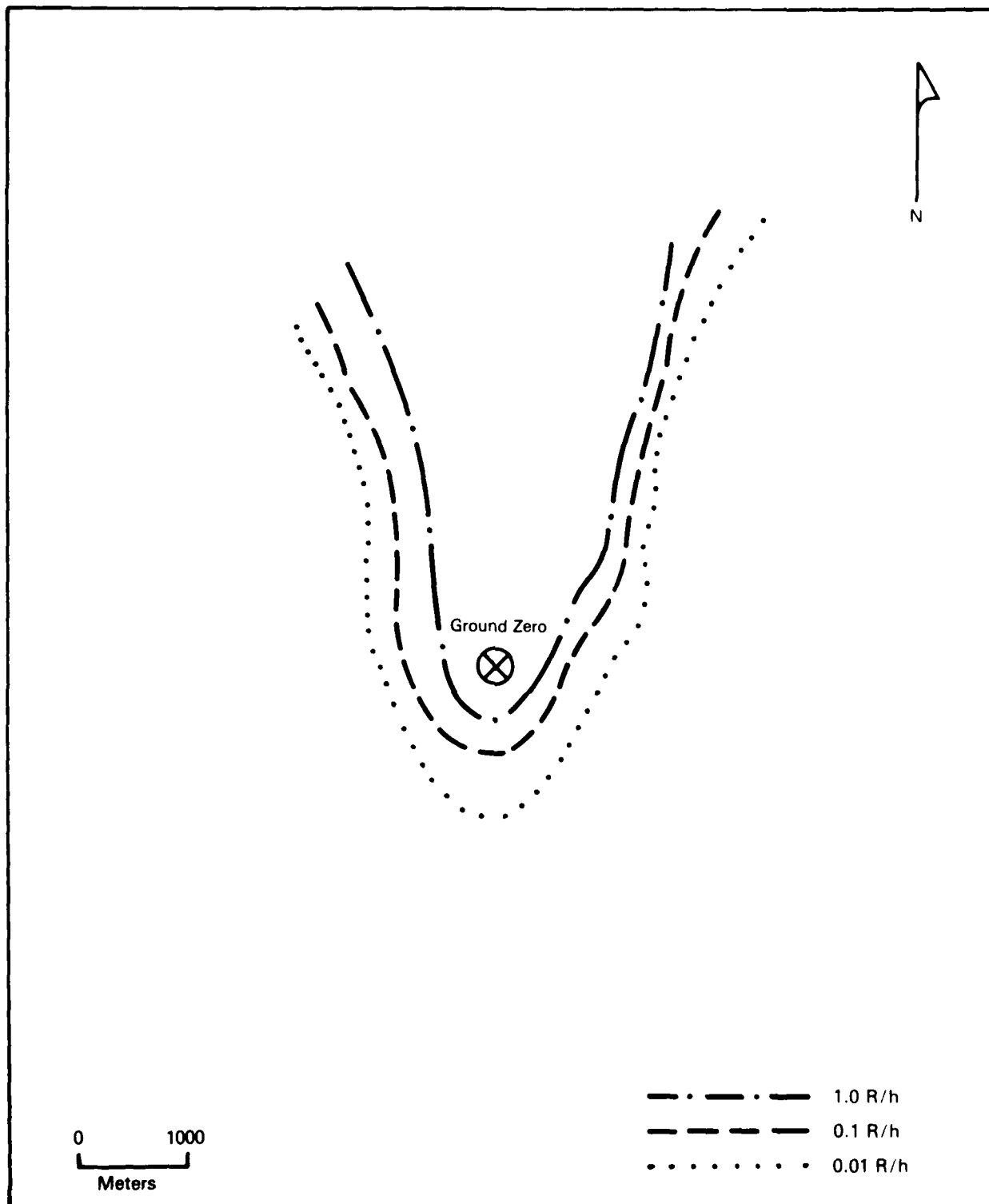
The initial monitoring party, consisting of two two-man teams in two radio-equipped vehicles, entered the shot area 30 minutes after the detonation. The teams proceeded into the

area after having received radiation data from detector units northeast of ground zero. After surveying the shot area, they radioed their data to personnel at plotting facilities in the forward area and at the Control Point. Radiological safety personnel then plotted isointensity maps showing the 0.01, 0.1, and 1 R/h radiation areas (73; 75). Figure 6-1 presents the results of the initial survey.

The monitoring party conducted a second radiological survey five hours after the detonation. They found that areas with radiation intensities of 0.01 R/h or more were within 800 meters of ground zero except to the north, where radiation areas extended beyond five kilometers. Subsequent surveys were performed one day and seven days after the detonation. After seven days, the 0.01 R/h area was confined to within about 400 meters of ground zero except to the north, where the 0.01 R/h line extended farther than 2,500 meters (73; 75).

USPHS personnel conducted offsite monitoring at JOHNIE BOY. Eleven mobile teams, each consisting of two men in a radio-equipped vehicle, were stationed at various locations north of ground zero. All 11 teams conducted surveys on shot-day, and four teams performed resurveys the next day. They encountered gamma intensities of 0.003 R/h four hours after the detonation in the area around Warm Springs, Nevada, 120 kilometers north of ground zero. Six hours after shot-time, they took readings of 0.002 R/h in the area of Rattlesnake Maintenance Station, Nevada, 150 kilometers north of ground zero. Gamma intensities on shot-day at other locations did not exceed 0.0015 R/h. By the day after the detonation, the readings at these locations had decreased to background levels (69).

In addition, the B-50 and U3A cloud-tracking aircraft monitored the cloud from Shot JOHNIE BOY. The maximum gamma reading registered inside the aircraft was 1 R/h. Other gamma readings ranged from background levels to about 0.2 R/h (69).



**Figure 6-1: ISOINTENSITY MAP FOR SHOT JOHNNIE BOY ABOUT
ONE HOUR AFTER DETONATION**

Reentry Procedures

After the initial onsite ground survey was completed, the Test Manager opened the shot area for recovery operations. Roads leading into the shot area had been barricaded, and radiological safety personnel from REECO reestablished a base station and a mobile check station along the main access road to prevent unauthorized entry into the shot area. The mobile check station was one kilometer south of ground zero, and the base station was four kilometers southeast of ground zero. Personnel entering the shot area had to pass through both of these stations. There, radiological safety personnel checked to ensure that entering personnel had access permits and were wearing film badges, anticontamination clothing, and pocket dosimeters (5; 73; 75).

The reentry of project personnel generally began after the entry of the initial monitoring teams and continued during the daylight hours on subsequent days. However, reentry was sometimes permitted earlier if instruments required prompt retrieval and if project participants were accompanied by monitors. Operations were interrupted by rehearsals for Exercise IVY FLATS and by the detonation of LITTLE FELLER I. The reentry parties consisted of from two to four personnel, except when additional personnel were required to provide access to instrumentation. A radiological safety monitor accompanied each party (31).

Decontamination

Radiological safety personnel operated a monitoring and decontamination facility at the base station for personnel and vehicles leaving the shot area (5; 73; 75). REECO radiological safety personnel also used an existing facility at Indian Springs AFB for monitoring and decontaminating personnel and aircraft involved with cloud-sampling activities. Radiological monitors found a maximum gamma reading of 15 R/h on the wing of the cloud-sampling aircraft. Decontamination reduced the radioactivity to acceptable levels (31; 44; 52).

SMALL BOY

SHOT SYNOPSIS

AEC TEST SERIES: DOMINIC II
DATE/TIME: 14 July 1962, 1130 hours
YIELD: Low
HEIGHT OF BURST: Ten feet (tower)

Purpose of Test: Weapons effects test designed to obtain information on the electromagnetic pulse produced by the burst and on weapons effects phenomena.

Weather: At shot-time, the temperature was 31.7 degrees Celsius. Winds were two knots from the southeast at surface level, 16 knots from the west-southwest at 10,000 feet, and 25 knots from the west at 20,000 feet.

Radiation Data: Results of the initial survey (mid-time 1230) indicated that radiation levels of 1 R/h and greater were limited to within 1,000 meters of ground zero except to the east, where they extended for 32 kilometers. By three days after the detonation, radiation areas exceeding 1 R/h did not extend beyond about 1,600 meters to the east.

Participants: Army Ballistic Research Laboratories; Stanford Research Institute; Air Force Weapons Laboratory; Naval Ordnance Laboratory; Sandia Laboratory; Massachusetts Institute of Technology; Army Engineer Waterways Experiment Station; Army Electronics Research and Development Laboratory; Army Nuclear Defense Laboratory; Weather Bureau Research Station; Naval Radiological Defense Laboratory; Naval Civil Engineering Laboratory; Boeing Company; Harry Diamond Laboratories; Hughes Aircraft Company; U.S. Geological Survey; Los Alamos Scientific Laboratory; Atomic Weapons Research Establishment (UK); AEC civilians; other contractors.

CHAPTER 7

SHOT SMALL BOY

Shot SMALL BOY was detonated on 14 July 1962 at 1136 hours Pacific Daylight Time in Frenchman Flat,* UTM coordinates 959733. This low-yield device was fired on a tower ten feet above the ground (5; 30; 31; 35).

At shot-time, the temperature at the surface was 31.7 degrees Celsius. Winds were two knots from the southeast at the surface, 16 knots from the west-southwest at 10,000 feet, and 25 knots from the west at 20,000 feet. The top of the cloud resulting from the detonation reached 19,000 feet and moved east-northeast (35).

7.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT SMALL BOY

Operation DOMINIC II was originally planned to include only Shot SMALL BOY. The purpose of Shot SMALL BOY was to provide information on electromagnetic pulse effects. Headquarters, DASA, consequently assigned Harry Diamond Laboratories, which had collected electromagnetic pulse data during Operation PLUMBBOB (1957), to provide Field Command with overall technical direction for all DOD programs. Program 6, Electromagnetic Effects, was given priority over the other programs, which were conducted according to strict guidelines designed to assure noninterference with Program 6 objectives (101).

SMALL BOY has been characterized as "evergrowing, complex, and knotty" (31). Originally planned for 31 DOD projects, the shot ultimately included 63 DOD projects; four Civil Effects

*Ground zero at Frenchman Flat is 3,078 feet above mean sea level.

projects; and 31 AEC projects, conducted by LASL, LRL, and Sandia. These projects required over 500 scientific stations, most of which operated successfully (31).

The 31 AEC scientific projects were added after the field phase had begun. These new projects introduced complications involving construction and noninterference, among other concerns (31).

A fallout program was also added after the onset of field activities. This program involved manned stations, fallout collection instruments out to 60 kilometers, and monitoring surveys extending 500 kilometers from ground zero. These activities required considerable coordination and extensive personnel training, which was difficult to accomplish in a short time. In addition, the program exacted "a tremendous drain" on already limited support equipment, such as vehicles and communications instruments (31).

7.1.1 Weapons Effects Tests

This section discusses the 63 DOD projects, 61 of which are identified in table 7-1. The other two discussed were VELA UNIFORM projects. In conducting these experiments, project participants spent several weeks before the detonation placing and calibrating various types of instruments and gauges in the shot area. Project personnel accompanied by a radiological safety monitor reentered the shot area at various times after the officially declared reentry hour to recover data and instruments (5; 30; 31).

The detonation of Shot SEDAN on 6 July 1962 as part of the PLOWSHARE Program affected project instrumentation. Shot SEDAN, a nuclear cratering experiment with a yield of 104 kilotons, had

Table 7-1: WEAPONS EFFECTS TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT SMALL BOY

| Project/ Program | Title | Participants |
|---------------------|--|--|
| 1.1 | Nuclear Airblast Phenomena | Army Ballistic Research Laboratories |
| 1.2 | Close-in Earth Motion | Stanford Research Institute |
| 1.3 | Underground Stress Measurements | Air Force Weapons Laboratory; United Electrodynamics; General American Transportation; Shannon and Wilson |
| 1.4 | Shock Photography | Naval Ordnance Laboratory; EG&G |
| 1.5 | Blast Effects in the High-pressure Region | Stanford Research Institute |
| 1.6 | Ground Motion Induced by a Near-surface Explosion | Sandia Laboratory |
| 1.7 | Shock Spectrum Measurements | Space Technology Laboratories |
| 1.8 | Soils Survey | Army Engineer Waterways Experiment Station |
| 1.9 | Crater Measurements | Army Engineer Waterways Experiment Station; American Aerial Surveys; REECO |
| 2.1 | Initial Radiation Measurements | Harry Diamond Laboratories |
| 2.2 | Measurement of Fast-neutron Dose Rate as a Function of Time | Army Electronics Research and Development Laboratory |
| 2.3 | Neutron Flux Measurements | Army Nuclear Defense Laboratory |
| 2.4 | Integrated Gamma Dose Measurements | Army Nuclear Defense Laboratory |
| 2.7 | Off-site Meteorology -- Winds Aloft | Weather Bureau Research Station |
| 2.8 | Radiological Surveys | Army Nuclear Defense Laboratory |
| 2.9 | Fallout Collection and Gross Sample Analysis | Naval Radiological Defense Laboratory; Laboratory of Nuclear Medicine and Radiation Biology of UCLA; 1st Marine Division and Force Troops, Fleet Marine Force Pacific; 3d Marine Aircraft Wing |
| 2.10 | Physiochemical and Radiochemical Analysis | Naval Radiological Defense Laboratory; 1st Marine Division and Force Troops, Fleet Marine Force Pacific; 3d Marine Aircraft Wing |
| 2.11 | Ionization Rate Measurements | Naval Radiological Defense Laboratory; University of California at Los Angeles; 1st Marine Division and Force Troops, Fleet Marine Force Pacific; 3d Marine Aircraft Wing |
| 2.12 | Rocket Sampling | Army Nuclear Defense Laboratory; American Machine and Foundry Company |
| 2.13 | Development and Evaluation of a Fallout Collector | Army Nuclear Defense Laboratory |
| 2.14 | Shielding Effectiveness of Compartmented Structures in a Fallout Field | Naval Radiological Defense Laboratory; 1st Marine Division and Force Troops, Fleet Marine Force Pacific; 3d Marine Aircraft Wing |
| 2.15 | Shielding Effectiveness of Enclosure Shields in a Fallout Field | Army Ballistic Research Laboratories; Office of Civil Defense |

Table 7-1: WEAPONS EFFECTS TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT SMALL BOY (CONTINUED)

| Project/ Program | Title | Participants |
|---------------------|---|--|
| 3.1 | Response of Buried Arch and Dome Models | Massachusetts Institute of Technology; Army Engineer Waterways Experiment Station |
| 3.2 | Dynamic Bearing Capacity of Soils -- Field Test -- Response of Impulsive Loaded Footings on Frenchman Flat Silt | Army Engineer Waterways Experiment Station |
| 3.3 | Behavior of Buried Model Arch Structures | Naval Civil Engineering Laboratory; Army Waterways Experiment Station; Army Ballistic Research Laboratories |
| 3.4 | Structures Instrumentation | Army Ballistic Research Laboratories |
| 6.1 | Weapons Effects Testing, EM (Electromagnetic) Pulse | Boeing Company; REEC; Harry Diamond Laboratories; Army Signal Research and Development Laboratory; Hughes Aircraft Company |
| 6.2 | Magnetic Loop Measurements | Harry Diamond Laboratories |
| 6.3 | Inherent Magnetic Field Measurement | Hughes Aircraft Company |
| 6.4 | Measurement of Gamma Dose Rate as a Function of Time | Army Electronics Research and Development Laboratory |
| 6.5 | Electromagnetic Pulse Current Transients | Sandia Corporation |
| 6.6 | Cable Loop Measurements | Air Force Weapon Laboratories; Space Technology Laboratories; Allied Research Associates |
| 6.7 | Soil Conductivity Measurements | U.S. Geological Survey |
| 6.8 | Earth's Static Field Measurements | Stanford Research Institute |
| 6.9 | Correlation of Present and Previous Electric Field Measurements | Denver Research Institute |
| 6.11 | Air Conductivity Measurements | MHD Research; Lawrence Radiation Laboratory |
| 6.12 | British Empire Measurements | Atomic Weapons Research Establishment (UK) |
| 6.13 | Troposcatter Test Installation Performance | Army CONUS Regional Communications Command |
| 7.1 | Pragmatic Instrumental Measurements | Air Force Special Weapons Center |
| 7.2 | Experimental Confirmation of Theoretical Development of Radiological Armor | Army Tank-Automotive Center; General Dynamics Corporation; Army Ballistics Research Laboratories; Army Nuclear Defense Laboratory |
| 7.5 | Response of Electrical Power Systems to Electromagnetic Effects of Nuclear Detonations | Army Engineer Research and Development Laboratories |
| 7.6 | Feasibility Evaluation of an Aerial Radiac Survey System | Army Electronic Proving Ground |

Table 7-1: WEAPONS EFFECTS TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT SMALL BOY (CONTINUED)

| Project/ Program | Title | Participants |
|---------------------|--|---|
| 7.6.1 | Evaluation of Aerial Radiac Monitor Systems for Interim Tripartite Standardization | Army Electronic Proving Ground; Directorate of Equipment Policy, British Army; Equipment Engineering Establishment, Canadian Army; Army Signal Research and Development Laboratory; Office of Civil Defense |
| 7.8 | Arming and Fuzing Component Test | Naval Ordnance Laboratory |
| 7.8.1 | Magnetic Detection Equipment Test | Naval Ordnance Laboratory |
| 7.9 | Prooftesting of Operational Shipboard Material | David Taylor Model Basin |
| 7.10 | Spectral Analysis with High-time Resolution of the Thermal Radiation Pulse | Army Nuclear Defense Laboratory; Frankford Arsenal; Natick Laboratories |
| 7.12 | Nuclear Effects on Television Camera Installations | Defense Communications Agency |
| 7.13 | F-100F/GAM-83B Simulation | Air Force Systems Command, 6570th Aerospace Medical Research Laboratories |
| 7.14 | Bomb Alarm Detector Test | Western Union Telegraph Company; Headquarters, Air Force |
| 7.15 | Effects of Nuclear Radiation on B-52/GAM-77 Weapon System | Air Force Systems Command |
| 7.16 | Airborne E-Field Radiation Measurements of Electromagnetic Pulse Phenomena | Naval Missile Center |
| 7.17 | Radiological Water Decontamination Study | Army Engineer Research and Development Laboratories |
| 9.10 | Design, Testing, and Field Pumping of Grout Mixtures | Army Engineer Waterways Experiment Station |

been buried 635 feet underground in Area 10 of the NTS. While the SEDAN cloud drifted generally north-northeast from the test site, some fallout was deposited in Frenchman Flat and occasionally triggered sensitive project instruments emplaced for Shot SMALL BOY. Within a few days after the SEDAN detonation, the fallout decayed to a negligible level. Thus, it did not compromise SMALL BOY results (101).

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

- Measure airblast phenomena in the regions of high, moderate, and low pressure along a blast line
- Integrate new data with existing nuclear blast information
- Evaluate new types of pressure gauges and recorders for use in nuclear tests.

Before the detonation, project personnel placed 57 self-recording and approximately 40 electronic gauges at 26 stations located 30 meters to 18.3 kilometers from the shot-tower. They placed instruments recording the gauge measurements and auxiliary equipment in an underground concrete shelter. After the detonation, three personnel recovered data collected during shot-time (71; 76).

Project 1.2, Close-in Earth Motion, was conducted by the Stanford Research Institute. The objective was to measure the airblast-induced ground motion from a surface detonation as a function of depth and ground range, particularly in the area at and near ground zero. Results of this experiment were used in developing criteria for designing protective structures.

Project personnel placed ground motion gauges in a vertical shaft at depths ranging from 45 to 250 feet directly beneath the shot-tower. In addition, personnel placed three other vertical shafts 20, 60, and 90 meters south of the shot-tower. Each shaft contained four or five ground motion gauges ranging from a depth

of five to 150 feet. Project participants also placed four other gauges from five to 15 feet in the ground 110 to 690 meters south of the shot-tower. After the detonation, four personnel entered the shot area to recover data (76; 94).

Project 1.3, Underground Stress Measurements, was conducted by the Air Force Weapons Laboratory, with support from United Electrodynamics, General American Transportation, and Shannon and Wilson. The objectives were to measure:

- Ground stress and strain and permanent earth displacement in the high-overpressure region resulting from a surface nuclear detonation
- Arrival times of the compression and shear portions of the stress pulse, using various stress, slope, and strain gauges.

Project personnel placed the instruments along a line south of the shot-tower at the following distances:

| Type of Gauge | Placement below Surface (feet) | Distance from Shot-tower (meters) |
|-----------------|--------------------------------|-----------------------------------|
| Slope Indicator | 30 | 20 to 60 |
| Time-of-arrival | 50 | 60 to 90 |
| Soil Stress | 3 20 | 60 to 90 |

To determine the extent of ground displacement, project personnel conducted surveys before and after the detonation and used data from the stress and time-of-arrival gauges (11).

Project 1.4, Shock Photography, was conducted by the Naval Ordnance Laboratory, assisted by EG&G. The objectives were to:

- Measure the shock position as a function of time from which shock velocities and pressures could be calculated

- Photograph and measure the growth of the fireball along and above the earth's surface.

EG&G personnel photographed the detonation with two cameras, one 2,900 meters northwest of the shot-tower and the other 3,200 meters north-northeast of the shot-tower (40).

Project 1.5, Blast Effects in the High-pressure Region, was conducted by the Stanford Research Institute. The objectives were to:

- Study the dynamic pressures produced by the precursor blast wave and dust loading in the high-pressure region of a surface detonation
- Provide information for Project 1.2 personnel conducting ground motion studies.

Data were obtained from 14 overpressure gauges placed on the surface or on three-foot towers 30 to 350 meters from ground zero. The same personnel who staged recovery operations for Project 1.2 retrieved data for this project (76; 95).

Project 1.6, Ground Motion Induced by a Near-surface Explosion, was conducted by the Sandia Laboratory. The purpose was to observe and measure ground motion induced by airblast from the detonation. Project personnel placed instruments for measuring ground motion, including accelerometers and various gauges, in borings at three stations: Station 1, at the shot-tower; Station 2, 40 meters from the shot-tower; and Station 3, 90 meters from the shot-tower. These instruments were to provide data from depths of 25 to 400 feet at Station 1, 300 feet at Station 2, and 200 feet at Station 3. Participants excavated a trench from ground zero out to about 45 meters to carry cables and wires from the Station 1 gauges to the underground recording shelter 670 meters from the shot-tower. Beyond 45 meters from ground zero, a trench carried the wires and cables from all three stations to the recording shelter. Five project personnel entered the recording shelter the day after the detonation to retrieve the recorded data (67; 76).

Project 1.7, Shock Spectrum Measurements, was conducted by Space Technology Laboratories to measure the displacement spectrum of the ground motion both at the surface and at a depth of ten feet. Information was obtained from 16 gauges installed on the surface and ten feet underground at four stations 56 to 90 meters from the shot-tower (7).

Project 1.8, Soils Survey, was conducted by the Army Engineer Waterways Experiment Station to:

- Obtain preshot data on the physical properties of the soil to a depth of 375 feet in the vicinity of the shot-tower
- Provide holes for the installation of instruments and sand columns
- Determine the density and water content of compacted soils used for backfill placed in instrument installations and around structures
- Obtain postshot data on physical properties of the soil to a depth of 75 feet.

Project personnel conducted these activities to support agencies participating in Projects 1.2, 1.3, 1.9, 3.1, 3.2, and 3.3, which involved blast effects analysis and shock wave measurements. The operations office for Project 1.8 was at Camp Mercury, while the field laboratory was a trailer located at Frenchman Flat. After the detonation, project personnel conducted soil surveys and collected samples. The samples were sent for analysis to the Army Engineer Waterways Experiment Station in Vicksburg, Mississippi (37).

Project 1.9, Crater Measurements, was conducted by the Army Engineer Waterways Experiment Station, with the assistance of American Aerial Surveys and REECo. The objectives were to measure the crater formed by the shot and the permanent earth deformation occurring beyond the crater boundary. Before the shot, project personnel placed 18 colored sand columns, each

20 centimeters wide, into holes drilled ten to 40 feet deep along two radials 36 meters from the shot-tower. The deformation of these sand columns after the detonation would reflect the permanent movement of the ground outside the crater. This earth movement could then be measured after the excavation of the columns.

Two days after the shot, American Aerial Surveys personnel took aerial photographs to use in measuring the crater. They conducted their mission in a Cessna 180 aircraft flying at a speed of 70 knots and at heights of 1,200 and 1,500 feet above the ground.

A ground survey was scheduled for immediately after the declaration of recovery hour. This survey was canceled, however, because the activities of another project disturbed the area near ground zero and made conditions difficult for such a survey. Sometime later, participants surveyed along the sand columns to check the extent of the crater indicated by aerial maps.

Excavation of the sand columns did not begin until April 1963, when natural decreases in the radiation levels made this activity possible. Army Engineer Waterways Experiment Station personnel, assisted by REECO personnel, completed all sand column excavation and measurement (21).

Project 2.1, Initial Radiation Measurements, was conducted by the Harry Diamond Laboratories. The objective was to measure the gamma ray intensity and neutron fluence resulting from the detonation. Project personnel installed equipment in two bunkers that also contained instruments from Projects 6.1 and 6.3. Bunker B, 490 meters from ground zero, was the main installation, but Bunker A, 190 meters northeast of ground zero, also contained some radiation-measuring instruments. Project personnel also installed tape recorders at Bunker B and at other stations

located about 1,220 meters northeast of ground zero. The instruments for measuring radiation and the tape recorders were electrically powered and timed to operate automatically. After the detonation, project personnel reentered the area to recover the instruments and tape recorders (14).

Project 2.2, Measurement of Fast-neutron Dose Rate as a Function of Time, was conducted by the Army Electronics Research and Development Laboratory. The objective was to measure fast-neutron intensity as a function of time and distance in support of Project 6.4. Before the detonation, project personnel placed instruments at stations located 190, 490, and 1,220 meters northeast of the shot-tower. They then set the automatic timer for the instruments and left the area. Project personnel and Project 6.4 participants reentered the shot area after the detonation to photograph the instruments. Two teams, each with three participants, retrieved data from the instruments (56; 76).

Project 2.3, Neutron Flux Measurements, was conducted by the Army Nuclear Defense Laboratory to support Program 6 projects. Project personnel installed neutron flux detectors 30 to 365 meters to the southwest, 80 to 1,220 meters to the northeast, and 190 to 1,220 meters to the northwest of the shot-tower. They attached most of the detectors to cables. Immediately after the detonation, nine personnel from Projects 2.3 and 2.4, assisted by Project 7.2 participants, entered the shot area in an M-88 tank retriever to drag the cables out of the area. They completed recovery operations within 24 hours after the detonation. They then transported the detectors to the Project 2.3 mobile laboratory at the Control Point (76; 80).

Project 2.4, Integrated Gamma Dose Measurements, was conducted by the Army Nuclear Defense Laboratory. The objective was to provide gamma support measurements for Program 6 projects. Before the detonation, project personnel placed gamma detectors

in blast shields, which they then attached to a recovery line used for Project 2.3. They also fastened a gamma detector to a wooden stake in the shot area. The detectors were 30 to 3,000 meters northeast, northwest, and southwest of the shot-tower. After the detonation, nine personnel from Projects 2.4 and 2.3 used an M-88 tank retriever to pull the recovery line out of the radiation field. They completed recovery operations within 24 hours after the detonation. The gamma detectors were then sent for analysis to the Army Nuclear Defense Laboratory and the Army Signal Research and Development Laboratory.

In addition to their field activities, Project 2.4 personnel supplied Project 7.2 participants with 100 gamma detectors for a shielding experiment. They also provided a set of gamma detectors to Project 7.8 personnel (76; 79).

Project 2.7, Off-site Meteorology--Winds Aloft, was conducted by the Weather Bureau Research Station of Las Vegas, Nevada. Objectives were to:

- Collect wind information from an extensive network of observation stations downwind of the detonation
- Provide data for the prediction and documentation of fallout.

Project personnel placed instruments used to measure wind data, such as theodolites, rawinsondes, and radar equipment, at 15 different locations, ranging from 30 to 400 kilometers east of the shot-tower. The sites were 80 to 130 kilometers apart. Information on winds from the surface up to 30,000 feet was recorded at these sites. Five cooperating Weather Bureau stations provided additional meteorological data (4).

Project 2.8, Radiological Surveys, was conducted by the Army Nuclear Defense Laboratory, with the assistance of the 50th Chemical Platoon from Fort Ord, California, the 22nd Chemical

Company from Fort McClellan, Alabama, and Chemical Corps officers supplied by Headquarters, Continental Army Command, Fort Monroe, Virginia. The objectives were to determine:

- Residual radiation patterns and decay rates resulting from a low-yield detonation
- Gamma exposure rates and decay rates in and around the crater resulting from the detonation.

To obtain data, ground-survey teams and helicopter-to-ground units surveyed radiation areas. In addition, personnel obtained information from dose-recording instruments placed near ground zero and from film badges positioned throughout the areas of expected fallout. The 50th Chemical Platoon was responsible for onsite ground surveying, and a platoon from the 22nd Chemical Company was responsible for ground surveying 50 to 500 kilometers from ground zero (8).

To establish ground-survey stations, project personnel placed north-south stake lines east of ground zero at 30-meter intervals to 1,200 meters; at 600-meter intervals between 1,200 and 3,650 meters; and at 4,600, 5,500, 8,000, 10,350, and 14,000 meters. They also placed three rows of stakes in both Indian Springs Valley and Three Lakes Valley, about 25 and 50 kilometers, respectively, from ground zero. In addition, they established stakes up to 3,000 meters southwest to northwest of ground zero (8).

The monitors followed the same basic procedures in conducting the surveys. These procedures are detailed in the Project 2.8 description for Shot LITTLE FELLER II.

Two-man teams began the initial onsite radiological survey in Frenchman Flat about one hour after the SMALL BOY detonation. The delay was caused by the slow-moving cloud and by uncertainty concerning the presence of "high-explosive hazards" in that area.

The initial teams surveyed all stake lines to the 10 R/h line. The second survey took readings ranging from 1 to 10 R/h on stake lines downwind. The survey was about 90 percent finished when stopped because of approaching darkness. The last survey located the 10 R/h contour and obtained as many readings as possible without causing participants to exceed the 1.5 R/h dose allowed for operations conducted on the day of detonation (8).

One day after the detonation, teams monitored areas in Frenchman Flat where the radiation was less than 10 R/h. They conducted resurveys on each succeeding day until the sixth day after the detonation (8).

Offsite ground surveys began when cloud-tracking missions identified the regions to be surveyed. Twelve teams conducted these surveys. Eight of the teams were positioned at various locations in Utah. The other four teams, based in Mercury, Nevada, monitored 40 to 160 kilometers from Frenchman Lake. Offsite surveys showed "very low" gamma rates 3 feet above the ground. These surveys began one day after the detonation and continued through six days after the detonation (8).

Helicopter operations for Shot SMALL BOY were similar to those identified in the Project 2.8 description for Shot LITTLE FELLER II. The participating helicopters and crews were from the Marine Corps. Chemical Corps officers from Headquarters, Continental Army Command, Fort Monroe, Virginia, conducted the measurements made from the aircraft (8).

Beginning 80 minutes after the detonation and continuing intermittently throughout the day, two helicopters flew dropping-probe missions. While instruments were lowered to the ground, the aircraft hovered at altitudes of 400 to 700 feet. The first instruments were positioned near the crater three hours and 20 minutes after the detonation. These missions were flown from one through five days after the detonation (8).

Project 2.9, Fallout Collection and Gross Sample Analysis, was conducted by the Naval Radiological Defense Laboratory and the Laboratory of Nuclear Medicine and Radiation Biology of the University of California at Los Angeles (UCLA). Assigned to the Naval Radiological Defense Laboratory for this project, as well as for Projects 2.10, 2.11, and 2.14, were 11 personnel from 1st Marine Division, Fleet Marine Force Pacific; 13 personnel from Force Troops, Fleet Marine Force Pacific; and three personnel from 3d Marine Aircraft Wing (102; 104). The objectives were to:

- Make quantitative collections of onsite and offsite fallout and determine mass per unit area, ionization decay rate and spectra, size-activity distribution, and size distribution as a function of time
- Provide fallout samples to Project 2.10 and 2.11 personnel
- Measure the deposition dynamics of arrival time, mass deposition rate, and time of cessation
- Determine airborne concentration as a function of time after detonation and measure the fraction of airborne particles that penetrated test ventilation equipment
- Estimate ground-level visibility in the dust cloud produced by blast and shock waves.

Project 2.9, 2.10, and 2.11 personnel collected, measured, and analyzed samples of the total fallout, incremented samples, and samples of airborne fallout particles.

Project personnel established six manned fallout stations in Frenchman Flat 1,220, 1,370, 2,440, 3,660, 5,480, and 7,920 meters east of the shot-tower. These stations, each consisting of an instrumented four-man fallout shelter, were buried to a depth of about six feet. Personnel also installed 24 unmanned stations in the Indian Springs Valley, 30 kilometers east of the shot-tower. Mobile field teams, directed across the predicted fallout path by radio and telephone, instrumented 247 offsite stations for fallout collection. These stations were 30 to

320 kilometers east and northeast of the shot-tower. Seven field teams monitored these stations (59).

Project 2.10, Physiochemical and Radiochemical Analysis, was conducted by the Naval Radiological Defense Laboratory. Assigned to the Naval Radiological Defense Laboratory for this project were the same Marine Corps personnel who participated in Project 2.9. The objective was to obtain data about the fallout particles that would help define fallout formation processes, fallout distribution patterns, and processes related to the radiological exposure environment. Project 2.9 personnel provided samples of onsite and offsite fallout. Project 2.10 personnel studied these samples to determine their physical, chemical, and radiological properties. Laboratory analysis determined the particle size and distribution, radiochemical properties, extent and kind of radiation emitted, and leachability of the radioactivity (34; 102; 104).

Project 2.11, Ionization Rate Measurements, was conducted by the Naval Radiological Defense Laboratory and UCLA. Assigned to the Naval Radiological Defense Laboratory for this project were the same Marine Corps personnel who participated in Project 2.9. Also participating were 22 personnel from the Naval Mobile Construction Battalion Eleven. Project participants placed gamma intensity versus time recorders, dosimeters, and radiacs in the anticipated fallout area. The instruments extended 30 kilometers on a north-south line 25 kilometers east of ground zero. Other instrument stations were 1.5 to 15 kilometers and 320 kilometers from ground zero (60; 102; 104).

Project 2.12, Rocket Sampling, was conducted by the Army Nuclear Defense Laboratory and the American Machine and Foundry Company. The objectives were to:

- Develop a rocket-mounted collector to take samples of the fireball, cloud, and stem shortly after the detonation

- Obtain samples of the fireball, cloud, and stem for Project 2.9 and 2.10 personnel
- Determine the variation in the activity of the cloud as a function of altitude.

The American Machine and Foundry Company designed and manufactured rockets for the project. These rockets contained dosimeters, filters, and bottles for collecting cloud samples. Project personnel constructed two sites in the shot area for launching the rockets. They established a control station for firing of the rockets about 4,570 meters southwest of the shot-tower. A firing cable connected the control station with the launching stations. One minute after the detonation, personnel in the control station launched five rockets. The rocket drop area was about 1,500 to 1,800 meters north of ground zero.

About 22 hours after the detonation, project personnel searched for the rockets and recovered filters, cloud samples, and dosimeters from one rocket. They delivered the samples to Project 2.10 personnel and returned the dosimeters for analysis to the American Machine and Foundry Company laboratories. Participants searched for the remaining rockets two days after the detonation. They found, however, only one booster. In late October 1962, Army Nuclear Defense Laboratory personnel, assisted by Army personnel from Project 2.8, renewed the search for the remaining rockets but did not find any (98).

Project 2.13, Development and Evaluation of a Fallout Collector, was conducted by the Army Nuclear Defense Laboratory. The objective was to develop and evaluate a new fallout collector. An estimated two project personnel spent about three days placing fallout collector instruments in the shot area 2,190, 4,760, and 8,530 meters northeast of the shot-tower, adjacent to Project 2.9 manned instrument stations. One week before the shot and again five days before the detonation,

project participants tested the instruments. Personnel recovered all fallout samples five hours after the detonation. They completed recovery of collecting instruments and other equipment seven days after the detonation (19).

Project 2.14, Shielding Effectiveness of Compartmented Structures in a Fallout Field, was conducted by the Naval Radiological Defense Laboratory. Assigned to the Naval Radiological Defense Laboratory for this project were the same Marine Corps personnel who participated in Project 2.9. The objectives were to:

- Measure the penetration of fallout gamma radiation into six compartmented structures
- Determine the free-field radiation characteristics of the fallout.

In the days preceding the detonation, project personnel set up six compartmented steel structures containing film packets at a number of sites approximately 2,900 meters from the shot-tower. Project participants entered the test area with survey instruments to check the dose rates at various sites two days after the detonation. Three days after the detonation, participants entered the shot area in a truck equipped with a spectrometer to measure radiation about 2,900 meters from ground zero. They continued to use the truck for these measurements for at least nine days (33; 89; 102; 104).

Project 2.15, Shielding Effectiveness of Enclosure Shields in a Fallout Field, was conducted by the Army Ballistic Research Laboratories and the Office of Civil Defense. The objective was to measure gamma dose resulting from fallout inside and outside several shield configurations for a period of 48 hours in order to determine the transmission of fallout gamma radiation through these shields. The data from these measurements aided in identifying the most effective radiological shielding in military vehicles.

Project participants placed enclosure shields, which were hollow-walled steel cubes and spheres of several sizes, in a 30-meter-wide strip located 4,880 meters northeast of ground zero, the direction of the expected fallout. In addition, they placed ten free-field radiation detectors midway between each shield and around the edges of the 30-meter strip. The detector outputs were wired to a mobile recording station in a revetment 1,520 meters north of the enclosure shield area.

Personnel checked and calibrated the equipment in the field one week and again one day before the detonation. Two or three personnel remained in the recording station through shot-time and continued operations there for 48 hours after the detonation. They also took a gamma survey of the enclosure shield area, out to a radius of 90 meters, 24 hours after the detonation (17; 76).

Project 3.1, Response of Buried Arch and Dome Models, was conducted by the School of Engineering of Massachusetts Institute of Technology, with fielding assistance from the Army Engineer Waterways Experiment Station. The objectives were to:

- Investigate the effect of the depth of cover on the failure pressure for reinforced concrete dome and arch structures buried under a shallow cover of soil
- Compare the failure pressure of the buried structures with the failure pressure of structures mounted on the surface.

Before the detonation, project personnel mounted scale models of four dome and four arch structures on the surface at five locations expected to have high overpressures. They buried scale models of 12 dome and 12 arch structures under a soil cover ranging from one-half to six inches at expected high overpressure locations. Participants also installed self-recording pressure gauges flush with the ground next to the models at four of the locations. After the announcement of recovery hour, personnel

reentered the test area to inspect and photograph the structures. They later sent the models to the Massachusetts Institute of Technology for testing (43).

Project 3.2, Dynamic Bearing Capacity of Soils--Field Test--Response of Impulsive Loaded Footings on Frenchman Flat Silt, was conducted by the Army Engineer Waterways Experiment Station. The purpose was to measure blast-loading and displacement responses of square interior and long-wall footings (supports) mounted on undisturbed Frenchman Flat soil to impulse loading from a surface nuclear detonation. Project personnel placed the square concrete footings 210 meters south of the shot-tower and two long-wall footings 100 meters south of the shot-tower. They instrumented the footings with a variety of strain and displacement gauges. Cables from the instruments went to a buried, unmanned instrument shelter 1,220 meters south of the shot-tower. After the detonation, six personnel entered the shot area to retrieve the data (76; 92).

Project 3.3, Behavior of Buried Model Arch Structures, was conducted by the Naval Civil Engineering Laboratory. Project 1.8 personnel from the Army Engineer Waterways Experiment Station provided soil density measurements. Project 3.4 personnel from the Army Ballistic Research Laboratories supplied instrumentation support. The objective was to gain information on the responses of buried arches to the blast wave. Project personnel buried six arches at various distances along a line running southwest of the shot-tower. They placed gauges on the arches to measure responses to soil pressure, air pressure, and ground displacement resulting from the detonation. Electronic devices in a bunker buried about 730 meters southeast of the shot-tower recorded data from the instruments. After the detonation, four personnel drove to the bunker to recover data (76; 93).

Project 3.4, Structures Instrumentation, was conducted by the Army Ballistic Research Laboratories to provide free-field airblast and structural response measurements for Projects 2.7, 3.1, 3.2, 3.3, and 7.2. Project personnel placed 23 gauges at various locations in the shot area. They installed the electronic equipment used to record the gauge measurements in an underground instrument shelter 730 meters south of ground zero. After the detonation, two parties, each of three personnel, went to the shelter to retrieve the instruments (76; 87).

Project 6.1, Weapons Effects Testing, EM (Electromagnetic) Pulse, was conducted by the Boeing Company. The following provided assistance: REECO, Harry Diamond Laboratories, Army Signal Research and Development Laboratory, and Hughes Aircraft Company. The objective was to measure various components of the electric field created by the nuclear detonation and to determine the effects of the detonation on the measuring equipment.

REECO and Boeing personnel constructed eight bunkers, 190 to 2,990 meters northeast of the shot-tower. The bunkers contained instruments provided by the assisting contractors. Two hours and 30 minutes before the detonation, participants closed the bunkers and cut off their external power. After the declaration of recovery hour, a crew of trained contractor personnel opened one of the bunkers. A second crew of contractor personnel then retrieved data from instruments in the bunker. This procedure was followed at each bunker location (10).

Project 6.2, Magnetic Loop Measurements, was conducted by the Harry Diamond Laboratories to measure the magnetic field component emanating from a nuclear device. Project participants installed self-powered magnetic tape recorders and antennas in underground concrete bunkers 80, 190, 490, 500, 1,220, and 3,000 meters northeast of the shot-tower. They placed additional recorders at stations 190, 490, and 1,220 meters northwest of the

shot-tower and at another station 490 meters southwest of the shot-tower. The instruments, started electronically several seconds before the detonation, recorded data through shot-time. After the detonation, four personnel entered the station area to retrieve data (15; 76).

Project 6.3, Inherent Magnetic Field Measurement, was conducted by the Hughes Aircraft Company. The objective was to measure the magnetic component of the electromagnetic pulse produced by a nuclear detonation. The measurements, along with measurements of the electrical component from Project 6.1 and measurements of the time duration of the magnetic component from Project 6.2, were to contribute to the theoretical treatment of the electromagnetic pulse phenomenon. Project personnel measured the magnetic field by using three magnetic field sensors placed in each of four bunkers located 190, 490, 1,220, and 3,000 meters northeast of the shot-tower (41).

Project 6.4, Measurement of Gamma Dose Rate as a Function of Time, was conducted by the Army Electronics Research and Development Laboratory. Objectives were to measure gamma rate as a function of distance for up to 100 seconds after the detonation.

Project personnel, assisted by Project 2.2 participants, placed various instruments, including a new type of gamma detector, in bunkers 190, 490, and 1,220 meters northeast of the shot-tower. They then photographed each equipment setting. After the declaration of recovery hour, two parties of three personnel each recovered data from the bunkers (57; 76).

Project 6.5, Electromagnetic Pulse Current Transients, was conducted by the Sandia Corporation. The main purpose was to investigate the response of buried communication cables to the electromagnetic pulse produced by a nuclear detonation. The

major emphasis was on the acquisition of cable current and voltage data, although earth potential gradients, magnetic fields, soil resistivity, and gamma and neutron dose levels in the earth at cable burial depths were also measured. Project participants buried various lengths and thicknesses of communication cable 18 inches deep at distances ranging from 15 meters to 1,830 meters from the shot-tower. They buried instruments to record responses of these cables at distances of 60 to 2,830 meters from the shot-tower. The cables and instruments were located south, southwest, and west of ground zero.

Another objective was to measure characteristics of the radiation field near the buried cables. Project personnel established 14 stations housing gamma and neutron detectors 30 to 8,050 meters north, northwest, and southeast of the shot-tower. Project personnel also investigated the effects of electromagnetic pulse on communication shelters, antenna elements, and magnetic memory components. They positioned stations for all of this equipment, except for the magnetic memory components, along a cable line 100 to 460 meters southeast of the shot-tower. They located the magnetic memory component station 100 meters west of the shot-tower. The project stations, all unmanned, were activated electronically. Upon the declaration of recovery hour, 14 parties totaling 51 project personnel retrieved data and the instruments. Attached to each party was a REECO monitor (32; 76).

Project 6.6, Cable Loop Measurements, was conducted by the Air Force Weapon Laboratories, TRW Space Technology Laboratories, and Allied Research Associates. The objective was to obtain data on the value of cable sheathing in limiting electromagnetic pulse effects in buried cables. The project consisted of three experiments (49).

For Experiment 6.6.1, project personnel buried two 900-meter cables at a depth of three feet. The cables extended 90 meters from the shot-tower to the southeast. For Experiment 6.6.2, participants buried two 30-meter diameter loops of insulated wire at a depth of one foot 230 meters west of the shot-tower. An unmanned bunker housed the electronic recording equipment for each circular cable loop. The cable configuration for Experiment 6.6.3 consisted of a large loop buried three feet deep and extending 100 to 370 meters southwest of the shot-tower. Personnel placed three bunkers with instruments along the loop to record the current induced by the electromagnetic pulse (49).

Project 6.7, Soil Conductivity Measurements, was conducted by the U.S. Geological Survey to determine the electrical conductivity of the alluvium in the Frenchman Lake area of the NTS. Project personnel buried three different electrode configurations at various locations in the shot area. They obtained information on soil density and moisture by placing 1.5-meter lengths of thin steel tubing in the soil to a depth of 4.5 feet. They then lowered measuring probes into the tubing so that the center of measurement occurred at a depth of 3.5 feet. Using these measuring probes and the electrodes, personnel took numerous preshot and postshot measurements approximately 2,000 and 4,000 feet northeast and northwest of ground zero (88).

Project 6.8, Earth's Static Field Measurements, was performed by the Stanford Research Institute. The objective was to measure and record the earth's static electric field in the vicinity of a nuclear detonation. Project personnel installed battery-operated instruments that measured the vertical electric field at the earth's surface at one kilometer northeast, three kilometers northeast, 6.5 kilometers west, ten kilometers east-northeast, and 12 kilometers northwest of the shot-tower. They connected recording devices to the instruments and installed these recorders in bunkers and waterproof cases near the

instruments. Participants also attached instruments to three balloons launched 6.5 kilometers west of the shot-tower. They launched the first balloon about two hours before the detonation, the second about ten minutes before the detonation, and the third about one hour after the detonation. Upon the declaration of recovery hour, three personnel retrieved data from the stations (76; 99).

Project 6.9, Correlation of Present and Previous Electric Field Measurements, was conducted by the Denver Research Institute. The purpose was to measure the vertical component of the electromagnetic pulse for correlation with data obtained from previous tests. The electromagnetic pulse detection and recording system was housed in a trailer located 12.3 kilometers northwest of the shot-tower (72).

Project 6.11, Air Conductivity Measurements, was conducted by MHD Research and Lawrence Radiation Laboratory. The objective was to measure the variation of the electrical conductivity produced in the ionized atmosphere surrounding a nuclear detonation on the earth's surface. Project personnel used four different methods of measuring air conductivity: microwave transmission, microwave interferometer measurements, radio-frequency circuit conductivity, and parallel plate conductivity. They took these measurements, except for the microwave transmission tests, at an unmanned instrument bunker 500 meters west of the shot-tower. For the microwave transmission tests, they positioned the transmitter tower 4.4 kilometers northeast of ground zero and the receiver tower 4.5 kilometers southwest of ground zero. Participants placed a small transmitter that would automatically trigger the microwave transmission equipment about 30 meters from ground zero. After the detonation, two personnel proceeded to the bunker 500 meters west of the shot-tower to recover data (54; 76).

Project 6.12, British Empire Measurements, was conducted by the Atomic Weapons Research Establishment, the nuclear weapons development agency of the United Kingdom. The objective was to measure air conductivity and the electromagnetic field. Project instrumentation was housed in steel shelters 490, 1,200, and 3,050 meters from ground zero. After the declaration of recovery hour, three parties totaling 21 individuals entered the shot area to retrieve data, which were then forwarded to the Chief, DASA (30).

Project 6.13, Troposcatter Test Installation Performance, was conducted by the Army CONUS Regional Communications Command. The objective was to document any phenomena occurring in a ground-to-ground communications path using a tropospheric scatter propagation mode before, during, and after the detonation. This experiment was conducted at two offsite stations, one near Death Valley Junction, California, and the other near Alamo, Nevada. Project personnel monitored instruments in these stations shortly before, during, and shortly after the detonation (36).

Project 7.1, Pragmatic Instrumental Measurements, was conducted by the Air Force Special Weapons Center. The overall objective of the experiment, which consisted of four subprojects, was to obtain information on the effects of the electromagnetic pulse on selected missile systems components.

The specific objective of Subproject 7.1.1 was to monitor logic circuits to determine the source and amplitude of voltage transients caused by the electromagnetic pulse. Project personnel placed test equipment, including logic circuitry and signal and power cables, in an unmanned bunker 210 meters southeast of the shot-tower (47).

The objective of Subproject 7.1.2 was to observe the effects of the electromagnetic pulse on magnetic computer memory

elements. Participants placed guidance computer memory units in the bunker used for Subproject 7.1.1 equipment and in a bunker 90 meters southeast of the shot-tower. They also buried lengths of antenna, ranging from three to 150 meters, at depths of two to eight feet in the area south of the shot-tower. Distances from the shot-tower to the ends of the antennas ranged from 90 to 700 meters (47).

Subproject 7.1.3 was to determine the extent of physical damage from the electromagnetic pulse to buried antennas, the magnitude of induced currents in the antenna elements and transmission cables, and the effectiveness of voltage surge protective devices incorporated into the antenna system (47).

The objective of Subproject 7.1.4, Transient Radiation Effects Measurements on Guidance System Circuits, was to obtain data on the transient response of typical ballistic missile guidance and control systems to the prompt gamma pulse from a nuclear detonation. The data were then compared to other data obtained by exposing the same types of electronic systems to radiation sources in the laboratory. Project personnel installed guidance and control systems at stations 850, 1,260, 1,740, and 2,290 meters southwest of the shot-tower. Signals from these stations went to unmanned bunkers containing electronic recording instruments. After the declaration of recovery hour, five personnel collected data from the stations and bunkers (76; 96).

Project 7.2, Experimental Confirmation on Theoretical Development of Radiological Armor, was conducted by the Army Tank - Automotive Center and General Dynamics Corporation, with assistance from the Army Ballistic Research Laboratories and the Army Nuclear Defense Laboratory. The objective was to evaluate the shielding integrity of radiological armor installed on a tank with special protection against radiation.

Project personnel placed M-48 tanks and assorted tank components 215, 365, 470, 550, and 640 meters southwest of the shot-tower. They installed various gamma detectors inside and outside the tanks and components. The detectors on the outside of the equipment were then attached to the Project 2.3 drag cable line, which lay adjacent to the tanks and components. After the detonation, three personnel in a heavy vehicle recovered the detectors attached to the cable by dragging the line out of the shot area. Four teams totaling 17 personnel entered the shot area, probably within 24 hours, to retrieve the remaining exterior instruments. Participants reentered the shot area 24 hours after the detonation to recover detectors within the tanks and components. During this activity, participants analyzed some of the detectors onsite. They sent others for analysis to the Army Nuclear Defense Laboratory (76; 78).

Project 7.5, Response of Electrical Power Systems to Electromagnetic Effects of Nuclear Detonations, was conducted by the Army Engineer Research and Development Laboratories. The objective was to determine the response of field army electrical power systems to the electromagnetic pulse from a surface nuclear detonation. The power unit tested was a 45-kilowatt engine-generator set with two 36-meter distribution cables, typical of power units used in field generating systems. The generator was positioned on the ground at an unspecified distance and direction from the shot-tower. Instruments to measure and record the generator's response to the electromagnetic pulse were nearby in a seven-foot deep concrete pit (23).

Project 7.6, Feasibility Evaluation of an Aerial Radiac Survey System, was conducted by the Army Electronic Proving Ground. The objective was to test and evaluate experimental aerial radiac equipment under actual nuclear conditions. Project personnel established an air operations center and drone launch, control, and recovery point about six kilometers northwest of the

shot-tower. In the operations center, personnel analyzed the telemetered and recorded data from manned and drone flights in the fallout path. Two HUS-1 helicopters from the 3d Marine Air Group, Santa Ana, California, flew over the fallout area about two, six, and 22 hours after the detonation. The helicopters operated out of a heliport at the Control Point. Drone aircraft flew over the fallout path ten, 11, and 15 hours after the detonation. The drone flights were limited to an area northeast of ground zero (50).

Project 7.6.1, Evaluation of Aerial Radiac Monitor Systems for Interim Tripartite Standardization, was conducted by the Army Electronic Proving Ground. Also participating were the Directorate of Equipment Policy of the British Army, the Equipment Engineering Establishment of the Canadian Army, the Army Signal Research and Development Laboratory, and the Office of Civil Defense. The purpose was to evaluate aerial radiac systems proposed by the United States, Canada, and the United Kingdom in order to standardize a system for interim use by these nations. Project personnel tested five types of aerial radiological survey equipment, which was supplied by the participating agencies. Representatives of each of the five agencies operated their own equipment and recorded and analyzed the data (51).

Two Marine Corps HUS-1 helicopters containing radiac equipment flew predetermined routes over radioactive areas at heights between 100 and 1,000 feet and at ground speeds of 50 to 100 knots. These helicopters also participated in Project 7.6. One helicopter carried all the survey equipment except the system developed by the Army Engineer Development Laboratory. This aircraft made a total of three flights, at two hours, six hours, and 22 hours after the detonation. The other HUS-1 carried the Army Engineer Development Laboratory's radiac system and an additional Canadian system. This helicopter's three flights were

at five, 24, and 47 hours after the detonation. Using information from these aerial surveys, participants plotted isodose contour maps and evaluated and compared the radiac systems (51).

Project 7.8, Arming and Fuzing Component Test, was conducted by the Naval Ordnance Laboratory. The objectives were to:

- Determine if radiation from a nuclear detonation would cause permanent damage to arming and fuzing components
- Compare nuclear weapon radiation effects with those produced by radiation simulators.

Project personnel installed an arming and fuzing component 190 meters from the shot-tower. They also installed gamma and neutron dosimeters and other instrumentation inside and outside the arming and fuzing component to measure radiation-induced phenomena. After the detonation, project personnel recovered the dosimeters and instruments from the area. The Army Nuclear Defense Laboratory analyzed the dosimeters (97).

Project 7.8.1, Magnetic Detection Equipment Test, was conducted by the Naval Ordnance Laboratory. The objective was to measure the electromagnetic field in the frequency range of one to 4,500 cycles per second. Project personnel set up electromagnetic detector instruments about eight kilometers from the shot-tower. A manned instrument station located nearby served as a base for recording data, for turning equipment on and off, and for checking proper operation of the equipment. Thirty seconds before shot-time, project personnel turned on the magnetic detection equipment at this station and kept the equipment running until about two minutes after the detonation. The recorded data were sent to the Naval Ordnance Laboratory for examination (85).

Project 7.9, Proof testing of Operational Shipboard Material, was conducted by the David Taylor Model Basin. The objective was to determine in selected shipboard components the extent of

damage caused by the airblast from a surface nuclear detonation. The components tested were several types of antennas, various styles of deckhouse structures, and two smokestacks. Strain gauges, displacement and velocity meters, and other instruments measured and recorded component responses to the airblast. Cables buried in a three-foot-deep trench connected these gauges to the recording instruments, located in a buried, unmanned bunker 760 meters southwest of the shot-tower. The shipboard structures were southwest of the shot-tower at distances ranging from 290 to 400 meters (42).

Project 7.10, Spectral Analysis with High-time Resolution of the Thermal Radiation Pulse, was conducted by the Army Nuclear Defense Laboratory, with the assistance of the Frankford Arsenal and the Natick Laboratories. Its primary objective was to investigate the spectral irradiance and luminosity of the first thermal pulse to furnish information for use in studies on protection against flash blindness and, possibly, in research involving trigger devices and other photographic equipment.

Before the detonation, project participants built three stations approximately two, four, and six kilometers due south of the shot-tower. The station located two kilometers from the shot-tower was used to test face masks. The stations four and six kilometers from ground zero were equipped with instruments to measure wavelength bands. Project personnel calibrated these instruments after they were installed. After the detonation, three project participants retrieved data from the instruments (64; 76).

Project 7.12, Nuclear Effects on Television Camera Installations, was conducted by the Defense Communications Agency. The objectives were to:

- Determine the blast and shock effects on television camera components

- Determine the effectiveness of a special shutter mechanism designed to protect the videotube of a television camera against damage from excessive light
- Make a motion picture record of the shot as viewed on a television monitor.

Project personnel installed television cameras and shutter devices 170 meters southwest and 250 meters southeast of the shot-tower. They placed a third camera station in a bunker 2,440 meters southwest of the shot-tower. Personnel rehearsed the experiment and photographed the activities of other project participants in the shot area before the shot. The two camera stations 170 and 250 meters from ground zero were unmanned and operated by battery. Project participants operated the camera station in the bunker through shot-time. After the area was opened for recovery operations, project personnel inspected the two forward camera stations to assess their operability. They also photographed the station areas (91).

Project 7.13, F-100F/GAM-83B Simulation, was conducted jointly by the Air Force Systems Command and the 6570th Aerospace Medical Research Laboratories. Its objectives were to determine F-100F response to weapons in the yield range of a GAM-83B missile, verify the existing structural analysis of the F-100F's response, and evaluate the effectiveness of devices designed to protect eyes from flash blindness and retinal burns.

On the day of the detonation, the F-100F aircraft left Nellis AFB with enough fuel for 50 minutes at the test site. Ground-installed positioning radar controlled the aircraft to ensure that it would arrive at 2,820 meters from ground zero at the time of the detonation. The aircraft maintained a ground speed of 270 meters per second (525 knots) and a height of 1,500 feet above the detonation throughout its flight path. After completing its mission, the F-100F landed at Indian Springs AFB (62).

Project 7.14, Bomb Alarm Detector Test, was conducted by Western Union Telegraph Company and Headquarters, Air Force. The objective was to prove that a bomb alarm system could recognize a nuclear event and indicate its occurrence. Project personnel installed detectors about one, two, three, six, 11, and 19 kilometers from the shot-tower. Cable circuits connected these detectors to the instrument station, a trailer containing sensitive recording equipment, located about six kilometers from the shot-tower. This station was about 1.5 kilometers east of the intersection of Mercury Highway and the east-west road into Frenchman Flat. Personnel spent several weeks at the NTS installing the equipment, rehearsing planned activities, and then operating the station before, during, and after the detonation (16).

Project 7.15, Effects of Nuclear Radiation on B-52/GAM-77 Weapon System, was conducted by the Aeronautical Systems Division of the Air Force Systems Command. The objective was to obtain information on the effects of nuclear radiation on the B-52/GAM-77 Weapon System.

Two Strategic Air Command B-52G aircraft from Seymour-Johnson AFB, North Carolina, flew over the detonation. Each of the B-52Gs had two GAM-77 missiles installed. The two aircraft began their test run 63 kilometers due south of the shot-tower. During the test run, the aircraft descended to their final altitudes of 10,600 feet and 12,581 feet, respectively.

Ten seconds before the detonation, the aircrews drew thermal curtains over all aircraft windows. The aircrews indicated that, during the shot, they felt a jolt somewhat greater than they had ever before experienced in flight. After passing over ground zero, the aircraft turned toward Winslow, Arizona, and eventually returned to Seymour-Johnson AFB. After the aircraft landed, personnel removed dosimetry packages from the B-52Gs. The

missiles were transported to North American Aviation for analysis. The aircrews' film badges were sent to the Air Force Radiological Health Laboratory at Wright-Patterson AFB, Ohio, for evaluation (25).

Project 7.16, Airborne E-Field Radiation Measurements of Electromagnetic Pulse Phenomena, was conducted by the Naval Missile Center. The objective was to measure, from the air, the vertical electric field of the radiated electromagnetic pulse from the detonation. Project participants placed electromagnetic pulse detection and recording equipment, including vertical whip antennas, magnetic tape recorders, and oscilloscopes, on one C-131F and one A-3A aircraft that flew over the shot area. At the time of detonation, the C-131F was 3,230 meters east of ground zero at an altitude of 13,680 feet. It had an airspeed of 155 knots and a heading of 170 degrees. The A-3A was at an altitude of 18,000 feet directly over ground zero at the time of detonation. Its airspeed was 250 knots, with a heading of 164 degrees. After the detonation, both aircraft landed at Indian Springs AFB for radiation monitoring before returning to Point Mugu, California (13).

Project 7.17, Radiological Water Decontamination Study, was conducted by the Army Engineer Research and Development Laboratories. The objectives were to:

- Study the effect of acidity or alkalinity, temperature, and time of contact upon the solubility of radioactive soil and debris in water
- Evaluate emergency methods of removing radioactive materials from water
- Evaluate Army and Civil Defense field methods of determining the concentration of radioactive materials in water
- Evaluate a proposed decontamination method for removing radioactivity from water.

Four days after the detonation, project participants scraped soil samples from the surface at the 10 R/h line. They removed the samples from the shot area and determined the specific activity of each sample. They then delivered the samples to a laboratory in Yucca Pass for analysis. After the soil samples were dissolved in water, personnel conducted solubility studies, tested instruments for detection of radioactivity in water, and tested Civil Defense and Army water decontamination techniques (61).

Projects 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, and 9.7 were support projects conducted by Field Command, DASA, with the assistance of other DOD agencies and contractors. Much of the work done by these projects involved aerial and ground photography performed by the Army Pictorial Center; Air Force Lookout Mountain Laboratories; EG&G, Incorporated; and Sandia Corporation. Depending on project requirements, the number of personnel directly involved numbered from one officer and seven enlisted men to four officers, 17 enlisted men, and four civilians (31).

Project 9.10, Design, Testing, and Field Pumping of Grout Mixtures, was conducted by the Army Engineer Waterways Experiment Station. The objective was to test a grout mixture in the field and determine the effects of a nuclear detonation on its physical properties. Project personnel placed the grout mixture, which they had previously developed in the laboratory, in several instrument holes installed in the shot area by the Stanford Research Institute and Sandia Corporation. Some of these holes were 1.5 to 350 meters southeast of the shot-tower (70).

Project 8.1, Intermediate Range Seismic Measurements, was conducted by the United States Coast and Geodetic Survey as part of the VELA UNIFORM projects, which were designed to improve U.S. capabilities in detecting and identifying underground nuclear detonations. The Project 8.1 objective was to record seismic

data at the time of detonation from six stations approximately 30 to 160 kilometers from ground zero. Seismometers and geophones were used to collect information (103).

Project 8.4, Long Range Seismic Studies, was conducted by the Geotechnical Corporation as part of the VELA UNIFORM series of projects. The objective was to record and analyze seismic signals. Information was obtained from approximately 40 stations located 75 to 4,000 kilometers from ground zero. The Air Force Technical Applications Center analyzed the data resulting from the project (103).

7.1.2 Air Force Special Weapons Center Activities

Under the operational control of AFSWC, various Air Force units conducted security, photography, cloud-sampling, courier, and cloud-tracking missions.

7.2 RADIATION PROTECTION AT SHOT SMALL BOY

Information is available concerning the results of onsite and offsite monitoring and the procedures used to control reentry into the shot and fallout areas at Shot SMALL BOY. In addition, some information is available on the decontamination of personnel and vehicles.

Monitoring

From the time of detonation until the time when the initial monitoring teams were permitted to enter the shot area, REECO personnel obtained data on gamma and beta radiation from the remote radiation detection stations. The stations were in a counter-clockwise pattern north to south of ground zero (73).

The initial onsite monitoring party, consisting of four two-man teams in four radio-equipped vehicles, entered the shot area 33 minutes after the detonation. The teams proceeded into the area after receiving radiation data from remotely operated detector units located north, south, and west of ground zero. The monitoring teams surveyed the shot area and then radioed their data to plotting facilities at the Control Point and the radiological safety base station. Using this information, radiological safety personnel plotted isointensity maps showing the 0.01, 0.1, 1, and 10 R/h radiation contours (73; 76). Figure 7-1 presents the results of the initial survey.

The monitoring party conducted a second radiological survey five hours after the detonation. The monitors found that the 0.01 R/h area was confined to within about 240 meters to the north and 400 meters to the south of ground zero but extended beyond six kilometers to the east. Radiological personnel surveyed the shot area daily for 11 days after the detonation. By the 11th day, the 0.01 R/h area still extended to the east for several kilometers but had receded to within 300 meters of ground zero in other directions (73; 76).

Personnel from the USPHS conducted offsite monitoring at Shot SMALL BOY. Twenty mobile monitoring teams, each consisting of two men in a radio-equipped vehicle, were stationed at various locations east of ground zero. Only 13 teams, however, participated in offsite monitoring on shot-day, with nine of the teams remonitoring the area the next day and two of the teams resurveying part of the area two days later. These teams monitored along highways east of ground zero. The gamma intensities encountered on shot-day ranged from background levels to 0.014 R/h, registered 13 miles south of Alamo, Nevada, on Highway 93. By the next day, gamma readings at this location had decreased to 0.002 R/h (69).

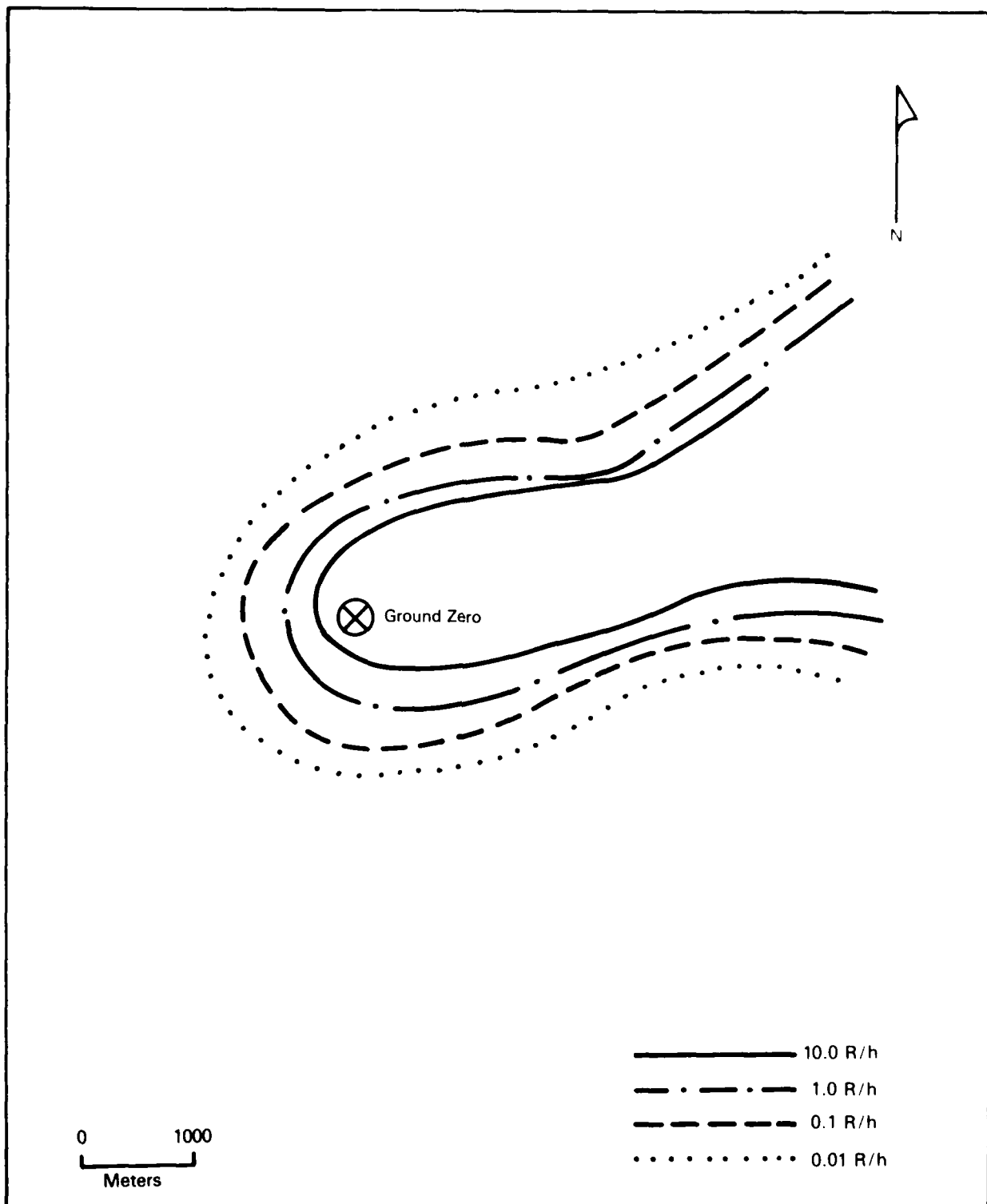


Figure 7-1: ISOINTENSITY MAP FOR SHOT SMALL BOY ABOUT ONE HOUR AFTER DETONATION

In addition, a two-man USPHS team in a WB-50 aircraft piloted by Air Force personnel conducted a cloud survey. The team monitored and tracked the cloud out to 320 kilometers from ground zero, beginning at 1130 hours and ending at 1600 hours on shot-day. The highest gamma reading recorded inside the aircraft was 0.35 R/h. Other gamma readings inside the aircraft ranged from background to about 0.3 R/h. This aircraft did not penetrate the cloud (69).

Reentry Procedures

After the initial onsite ground survey was completed, the Test Manager opened the shot area for recovery operations. To enter the shot area, each recovery party had to have an access permit and each participant had to wear anticontamination clothing and equipment, a pocket dosimeter, and a film badge. Because there were so many recovery parties at SMALL BOY, onsite reentry procedures were staged from two areas, Control Point Building 2 and the radiological safety base station. On shot-day and the day after, access permits and anticontamination clothing were issued to personnel from Control Point Building 2, while pocket dosimeters and film badges were issued at the Area 5 Base Station. Two days after the detonation, radiological safety personnel controlled reentry procedures from the Area 5 base station. Radiological Safety Division personnel established a similar checkpoint at Indian Springs AFB. The station was east of the runways on an access road. Entering personnel were issued anticontamination clothing, respiratory protective equipment, and pocket dosimeters. Upon exiting from the area, personnel and equipment were monitored and decontaminated as necessary (73; 76).

In another measure to control reentry, Radiological Safety Division personnel barricaded all but one road leading into the shot area and established a forward control point along this road. Personnel entering the shot area had to pass through this

control point. Radiological safety personnel manned the station on shot-day and checked to ensure that each group had an access permit. The day after the detonation, the forward control point was moved closer to ground zero so roads into other parts of the shot area could be opened (5).

The reentry on the ground of project personnel generally began after the entry of the initial monitoring teams and continued during the daylight hours on subsequent days. However, reentry was sometimes permitted earlier if instruments required prompt retrieval and if project participants were accompanied by monitors. Aerial reentry began about 30 minutes after the detonation. Personnel were directed to leave most of the manned shelters by midafternoon because of the fallout pattern over these shelters. The last shelter was evacuated at 1930 hours on the day of detonation. Recovery of instrumentation and data from stations close to ground zero was delayed until ten days after the detonation because of radiation levels (31).

In most cases, the size of reentry parties was from two to four men. Exceptions were made when additional personnel were needed to reopen stations and bunkers to permit data retrieval. Each reentry party was required to be accompanied by one radiological safety monitor (31).

Decontamination

Radiological safety personnel monitored and decontaminated personnel and vehicles at Control Point Building 2, the radiological safety base station in Area 5, and Indian Springs AFB. Personnel were decontaminated by washing or showering. Teams decontaminated vehicles with detergent and water and by steam cleaning. Onsite, they worked on the vehicles primarily at the radiological safety base station in Area 5, although vehicle decontamination also took place at the Control Point (73; 76).

Radiological Safety Division personnel used the facility at Indian Springs AFB for decontaminating the personnel and aircraft involved with cloud-sampling activities at SMALL BOY. Radiological monitors found a maximum gamma reading of 50 R/h on the right wing tank of one aircraft that had probably been used for cloud sampling. The aircraft was parked overnight, and decontamination was completed the next day. The pilot and crew were monitored and decontaminated shortly after completion of their mission (44; 52).

LITTLE FELLER I

SHOT SYNOPSIS

AEC TEST SERIES: DOMINIC II
DATE/TIME: 17 July 1962, 1000 hours
YIELD: Low
HEIGHT OF BURST: Three feet above ground

Purpose of Test: Weapons effects test designed to:
(1) Test the DAVY CROCKETT weapons system in a simulated tactical situation
(2) Train military personnel in the use of tactical nuclear weapons under simulated battlefield conditions
(3) Obtain data on weapons effects characteristics from a low-yield nuclear detonation.

Weather: At shot-time, the temperature was 29.7 degrees Celsius. Winds were 15 knots from the south-southwest at surface level and 11 knots from the south-southeast at 10,000 feet.

Radiation Data: Three hours after shot-time, radiation intensities of 0.1 R/h or greater were confined to within 300 meters of ground zero except to the north, where they extended for about 3,000 meters. Six days after the detonation, radioactivity levels higher than 0.1 R/h were confined to an area 300 meters from ground zero.

Participants: Exercise IVY FLATS troops; Army Ballistic Research Laboratories; Army Engineer Waterways Experiment Station; Army Nuclear Defense Laboratory; Air Force Weapons Laboratory; Sandia Corporation; Air Force Special Weapons Center; Army Engineer Research and Development Laboratories; Army Electronics Research and Development Laboratory; Los Alamos Scientific Laboratory; AEC civilians; other contractors.

CHAPTER 8

SHOT LITTLE FELLER I

Shot LITTLE FELLER I was detonated on 17 July 1962 at 1000 hours Pacific Daylight Time in Area 18 of Yucca Flat, UTM coordinates 606069. Figures 8-1 and 8-2 show the LITTLE FELLER I event, figure 8-1 at 20 seconds after the detonation and figure 8-2 at 40 seconds after the detonation (29). Sponsored by the Department of Defense, LITTLE FELLER I was a stockpile DAVY CROCKETT tactical weapon, similar to Shot LITTLE FELLER II. Army personnel fired the device as part of IVY FLATS, the troop exercise conducted after the detonation. The LITTLE FELLER I device was detonated near the surface and had a low yield (5; 29; 31).

At shot-time, the temperature at the surface was 29.7 degrees Celsius. Winds were 15 knots from the south-southwest at the surface and 11 knots from the south-southeast at 10,000 feet. The top of the cloud formed by the shot reached 11,000 feet and moved north-northwest from the point of detonation (35).

Shot LITTLE FELLER I was originally planned as one of three LITTLE FELLER detonations. The original plans for these shots are outlined at the beginning of chapter 5.

8.1 EXERCISE IVY FLATS

Exercise IVY FLATS, with approximately 1,000 participating soldiers, involved more DOD personnel than any other Nevada Test Site Organization project conducted at Shot LITTLE FELLER I. Sponsored by Headquarters, Sixth Army, the maneuver was designed to:

- Test equipment, tactics, and techniques for use of the DAVY CROCKETT weapons system in ground combat



Figure 8-1: SHOT LITTLE FELLER I EVENT, LOOKING NORTH 20 SECONDS AFTER
DETONATION



Figure 8-2: SHOT LITTLE FELLER I EVENT. LOOKING NORTH 40 SECONDS AFTER
DETONATION

- Test the ability of Army personnel to operate under the conditions resulting from a low-yield nuclear detonation
- Give Army personnel experience in preparing and conducting a nuclear tactical exercise (46).

A task force from the 1st Mechanized Infantry Battalion, 12th Infantry, conducted the exercise. This task force consisted of elements from the units listed below. These units were all from the 4th Infantry Division, Fort Lewis, Washington, except for the Army Aviation Detachment (45).

| Unit | Number of Participants |
|--|---------------------------|
| Headquarters and Headquarters Company* | 199 |
| Company A | 193 |
| Company B (Command Post Exercise) | 6 |
| Company C (Command Post Exercise) | 6 |
| Artillery Battery | 91 |
| Forward Air Control Section | 2 |
| Liaison Section | 3 |
| Forward Observer Section | 6 |
| Survey Party | 8 |
| Maintenance Unit | 2 |
| Tank Platoon | 21 |
| Army Aviation Detachment | <u>12</u> |
| Total | 549 |

*Probably included the DAVY CROCKETT platoon

Company A was the only line company of the battalion to participate in this maneuver. Companies B and C were represented by command and communication elements only. Company A was supported in the exercise by a tank platoon, a 105mm artillery

battery, a battalion mortar element, elements of the Army Aviation Detachment, and a DAVY CROCKETT platoon. The DAVY CROCKETT platoon consisted of a headquarters, staffed by an officer and two enlisted men, and a heavy squad and a light squad, each with five men. The heavy squad operated a DAVY CROCKETT launcher mounted on an armored personnel carrier, and the light squad operated a launcher mounted on a 1/4-ton truck (45; 46).

In addition to the task force, a support group provided personnel, supply, transportation, and maintenance services for the task force and for the IVY FLATS Headquarters. This group consisted of the following units (45; 46):

| Unit | Home Station | Number of Participants |
|--|------------------------|------------------------|
| Command element | Fort Lewis, Washington | 5 |
| Explosive Ordnance Disposal Detachment | 6th Army* | 13 |
| Ordnance Officer | Fort Lewis | 1 |
| Quartermaster Officer | Fort Lewis | 1 |
| Warhead Supply Section | Fort Sill, Oklahoma | 8 |
| Maintenance Detachment, 3rd Echelon | | |
| • Ordnance Detachment | Fort Lewis | 21 |
| • Engineer Detachment | Fort Lewis | 5 |
| • Signal Detachment | Fort Lewis | 5 |
| Medical Support and Evacuation | 6th Army* | 20 |
| Army Aviation Detachment | 6th Army* | 39 |
| Army Aircraft Repair Team | 6th Army* | 23 |
| Transportation Section | 6th Army* | 20 |

*Home station unknown.

| | | |
|----------------------------------|--------------------------------------|------------|
| DAVY CROCKETT Display Section | 4th Infantry Division, Fort Lewis | 15 |
| Security Platoon | | |
| ● Security Detachment | 4th Infantry Division, Fort Lewis | 28 |
| ● Warhead Security Section | 4th Infantry Division, Fort Lewis | 4 |
| Total | | <u>208</u> |

A third category of military personnel participated in the maneuver as observers. Approximately 395 military and civilian DOD personnel, escorted by about 20 additional officers and 85 support personnel, observed the exercise from bleachers southwest of ground zero. The Control, Safety, and Evaluation Group comprised a fourth category of military participants. Some of these personnel accompanied the battalion task force, and others were at the command post during the maneuver to ensure that it was performed as closely to plan and as safely as possible (45; 46).

Exercise IVY FLATS was based on the following scenario. The United States was engaged in a war in which tactical nuclear weapons had been used. As part of a general offensive, a mechanized infantry battalion was given the mission of protecting the division right flank by seizing Objective 1. The battalion commander was allocated DAVY CROCKETT weapons, one of which was the nuclear warhead and the others high-explosive weapons, which were to simulate nuclear weapons. Company A of the battalion had priority of fire from a battery of 105mm howitzers. The company was also supported by a platoon of tanks and mortars. The maneuver, to be conducted shortly after the LITTLE FELLER I detonation, was designed so that soon after the attack was launched, an enemy threat to the right flank was to be discovered. The battalion commander would then use two high-explosive weapons

(simulated nuclear weapons) to neutralize this threat. Upon seizing Objective 1 and neutralizing the threat to the right flank, the exercise was to end (46).

To prepare for this exercise, the battalion task force observed Shot JOHNIE BOY, on 11 July, and received a briefing from NTSO instructors on the requirements of the planned maneuver. In addition, the task force conducted rehearsals on 13, 14, and 15 July 1962. On 17 July 1962, from 0400 to 0530 hours, trained personnel from the task force transported the weapons from the Special Ammunition Supply Point to the Delivery Unit Supply Point. From 0530 to 0630 hours, Delivery Unit Supply Point teams unpacked and inspected the weapons. They then gave one high-explosive weapon to each leader of the two five-man squads that were to participate in the exercise.

At 0600 hours, the troops arrived at the exercise ground, located in Area 18 of the Nevada Test Site. They took their positions at the locations shown in figure 8-3. From 0700 to 0800 hours, the light and heavy squads practiced firing the DAVY CROCKETT launchers to check and calibrate the range of weapon to the target. Scientific personnel then moved forward under the direction of DASA and the AEC to check instrumentation in the target area. Meanwhile, one L-20 flew an aerial survey mission to ensure that no unauthorized personnel were in or approaching the target area. By 0847 hours, all scientific personnel had left the shot area (46).

At 0930 hours, 30 minutes before the detonation, the AEC started its countdown for Shot LITTLE FELLER I. It announced the countdown over radio and public address systems located at the military observer bleacher sites, the control tower and the battalion headquarters, and mechanized company and tank platoon positions. Figure 8-3 shows these positions. From 0945 to 0955 hours, all personnel forward of the bleacher site entered

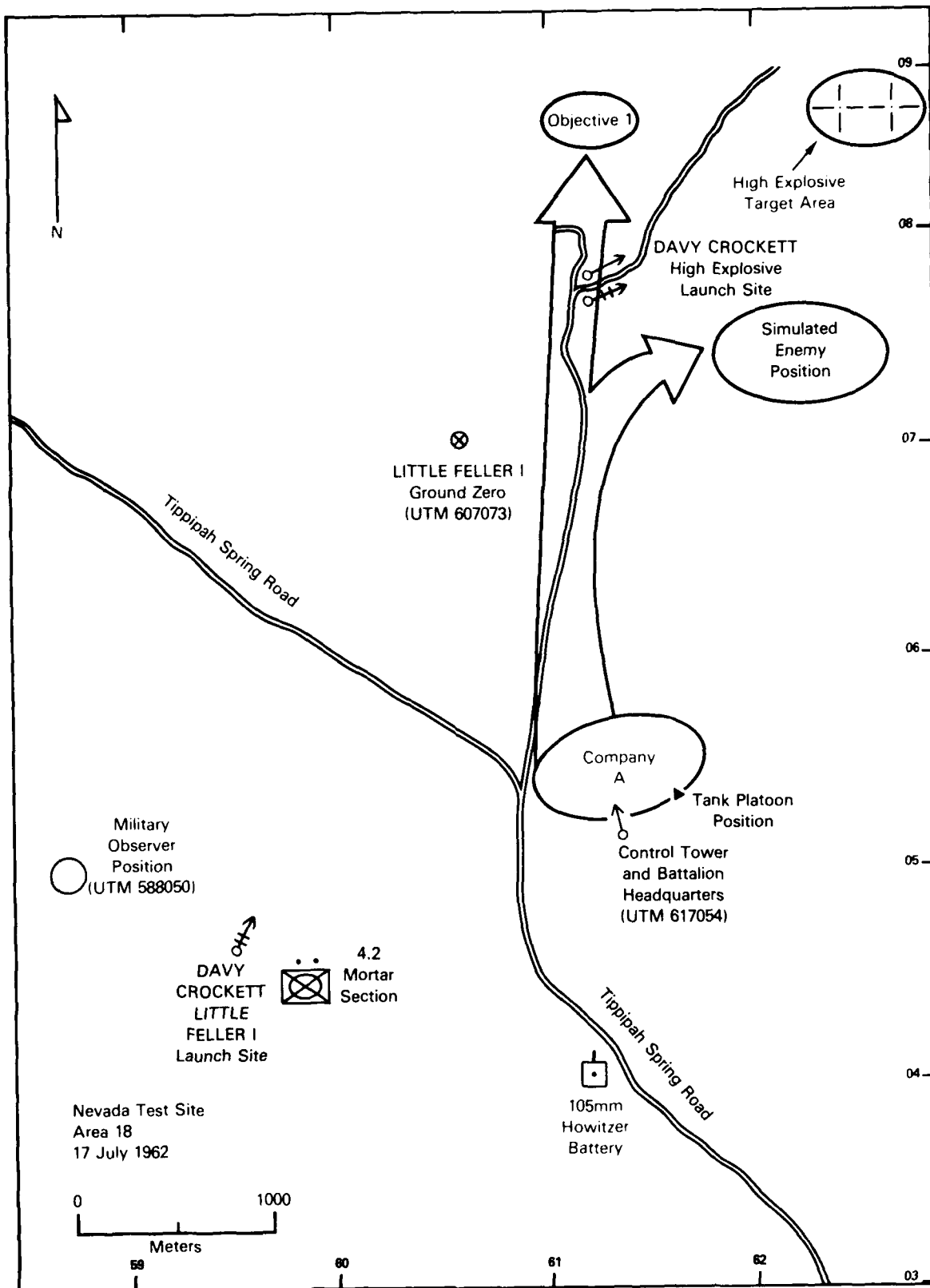


Figure 8-3: EXERCISE IVY FLATS MANEUVER AREA

previously prepared trenches, where they remained until after the detonation. Shot LITTLE FELLER I was launched at 1000 hours from the weapon launcher mounted on the armored personnel carrier. The warhead detonated on target, 2,853 meters from the firing position (46).

Three initial survey teams from the Radiological Safety Division traversed the south end of the area within a few minutes after the detonation to conduct a preliminary survey before the DOD exercises. At about 1003, the battalion commander assessed the damage from one H-23 helicopter flying over the shot area (46).

According to plans, the initial combat formation for the advance of Company A was to be a diamond with the tank platoon leading, the first and second rifle platoons following, and the third rifle platoon in the rear of the formation. Company A was to proceed north to the dismount area at about UTM 615085, where the platoons would dismount from armored personnel carriers and attack Objective 1 located nearby. Figure 8-4 shows Company A personnel after dismounting and in support of the tank platoon (29). The battalion commander estimated that the maneuver troops could seize the objective about 30 minutes after departure. Based on this estimate, he ordered the DAVY CROCKETT squads, both probably accompanied by radiological safety monitors, to a position on the ridge about 1,000 meters south of Objective 1. At about 1055 hours, the mortar and DAVY CROCKETT platoon leaders were to use conventional weapons to engage the target of opportunity. This target, shown in figure 8-3, was the location of the simulated enemy threat on the right flank. At the close of the maneuver, the light and heavy squads were to neutralize this threat by conventional fire.

At 1026 hours, after the radiation surveys were completed, the troops were ordered to enter their vehicles and move into the



Figure 8-4: COMPANY A PERSONNEL AFTER DISMOUNTING AND IN SUPPORT OF TANK PLATOON

shot area. The light DAVY CROCKETT squad was to move directly behind Company A, while the heavy squad was to move to the left of ground zero. The light squad had difficulties traveling cross-country, probably because of the sandy terrain. The heavy squad was required to alter its planned route, as it attempted to bypass a 12 R/h radiation area and veered farther away from ground zero. These difficulties delayed the firing of the high-explosive projectiles from 1055 to 1110 hours. At about 1050 hours, the heavy squad occupied the forward firing position, shown in figure 8-3. Shortly thereafter, the light squad reached its firing position (45; 46).

During the initial forward movement of Company A, the second rifle platoon and two tanks were detached from the main assault and deployed against a simulated enemy position at UTM coordinates 618075. The purpose of this deployment was to roll back the enemy at that position and to secure the right flank. The platoon and tanks were supported in their advance by 4.2-inch mortars, 81mm mortars, and 106mm recoilless rifles. The 105mm howitzer battery also provided support with an artillery barrage. After the platoon had seized the enemy position, the 81mm mortars and the two tanks rejoined Company A to support the main attack on Objective 1 (45; 46).

Company A, now consisting of the first and third rifle platoons and the tanks, continued the attack on Objective 1. It was supported by tank and mortar fire. Company A seized Objective 1 at 1059 hours. Meanwhile, as armed helicopters were employed against an enemy counterattack on the right flank, mortar and platoon leaders directed the firing of both DAVY CROCKETT high-explosive weapons at the enemy target, shown in figure 8-3, at 1115 hours. The ranges of the projectiles were 1,850 meters and 1,575 meters. The tactical exercise ended with the firing of these two weapons. All personnel forward of the line of departure moved to the battalion decontamination station

near the battalion command post. There, they were monitored for contamination and, if necessary, decontaminated (45; 46).

Military observers witnessed Shot LITTLE FELLER I and the IVY FLATS maneuver. They arrived by bus at the observation site, UTM coordinates 588050, about 90 minutes before the nuclear detonation. About 40 minutes before the shot, an instructor explained the planned maneuver to the observers. Wearing high-density goggles, the observers watched the detonation and subsequent maneuver from bleachers at the observation site. Using a chart, an easel, and a display of the DAVY CROCKETT weapon system located near the bleachers, the instructor described the maneuver as it was being conducted (45).

About 20 minutes after the conclusion of the maneuver, officers from the Visitors' Bureau escorted the observers to waiting buses, which took them to the target area. Leaving their buses, the observers viewed the weapon effects and listened to a 30-minute briefing from an instructor. They then boarded buses and went to the decontamination station to be monitored and, if necessary, decontaminated (45).

8.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT LITTLE FELLER I

Department of Defense personnel participated in a number of scientific projects conducted by the Weapons Effects Test Group at Shot LITTLE FELLER I. These projects and their participants are identified in table 8-1. DOD personnel also took part in AFSWC activities providing support to some of the test group projects and to the Test Manager.

Table 8-1: WEAPONS EFFECTS TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT LITTLE FELLER I

| Project/ Program | Title | Participants |
|---------------------|--|---|
| 1.1 | Airblast Phenomena from Small Yield Devices | Army Ballistic Research Laboratories |
| 2.3 | Neutron Flux Measurements | Army Nuclear Defense Laboratory |
| 2.4 | Integrated Gamma Dose Measurements | Army Nuclear Defense Laboratory |
| 2.8 | Radiological Surveys | Army Nuclear Defense Laboratory |
| 4.1 | Tissue Dosimetry | Air Force Weapons Laboratory; Army Signal Research and Development Laboratory; Los Alamos Scientific Laboratory |
| 6.6 | Initial Gamma Rate Measurements | Air Force Special Weapons Center |
| 6.6b | Electromagnetic Measurements | Air Force Special Weapons Center; Sandia Corporation |
| 7.17 | Radiological Water Decontamination Study | Army Engineer Research and Development Laboratories |
| 8.1 | High Time Resolution of the First Thermal Pulse | Army Electronics Research and Development Laboratory |
| 8.2 | <i>Fallout Hazard Determination by Fireball Spectroscopy</i> | Army Electronics Research and Development Laboratory |
| 9.2 | Documentary Photography | Field Command, DASA |
| 9.4 | Weapon Test Reports | Field Command, DASA |
| 9.5 | Communications | Field Command, DASA |
| 9.6 | General DOD Support | Field Command, DASA |
| 9.7 | Engineering and Field Operations | Field Command, DASA; Holmes and Narver; REEC |

8.2.1 Weapons Effects Tests

The Weapons Effects Test Group projects conducted at Shot LITTLE FELLER I were similar to those conducted at Shot LITTLE FELLER II but less extensive since the main objective of the shot was to test the DAVY CROCKETT weapons system and to stage the tactical exercise. The projects that were conducted were designed to provide data on the blast, shock, prompt nuclear radiation, and fallout effects of a low-yield nuclear detonation. Participants in these activities spent several weeks before the detonation placing and calibrating various types of instruments and gauges in the shot area. Project personnel accompanied by radiological safety monitors reentered the shot area at various times after the officially declared reentry hour to retrieve instruments and analyze data (5; 29; 31).

Project 1.1, Airblast Phenomena from Small Yield Devices, was conducted by the Army Ballistic Research Laboratories to:

- Measure the free-field overpressure and dynamic pressure versus time resulting from the detonation of a DAVY CROCKETT weapon
- Measure the free-air overpressure versus time resulting from the detonation of a DAVY CROCKETT weapon
- Integrate the results with existing subkiloton nuclear and multiton high-explosive data
- Provide supporting free-field measurements of blast parameters to other projects as required.

Project personnel placed nine self-recording gauges along a line 1.3 to 3,620 meters from ground zero. Only the gauge farthest from ground zero worked properly (65).

Project 2.3, Neutron Flux Measurements, was conducted by the Army Nuclear Defense Laboratory. The objective was to document neutron flux versus ground range. Project personnel installed neutron flux detectors 30 to 45 meters northeast of ground zero,

30 to 460 meters southeast of ground zero, and 30 to 730 meters southwest of ground zero. They attached most of the detectors to cables. Immediately after the detonation, project personnel, assisted by Project 7.2 participants, entered the shot area in an M-88 tank retriever to drag the cables out of the area. They transported the detectors to the Project 2.3 mobile laboratory at the Control Point (80).

Project 2.4, Integrated Gamma Dose Measurements, was conducted by the Army Nuclear Defense Laboratory to document gamma dose versus ground range. Before the detonation, project personnel installed gamma detectors along four lines, three of which were parallel to one another southeast of ground zero. The fourth line of instruments was southwest of ground zero. The gamma detectors, which project personnel attached to a recovery line, were positioned from 30 to 730 meters from ground zero. After the detonation, personnel from Projects 2.4 and 2.3 used an M-88 tank retriever to pull the recovery line out of the radiation field. They completed recovery within three hours after the detonation. The gamma detectors were then sent for analysis to the Army Nuclear Defense Laboratory and the Army Signal Research and Development Laboratory (79).

Project 2.8, Radiological Surveys, was conducted by the Army Nuclear Defense Laboratory. The objectives were to determine:

- Residual radiation patterns and decay rates resulting from a low-yield detonation
- Gamma exposure rates and decay rates.

To obtain data, ground-survey teams and helicopter-to-ground units surveyed radiation areas. In addition, personnel obtained information from a dose-recording instrument placed near the crater resulting from the detonation and from film badges positioned throughout the region of expected fallout (8).

Ground-survey stations were established along roads in the shot area. For LITTLE FELLER I, 12 new roads were made 60 to 1,500 meters downwind of ground zero. Beyond 1,500 meters, project personnel used the road networks established for Shots LITTLE FELLER II and JOHNNIE BOY and described in chapters 5 and 6 of this report. Upwind stake lines were southeast to southwest of ground zero (8).

The monitors followed the same basic procedures in conducting the surveys. These procedures are detailed in the Project 2.8 description for Shot LITTLE FELLER II.

The one ground survey conducted on the day of Shot LITTLE FELLER I was begun three hours after the detonation. Troop operations in the shot area following the detonation caused the delay in the onset of the survey. A survey to the 10 R/h line was not made until the first day after the detonation. This delay occurred because the monitors had previously participated at Shots LITTLE FELLER II and JOHNNIE BOY and had nearly reached their maximum permissible doses (8). To obtain information on the rate of decay, resurveys of selected stations were conducted on the second, third, and fourth days after the detonation. Personnel recovered film badges in the area during the third day after the shot (8).

Helicopter operations were limited for Shot LITTLE FELLER I because of the IVY FLATS maneuver in the area. Ninety minutes after the detonation, personnel placed an instrument near the crater using the procedures identified in the description for Shot LITTLE FELLER II. Four aerial survey missions were accomplished over the ground zero area on the day of detonation. Resurveys were conducted on the first and second days after the shot. The participating helicopters and crews were from the Marine Corps. Chemical Corps officers from Headquarters, Continental Army Command, Fort Monroe, Virginia, conducted the measurements from the aircraft (8).

Project 4.1, Tissue Dosimetry, was conducted by the Air Force Weapons Laboratory, with assistance from the Army Signal Research and Development Laboratory and the Los Alamos Scientific Laboratory. Objectives were to:

- Measure initial levels of neutron and gamma radiation in the shot area
- Measure and compare radiation levels in the air and at various depths in animal tissue and in synthetic materials equivalent in density to animal tissue
- Evaluate the performance of various types of dosimeters in field conditions.

Project personnel placed gamma and neutron dosimeters on stakes, inside sheep carcasses, and inside synthetic tissue materials. They located these test specimens 300, 400, and 460 meters from ground zero. Three hours after the detonation, three participants in two vehicles returned to the shot area and recovered the dosimeters. Five hours after the detonation, personnel began dosimetry readings, an activity continued until the day after the detonation (20; 74).

Project 6.6, Initial Gamma Rate Measurements, was conducted by the Air Force Special Weapons Center. Objectives were to:

- Measure the gamma dose rate as a function of time from time zero to 1,000 microseconds after the detonation
- Determine the feasibility of moving a fully instrumented bunker from one shot area to another.

Project personnel had constructed a bunker from a five-meter section of a metal pipe three meters in diameter, the ends of which were closed with steel plates. After the JOHNNIE BOY detonation, they used a flatbed truck to transport the material to the LITTLE FELLER I shot area. Participants then placed the bunker in a hole 70 meters southeast of ground zero and put gamma

detectors and automatic cameras inside the bunker. Two hours before the detonation, participants reentered the shot area to check the instruments and secure the bunker. For the first 30 seconds after the detonation, the instruments in the bunker automatically collected data. Project personnel returned to the shot area three days after the shot to recover film and other recorded data. They brought the film for processing to the EG&G photography trailer near the Control Point (63).

Project 6.6b, Electromagnetic Measurements, was conducted by the Air Force Special Weapons Center and the Sandia Corporation. The main objective was to obtain and correlate data concerning gamma radiation rates from a nuclear detonation, the resultant electromagnetic field, and field-induced currents in various cable configurations. Project personnel extended two copper wires from the southeast to within 15 meters of ground zero at a depth of one foot. They instrumented the wire for dynamic current measurements at 60 and 300 meters from ground zero and for passive current measurements at various other distances along the cables. Signals from these instruments were carried by wire to the recording station, where they were recorded on magnetic tapes (48).

Project 7.17, Radiological Water Decontamination Study, was conducted by the Army Engineer Research and Development Laboratories. The objectives were to evaluate:

- The effect of acidity or alkalinity, temperature, and time of contact upon the solubility of radioactive soil and debris in water
- Emergency methods of removing radioactive materials from water
- Army and Civil Defense field methods of determining the concentration of radioactive materials in water
- A proposed decontamination method for removing radioactivity from water.

Two days after the detonation, project participants took soil samples from the center of the crater. They removed the samples from the shot area and determined the specific activity of each sample. They then delivered the samples to a laboratory in Yucca Pass for analysis. There, personnel conducted solubility studies, tested instruments for detection of radioactivity in water, and tested Civil Defense and Army water decontamination techniques (61).

Project 8.1, High Time Resolution of the First Thermal Pulse, was conducted by the Army Electronics Research and Development Laboratory. The objective was to analyze the total energy in the thermal radiation pulse resulting from the detonation. The project was originally scheduled for LITTLE FELLER II, in addition to LITTLE FELLER I. However, since measuring equipment did not arrive at the NTS until 9 July 1962, after Shot LITTLE FELLER II, all measurements were made at LITTLE FELLER I.

Project participants installed photo detectors and oscilloscope cameras in the trailers of three small trucks parked in Area 18, about three kilometers from ground zero. Personnel monitored the detectors and cameras at the time of the detonation and analyzed data after the shot (6).

Project 8.2, Fallout Hazard Determination by Fireball Spectroscopy, was conducted by the Army Electronics Research and Development Laboratory. The objective was to determine the possibility of using spectroscopic analysis to predict the characteristics of fallout from a surface detonation. Project personnel placed two spectrometers connected to 35-millimeter movie cameras in the open with no special protection. The instruments, approximately 90 meters east of the forward control point, were about 3,660 meters from ground zero. The cameras,

started three seconds before shot-time, operated for approximately 18 seconds, as planned. The film was sent for development and analysis to the Army Electronics Research and Development Laboratory (9).

Projects 9.2, 9.4, 9.5, 9.6, and 9.7 were support projects conducted by Field Command, DASA, with the assistance of other DOD agencies or contractors. Much of the work done by these projects involved aerial and ground photography performed by the Army Pictorial Center; the Air Force Lookout Mountain Laboratories; EG&G, Incorporated; and the Sandia Corporation. Depending on the workload, the number of personnel directly involved numbered from one officer and seven enlisted men to four officers, 17 enlisted men, and four civilians (31).

Specific information is available on Project 9.2, Documentary Photography. On the day before the detonation, two project participants entered the shot area in one vehicle to take preshot photographs of ground zero. Two hours before the detonation, 12 participants drove into the shot area in three vehicles to establish a manned photography station 1.8 kilometers from ground zero. These personnel took still and motion pictures of the detonation. An aerial team also took part in the project. From 30 minutes before to 45 minutes after the detonation, three participants in one H-21 helicopter orbited south of ground zero and took documentary photographs (74).

8.2.2 Air Force Special Weapons Center Activities

Personnel from AFSWC and other Air Force units performed security, photography, cloud-sampling, courier, and cloud-tracking missions during Shot LITTLE FELLER I.

Security Sweep Missions

One L-20 aircraft, with a crew of two, and one H-13 helicopter, with a crew of about five, conducted a security check of the shot area prior to the detonation to ensure that all personnel had left the area and that no unauthorized vehicles were approaching (31).

Photography

One H-21 helicopter, probably with a crew of five, photographed the detonation (31).

Cloud Sampling

A B-57 aircraft, with a pilot and a radiological safety monitor, flew a cloud-sampling mission to obtain particulate cloud debris for analysis (31).

Cloud Tracking

A single U3A aircraft conducted a cloud-tracking mission (31).

8.3 RADIATION PROTECTION AT SHOT LITTLE FELLER I

In addition to the radiological safety program of the Nevada Test Site Organization, the Army established a separate radiological safety program for its IVY FLATS maneuver. Both programs followed the exposure guidelines established by the AEC. REECO Radiological Safety Division personnel trained the IVY FLATS monitors and provided them with instruments (5; 73).

8.3.1 IVY FLATS Radiation Protection Activities

The IVY FLATS Radiological Safety Control Section was responsible for the radiological safety of troops during the

maneuver. The Test Manager supervised the radiological safety program, but the Radiological Safety Officer was responsible for its operational direction. He was assisted by the Safety Control Officer who accompanied participating units into the shot area to implement safety procedures (46).

Dosimetry and Protective Equipment

Radiological safety personnel at the Final Assembly Station checked each troop participant to ensure that he had a film badge and that certain individuals in each unit had a pocket dosimeter. Maneuver troops did not wear special anticontamination clothing, but they were advised to keep their fatigues tucked securely into their boots and to keep their sleeves and collars tightly buttoned. Upon leaving the shot area, participants exchanged their film badges and turned in pocket dosimeters to personnel at the Final Assembly Station (46).

Monitoring

After NTSO personnel had conducted the initial ground survey and opened the area for the IVY FLATS maneuver, a scout section entered the shot area in advance of the troops and surveyed the area to determine and mark the 10 R/h intensity line, beyond which the troops could not advance. In addition to the scout section, radiological safety monitors accompanied the troops on their maneuvers. These monitors continually surveyed the areas over which the troops were passing in order to reroute them if they approached the 10 R/h intensity line. Rerouting of troop units was necessary twice during the operation, but most units did not encounter radiation levels greater than 1 R/h (46).

A helicopter with a REECO radiological safety monitor and an AFSWC pilot onboard conducted an aerial survey of the shot area during the maneuver. The survey's success was limited by poor radio communication between the helicopter and ground personnel

and by the pilot's unfamiliarity with the terrain in the shot area (46).

Decontamination

The REECO Radiological Safety Division was responsible for monitoring and, if necessary, decontaminating IVY FLATS personnel and vehicles. Personnel from the division and from the IVY FLATS Radiological Safety Control Section established and operated several decontamination stations outside the shot area. After leaving the shot area, personnel and vehicles first stopped at the initial decontamination area, where radiological safety personnel removed loose contamination by brushing and sweeping the outer garments of personnel and the surfaces and undercarriages of vehicles. From this area, the maneuver troops walked to the Personnel Check Point for monitoring, while the vehicles were driven to the Vehicle Check Point. Uncontaminated personnel and vehicles continued directly to the Film Badge Exchange Station in the Final Assembly Area and then returned to duty. Contaminated personnel and vehicles were sent from the checkpoints to the Personnel Decontamination Station or the Vehicle Decontamination Station. Shower facilities were provided for the decontamination of personnel. Vehicles were decontaminated by washing with detergent and water. After they were decontaminated, personnel and vehicles proceeded to the Film Badge Exchange Station and then returned to duty (46).

8.3.2 Nevada Test Site Organization Radiation Protection Activities

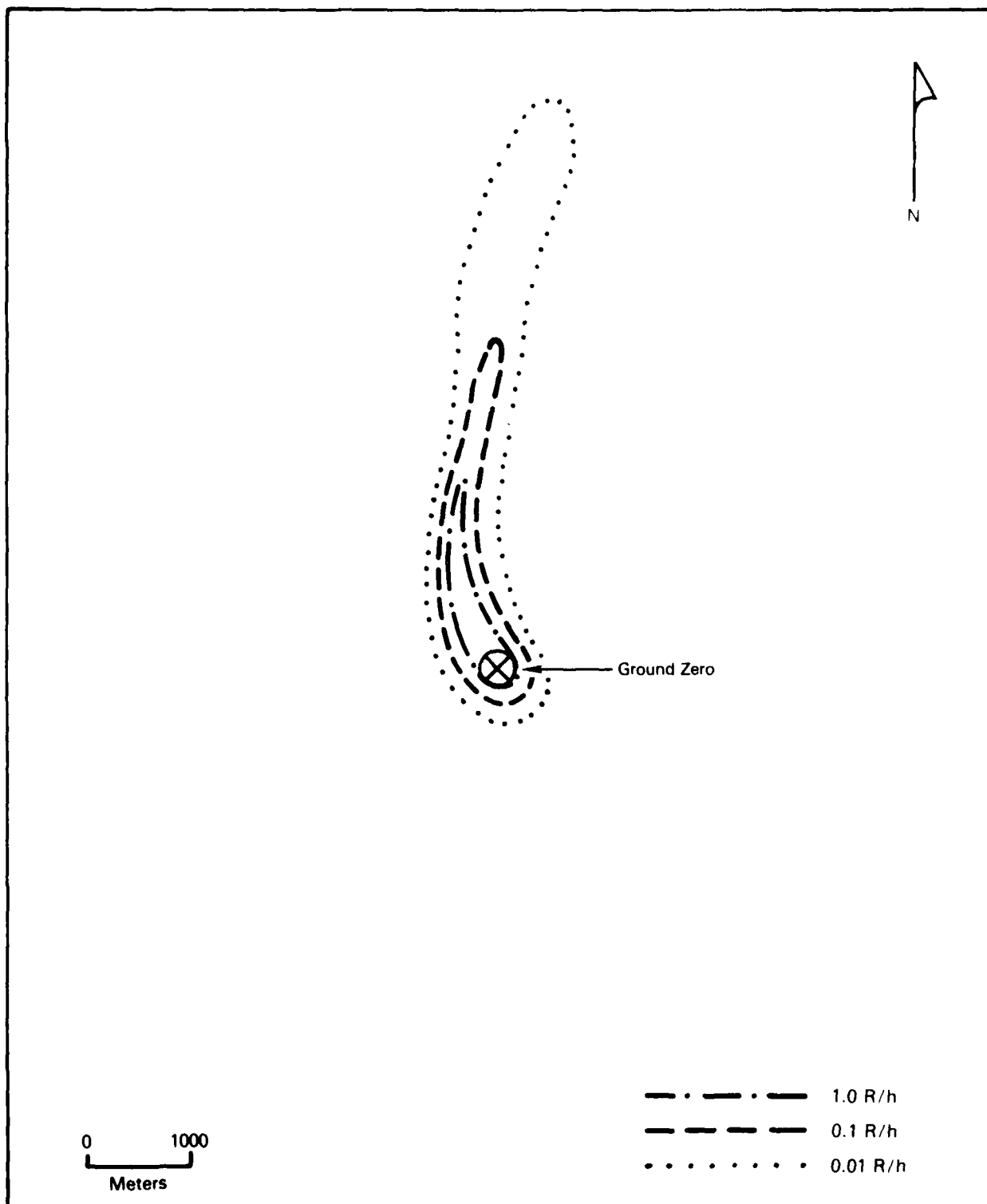
Information is available on the results of onsite and offsite monitoring and the procedures used to control reentry into the shot area at LITTLE FELLER I. Decontamination of personnel and vehicles has also been documented.

Monitoring

The initial monitoring party, consisting of three two-man teams in radio-equipped vehicles, entered the shot area immediately after the detonation to conduct a preliminary survey. Results of this survey were radioed to the IVY FLATS organization before the beginning of the maneuver. Preliminary information on gamma and beta radiation was also obtained from 13 remote radiation detection stations located 300 to 1,200 meters from ground zero. Two of these stations were south and another was southeast of ground zero. The other ten stations were positioned west to east in a clockwise pattern from ground zero (73). After the maneuver, the NTSO monitoring teams made a complete survey of the shot area and transmitted the data to the plotting facilities at the Command Post. Using this information, Radiological Safety Division personnel plotted an isointensity map showing the 0.01, 0.1, and 1 R/h radiation lines (73). Figure 8-5 presents results of the NTSO survey.

Ground monitoring teams conducted subsequent surveys one and six days after the detonation. The day after the detonation, the 1 R/h area was confined to within 100 meters of ground zero, except to the northwest, where it extended to 450 meters. The 0.01 R/h area was contained within about 300 meters of ground zero except to the northwest, where it extended beyond 2,000 meters. By the sixth day, gamma intensities around ground zero were less than 1 R/h. The 0.1 R/h line was within 30 meters of ground zero except to the northwest, where it extended about 300 meters (73).

USPHS personnel, supported by REECO radiological safety personnel, conducted offsite monitoring at Shot LITTLE FELLER I. Seven mobile monitoring teams conducted ground surveys in areas north of ground zero. They detected gamma readings ranging from background up to 0.016 R/h at Goldflat Junction near Mellan,



**Figure 8-5: ISOINTENSITY MAP FOR SHOT LITTLE FELLER I
THREE HOURS AFTER DETONATION**

Nevada, located about 50 kilometers north of ground zero. They encountered only background readings in other offsite areas. In addition, USPHS personnel in a U3A aircraft conducted a cloud survey. During the mission, which took about two hours, the highest gamma reading recorded within the aircraft was 1 R/h (69).

Reentry Procedures

After the initial onsite ground survey was completed, the Test Manager opened the shot area for recovery operations. To prevent unauthorized entry, roads leading into the shot area had been barricaded, and radiological safety personnel from REEC0 established a base station and mobile check station on the main access road to ground zero. The base station was about 2.5 kilometers southeast of ground zero. Personnel had to pass through the base station and the check station to enter the shot area. Radiological safety personnel at the mobile station checked each group to ensure that it had an authorized access permit and that each individual wore anticontamination clothing, a film badge, and a pocket dosimeter. Personnel at the base station issued anticontamination clothing and pocket dosimeters to participants entering either the shot area or fallout pattern areas. Radiological Safety Division personnel provided similar support for aircraft and personnel staging from Indian Springs AFB (5; 73).

Reentry occurred in two phases, the first of which began about three minutes after the detonation and ended about 25 minutes after the detonation. This phase engaged only one recovery party, which obtained rapid decay data on neutron and gamma flux that would have been lost on a later effort. The rest of the reentry teams delayed operations until the conclusion of Exercise IVY FLATS. The second reentry phase began about three hours after the detonation and continued in the daylight hours through the sixth day after the detonation (31).

Decontamination

REECo radiological safety personnel operated a monitoring and decontamination facility at the base station for personnel and vehicles leaving the shot area (5; 73). They also operated the facility at Indian Springs AFB for monitoring and decontaminating personnel and aircraft involved with cloud sampling and other missions (44).

REFERENCE LIST

The following list of references represents all the documents consulted during the preparation of the Operation DOMINIC II volume.

The project reports for DOMINIC II bear both Weapons Test (WT) and Project Officer Report (POR) alpha-numeric designations. The National Technical Information Service uses the POR prefix and the Coordination and Information Center uses both designations. The WT prefix is used in this listing.

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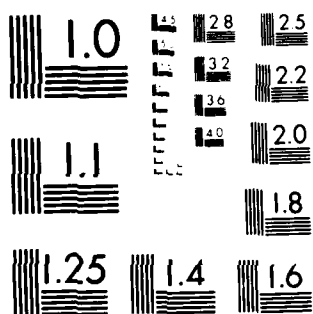
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25 cy ATTN: TITL

Defense Tech Info Center
12 cy ATTN: DD

Field Command
Defense Nuclear Agency
ATTN: FCTT, W. Summa
ATTN: FCLS, MAJ D. Norton
ATTN: FCTT, G. Ganong
ATTN: FCLS
ATTN: FCTXE

Interservice Nuclear Weapons School
ATTN: TTV

National Defense University
ATTN: ICAF, Tech Library

DEPARTMENT OF THE ARMY

Army Library
ATTN: Military Documents Sect

Army Nuclear Test Personnel Review
2 cy ATTN: DAAG-AMR, R. Tago

U.S. Army Center of Military History
ATTN: DAMH-HSO

U.S. Army Chemical School
ATTN: ATZN-CM-AL
ATTN: ATZN-CM-CS

U.S. Army Comd & General Staff College
ATTN: Library

U.S. Army Nuclear & Chemical Agency
ATTN: Library

U.S. Army War College
ATTN: Library

U.S. Military Academy
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DEPARTMENT OF THE NAVY

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ATTN: Library

Bureau of Medicine and Surgery
ATTN: Asst. for Medical Surgery

James Carson Breckinridge Lib
ATTN: Library Div

Marine Corps Base
ATTN: Document Custodian

Marine Corps Dev & Education Command
ATTN: J. C. Breckinridge Lib

Marine Corps Historical Center
2 cy ATTN: Code HDH-2

Marine Corps Nuc Test Personnel Review
ATTN: Code MSRB-60

Merchant Marine Academy
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Naval Historical Center
ATTN: Operational Archives Branch

Naval Hospital Corps School
ATTN: Library

Naval Ocean Systems Center
ATTN: Library

Naval Oceanographic Office
ATTN: Code 025, Historian

Naval Postgraduate School
ATTN: Code 1424, Library

Naval Research Laboratory
ATTN: Library

Naval School
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Naval Sea Systems Command
ATTN: Nuclear Technology Div

Naval Surface Weapons Center
ATTN: Library

Naval War College
ATTN: Professor 8 Libraries

Naval Weapons Center
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DEPARTMENT OF THE NAVY (Continued)

Navy Department Library
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Navy Nuclear Power School
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Navy Nuclear Test Personnel Review
2 cy ATTN: W. Loeffler

Nimitz Library
ATTN: Documents & Reports Dept

Office of the Judge Adv Gen
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U.S. Merchant Marine Academy
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U.S. Naval Air Station Library
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DEPARTMENT OF THE AIR FORCE

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Air Force Communications Command
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Air Force Institute of Technology
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Air Force Logistics Command
ATTN: Historian

Air Force Nuclear Test Personnel Review
ATTN: HQ USAF/SGES

Air Force Systems Command
ATTN: Historian

Air Force Technical Applications Ctr
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Air Force Weapons Laboratory
ATTN: Tech Library

Air National Guard
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Air Training Command
ATTN: Historian

Air University Library
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Military Airlift Command
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Pacific Air Forces
ATTN: Historian

Strategic Air Command
ATTN: Historian
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DEPARTMENT OF THE AIR FORCE (Continued)

Tactical Air Command
ATTN: Historian

U.S. Air Force Academy Library
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U.S. Air Force Occupational & Env Health Lab
ATTN: NTPR

USAF School of Aerospace Medicine
ATTN: Strughold Library

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Nevada Operations Office
ATTN: Health Physics Div
2 cy ATTN: R. Nutley

Human Health & Assessments Div
ATTN: Librarian

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Lawrence Livermore National Lab
ATTN: Technical Info Dept Library

Los Alamos National Laboratory
ATTN: M. Walz, ADLA MS A183
ATTN: D. Cobb, ESS MSS D466
2 cy ATTN: Library
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Reynolds Electrical & Engr Co, Inc
ATTN: CIC
ATTN: W. Brady

Sandia National Lab
ATTN: Central Library
ATTN: W. Hereford

OTHER GOVERNMENT AGENCIES

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ATTN: G. Caldwell

Central Intelligence Agency
ATTN: Office of Medical Services

Dept of Health & Human Svcs
ATTN: Office of General Counsel

Exec Ofc of the President
Management & Budget Ofc Lib
ATTN: Librarian

Library of Congress
ATTN: Library Service Division
ATTN: Science & Technology Div
ATTN: Serial & Govt Publication

OTHER GOVERNMENT AGENCIES (Continued)

National Archives
ATTN: Librarian

National Atomic Museum
ATTN: Historian

Department of Commerce
ATTN: Librarian

Occupational Safety & Health Admin
ATTN: Library

Office of Health & Disability
ATTN: R. Copeland

Office of Workers Compensation Pgrm
ATTN: R. Larson

U.S. Coast Guard Academy Library
ATTN: Librarian

U.S. House of Representatives
2 cy ATTN: Committee on Armed Services

U.S. House of Representatives
ATTN: Subcommittee on Health & Envir

U.S. Senate
ATTN: Committee on Veterans Affairs

U.S. Senate
ATTN: Committee on Veterans Affairs

Veterans Administration - RO
Providence, RI
ATTN: Director

Veterans Administration
Washington, D.C.
ATTN: Board of Veteran Appeal

Veterans Administration - Ofc Central
Washington, D.C.
ATTN: Dept Veterans Benefit, Central Ofc
ATTN: Director

Veterans Administration - RO
Montgomery, AL
ATTN: Director

Veterans Administration - RO
Anchorage, AK
ATTN: Director

Veterans Administration - RO
Phoenix, AZ
ATTN: Director

Veterans Administration - RO
Little Rock, AR
ATTN: Director

Veterans Administration -RO
Los Angeles, CA
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration - RO
San Francisco, CA
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Veterans Administration - RO
Denver, CO
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Veterans Administration - RO
Hartford, CT
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Veterans Administration - RO
Wilmington, DE
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Veterans Administration - RO
St. Petersburg, FL
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Veterans Administration - RO
Atlanta, GA
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Veterans Administration - RO
Honolulu, HI
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Veterans Administration - RO
Chicago, IL
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Veterans Administration - RO
Seattle, WA
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Veterans Administration - RO
Indianapolis, IN
ATTN: Director

Veterans Administration - RO
Des Moines, IA
ATTN: Director

Veterans Administration - RO
Wichita, KS
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Veterans Administration - RO
Louisville, KY
ATTN: Director

Veterans Administration - RO
New Orleans, LA
ATTN: Director

Veterans Administration - RO
Togus, ME
ATTN: Director

Veterans Administration - RO
Baltimore, MD
ATTN: Director

Veterans Administration - RO
Boston, MA
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

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St. Paul, MN
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Veterans Administration - RO
Jackson, MS
ATTN: Director

Veterans Administration - RO
Huntington, WV
ATTN: Director

Veterans Administration - RO
St. Louis, MO
ATTN: Director

Veterans Administration - RO
Fort Harrison, MT
ATTN: Director

Veterans Administration - RO
Lincoln, NE
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Veterans Administration - RO
Reno, NV
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Veterans Administration - RO
Manchester, NH
ATTN: Director

Veterans Administration - RO
Newark, NJ
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Veterans Administration - RO
Milwaukee, WI
ATTN: Director

Veterans Administration - RO
Albuquerque, NM
ATTN: Director

Veterans Administration - RO
Buffalo, NY
ATTN: Director

Veterans Administration - RO
New York, NY
ATTN: Director

Veterans Administration - RO
Winston Salem, NC
ATTN: Director

Veterans Administration - RO
Fargo, ND
ATTN: Director

Veterans Administration - RO
Cleveland, OH
ATTN: Director

Veterans Administration - RO
Muskogee, OK
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration - RO
Portland, OR
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Veterans Administration - RO
Pittsburgh, PA
ATTN: Director

Veterans Administration - RO
Philadelphia, PA
ATTN: Director

Veterans Administration - RO
APO San Francisco
ATTN: Director

Veterans Administration - RO
San Juan, Puerto Rico
ATTN: Director

Veterans Administration - RO
Columbia, SC
ATTN: Director

Veterans Administration - RO
Sioux Falls, SD
ATTN: Director

Veterans Administration - RO
Houston, TX
ATTN: Director

Veterans Administration - RO
Waco, TX
ATTN: Director

Veterans Administration - RO
Salt Lake City, UT
ATTN: Director

Veterans Administration - RO
White River Junction, VT
ATTN: Director

Veterans Administration - RO
Roanoke, VA
ATTN: Director

Veterans Administration - RO
Cheyenne, WY
ATTN: Director

Veterans Administration - RO
San Diego, CA
ATTN: Director

Veterans Administration - RO
Boise, ID
ATTN: Director

Veterans Administration - RO
Detroit, MI
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans administration - RO
Nashville, TN
ATTN: Director

The White House
ATTN: Domestic Policy Staff

DEPARTMENT OF DEFENSE CONTRACTORS

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JAYCOR
ATTN: A. Nelson
10 cy ATTN: Health & Environment Div

Kaman Tempo
ATTN: E. Martin
ATTN: DASAC

Kaman Tempo
ATTN: R. Miller

Kaman Tempo
10 cy ATTN: C. Jones

National Academy of Sciences
ATTN: C. Robinette
ATTN: Medical Follow-up Agency
ATTN: National Materials Advisory Board

Pacific-Sierra Research Corp
ATTN: H. Brode, Chairman SAGE

R & D Associates
ATTN: P. Haas

Science Applications, Inc
ATTN: Tech Library

Science Applications, Inc
10 cy ATTN: L. Novotney

OTHER

Adams State College
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Akron Public Library
ATTN: Govt Publication Librarian

Alabama St Dept of Archives & History
ATTN: Military Records Division

University of Alabama
ATTN: Reference Dept/Documents

University of Alaska
ATTN: Director of Libraries

University of Alaska
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OTHER (Continued)

Albany Public Library
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Alexander City State Jr College
ATTN: Librarian

Allegheny College
ATTN: Librarian

Allen County Public Library
ATTN: Librarian

Altoona Area Public Library
ATTN: Librarian

American Statistics Index
ATTN: Cathy Jarvey

Anaheim Public Library
ATTN: Librarian

Andrews Library, College of Wooster
ATTN: Government Documents

Angelo State University Library
ATTN: Librarian

Angelo Jacoboni Pub Lib
ATTN: Librarian

Anoka County Library
ATTN: Librarian

Appalachian State University
ATTN: Library Documents

Arizona State University Library
ATTN: Librarian

University of Arizona
ATTN: Gov Doc Dept, C. Bower

Arkansas College Library
ATTN: Library

Arkansas Library Comm
ATTN: Library

Arkansas State University
ATTN: Library

University of Arkansas
ATTN: Government Documents Div

Austin College
Arthur Hopkins Library
ATTN: Librarian

Atlanta Public Library
ATTN: Ivan Allen Dept

Atlanta University Center
ATTN: Librarian

OTHER (Continued)

Auburn Univ at Montgomery Lib
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B. Davis Schwartz Mem Lib
ATTN: Librarian

Bangor Public Library
ATTN: Librarian

Bates College Library
ATTN: Librarian

Baylor University Library
ATTN: Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

Benjamin F. Feinberg Library
State University College
ATTN: Government Documents

Bierce Library, Akron University
ATTN: Government Documents

Boston Public Library
ATTN: Documents Department

Bowdoin College
ATTN: Librarian

Bowling Green State Univ
ATTN: Govt Docs Services

Bradley University
ATTN: Govt Publication Librarian

Brandeis University Lib
ATTN: Documents Section

Brigham Young University
ATTN: Librarian

Brigham Young University
ATTN: Documents Collection

Brookhaven National Laboratory
ATTN: Technical Library

Brooklyn College
ATTN: Documents Division

Broward County Library Sys
ATTN: Librarian

Brown University
ATTN: Librarian

Bucknell University
ATTN: Reference Dept

OTHER (Continued)

Buffalo & Erie Co Pub Lib
ATTN: Librarian

Burlington Library
ATTN: Librarian

California at Fresno State Univ Lib
ATTN: Library

California at San Diego University
ATTN: Documents Department

California at Stanislaus St Clg Lib
ATTN: Library

California St Polytechnic Univ Lib
ATTN: Librarian

California St Univ at Northridge
ATTN: Gov Doc

California State Library
ATTN: Librarian

California State Univ at Long Beach Lib
ATTN: Librarian

California State University
ATTN: Librarian

California State University
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California Univ Library
ATTN: Govt Publications Dept

California Univ Library
ATTN: Librarian

California University Library
ATTN: Govt Documents Dept

California University Library
ATTN: Documents Sec

California University
ATTN: Government Documents Dept

Calvin College Library
ATTN: Librarian

Calvin T. Ryan Library
Kearney State College
ATTN: Govt Documents Dept

Carleton College Library
ATTN: Librarian

Carnegie Library of Pittsburgh
ATTN: Librarian

Carnegie Mellon University
ATTN: Director of Libraries

OTHER (Continued)

Carson Regional Library
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Case Western Reserve University
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University of Central Florida
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Central Michigan University
ATTN: Library Documents Section

Central Missouri State Univ
ATTN: Government Documents

Central State University
ATTN: Library Documents Dept

Central Washington University
ATTN: Library Docs Section

Central Wyoming College Library
ATTN: Librarian

Charleston County Library
ATTN: Librarian

Charlotte & Mecklenburg County Pub Lib
ATTN: E. Correll

Chattanooga Hamilton Co
ATTN: Librarian

Chesapeake Pub Lib System
ATTN: Librarian

Chicago Public Library
ATTN: Governments Publications Dept

State University of Chicago
ATTN: Librarian

Chicago University Library
ATTN: Director of Libraries
ATTN: Documents Processing

Cincinnati University Library
ATTN: Librarian

Claremont Colleges Libs
ATTN: Doc Collection

Clemson University
ATTN: Director of Libraries

Cleveland Public Library
ATTN: Documents Collection

Cleveland State Univ Lib
ATTN: Librarian

Coe Library
ATTN: Documents Division

OTHER (Continued)

Colgate Univ Library
ATTN: Reference Library

Colorado State Univ Libs
ATTN: Librarian

Colorado University Libraries
ATTN: Director of Libraries

Columbia University Library
ATTN: Documents Service Center

Columbus & Franklin Cty Public Lib
ATTN: Gen Rec Div

Compton Library
ATTN: Librarian

Connecticut State Library
ATTN: Librarian

University of Connecticut
ATTN: Govt of Connecticut

Connecticut University
ATTN: Director of Libraries

Cornell University Lib
ATTN: Librarian

Corpus Christi State University Lib
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Culver City Library
ATTN: Librarian

Curry College Library
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Dallas County Public Library
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Dallas Public Library
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Dalton Jr College Library
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Dartmouth College
ATTN: Librarian

Davenport Public Library
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Davidson College
ATTN: Librarian

Dayton & Montgomery City Pub Lib
ATTN: Librarian

University of Dayton
ATTN: Librarian

OTHER (Continued)

Decatur Public Library
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Dekalb Comm Coll So Cpus
ATTN: Librarian

Delaware Pauw University
ATTN: Librarian

University of Delaware
ATTN: Librarian

Delta College Library
ATTN: Librarian

Delta State University
ATTN: Librarian

Denison Univ Library
ATTN: Librarian

Denver Public Library
ATTN: Documents Div

Dept of Lib & Archives
ATTN: Librarian

Detroit Public Library
ATTN: Librarian

Dickinson State College
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Drake Memorial Learning Resource Ctr
ATTN: Librarian

Drake University
ATTN: Cowles Library

Drew University
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Duke University
ATTN: Public Docs Dept

Duluth Public Library
ATTN: Documents Section

Earlham College
ATTN: Librarian

East Carolina University
ATTN: Library Docs Dept

East Central University
ATTN: Librarian

East Islip Public Library
ATTN: Librarian

East Orange Public Lib
ATTN: Librarian

East Tennessee State Univ Sherrod Lib
ATTN: Documents Dept

OTHER (Continued)

East Texas State University
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Eastern Branch
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Eastern Illinois University
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Eastern Kentucky University
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Eastern Michigan University Lib
ATTN: Documents Libn

Eastern Montana College Library
ATTN: Documents Dept

Eastern New Mexico Univ
ATTN: Librarian

Eastern Oregon College Library
ATTN: Librarian

Eastern Washington Univ
ATTN: Librarian

El Paso Public Library
ATTN: Documents & Geneology Dept

Elko County Library
ATTN: Librarian

Elmira College
ATTN: Librarian

Elon College Library
ATTN: Librarian

Enoch Pratt Free Library
ATTN: Documents Office

Emory University
ATTN: Librarian

Evansville & Vanderburgh County Pub Lib
ATTN: Librarian

Everett Public Library
ATTN: Librarian

Fairleigh Dickinson Univ
ATTN: Depository Dept

Florida A & M Univ
ATTN: Librarian

Florida Atlantic Univ Lib
ATTN: Div of Public Documents

Florida Institute of Tech Lib
ATTN: Federal Documents Dept

Florida Intl Univ Library
ATTN: Docs Section

OTHER (Continued)

Florida State Library
ATTN: Documents Section

Florida State University
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Florida University Libraries
ATTN: Documents Dept

Fond Du Lac Public Lib
ATTN: Librarian

Fort Hays State University
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Fort Worth Public Library
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Free Pub Lib of Elizabeth
ATTN: Librarian

Free Public Library
ATTN: Librarian

Freeport Public Library
ATTN: Librarian

Fresno County Free Library
ATTN: Librarian

Gadsden Public Library
ATTN: Librarian

Garden Public Library
ATTN: Librarian

Gardner Webb College
ATTN: Documents Librn

Gary Public Library
ATTN: Librarian

Georgetown Univ Library
ATTN: Govt Docs Room

Georgia Inst of Tech
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Georgia Southern College
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Georgia Southwestern College
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Georgia State Univ Lib
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University of Georgia
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Glassboro State College
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Gleeson Library
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OTHER (Continued)

Government Publications Library-M
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Graceland College
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Grand Forks Public City-County Library
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Grand Rapids Public Library
ATTN: Director of Libraries

Greenville County Library
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Guam RFK Memorial University Lib
ATTN: Fed Depository Collection

University of Guam
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Gustavus Adolphus College
ATTN: Library

Hardin-Simmons University Library
ATTN: Librarian

Hartford Public Library
ATTN: Librarian

Harvard College Library
ATTN: Director of Libraries

Harvard College Library
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University of Hawaii
ATTN: Government Docs Collection

Hawaii State Library
ATTN: Federal Documents Unit

University of Hawaii at Monoa
ATTN: Director of Libraries

University of Hawaii
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Haydon Burns Library
ATTN: Librarian

Henry Ford Comm College Lib
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Herbert H. Lehman College
ATTN: Library Documents Division

Hofstra Univ Library
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Hollins College
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Hoover Institution
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OTHER (Continued)

Hopkinsville Comm College
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University of Houston, Library
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Houston Public Library
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Hoyt Public Library
ATTN: Librarian

Humboldt State College Library
ATTN: Documents Dept

Huntington Park Library
ATTN: Librarian

Hutchinson Public Library
ATTN: Librarian

Idaho Public Lib & Info Center
ATTN: Librarian

Idaho State Library
ATTN: Librarian

Idaho State University Library
ATTN: Documents Dept

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

University of Illinois, Library
ATTN: Documents Section

Illinois State Library
ATTN: Government Documents Branch

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

Illinois Valley Comm Coll
ATTN: Library

Indiana State Library
ATTN: Serial Section

Indiana State University
ATTN: Documents Libraries

Indiana University Library
ATTN: Documents Department

Indianapolis Marion Cty Pub Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Govt Documents Dept

Iowa University Library
ATTN: Government Documents Dept

OTHER (Continued)

Butler University, Irwin Library
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James Madison University
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Jefferson County Public Lib
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Jersey City State College
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Johns Hopkins University
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John J. Wright Library, La Roche College
ATTN: Librarian

Johnson Free Public Lib
ATTN: Librarian

Kahului Library
ATTN: Librarian

Kalamazoo Public Library
ATTN: Librarian

Kansas City Public Library
ATTN: Documents Div

Kansas State Library
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Kansas State Univ Library
ATTN: Documents Dept

University of Kansas
ATTN: Director of Libraries

Kent State University Library
ATTN: Documents Div

Kentucky Dept of Library & Archives
ATTN: Documents Section

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

Kenyon College Library
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Lake Forest College
ATTN: Librarian

Lake Sumter Comm Coll Lib
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Lakeland Public Library
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OTHER (Continued)

Lancaster Regional Library
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Lawrence University
ATTN: Documents Dept

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

Library & Statutory Distribution & Svc
2 cy ATTN: Librarian

Little Rock Public Library
ATTN: Librarian

Long Beach Publ Library
ATTN: Librarian

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

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

Louisville Free Pub Lib
ATTN: Librarian

Louisville Univ Library
ATTN: Librarian

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

Maine Maritime Academy
ATTN: Librarian

Maine University at Orono
ATTN: Librarian

University of Maine
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Manchester City Library
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Mankato State College
ATTN: Govt Publications

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

Marathon County Public Library
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Marshall Brooks Library
ATTN: Librarian

University of Maryland
ATTN: McKeldin Libr Docs Div

University of Maryland
ATTN: Librarian

OTHER (Continued)

University of Massachusetts
ATTN: Government Docs College

McNeese State Univ
ATTN: Librarian

Memphis Shelby County Pub Lib & Info Ctr
ATTN: Librarian

Memphis State University
ATTN: Librarian

Mercer University
ATTN: Librarian

Mesa County Public Library
ATTN: Librarian

University of Miami, Library
ATTN: Government Publications

Miami Public Library
ATTN: Documents Division

Miami Univ Library
ATTN: Documents Dept

Michel Orradre Library
University of Santa Clara
ATTN: Documents Div

Michigan State Library
ATTN: Librarian

Michigan State University Library
ATTN: Librarian

Michigan Tech University
ATTN: Library Documents Dept

University of Michigan
ATTN: Acq Sec Documents Unit

Middlebury College Library
ATTN: Librarian

Millersville State Coll
ATTN: Librarian

Milne Library
State University of New York
ATTN: Docs Librn

Milwaukee Pub Lib
ATTN: Librarian

Minneapolis Public Lib
ATTN: Librarian

Minnesota Div of Emergency Svcs
ATTN: Librarian

Minot State College
ATTN: Librarian

Mississippi State University
ATTN: Librarian

OTHER (Continued)

University of Mississippi
ATTN: Director of Libraries

Missouri Univ at Kansas City Gen
ATTN: Librarian

Missouri University Library
ATTN: Government Documents

M.I.T. Libraries
ATTN: Librarian

Mobile Public Library
ATTN: Governmental Info Division

Moffett Library
ATTN: Librarian

Montana State Library
ATTN: Librarian

Montana State University, Library
ATTN: Librarian

University of Montana
ATTN: Documents Div

Moorhead State College
ATTN: Library

Mt Prospect Public Lib
ATTN: Librarian

Murray State Univ Lib
ATTN: Library

Nassau Library System
ATTN: Librarian

Natrona County Public Library
ATTN: Librarian

Nebraska Library Comm
ATTN: Librarian

Univ of Nebraska at Omaha
ATTN: Librarian

Nebraska Western College Library
ATTN: Librarian

Univ of Nebraska at Lincoln
ATTN: Director of Libraries

Univ of Nevada at Reno
ATTN: Governments Pub Dept

Univ of Nevada at Las Vegas
ATTN: Director of Libraries

New Hampshire University Lib
ATTN: Librarian

New Hanover County Public Library
ATTN: Librarian

Nebraska University Lib
ATTN: Acquisitions Dept

OTHER (Continued)

New Mexico State Library
ATTN: Librarian

New Mexico State University
ATTN: Lib Documents Div

University of New Mexico
ATTN: Director of Libraries

University of New Orleans Library
ATTN: Govt Documents Div

New Orleans Public Lib
ATTN: Library

New York Public Library
ATTN: Librarian

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

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

New York State Univ Col at Cortland
ATTN: Librarian

State Univ of New York
ATTN: Library Documents Sec

State Univ of New York
ATTN: Librarian

New York State University
ATTN: Documents Center

State University of New York
ATTN: Documents Dept

New York University Library
ATTN: Documents Dept

Newark Free Library
ATTN: Librarian

Newark Public Library
ATTN: Librarian

Niagara Falls Pub Lib
ATTN: Librarian

Nicholls State Univ Library
ATTN: Docs Div

Nieves M. Flores Memorial Lib
ATTN: Librarian

Norfolk Public Library
ATTN: R. Parker

North Carolina Agri & Tech State Univ
ATTN: Librarian

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

Univ of North Carolina at Greensboro, Library
ATTN: Librarian

OTHER (Continued)

North Carolina Central University
ATTN: Librarian

North Carolina State University
ATTN: Librarian

North Carolina University at Wilmington
ATTN: Librarian

University of North Carolina
ATTN: BA SS Division Documents

North Dakota State University Lib
ATTN: Docs Librarian

University of North Dakota
ATTN: Librarian

North Georgia College
ATTN: Librarian

North Texas State University Library
ATTN: Librarian

Northeast Missouri State University
ATTN: Librarian

Northeastern Illinois University
ATTN: Library

Northeastern Oklahoma State Univ
ATTN: Librarian

Northeastern University
ATTN: Dodge Library

Northern Arizona University Lib
ATTN: Government Documents Dept

Northern Illinois University
ATTN: Librarian

Northern Iowa University
ATTN: Library

Northern Michigan Univ
ATTN: Documents

Northern Montana College Library
ATTN: Librarian

Northwestern Michigan College
ATTN: Librarian

Northwestern State Univ
ATTN: Librarian

Northwestern State Univ Library
ATTN: Librarian

Northwestern University Library
ATTN: Govt Publications Dept

Norwalk Public Library
ATTN: Librarian

OTHER (Continued)

University of Notre Dame
ATTN: Document Center

Oakland Comm College
ATTN: Librarian

Oakland Public Library
ATTN: Librarian

Oberlin College Library
ATTN: Librarian

Ocean County College
ATTN: Librarian

Ohio State Library
ATTN: Librarian

Ohio State University
ATTN: Libraries Documents Division

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librarian

Oklahoma City University Library
ATTN: Librarian

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

University of Oklahoma
ATTN: Documents Div

Old Dominion University
ATTN: Doc Dept Univ Library

Olivet College Library
ATTN: Librarian

Omaha Pub Lib Clark Branch
ATTN: Librarian

Oregon State Library
ATTN: Librarian

University of Oregon
ATTN: Documents Section

Quachita Baptist University
ATTN: Librarian

Pan American University Library
ATTN: Librarian

Passaic Public Library
ATTN: Librarian

Paul Klapper Library
ATTN: Documents Dept

Pennsylvania State Library
ATTN: Government Publications Section

OTHER (Continued)

Pennsylvania State University
ATTN: Library Document Sec

University of Pennsylvania
ATTN: Director of Libraries

Penrose Library
University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Govt Publications Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librarian

University of Pittsburgh
ATTN: Documents Office G 8

Plainfield Public Library
ATTN: Librarian

Popular Creek Public Lib District
ATTN: Librarian

Association of Portland Lib
ATTN: Librarian

Portland Public Library
ATTN: Librarian

Portland State University Library
ATTN: Librarian

Prescott Memorial Lib
Louisiana Tech Univ
ATTN: Librarian

Princeton University Library
ATTN: Documents Division

Providence College
ATTN: Librarian

Providence Public Library
ATTN: Librarian

Cincinnati & Hamilton County Public Library
ATTN: Librarian

Public Library of Nashville and Davidson County
ATTN: Library

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librarian

OTHER (Continued)

Quinebaug Valley Community Col
ATTN: Librarian

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

Rapid City Public Library
ATTN: Librarian

Reading Public Library
ATTN: Librarian

Reed College Library
ATTN: Librarian

Reese Library
Augusta College
ATTN: Librarian

University of Rhode Island Library
ATTN: Govt Publications Office

University of Rhode Island
ATTN: Director of Libraries

Rice University
ATTN: Director of Libraries

Richard W. Norton Mem Lib
Louisiana College
ATTN: Librarian

Richland County Pub Lib
ATTN: Librarian

University of Richmond
ATTN: Library

Riverside Public Library
ATTN: Librarian

University of Rochester Library
ATTN: Documents Section

Rutgers University, Camden Library
ATTN: Librarian

Rutgers State University
ATTN: Librarian

Rutgers University, Lib of Sci and Med
ATTN: Government Documents Dept

Rutgers University Law Library
ATTN: Federal Documents Dept

Salem College Library
ATTN: Librarian

Samford University
ATTN: Librarian

San Antonio Public Library
ATTN: Bus Science & Tech Dept

OTHER (Continued)

San Diego County Library
ATTN: C. Jones, Acquisitions

San Diego Public Library
ATTN: Librarian

San Diego State University Library
ATTN: Govt Pubs Dept

San Francisco Public Library
ATTN: Govt Documents Dept

San Francisco State College
ATTN: Govt Pub Collection

San Jose State College Library
ATTN: Documents Dept

San Luis Obispo City-County Library
ATTN: Librarian

Savannah Pub & Effingham Libty Reg Lib
ATTN: Librarian

Scottsbluff Public Library
ATTN: Librarian

Scranton Public Library
ATTN: Librarian

Seattle Public Library
ATTN: Ref Doc Asst

Selby Public Library
ATTN: Librarian

Shawnee Library System
ATTN: Librarian

Shreve Memorial Library
ATTN: Librarian

Silas Bronson Public Library
ATTN: Librarian

Simon Schwob Mem Lib
Columbus College
ATTN: Librarian

Sioux City Public Library
ATTN: Librarian

Skidmore College
ATTN: Librarian

Slippery Rock State College Library
ATTN: Librarian

South Carolina State Library
ATTN: Librarian

University of South Carolina
ATTN: Librarian

OTHER (Continued)

University of South Carolina
ATTN: Government Documents

South Dakota Sch of Mines & Tech
ATTN: Librarian

South Dakota State Library
ATTN: Federal Documents Department

University of South Dakota
ATTN: Documents Librarian

South Florida University Library
ATTN: Librarian

Southdale-Hennepin Area Library
ATTN: Government Documents

Southeast Missouri State University
ATTN: Librarian

Southeastern Massachusetts University Library
ATTN: Documents Sec

University of Southern Alabama
ATTN: Librarian

Southern California University Library
ATTN: Documents Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librarian

Southern Illinois University
ATTN: Documents Ctr

Southern Methodist University
ATTN: Librarian

University of Southern Mississippi
ATTN: Library

Southern Oregon College
ATTN: Library

Southern University in New Orleans, Library
ATTN: Librarian

Southern Utah State College Library
ATTN: Documents Department

Southwest Missouri State College
ATTN: Library

Southwestern University of Louisiana, Libraries
ATTN: Librarian

Southwestern University School of Law Library
ATTN: Librarian

OTHER (Continued)

Spokane Public Library
ATTN: Reference Dept

Springfield City Library
ATTN: Documents Section

St. Bonaventure University
ATTN: Librarian

St. Joseph Public Library
ATTN: Librarian

St. Lawrence University
ATTN: Librarian

St. Louis Public Library
ATTN: Librarian

St. Paul Public Library
ATTN: Librarian

Stanford University Library
ATTN: Govt Documents Dept

State Historical Soc Lib
ATTN: Docs Serials Section

State Library of Massachusetts
ATTN: Librarian

State University of New York
ATTN: Librarian

Stetson Univ
ATTN: Librarian

University of Steubenville
ATTN: Librarian

Stockton & San Joaquin Public Lib
ATTN: Librarian

Stockton State College Library
ATTN: Librarian

Superior Public Library
ATTN: Librarian

Swarthmore College Lib
ATTN: Reference Dept

Syracuse University Library
ATTN: Documents Div

Tacoma Public Library
ATTN: Librarian

Tampa, Hillsborough County Public Lib
ATTN: Librarian

Temple University
ATTN: Librarian

Tennessee Technological University
ATTN: Librarian

OTHER (Continued)

University of Tennessee
ATTN: Dir of Libraries

Terteling Library
College of Idaho
ATTN: Librarian

Texas A & M University Library
ATTN: Librarian

University of Texas at Arlington
ATTN: Library Documents

University of Texas at San Antonio
ATTN: Library

Texas Christian University
ATTN: Librarian

Texas State Library
ATTN: U.S. Documents Sect

Texas Tech University Library
ATTN: Govt Docs Dept

Texas University at Austin
ATTN: Documents Coll

Texas University at El Paso
ATTN: Documents and Maps Lib

University of Toledo Library
ATTN: Librarian

Toledo Public Library
ATTN: Social Science Dept

Torrance Civic Center Library
ATTN: Librarian

Traverse City Public Library
ATTN: Librarian

Trenton Free Public Library
ATTN: Librarian

Trinity College Library
ATTN: Librarian

Trinity University Library
ATTN: Documents Collection

Tufts University Library
ATTN: Documents Dept

Tulane University
ATTN: Documents Dept

University of Tulsa
ATTN: Librarian

UCLA Research Library
ATTN: Public Affairs Svc/US Docs

OTHER (Continued)

Uniformed Svcs Univ of the Hlth Sci
ATTN: LRC Library

University Libraries
ATTN: Dir of Libraries

Upper Iowa College
ATTN: Documents Collection

Utah State University
ATTN: Librarian

University of Utah
ATTN: Special Collections

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

Valencia Library
ATTN: Librarian

Vanderbilt University Library
ATTN: Govt Docs Sect

University of Vermont
ATTN: Director of Libraries

Virginia Commonwealth University
ATTN: Librarian

Virginia Military Institute
ATTN: Librarian

Virginia Polytechnic Inst Lib
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Section

University of Virginia
ATTN: Public Documents

Volusia County Public Libraries
ATTN: Librarian

Washington State Library
ATTN: Documents Section

Washington State University
ATTN: Lib Documents Section

Washington University Libraries
ATTN: Dir of Libraries

University of Washington
ATTN: Documents Div

Wayne State University Library
ATTN: Librarian

Wayne State University Law Library
ATTN: Documents Dept

Weber State College Library
ATTN: Librarian

Wagner College
ATTN: Librarian

OTHER (Continued)

Wesleyan University
ATTN: Documents Librarian

West Chester State Coll
ATTN: Documents Dept

West Covina Library
ATTN: Librarian

University of West Florida
ATTN: Librarian

West Hills Community Coll
ATTN: Library

West Texas State University
ATTN: Library

West Virginia Coll of Grad Studies Lib
ATTN: Librarian

University of West Virginia
ATTN: Dir of Libraries

Westerly Public Library
ATTN: Librarian

Western Carolina University
ATTN: Librarian

Western Illinois University Lib
ATTN: Librarian

Western Washington Univ
ATTN: Librarian

Western Wyoming Community College Lib
ATTN: Librarian

Westmoreland Cty Comm Coll
ATTN: Learning Resource Ctr

Whitman College
ATTN: Librarian

Wichita State Univ Library
ATTN: Librarian

William & Mary College
ATTN: Docs Dept

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

William College Library
ATTN: Librarian

Willimantic Public Library
ATTN: Librarian

Winthrop College
ATTN: Documents Dept

University of Wisconsin at Whitewater
ATTN: Governments Documents Library

OTHER (Continued)

Wisconsin Milwaukee University
ATTN: Librarian

Wisconsin Ushkosh University
ATTN: Librarian

Wisconsin Platteville University
ATTN: Librarian

Wisconsin University at Stevens Point
ATTN: Docs Section

University of Wisconsin
ATTN: Govt Pubs Dept

University of Wisconsin
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librarian

OTHER (Continued)

Yale University
ATTN: Director of Libraries

Yeshiva University
ATTN: Librarian

Yuma City County Library
ATTN: Librarian

Wright State Univ Library
ATTN: Govts Documents Dept

Wyoming State Library
ATTN: Librarian

University of Wyoming
ATTN: Documents Div