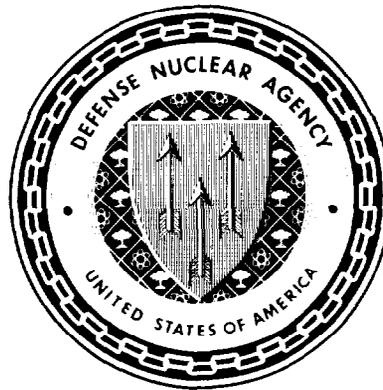


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OPERATION BUSTER-JANGLE 1951



United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

Prepared by the Defense Nuclear Agency as Executive Agency
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the activities of DOD military and civilian personnel in Operation BUSTER-JANGLE, the second series of atmospheric nuclear weapons tests conducted at the Nevada Proving Ground from 22 October through 29 November 1951. The BUSTER-JANGLE series consisted of seven events. DOD personnel participated in Exercises Desert Rock I, II, III and in scientific projects conducted by the test units. Radiological safety criteria and procedures were established and implemented during Operation BUSTER-JANGLE to minimize participants' exposure to ionizing radiation.		

18. SUPPLEMENTARY NOTES (continued)

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

Fact Sheet



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

Subject: Operation BUSTER-JANGLE

Operation BUSTER-JANGLE, the second series of atmospheric nuclear weapon tests conducted at the Nevada Proving Ground (NPG),* consisted of seven nuclear detonations. Four of the detonations were airdrops. The other three shots consisted of one tower, one surface, and one underground detonation. The surface and underground detonations were the first of either type at the NPG. Operation BUSTER-JANGLE lasted from 22 October to 29 November 1951 and involved an estimated 9,000 Department of Defense (DOD) personnel in observer programs, tactical maneuvers, damage effects tests, scientific and diagnostic studies, and support activities. The series was intended to test nuclear devices for possible inclusion in the weapons arsenal and to improve military tactics, equipment, and training.

Department of Defense Involvement

Approximately 6,500 DOD personnel at Operation BUSTER-JANGLE took part in Exercises Desert Rock I, II, and III, Army programs involving members of all four armed services. The remaining DOD personnel provided support for the Desert Rock exercises or participated in scientific activities.

Exercise Desert Rock I was conducted at Shot DOG, and Exercises Desert Rock II and III were conducted at Shots SUGAR and UNCLE, respectively. The troop exercises were the first staged by the Armed Forces during continental nuclear weapons testing. The Desert Rock exercises included observer programs, tactical maneuvers, and damage effects tests. Observer programs, conducted at Shots DOG, SUGAR, and UNCLE, generally involved lectures and briefings on the effects of nuclear weapons, observation of a nuclear detonation, and a subsequent tour of a display of military equipment exposed to the detonation. Tactical maneuvers, conducted after Shot DOG, were designed both to train troops and to test military tactics. Damage effects tests, conducted at Shots DOG, SUGAR, and UNCLE, were performed to determine the effects of a nuclear detonation on military equipment and field fortifications. Support for Exercises Desert Rock I, II, and III included radiological safety, security, transportation, communications, construction, and logistics services. During BUSTER-JANGLE, approximately 2,500 support troops, primarily from units of the Sixth Army, were present at Camp Desert Rock to provide such services.

*Renamed the Nevada Test Site in 1955.

The Atomic Energy Commission (AEC) and the DOD conducted scientific studies to assess the effects of the nuclear detonations. Scientists and technicians from these agencies placed gauges, detectors, and other equipment around the point of detonation in the weeks before each scheduled nuclear test. After each detonation, when the Test Director had determined that the area was radiologically safe for limited access, these participants returned to the test area to recover equipment and gather data. The Air Force Special Weapons Command (SWC) provided military support, including weather and air support activities, for the test organization.

Summaries of BUSTER-JANGLE Nuclear Events

The seven BUSTER-JANGLE events are summarized in the accompanying table. The accompanying figure shows the ground zeros of the seven shots. The three events involving the largest numbers of DOD participants were Shots DOG, SUGAR, and UNCLE.

Shot DOG, an airdropped nuclear device, was detonated with a yield of 21 kilotons at 0730 hours on 1 November 1951. The shot was fired 1,417 feet above the terrain of Area 7, Yucca Flat. As part of Exercise Desert Rock I, the armed services fielded a troop observer program with 2,796 participants, a tactical troop maneuver with 883 participants, and damage effects tests with 60 participants. All troops observed the shot from a location 11 kilometers south of ground zero.

The following Army units conducted the tactical maneuver at Shot DOG:

UNIT	HOME STATION
1st Battalion, 188th Airborne Infantry Regiment, 11th Airborne Division	Camp Campbell, Kentucky
3rd Medical Platoon, 188th Airborne Medical Company	Camp Campbell
Platoon, Company A, 127th Engineer Battalion	Camp Campbell
Battery C, 546th Field Artillery Battalion	Fort Lewis, Washington

The Army units formed a Battalion Combat Team (BCT) for the maneuver. During the weeks preceding the shot, BCT personnel dug foxholes and built gun emplacements and bunkers in a tactical defensive position southwest of ground zero. Several hours before the shot, the BCT and observers went by truck and bus convoy into the forward area. They proceeded to the observation point about 11 kilometers from ground zero, where they witnessed Shot DOG. After the detonation, the troops moved by convoy to their tactical defensive position, where they viewed the effects of the nuclear detonation on the fortifications. The BCT then proceeded in an attack formation to its objective. The objective was southwest of ground zero; at its closest point, it was 460 meters from ground zero. The BCT was accompanied by radiological safety monitors and was preceded by radiation survey teams who determined the limits of safe advance. After reaching the objective, the troops toured two equipment displays 900 and 1,350 meters south of ground zero. The troops were then trucked to a display position over six kilometers south of ground zero. During these activities, Human Resources Research Office personnel tested the troops to determine their psychological reactions to the detonation.

In addition to Desert Rock I participants, about 300 DOD personnel participated in scientific projects coordinated by the test organization at Shot DOG. Approximately 300 SWC personnel from the 4925th Test Group (Atomic) and the 4901st Support Wing (Atomic) performed support missions.

Shot SUGAR, the first surface detonation at the NPG, was fired with a yield of 1.2 kilotons at 0900 hours on 19 November 1951. The SUGAR device was detonated 3.5 feet above the ground in Area 9, Yucca Flat. The initial survey detected onsite fallout to the north of ground zero.

As part of Exercise Desert Rock II, the armed services conducted a troop observer program and damage effects tests. The observers, who were from the Army, witnessed the shot from a location nine kilometers south of ground zero. At least one day after the shot, the observers toured the display areas in a bus convoy. Five ten-man evaluation teams also toured the equipment displays on 20 November. One team came from each of the following Camp Desert Rock sections: Chemical, Signal, Engineer, Ordnance, and Quartermaster. The teams reentered the forward area during the next five days to retrieve test equipment.

About 550 DOD personnel participated in scientific projects conducted by the two test units at Shot SUGAR. Approximately 450 SWC participants performed support missions. Perhaps an additional 100 DOD personnel worked for various units coordinated by the test organization.

Shot UNCLE, the first underground nuclear detonation at the NPG, was fired with a yield of 1.2 kilotons at 1200 hours on

29 November 1951. The nuclear device was detonated 17 feet beneath the ground in Area 10 of Yucca Flat. The initial survey showed onsite fallout north of ground zero.

Exercise Desert Rock III activities were similar to those of Exercise Desert Rock II. The armed services conducted a troop observer program at UNCLE with 202 Army participants. The observers witnessed the shot from a location 9.5 kilometers southwest of ground zero. Two days after the shot, they viewed display areas from buses. About 60 participants from the same Camp Desert Rock sections that had participated at Shot SUGAR conducted damage effects tests.

In addition to Desert Rock participants, approximately 650 DOD personnel participated in scientific projects conducted by the two test units at Shot UNCLE. About 550 SWC participants performed support activities, including cloud-sampling, courier, cloud-tracking, and aerial survey missions. Perhaps another 125 DOD personnel worked for various units coordinated by the test organization.

Safety Standards and Procedures

The Atomic Energy Commission established safety criteria to minimize individual exposure to ionizing radiation while allowing participants to accomplish their missions. The AEC established a limit of 1 roentgen of whole body gamma exposure for participants in Exercise Desert Rock I and a limit of 3 roentgens for participants in Exercises Desert Rock II and III, test organization, and SWC activities. SWC sampling pilots and crews were authorized to receive up to 3.9 roentgens because their mission required them to penetrate the clouds resulting from the detonations.

Although the Test Manager was responsible for the radiological safety of all participants at BUSTER-JANGLE, Exercises Desert Rock I, II, and III, the test organization, and SWC each had responsibility for implementing radiological safety procedures for its personnel. The AEC assisted with radiological safety activities for the Desert Rock exercises. The Test Manager was responsible for the safety of test organization personnel at the NPG and for the radiological safety of individuals residing within a 320-kilometer radius of the NPG. The Radiological Safety and Health Unit, composed of personnel from the Los Alamos Scientific Laboratory (LASL), the armed services, and various civilian groups performed onsite and offsite radiological safety operations. The Radiological Safety Officer, who was appointed by the Test Director, was from LASL and headed this unit. Radiological safety procedures for SWC personnel at Indian Springs Air Force Base were implemented by the 4925th Test Group (Atomic). For SWC personnel at Kirtland Air Force Base, the 4901st Support Wing (Atomic) handled these procedures.

Although the missions of each organization required different activities and separate radiation protection plans and staffs, the general procedures were similar:

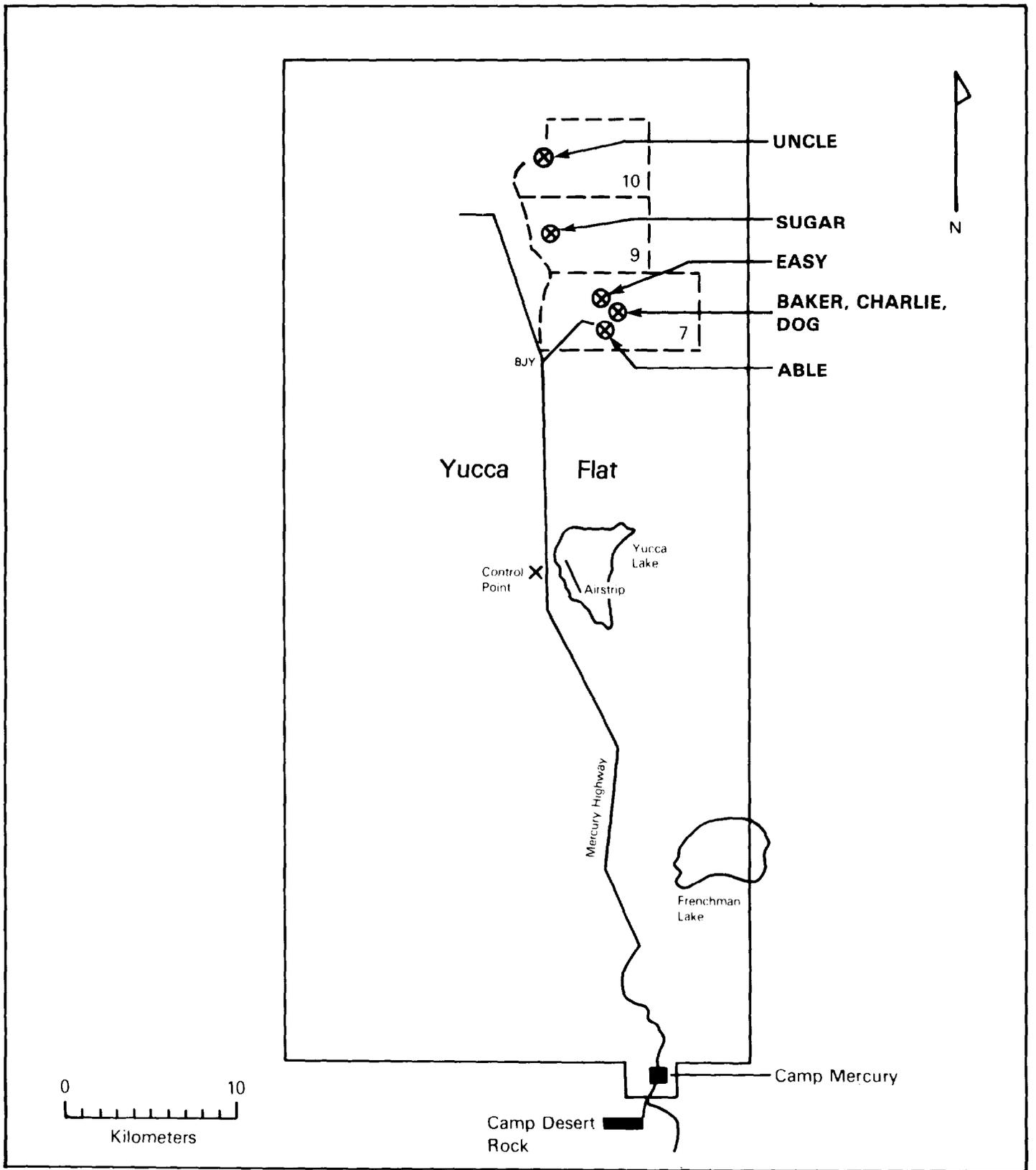
- Orientation and training - preparing radiological monitors for their work and familiarizing participants with radiological safety procedures.
- Personnel dosimetry - issuing, exchanging, developing, and evaluating film badges to determine gamma exposure
- Use of protective equipment - providing clothing, respirators, and other protective equipment
- Monitoring - performing radiological surveys and controlling access to radiation areas
- Briefing - informing observers and project personnel of radiation characteristics and the current radiation intensities in the test area
- Decontamination - detecting and removing contamination from personnel and equipment to prevent its spread to uncontrolled areas.

Radiation Exposures at BUSTER-JANGLE

As of June 1982, 6,830 participants in BUSTER-JANGLE events had been identified by name. Film badge data for 2,642 of these participants are presented in the final table of this fact sheet, "Summary of Dosimetry for Operation BUSTER-JANGLE."

SUMMARY OF OPERATION BUSTER-JANGLE EVENTS (1951)

Shot	ABLE	BAKER	CHARLIE	DOG	EASY	SUGAR	UNCLE
Sponsor	LASL	LASL	LASL	LASL	LASL	DOD	DOD/LASL
Planned Date	19 October	23 October	26 October	29 October	1 November	15 November	29 November
Actual Date	22 October	28 October	30 October	1 November	5 November	19 November	29 November
Local Time	0600	0720	0700	0730	0830	0900	1200
NPG Location	Area 7	Area 9	Area 10				
Type	Tower	Airdrop	Airdrop	Airdrop	Airdrop	Surface	Underground
Height of Burst (feet)	100	1,118	1,132	1,417	1,314	3.5	17
Yield (kilotons)	<0.1	3.5	14	21	31	1.2	1.2



NEVADA PROVING GROUND SHOWING GROUND ZEROS FOR OPERATION BUSTER-JANGLE

**SUMMARY OF DOSIMETRY FOR OPERATION
BUSTER-JANGLE AS OF JUNE 1982**

Service	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Gamma Exposure (Roentgens)					Number of Personnel with Zero Gamma Exposure*	Average Gamma Exposure (Roentgens)	Maximum Gamma Exposure (Roentgens)
			<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+			
Army	5443	1836	1343	358	117	16	2	0	0.251	5.8
Navy	203	181	33	97	48	3	0	9	0.729	3.5
Marine Corps	115	90	88	0	2	0	0	83	0.041	1.9
Air Force	863	329	156	115	41	17	0	78	0.539	4.9
Scientific Personnel Contractors, and Observers	185	185	93	80	12	0	0	8	0.261	2.4
Service Unknown**	21	21	13	8	0	0	0	2	0.116	0.6
Total	6830	2642	1726	658	220	36	2	180	0.312	

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

** Film badge data are available, but service affiliation is not known.

PREFACE

Between 1945 and 1962, the U.S. Government, through the Manhattan Engineer District and its successor, 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 Proving Ground (NPG),* northwest of Las Vegas, Nevada.

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

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

*Renamed the Nevada Test Site in 1955. Some of the documents written during Operation BUSTER-JANGLE, however, refer to the area as the NTS.

**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).

civilian participants in atmospheric nuclear weapons testing. The 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
- 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 BUSTER-JANGLE is based on the military and technical documents associated with each of the atmospheric nuclear weapons tests. Many of the documents pertaining specifically to DOD participation in Operation BUSTER-JANGLE were found in the National Archives, the Defense Nuclear Agency Technical Library, and the Office of Air Force History.

In most cases, the surviving historical documentation of activities conducted during Operation BUSTER-JANGLE addresses test specifications and technical information, rather than personnel data. Moreover, the available documents sometimes have inconsistencies in vital facts. These contradictions have been resolved when possible, or otherwise brought to the attention of the reader.

For several of the Desert Rock exercises and test organization projects discussed in this volume, the only documents available are the Sixth Army Desert Rock operation orders and the Test Director's schedule of events from "Operation Order 1-51." These sources detail the plans developed by DOD and AEC personnel prior to Operation BUSTER-JANGLE. It is not known if all the projects addressed in the planning documents were conducted exactly as planned. Although some of the after-action documents summarize the projects performed during the series, they do not

always supply shot-specific information. In the absence of shot-specific after-action reports, projects are described according to the way they were planned. The references indicate whether the description of activities is based on the schedule of events, operation orders, or after-action reports.

This volume uses the project titles and agency designations given in "Operation BUSTER, Final Report" and "Summary Report: Weapons Effects Tests, Operation JANGLE." Information on the dates and yields of the detonations, fallout patterns, meteorological conditions, and nuclear cloud dimensions is taken from General Electric Company-TEMPO's Compilation of Local Fallout Data from Test Detonations 1945-1962, Extracted from DASA 1251, Volume 1, except in instances where more specific information is available elsewhere.

ORGANIZATION OF BUSTER-JANGLE SERIES REPORTS

This volume details participation by DOD personnel in Operation BUSTER-JANGLE, the second atmospheric nuclear weapons testing series conducted at the NPG. Two other publications address DOD activities during Operation BUSTER-JANGLE:

- Multi-shot volume: Shots ABLE to EASY, the First Five Tests of the BUSTER-JANGLE Series
- Multi-shot volume: Shots SUGAR and UNCLE, the Final Tests of the BUSTER-JANGLE Series.

The volumes addressing the test events of Operation BUSTER-JANGLE are designed for use with one another. The series volume provides general information, such as a discussion of the historical background, organizational relationships, and radiological safety procedures. In addition, it addresses the overall objectives of the operation, describes the layout of the NPG, and contains a bibliography of all works consulted in the preparation of the three BUSTER-JANGLE reports. The multi-shot volumes combine shot-specific descriptions for the seven BUSTER-JANGLE

nuclear events. These volumes contain bibliographies only of the sources referenced in each of the two texts. Descriptions of activities concerning any particular BUSTER-JANGLE shot may be supplemented by the general radiological safety and organizational information contained in this volume.

This volume is divided into six chapters. Chapter 1 provides background information on Operation BUSTER-JANGLE, including an explanation of the historical context of the series, a description of the NPG, a summary and comparison of the seven events in the series, and a summary of the activities of DOD participants. Chapter 2 describes the test organization and Exercise Desert Rock, the two groups with major DOD participation at Operation BUSTER-JANGLE. This chapter defines the responsibilities of each group in planning, administering, and supporting the various nuclear test events and in conducting other activities in conjunction with those tests. Chapter 3 discusses the Exercise Desert Rock I, II, and III military maneuvers conducted during the series, and chapter 4 describes the scientific experiments and support activities coordinated by the test organization and engaging DOD personnel. Chapters 3 and 4 define the objectives of the activities, describe the planned and actual procedures, and indicate at which shots the programs were conducted. Chapter 5 describes the radiological safety criteria and procedures in effect for each of the DOD groups with significant participation. Chapter 6 is a study of the results of the radiation protection program during Operation BUSTER-JANGLE, including an analysis of film badge readings for DOD personnel.

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 has well as a list of acronyms and a glossary of terms used in the reports addressing test events in the continental United States.

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC	Atomic Energy Commission
AFB	Air Force Base
AFSWP	Armed Forces Special Weapons Project
BCT	Battalion Combat Team
BJY	BUSTER-JANGLE Y
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Inc.
FCDA	Federal Civil Defense Administration
HE	High Explosives
HumRRO	Human Resources Research Office
IBDA	Indirect Bomb Damage Assessment
LASL	Los Alamos Scientific Laboratory
NPG	Nevada Proving Ground
R/h	Roentgens per hour
REECo	Reynolds Electrical and Engineering Company
SWC	Special Weapons Command
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Operation BUSTER-JANGLE, the second series of atmospheric nuclear weapons tests conducted at the Nevada Proving Ground, consisted of seven nuclear detonations. This test series lasted from 22 October through 29 November 1951 and involved about 9,000 Department of Defense personnel in observer programs, tactical maneuvers, and scientific and diagnostic studies. The operation was intended to test nuclear weapons for possible inclusion in the defense arsenal and to improve military tactics, equipment, and training.

This volume summarizes information on the organizations, procedures, and activities of Operation BUSTER-JANGLE. The background information in this chapter includes:

- A discussion of the historical background and the establishment of Operation BUSTER-JANGLE
- A description of the NPG
- A synopsis of the seven individual nuclear events
- An overview of DOD participation at this test series.

This information provides a basis for understanding the nature and extent of DOD participation discussed in more detail in subsequent chapters of this volume and in the BUSTER-JANGLE multi-shot reports.

1.1 INTERNATIONAL BACKGROUND AND THE ESTABLISHMENT OF OPERATION BUSTER-JANGLE

The origin of Operation BUSTER-JANGLE and all U.S. nuclear test series can be traced to the post-World War II tension

between the United States and the Soviet Union. Expecting eventual Soviet development of nuclear weapons, the United States continued to expand its nuclear arsenal to maintain superiority over its most potentially dangerous adversary. The Soviet Union exploded its first nuclear device in 1949, well ahead of expectations. Operation BUSTER-JANGLE was an outgrowth of America's reaction to the Soviet threat.

This series was planned as two separate weapons testing programs: Operation BUSTER and Operation JANGLE. In November 1950, the AEC notified the DOD that plans were underway to conduct nuclear weapons development tests, to be called Operation BUSTER, in the fall of 1951 at the NPG. On 12 February 1951, the Armed Forces Special Weapons Project (AFSWP) presented an outline to the Joint Chiefs of Staff concerning military participation in the BUSTER tests. On 8 March 1951, AFSWP asked the Departments of the Army, Navy, and Air Force to submit proposals for projects to be conducted during the operation. During the spring of 1951, the AFSWP Research and Development Board reviewed the proposals and approved a comprehensive testing program. The BUSTER tests were to evaluate new devices developed by the Los Alamos Scientific Laboratory (LASL) and to obtain data on the basic phenomena associated with these devices.

Plans for Operation JANGLE, consisting of the first underground and surface detonations, originated with Operation CROSSROADS, conducted at Bikini in 1946. Scientific studies of the underwater CROSSROADS detonation led to inquiries concerning the effects and possible military value of an underground nuclear detonation. The Joint Chiefs of Staff obtained AEC agreement to conduct tests involving an underground and a surface nuclear

detonation. The general objectives of the tests were to determine the effects of an underground and a surface detonation and to study the devices for inclusion in the nuclear arsenal (55).*

During 1950, the AEC and the DOD looked for a suitable test site. They considered locations in the Pacific and Atlantic Oceans, as well as within the continental United States. They eventually selected Amchitka Island, one of the Aleutian Islands, as the site for the tests, to be called Operation WINDSTORM and to be conducted from 15 September to 15 November 1951. In late September 1950, the Joint Chiefs of Staff approved the site and schedule and delegated responsibility to the Chief of Naval Operations for administering the testing. On 30 November 1950, President Truman endorsed the plans for Operation WINDSTORM (55).

AFSWP then asked the Army, Navy, and Air Force to submit proposals for projects they wanted to conduct during the two nuclear events. Upon receiving proposals from the armed services, the AFSWP Research and Development Board developed a comprehensive test program. In so doing, the Board recommended that the tests be conducted not at Amchitka Island but within the continental United States (55).

On 28 March 1951, representatives of AFSWP, the AEC, and the Joint Chiefs of Staff met to consider the location of the test site. They decided that the tests should be conducted at the NPG and be coordinated by the Air Force. The two nuclear events were subsequently renamed Operation JANGLE (55).

Because BUSTER and JANGLE were then both scheduled for the fall of 1951 at the NPG, AFSWP recommended that the two series be

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

conducted as consecutive phases of one series, Operation BUSTER-JANGLE. On 19 June 1951, the AEC approved this AFSWP recommendation (55).

1.2 THE NEVADA PROVING GROUND

Operation BUSTER-JANGLE, like Operation RANGER earlier that year, was conducted at the Nevada Proving Ground. Originally established by the AEC in December 1950, the NPG is located in the southeastern part of Nevada, 100 kilometers* northwest of Las Vegas, as shown in figure 1-1.

The NPG, depicted in figure 1-2, is an area of high desert and mountain terrain encompassing approximately 1,600 square kilometers in Nye County. On its eastern, northern, and western boundaries, it adjoins the Nellis Bombing and Gunnery Range, of which it was originally a part. The NPG has been the location for the atmospheric nuclear weapons tests conducted within the continental United States from 1951 to the present.

The BUSTER-JANGLE shots were detonated in Yucca Flat, a 320-square-kilometer desert valley surrounded by mountains. Situated in the north-central part of the NPG, Yucca Flat is approximately 4,000 feet above mean sea level. The Control Point, which consisted of several permanent buildings, was on the west side of Yucca Pass, which permitted visual observation of Yucca Flat to the north. Power and timing cables led from the control building to each test area. The Control Point was also the location of decontamination facilities for personnel and vehicles returning from the testing areas and for the Air Operations Center, which controlled all aircraft conducting test support missions over the NPG.

*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.

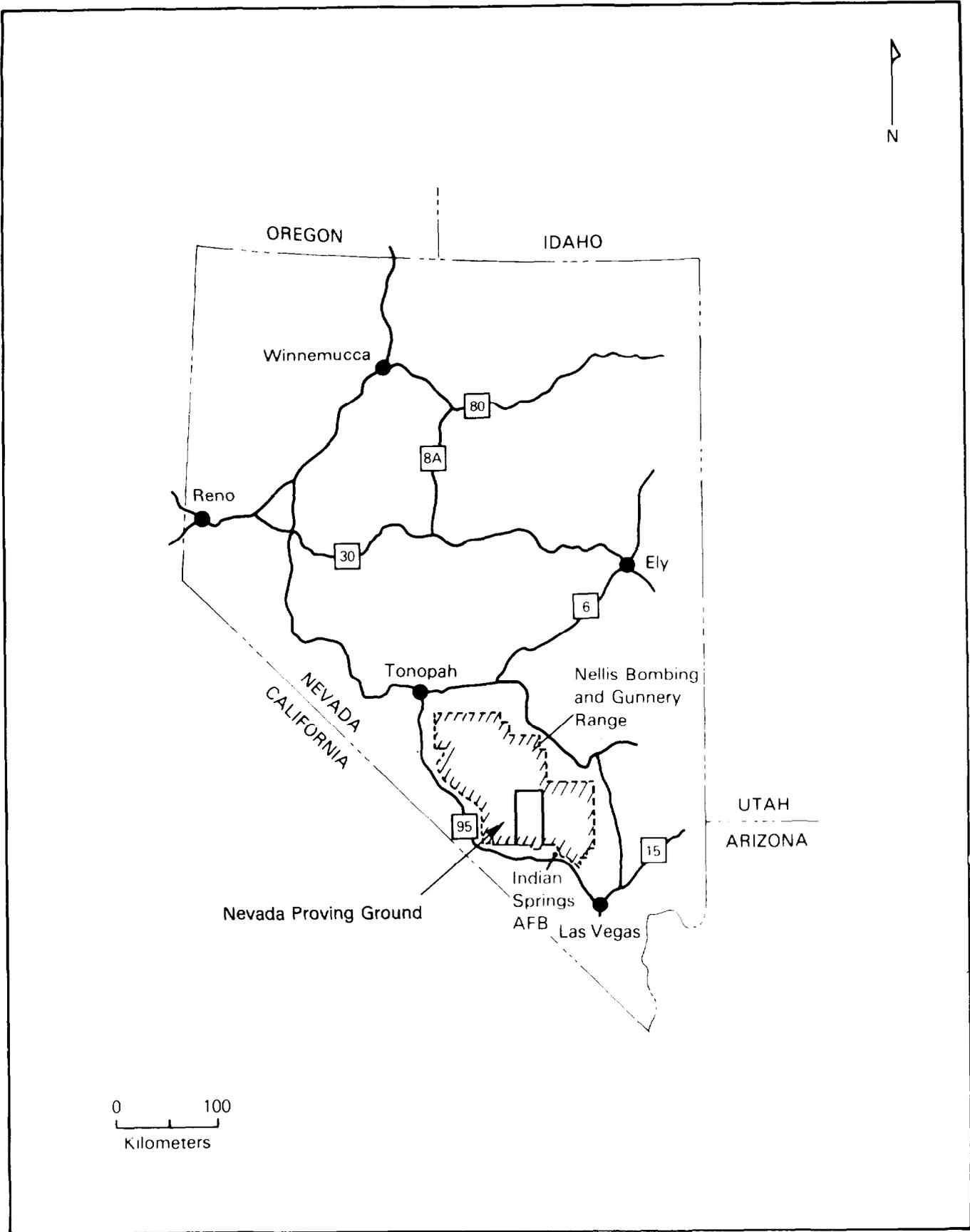


Figure 1-1: LOCATION OF NEVADA PROVING GROUND

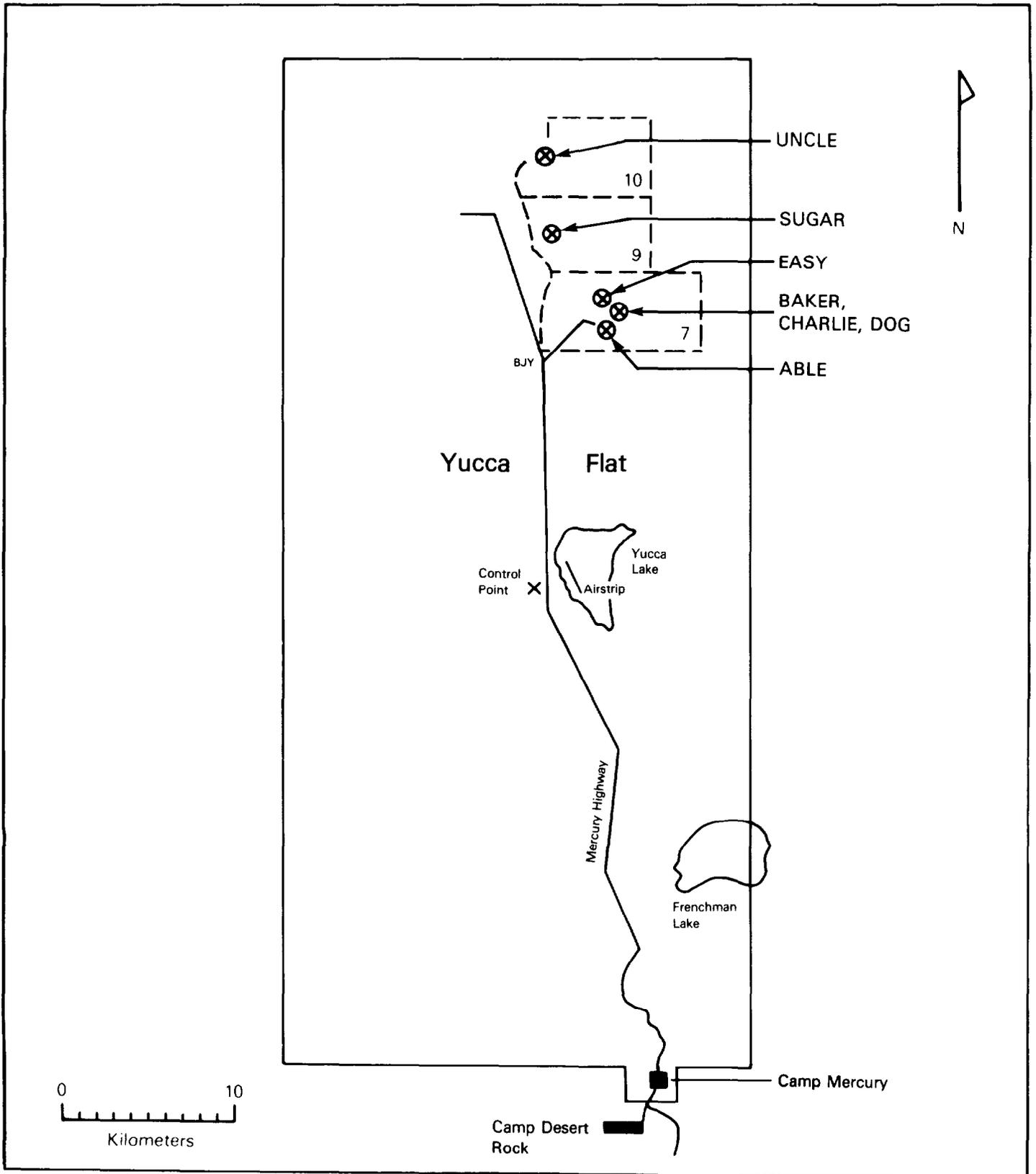


Figure 1-2: NEVADA PROVING GROUND SHOWING GROUND ZEROS FOR OPERATION BUSTER-JANGLE

Camp Mercury, at the southern boundary of the NPG, was the base of the test organization. Camp Mercury provided office and living quarters, as well as laboratory facilities and warehouses, for the participants in various AEC and DOD test activities.

Indian Springs Air Force Base (AFB), located 30 kilometers east of Camp Mercury, and Kirtland AFB in New Mexico served as the principal staging and decontamination areas for Air Force aircraft participating in Operation BUSTER-JANGLE.

Camp Desert Rock, headquarters of the Desert Rock exercises, was just off the NPG, three kilometers southwest of Camp Mercury. Camp Desert Rock consisted of Quonset huts and semi-permanent structures augmented by trailers and tents. The camp was established during Operation BUSTER-JANGLE to serve as a base for the first military training maneuvers conducted during a nuclear test series: Exercises Desert Rock I, II, and III. During BUSTER-JANGLE, Camp Desert Rock housed several thousand DOD personnel (57; 60).

1.3 SUMMARY OF OPERATION BUSTER-JANGLE EVENTS

During the planning for Operation BUSTER-JANGLE, the AEC directed LASL and the DOD to indicate experimental areas that could be pursued during the 1951 test series. Based on the responses of these two organizations, the AEC scheduled the seven events listed in table 1-1.* The first BUSTER-JANGLE detonation occurred on 22 October after a three-day delay. Inclement weather and technical difficulties caused delays in all the tests except for Shot UNCLE, fired as planned on 29 November as the final event of the series. Shots DOG, SUGAR, and UNCLE, which

*As seen in table 1-1, Universal Transverse Mercator (UTM) coordinates are used in this report. The first three digits refer to a point on an east-west axis, and the second three 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 BUSTER-JANGLE EVENTS (1951)

Shot	ABLE	BAKER	CHARLIE	DOG	EASY	SUGAR	UNCLE
Sponsor	LASL	LASL	LASL	LASL	LASL	DOD	DOD/LASL
Planned Date	19 October	23 October	26 October	29 October	1 November	15 November	29 November
Actual Date	22 October	28 October	30 October	1 November	5 November	19 November	29 November
Local Time	0600	0720	0700	0730	0830	0900	1200
NPG Location	Area 7	Area 9	Area 10				
UTM Coordinates	868042	870045	870045	871044	867053	854097	850139
Type	Tower	Airdrop	Airdrop	Airdrop	Airdrop	Surface	Underground
Height of Burst (feet)	100	1,118	1,132	1,417	1,314	3.5	- 17
Yield (kilotons)	<0.1	3.5	14	21	31	1.2	1.2

involved Desert Rock exercises, engaged the largest numbers of DOD participants (57; 60).

1.4 DEPARTMENT OF DEFENSE PARTICIPANTS AND ACTIVITIES

An estimated 9,000 military and civilian DOD personnel participated in Operation BUSTER-JANGLE. Approximately 70 percent of these participants took part in Desert Rock operations. According to the Desert Rock I final report, Exercise Desert Rock I activities at Shot DOG involved 3,700 participants (57). The documentation is not as complete for Exercises Desert Rock II and III. Only two sources, a bus roster and a report by an officer observer, give DOD personnel totals for Desert Rock III activities at Shot UNCLE. These documents state that 135 Camp Desert Rock observers and 67 officer observers took part in Desert Rock III (10; 59). No personnel totals are documented for Desert Rock II exercises at Shot SUGAR.

According to the Desert Rock I final report, 2,500 support troops were attached to Camp Desert Rock for Shot DOG (57). Because there were fewer DOD participants at Desert Rock II and III, the number of support personnel was reduced after Desert Rock I.

The remaining 2,500 DOD personnel, 30 percent of the DOD participants, either assisted in the administration of BUSTER-JANGLE, provided air or ground support, or took part in the scientific and diagnostic programs conducted by the two test units of the AEC test organization, the principal authority for planning and directing the series.

The five BUSTER 'shots (ABLE, BAKER, CHARLIE, DOG, and EASY) were concentrated on AEC weapons development but, nevertheless, had by far the majority of DOD participants. Desert Rock troop

maneuvers were restricted to Operation BUSTER. The two JANGLE shots (SUGAR and UNCLE) were intended to test weapons effects. DOD field participants in these events were essentially limited to observers and to personnel who provided support to the Weapons Effects Test Unit.

CHAPTER 2

FUNCTIONS OF THE ADMINISTRATIVE ORGANIZATIONS DURING OPERATION BUSTER-JANGLE

The test organization and Exercises Desert Rock I, II, and III managed the many activities associated with Operation BUSTER-JANGLE. This chapter discusses the organizational structures of these groups as a basis for describing their activities in chapters 3 and 4.

The test organization was principally staffed by representatives from both the Atomic Energy Commission and the Department of Defense. The primary responsibilities of this organization were to schedule and detonate the nuclear devices and to evaluate the results of each detonation. The Test Manager and his staff performed the first function, while the Test Director and his staff were responsible for the second. Section 2.1 of this chapter describes the roles and responsibilities of both the Test Manager and the Test Director.

Exercises Desert Rock I, II, and III were staffed and administered by the Army. Desert Rock functioned separately from the test organization, with liaison between the two groups to ensure that Desert Rock training programs did not interfere with the scientific programs of the test organization. Army personnel from various units served either as support troops or as exercise troops, as described in section 2.2. During their period of participation, troops resided at Camp Desert Rock. Support troops provided such services as security and law enforcement, radiological safety, medical care, transportation, construction, communications, food, and laundry. Exercise troops were assigned to Camp Desert Rock for periods of one to several weeks to participate in a particular military training program.

In addition to those from the AEC and DOD, participants at BUSTER-JANGLE included employees of other Federal agencies, research laboratories, and private firms under contract to the Government. DOD personnel also participated in the activities of many of these organizations.

2.1 THE TEST ORGANIZATION

The Atomic Energy Commission and the Department of Defense shared responsibility for planning and implementing the atmospheric nuclear weapons test program. The AEC was responsible for exploring and developing new areas of nuclear weapons technology, while the DOD was to incorporate the weapons into the military defense program.

The Director of the AEC Division of Military Application, who was a member of the Armed Forces, supervised nuclear test operations from AEC headquarters in Washington, D.C. This individual delegated onsite responsibility for test preparations at the Nevada Proving Ground to the Manager of the AEC Santa Fe Operations Office. This responsibility included supervising the preparation and use of the various test areas at the NPG and managing the necessary AEC contractor support for each agency involved in test activities. Prior to Operation BUSTER-JANGLE, the Director of the Division of Military Application had appointed the Manager of the Santa Fe Operations Office as the Test Manager of the test organization at the NPG. Figure 2-1 shows the structure of the test organization and the Desert Rock exercises within the Federal Government (1; 14; 15; 61).

In mid-1951, the Air Force Chief of Staff, in his capacity as executive agent for the coordination of military nuclear test programs and military support to the AEC, designated the Special Weapons Command (SWC) as the DOD agency responsible for coordinating military participation and military support for the

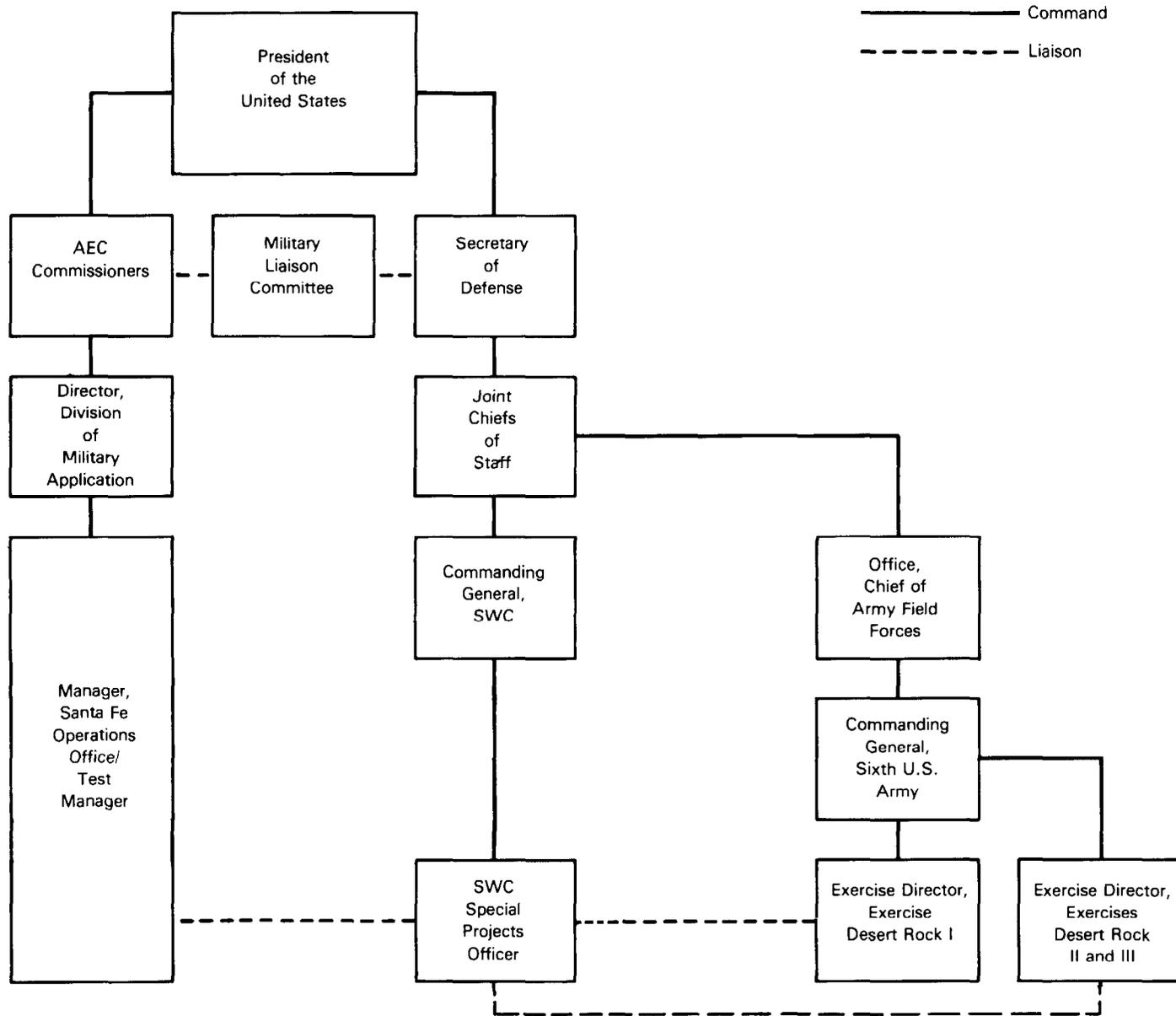


Figure 2-1: TEST ORGANIZATION/EXERCISES DESERT ROCK I, II, AND III STRUCTURE WITHIN FEDERAL GOVERNMENT

continental nuclear test program. The Commanding General of SWC delegated this responsibility to a Special Projects Officer, who became the Commanding General's representative at the NPG. He and his staff established direct liaison with the AEC Santa Fe Operations Office and Exercise Desert Rock officials (47; 55; 58; 61).

Although SWC was in charge of overall military activities for BUSTER-JANGLE, the Commanding General of the Sixth U.S. Army had direct command of Desert Rock activities. The Joint Chiefs of Staff supervised Exercise Desert Rock through the Office, Chief of Army Field Forces (57; 69).

2.1.1 Test Manager's Organization

The Test Manager was responsible for the overall direction of Operation BUSTER-JANGLE. This responsibility included deciding whether or not to proceed with a shot as planned, coordinating the agencies involved in the weapons development and weapons effects projects, and supervising the staff units that performed support functions for the test participants.

The Test Manager was assisted by personnel from the AEC Santa Fe Operations Office, AEC contractors, and various DOD agencies. Figure 2-2 shows the elements of his staff (55).

The Advisory Panel consisted of representatives from SWC and scientists from the Los Alamos Scientific Laboratory, an AEC nuclear weapons development laboratory. This panel advised the Test Manager on such factors as weather conditions and their potential effects on the scheduled tests.

The Field Manager provided for and supervised all auxiliary services required for operating the NPG during Operation BUSTER-JANGLE.

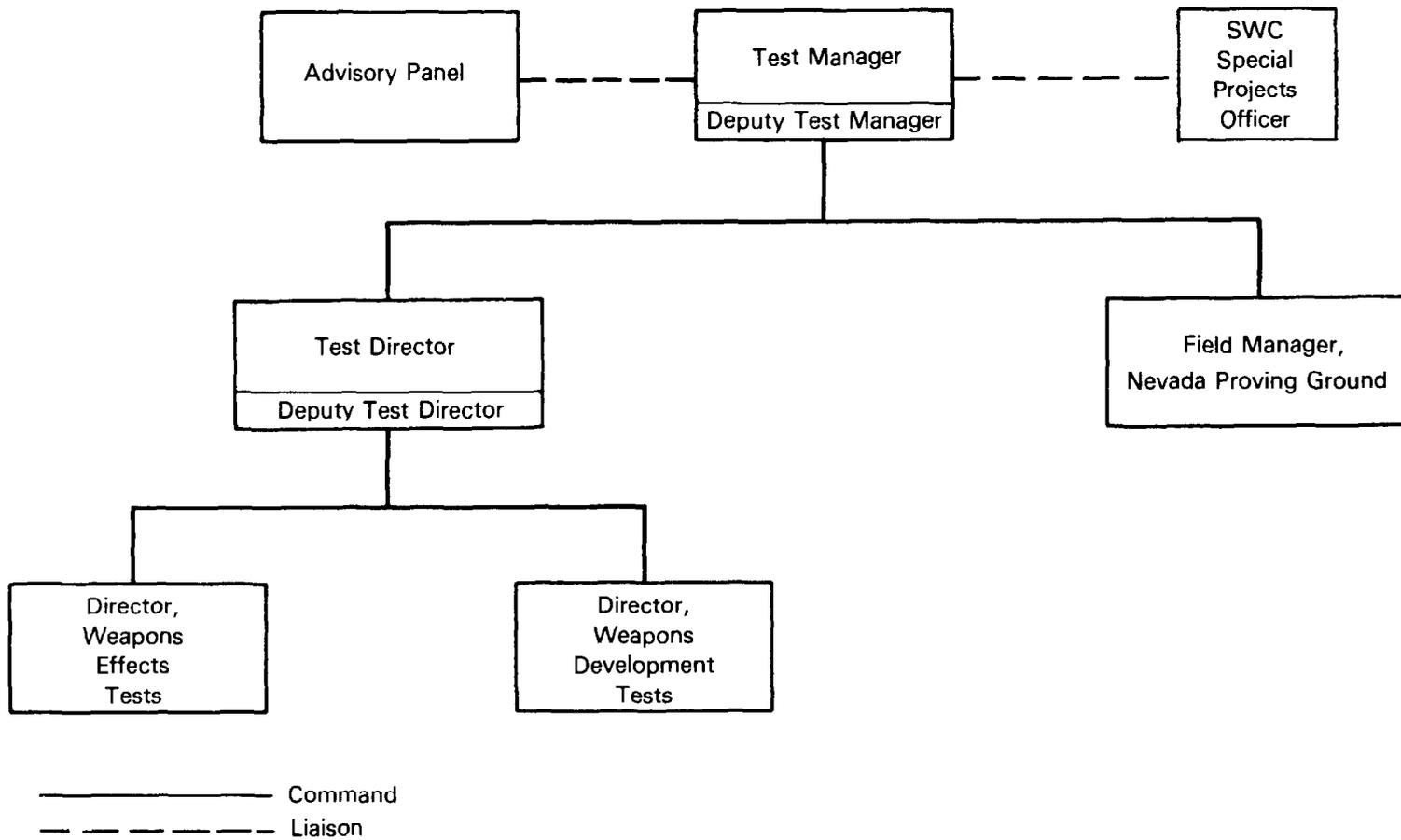


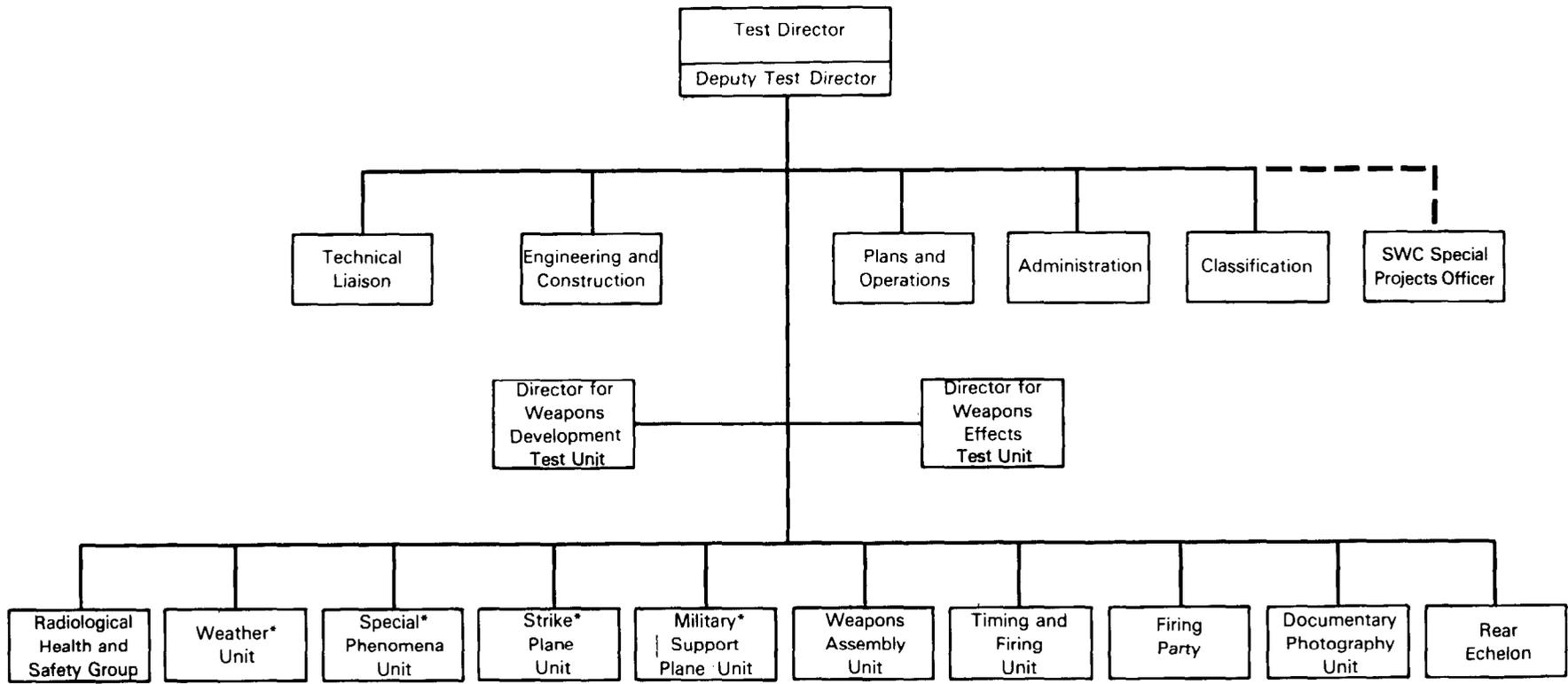
Figure 2-2: TEST MANAGER'S ORGANIZATION

2.1.2 Test Director's Organization

While the Test Manager and his staff provided the guidance necessary to conduct Operation BUSTER-JANGLE, the day-to-day responsibility for preparing the nuclear devices and planning and implementing the experiments during the operation was delegated to the Test Director (55; 61).

The daily planning and implementation of the many test programs performed by agencies and contractors of the AEC and DOD required close liaison between the agencies involved and the units administered by the Test Director, a representative of LASL. The principal components of the Test Director's organization were the Weapons Effects Test Unit and the Weapons Development Test Unit. The Weapons Effects Test Unit conducted scientific experiments designed to measure the effects of each detonation. Although administered by SWC, these experiments were planned and implemented by the AEC, the Armed Forces Special Weapons Project, and various military agencies and laboratories. Both the administration and scientific activities of the Weapons Development Test Unit, which conducted scientific experiments to evaluate the nuclear devices detonated, were under the direction of the Los Alamos Scientific Laboratory.

As shown in figure 2-3, the Test Director's organization included several subsections. These subsections were responsible for technical liaison, engineering and construction, plans and operations, administration, classification, and liaison with SWC. Consisting of representatives from various DOD and AEC agencies, the subsections provided services to projects of both the weapons effects program and the weapons development program.



*Military Support Provided by Special Weapons Command

————— Command
 - - - - - Liaison

Figure 2-3: TEST DIRECTOR'S ORGANIZATION

Other units provided services to the Test Director. As indicated in figure 2-3, SWC supported four of the ten units. The six units not involving SWC support were (55; 61):

- Radiological Health and Safety
- Weapons Assembly
- Timing and Firing
- Firing Party
- Documentary Photography
- Rear Echelon.

The Radiological Health and Safety Group supervised onsite and offsite radiological safety activities at BUSTER-JANGLE. The Onsite Operations Officer was responsible for the area within a 32-kilometer radius of each ground zero. He and his staff issued film badges during BUSTER-JANGLE, directed monitoring activities, and briefed recovery and decontamination personnel prior to their postshot entry in the shot area. The Offsite Operations Officer was responsible for radiological safety activities extending to a 320-kilometer radius of the test site. He and his staff supervised both ground and aerial surveys, maintained liaison with the Air Weather Service and the Civil Aeronautics Administration, and managed an Information Center. The Offsite Operations staff included a representative from the Civil Aeronautics Administration, who helped determine the airways to be closed to commercial aircraft on shot-days. The Radiological Health and Safety Group is discussed further in section 5.2 of this volume, Radiation Protection for the Test Organization (86; 102).

The Weapons Assembly Unit included personnel from Sandia Corporation whose responsibilities involved preparing the nuclear device for detonation.

The Timing and Firing Unit, which included personnel from Edgerton, Germeshausen, and Grier, Inc. (EG&G), provided instruments and apparatus for setting the timing for the

detonations and for firing the nuclear devices. The Firing Party prepared for detonation the nuclear devices that were not dropped from aircraft.

The Documentary Photography Unit consisted of personnel from LASL. These individuals took motion pictures and still photographs for the scientific and technical programs.

The Rear Echelon notified the Director of LASL of the readiness and progress of test unit activities (55; 61).

The units of the Test Director's organization receiving SWC support were:

- Weather
- Special Phenomena
- Strike Plane
- Military Support Plane.

The Weather Unit gave the Test Director meteorological information important in scheduling the detonations, such as specific data on wind and cloud conditions. The 2059th Air Weather Group, Tinker AFB, Oklahoma, directed the meteorological analysis from the Control Point Weather Station and stations in the surrounding area. The 6th Weather Squadron was assisted by a consultant from Andrews AFB, Maryland.

The Special Phenomena Unit conducted cloud sampling and cloud tracking. Section 4.3 of this volume, Air Force Support Missions at Operation BUSTER-JANGLE, discusses these activities.

The Strike Plane Unit was responsible for the air delivery of nuclear devices.

The Military Support Plane Unit supplied air transportation support to the Test Director. The group also operated helicopters required for radiological safety surveys (55; 61).

The Test Director's technical advisors and support personnel planned and conducted the day-to-day test activities. The technical advisors reviewed the proposed activities for each program and project of the various laboratories and agencies. Working with the technical advisors and representatives of the support group, the Test Director and his staff revised the proposed plans to include schedules, construction, supplies, transportation, radiological safety, air support, and postshot recovery operations. The Test Director and his staff presented these revised plans to the Test Manager, who had final authority to review and approve activities associated with Operation BUSTER-JANGLE.

2.1.3 Field Manager's Organization

The Field Manager was in charge of auxiliary services required for maintenance of the NPG, including Camp Mercury. These services included administration; operations, which involved construction, camp maintenance, and transportation; communications; security; and public relations. While the Field Manager and his staff were mostly AEC personnel, various contractors performed the services. The specific duties of the sections responsible for these services are indicated by their titles in figure 2-4 (55).

2.2 THE ORGANIZATION OF EXERCISES DESERT ROCK I, II, AND III

Exercise Desert Rock troops were present at Operation BUSTER-JANGLE through an agreement between the AEC and DOD. Desert Rock activities were contingent upon approval of the Test Manager. The Test Manager had final control over the planning and scheduling of the nuclear events and review and approval authority over all associated program activities at the NPG. Therefore, his influence extended to Desert Rock activities. Operationally, however, Desert Rock had its own administrative structure.

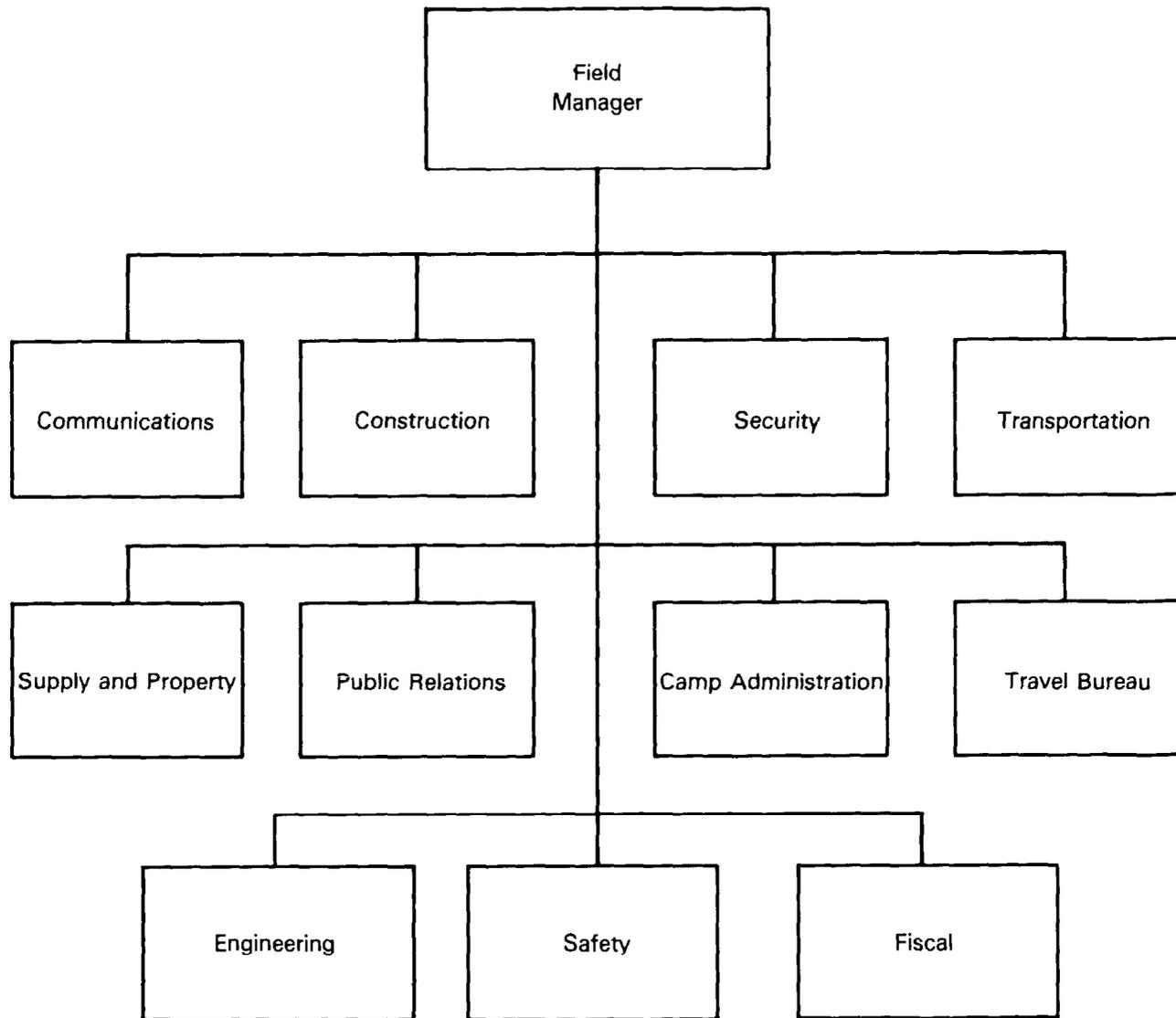


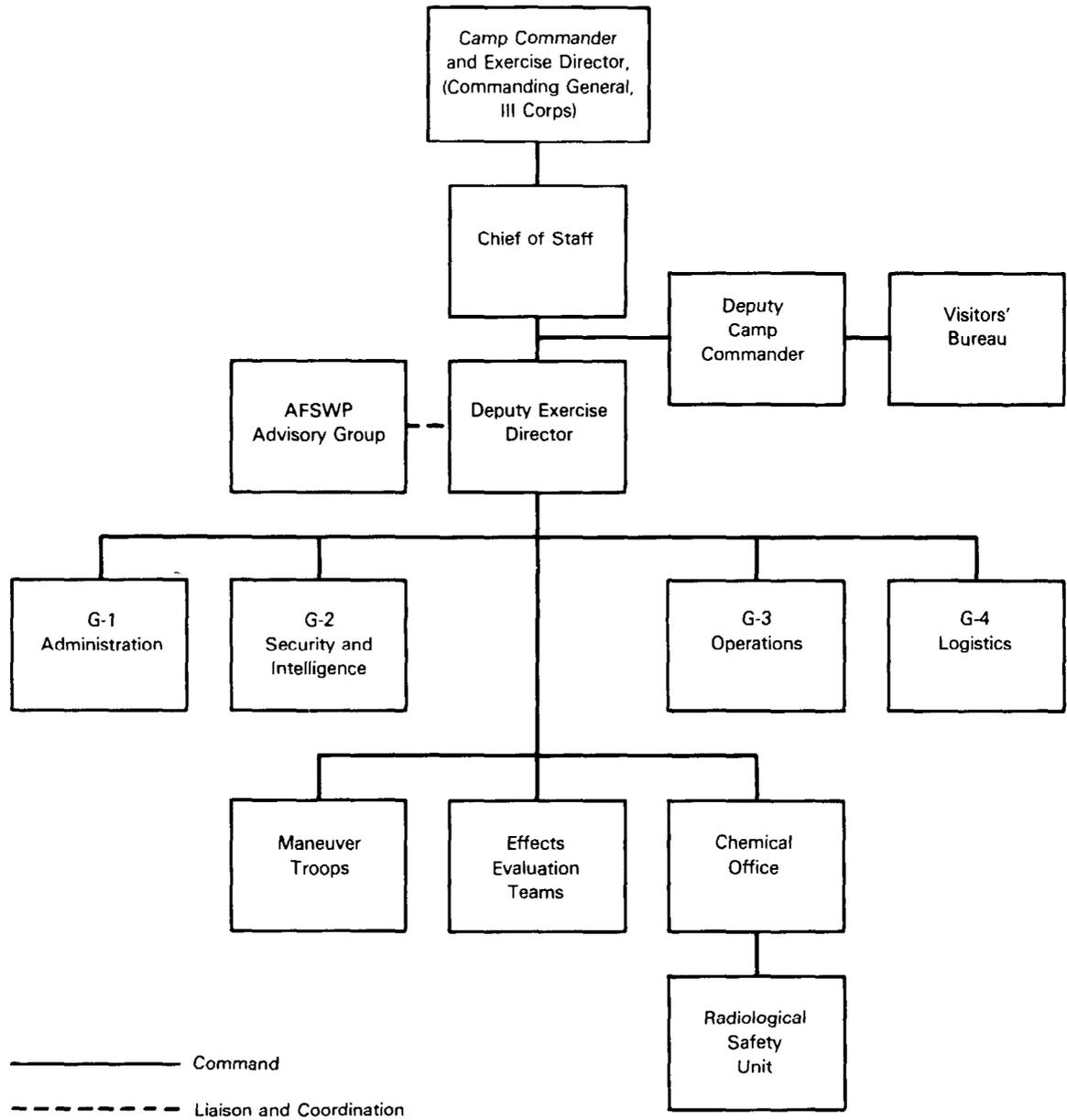
Figure 2-4: FIELD MANAGER'S ORGANIZATION

Headquarters for Exercises Desert Rock I, II, and III were formally established in the spring and summer of 1951. Although there were three exercises, there were only two Desert Rock organizations at Operation BUSTER-JANGLE. The first organization conducted Exercise Desert Rock I at Shot DOG, and the second implemented Exercise Desert Rock II at Shot SUGAR and Exercise Desert Rock III at Shot UNCLE. The two Desert Rock organizations were complex and included many military units. The following paragraphs highlight the key elements within the Desert Rock organizations.

Exercise Desert Rock I was directed by the Commanding General of III Corps, as shown in figure 2-5. The Exercise Director was also the Commander of Camp Desert Rock. As Exercise Director, he was responsible for supervising the activities of the exercise troops, as well as those of the support troops. Exercise troops were organized under unit commanders, who reported to the Exercise Director. As Camp Desert Rock Commander, the Exercise Director supervised the administration of base facilities.

The Exercise Director was assisted by administrative and staff units. These units provided the services necessary to sustain the exercise troops participating in specific test activities (57; 60).

The Chief of Staff was responsible for coordinating all staff functions related to Exercise Desert Rock I. The Deputy Exercise Director and the Deputy Camp Commander reported to the Chief of Staff. The Deputy Exercise Director directed Desert Rock I activities. The Deputy Camp Commander administered Camp Desert Rock and provided the Exercise Director with clerical and administrative support. The Deputy Camp Commander also administered the Camp Desert Rock Visitors' Bureau. The Visitors' Bureau planned and administered many aspects of the



**Figure 2-5: CAMP DESERT ROCK ORGANIZATION,
EXERCISE DESERT ROCK I**

observers' activities, including transport between Camp Desert Rock and the NPG (57).

General staffs for administration, security and intelligence, operations, and logistics coordinated the activities of the Desert Rock support and maneuver units, which operated Camp Desert Rock and conducted the Desert Rock exercises.

The G-1, Administration, established personnel management and other administrative policies for Camp Desert Rock (57).

The G-2, Security and Intelligence, was responsible for arranging adequate security safeguards for all classified material connected with Exercise Desert Rock I and ensuring that all personnel had proper security clearances. The staff maintained close liaison with the Security Branch of the test organization to ensure a smooth flow of troop observer and troop maneuver convoys into the NPG on shot-days (57).

The G-3, Operations, was responsible for planning and coordinating the troop exercise. Specific duties included coordinating the involvement of the effects evaluation teams and the maneuver troops and overseeing radiological safety procedures (57).

The III Corps technical service representatives, in coordination with the AFSWP Advisory Group, conducted the Desert Rock I effects tests. Six evaluation teams, each consisting of approximately ten persons, studied the effects of Shot DOG on military equipment and field fortifications. One team came from each of the following branches: Chemical, Signal, Engineer, Medical, Ordnance, and Quartermaster. Section 3.3 details activities of the evaluation teams during Exercises Desert Rock I, II, and III (57).

Working through the G-3, the Deputy Exercise Director directed the troop maneuver at Shot DOG. Section 3.2 discusses this troop maneuver, which was the only one conducted during Operation BUSTER-JANGLE.

The Chemical Officer, who worked with the G-3, was responsible for the Desert Rock Radiological Safety Unit, which planned and conducted the radiological safety procedures developed to limit the exposure received by troops entering the forward area. The Desert Rock Radiological Safety Unit was assisted by the AFSWP Advisory Group. The unit operated separately from but with the guidance of the AEC Radiological Health and Safety Group. Before the Desert Rock exercises began, AEC radiological safety instructors trained Desert Rock personnel in radiological safety procedures. Desert Rock monitors conducted ground surveys before troops entered the forward area after a detonation. Monitors also accompanied Desert Rock participants entering the forward area (57; 101).

The G-4, Logistics, was responsible for logistical services for Camp Desert Rock and the exercise troops. This section coordinated the procurement of equipment and materials for displays, construction materials for bunkers and gun emplacements, and heavy construction equipment. It also provided staff supervision for construction, communications, and transportation (57).

Exercises Desert Rock II and III were administered by an organization similar to but smaller than the structure established for Exercise Desert Rock I. The Desert Rock II and III organization, shown in figure 2-6, was headed by the Exercise Director. He was an Army general, although not the Commanding General of III Corps, as in Exercise Desert Rock I. The Exercise Director of Desert Rock II and III supervised troop participation

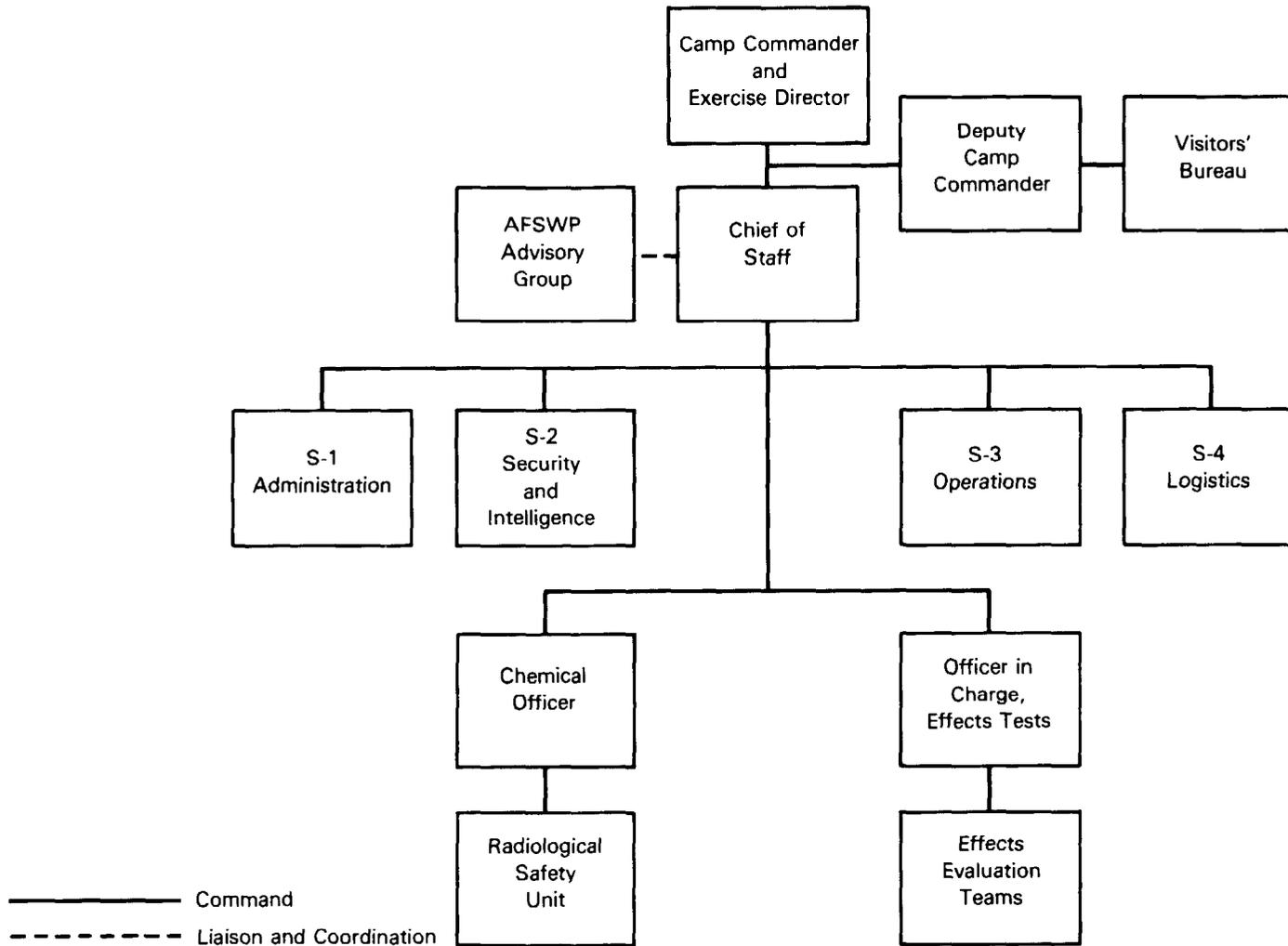


Figure 2-6: CAMP DESERT ROCK ORGANIZATION, EXERCISES DESERT ROCK II AND III

in Desert Rock activities and directed Camp Desert Rock activities. He was assisted in his duties by the Chief of Staff and the Deputy Camp Commander. The Chief of Staff also coordinated Desert Rock II and III activities, a responsibility he did not have in Exercise Desert Rock I. The Deputy Camp Commander functioned as he did in Exercise Desert Rock I, administering Camp Desert Rock and the Visitors' Bureau (60).

The Officer in Charge, Effects Tests, was responsible to the Chief of Staff. Working with the AFSWP Advisory Group, this officer commanded the damage effects evaluation teams at SUGAR and UNCLE. The position of Officer in Charge, Effects Tests, did not exist in the Desert Rock I organization (60).

Because Desert Rock II and III were not structured on the Corps level, the organization included staff sections designated S-1, S-2, S-3, and S-4, rather than general staff sections (60). Their responsibilities were basically the same as those of the general staff sections in the Exercise Desert Rock I organization.

CHAPTER 3

EXERCISE DESERT ROCK PROGRAMS AT OPERATION BUSTER-JANGLE

Exercises Desert Rock I, II, and III were troop training programs organized by the Sixth U.S. Army at Operation BUSTER-JANGLE. Exercise Desert Rock I was conducted at Shot DOG, and Exercises Desert Rock II and III were conducted at Shots SUGAR and UNCLE, respectively. The exercises were the first staged by the Armed Forces during continental nuclear weapons testing.

During the summer of 1951, the Chairman of the Atomic Energy Commission received the proposal for Exercise Desert Rock I through the Military Liaison Committee. The Chairman agreed to the outline for the operations, which included a troop maneuver at Shot DOG and activities for military observers and effects evaluation teams at all three shots (7; 76).

Because of the increasing dependence of U.S. defense policy on nuclear capabilities, the armed services developed Exercise Desert Rock to test tactics and protective measures for use during a nuclear conflict. The objectives were to (57; 60):

- Study the military uses of nuclear weapons
- Train military personnel in the tactical use of nuclear weapons
- Study the psychological reactions of military participants to the detonation of a nuclear weapon
- Test the effects of a nuclear detonation on animals and military equipment

- Determine the effects of a nuclear detonation on field fortifications and defensive structures
- Determine appropriate measures for radiation protection and instruct participants in those measures.

Approximately 6,500 individuals took part in Exercise Desert Rock I, II, and III activities. DOD personnel at Camp Desert Rock, located just outside the southern boundary of the NPG, were divided into two groups: Camp Desert Rock troops and Desert Rock exercise troops (57; 85; 102).

Camp Desert Rock Troops

Camp Desert Rock troops consisted of about 2,500 soldiers at the beginning of Exercise Desert Rock I. These soldiers were drawn mainly from units of the Sixth U.S. Army. Some Desert Rock troops were stationed at the camp throughout Exercises Desert Rock I, II, and III. Many troops, however, returned to their home stations after the first and largest exercise was completed on 1 November 1951. Desert Rock personnel provided necessary support functions for the camp, such as administration, transportation, construction, communications, security, food, and laundry.

Some Desert Rock participants entered the forward testing areas of Yucca Flat to help prepare for specific Desert Rock activities, to assist in operations during test events, or to help ensure safe postshot recovery operations. Three units particularly involved in shot-day operations were the Control Group, the Radiological Safety Unit, and the AFSWP Advisory Group.

The Control Group, composed of members of the Camp Desert Rock staff sections, along with military police and signal

personnel, accompanied the troops into the forward area. Their duties were to supervise Desert Rock operations and to maintain contact with the Exercise Director.

The functions of the Radiological Safety Unit included:

- Enforcing radiological safety criteria
- Issuing and collecting film badges
- Providing radiological safety monitors to supplement those provided by the AEC
- Conducting radiological surveys after the initial AEC survey
- Accompanying observers and evaluation teams on their postshot inspections of the equipment displays
- Establishing decontamination stations and procedures.

The functions of the Radiological Safety Unit are discussed generally in chapter 2 and specifically in chapter 5 of this volume (57; 60; 102).

The AFSWP Advisory Group, consisting of three AFSWP officers, was assigned to Camp Desert Rock to provide technical assistance and advice to Desert Rock personnel. Before the shot, they instructed observers and maneuver troops in nuclear weapons and their effects. After the detonation, they briefed the participants as they toured the equipment displays. In addition, they assisted the evaluation teams in assessing and then preparing reports on the detonation's effects on the displays.

Besides the Control Group, the Radiological Safety Unit, and the Advisory Group, several other Desert Rock support elements engaged in activities before shot-day and on the day of the detonation. Members of the 231st Engineer Combat Battalion spent from one to five days constructing field fortifications in the display areas prior to Shots DOG, SUGAR, and UNCLE. On shot-day,

transportation personnel conveyed observers to a location at least nine kilometers from ground zero, where they witnessed the detonation. After the detonation, they transported the observers and evaluation teams into the forward area for an inspection of the equipment displays. This inspection took place on shot-day at Shot DOG but not until one day after Shot SUGAR and two days after Shot UNCLE. The Shot DOG observers left the buses to walk through the display. At Shots SUGAR and UNCLE, however, observers remained on the buses while they drove through the displays.

Military police provided traffic control in Camp Desert Rock and at the Nevada Proving Ground during the rehearsals conducted before shot-day and during the activities on the day of detonation and the days following.

Signal Corps personnel installed, operated, and maintained wire and radio communications within the forward area, as well as at Camp Desert Rock. They also established public address systems at the observation points and display areas to be used for briefing participating troops.

Medical support was provided in the forward area, as well as at Camp Desert Rock. During operations on shot-day, a medical aid station was established at the observation point. Maneuver units also provided some of their own medical support (57; 60).

Desert Rock Exercise Troops

Approximately 3,700 exercise troops participated in Exercise Desert Rock I indoctrination and training programs. At least several hundred exercise troops took part in Exercises Desert Rock II and III, but the total has not been documented. These troops, unlike the support troops, were stationed at Camp Desert Rock for short periods ranging from several days to about two weeks.

Exercises Desert Rock I, II, and III consisted of the following activities:

- Troop observer program
- Troop maneuver
- Damage effects tests.

The troop observer program was designed to acquaint military and civilian Department of Defense personnel with the effects of nuclear detonations. The program consisted of preshot lectures and films, observations of nuclear detonations in the forward area of the Nevada Proving Ground, and postshot tours of equipment display areas (57; 60).

The troop maneuver was designed to train participants in the tactical use of nuclear weapons and to demonstrate to participants the effects of nuclear detonations. A troop maneuver was conducted at Shot DOG as part of Exercise Desert Rock I. Troop maneuvers were not conducted at Shots SUGAR and UNCLE (60).

The damage effects tests were conducted to determine the effects of a nuclear detonation on military equipment, field fortifications, and animals (57; 60).

3.1 OBSERVER ACTIVITIES AT EXERCISES DESERT ROCK I, II, AND III

The Exercise Desert Rock I observer program involved 2,796 Army, Navy, Marine Corps, and Air Force personnel. Army personnel comprised the largest number of observers. A documented total number of observers for Desert Rock II and III is unavailable, although an observer bus roster and an observer's report indicate that 135 Camp Desert Rock observers and 67 officer observers participated in Desert Rock III activities at Shot UNCLE (10; 55; 59; 60).

Participation in nuclear test events was basically the same for all Exercise Desert Rock observers at any particular shot. The armed services were invited to send observers to the nuclear tests. Each service was informed of the reporting and departure date for each shot, as well as the records and equipment to be carried to Camp Desert Rock by individual observers.

After arrival at Camp Desert Rock, the observers began a scheduled routine which, although it varied from shot to shot, included a standard set of activities. In the days preceding the detonation, instructors from the Advisory Group provided the observers with films and lectures on the characteristics of a nuclear detonation and the procedures to follow during a nuclear detonation. The orientation also involved a rehearsal of shot-day activities, including a visit to the area observers would occupy on shot-day, a practice of the countdown and activities scheduled for the detonation, and a tour of the display areas. Figure 3-1 indicates the observation points and the display areas for Shots DOG, SUGAR, and UNCLE (57).

About one hour before the scheduled shot, participants arrived at the observation area by truck or bus convoy. There, Advisory Group instructors briefed them on the scheduled detonation and on safety procedures. Figure 3-2 shows the briefing of observers at the observation point before the Shot DOG detonation. Shortly before the shot, the instructors directed observers to sit on the ground with their backs toward ground zero. After the initial flash of light from the detonation, they directed the observers to turn and view the fireball and cloud. Observers inspected the display areas when radiological safety conditions permitted entry into the forward areas. Accompanied on their tour by Advisory Group instructors, they examined the effects of the detonation on military equipment and fortifications (57; 60).

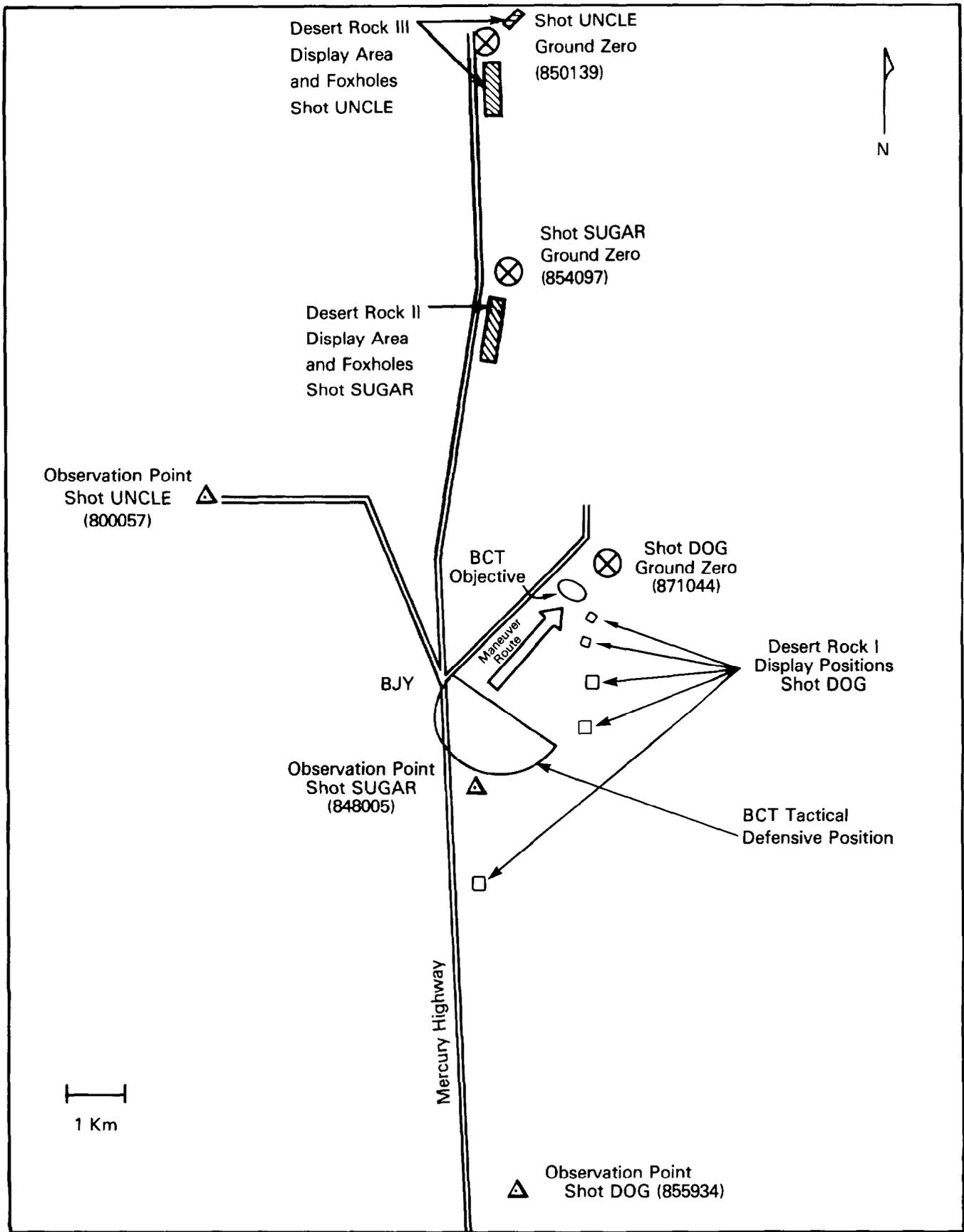


Figure 3-1: GROUND ZEROS, OBSERVATION POINTS, AND DISPLAY AREAS FOR SHOTS DOG (EXERCISE DESERT ROCK I), SUGAR (EXERCISE DESERT ROCK II), AND UNCLE (EXERCISE DESERT ROCK III)

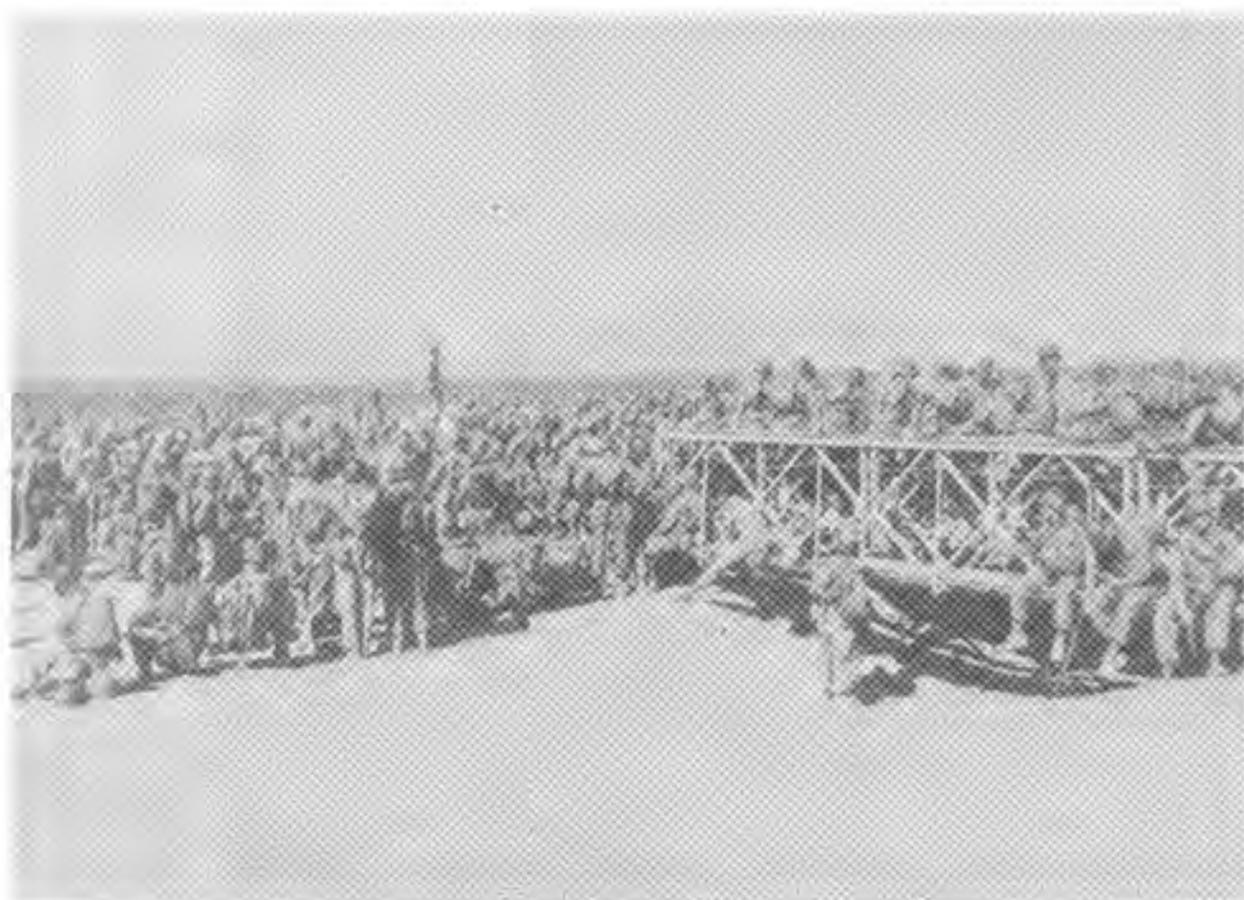


Figure 3-2: BRIEFING OF OBSERVERS AT THE OBSERVATION POINT BEFORE SHOT DOG

3.2 TROOP MANEUVER AT EXERCISE DESERT ROCK I

The military services developed the troop maneuver at Shot DOG according to the following scenario. An aggressor with overwhelming forces invaded the western United States and established a line of strong defensive positions which resisted breakthrough by friendly forces using conventional weapons. To gain the offensive and penetrate enemy lines, friendly forces counterattacked with Shot DOG. After the detonation, they advanced to capture the enemy objective.

The maneuver involved 883 men from four units (57):

- 1st Battalion, 188th Airborne Infantry Regiment, 11th Airborne Division, Camp Campbell, Kentucky
- 3rd Medical Platoon, 188th Airborne Medical Company, Camp Campbell
- Platoon, Company A, 127th Engineer Battalion, Camp Campbell
- Battery C, 546th Field Artillery Battalion, Fort Lewis, Washington.

At Camp Desert Rock, the participants were organized into a Battalion Combat Team (BCT). Their activities involved (57):

- Preparing tactical defensive positions
- Observing the nuclear blast
- Conducting a tactical maneuver
- Touring the display areas.

During the two weeks preceding Shot DOG, BCT personnel dug foxholes and built gun emplacements and bunkers in a tactical defensive position southwest of ground zero. This position was developed to test the effects of weapons on the structures and emplacements. Participants did not occupy the structures and emplacements at shot-time.

Several hours before the shot, the BCT and the observers boarded vehicles which took them to an observation point 11 kilometers south of ground zero, where they witnessed the detonation, as shown in figure 3-3. After the detonation, the troops moved by convoy to their prepared defensive position, where they viewed the effects of the detonation on the position. On order, the BCT moved forward in an attack formation to an objective southwest of ground zero, as shown in figure 3-1. At its closest point, the objective was 460 meters from ground zero. The BCT was accompanied by radiological safety monitors and was preceded by radiation survey teams who determined the limits of safe advance. After reaching the objective, the BCT toured display positions 900 and 1,350 meters south of ground zero. The troops were then taken by truck to view a display position over six kilometers south of ground zero. Available documents indicate that the troops did not visit the other two display areas. The trucks and buses then transported the troops and observers to the decontamination station at Yucca Pass. After monitoring, the troops and observers returned to Camp Desert Rock (57).

An additional study associated with the troop maneuver was performed by the Human Resources Research Office (HumRRO), a civilian agency under contract to the Department of the Army. At Shot DOG, HumRRO investigated the psychological reactions of the maneuver troops. The agency was particularly interested in troop behavior during the maneuver and the changes in troop attitudes about nuclear weapons before and after participation in the activity. In addition, the agency assessed factors governing the amount of information on nuclear testing communicated to other troops by participants returning to their bases. The data collected by HumRRO assisted the Army in determining the probable behavior of troops involved in nuclear warfare (13).



Figure 3-3: TROOPS AT THE OBSERVATION POINT WATCHING SHOT DOG

3.3 DAMAGE EFFECTS TESTS AT EXERCISES DESERT ROCK I, II, AND III

During Desert Rock I, II, and III, evaluation teams, each consisting of as many as ten men, studied the effects of the detonations on military equipment and field fortifications. The Chemical, Signal, Engineer, Medical, Ordnance, and Quartermaster sections of Camp Desert Rock each supplied one team, except for Exercise Desert Rock II, where the medical team apparently did not participate. Each team was responsible for constructing equipment displays at the display areas shown in figure 3-1, for recovering test equipment after the detonation, and for preparing a report of its findings (57; 60).

Members of the 231st Engineer Combat Battalion spent several days before each detonation constructing the displays. In addition, they instrumented foxholes with film badges to indicate the radiation exposure that personnel might have received had they been in the foxholes during the detonation.

After each shot, the evaluation teams went to the display areas to assess the damage to the equipment and fortifications. Each team was accompanied by a radiological monitor to warn personnel if they were approaching areas with hazardous radiation intensities. The teams later reentered the forward area to retrieve test equipment. Members of the 231st Engineer Combat Battalion recovered materials used in the fortifications (57-60).

In preparing their reports, the teams received technical information from the AFSWP Advisory Group. They also received assistance from the LASL Graphic Arts Group, which provided photographs of the weapons effects tests for the reports (57; 60).

CHAPTER 4

DEPARTMENT OF DEFENSE PARTICIPATION IN TEST ORGANIZATION PROGRAMS AT OPERATION BUSTER-JANGLE

During Operation BUSTER-JANGLE, the test organization coordinated separate programs of scientific research, including tests of the nuclear devices and tests of military effects of the detonations. Air support, coordinated by the Air Force Special Weapons Command, was provided to these programs as needed. In most cases, the individual projects conducted under each program required relatively few personnel. Only about 30 percent of the Department of Defense participants in BUSTER-JANGLE, about 2,500 personnel, were part of the test organization. Although their numbers were relatively small compared to Desert Rock personnel, the test organization participants' activities are significant, since they often repeated their tasks throughout the entire series of atmospheric nuclear tests.

This chapter describes these test activities, beginning with the scientific and diagnostic experiments conducted by two test units:

- Weapons Effects Test Unit
- Weapons Development Test Unit.

Composed of scientists, technicians, and military personnel from various military and civilian laboratories and support contractors, the test units developed and conducted field experiments to gather data before, during, and after the nuclear detonations.

Of the test units at Operation BUSTER-JANGLE, the Weapons Effects Test Unit involved the greater number of DOD participants. The mission of the Weapons Effects Test Unit was to measure weapons effects characteristics. The data obtained from the atmospheric nuclear weapons tests were used to strengthen the nuclear arsenal and to expand techniques and strategies for using

that arsenal. The Weapons Development Test Unit, through its AEC nuclear weapons development laboratory, the Los Alamos Scientific Laboratory, performed diagnostic tests on the phenomena produced by nuclear devices. The data from these experiments were used to improve the weapons and to develop new designs (5; 48; 55).

Throughout Operation BUSTER-JANGLE, numbers were used to identify the sponsors of the technical programs and experiments performed by the test units:

- Programs 1 through 4 and 6 through 9 were conducted by the Weapons Effects Test Unit.
- Program 10 was conducted by the Weapons Development Test Unit.

The final section of this chapter describes the air support and services provided by the Special Weapons Command. Permanently based at Kirtland AFB, SWC supported the Test Manager and the test units by supplying crews and aircraft for airdrop delivery missions, cloud-sampling and cloud-tracking missions, aerial surveys, and other air missions as requested. The Air Operations Center, located at the AEC Control Point in Yucca Pass, maintained operational control over all aircraft flying over and near the Nevada Proving Ground during testing periods (55).

4.1 DEPARTMENT OF DEFENSE INVOLVEMENT IN WEAPONS EFFECTS TESTS

During Operation BUSTER-JANGLE, the Weapons Effects Test Unit conducted experiments to provide a better understanding of the effects of nuclear weapons for both offensive and defensive deployment. The Director of the Weapons Effects Test Unit, who reported to the Test Director, coordinated these activities. Each program was managed by a program director, who was responsible to the Director of the Weapons Effects Test Unit. Each program was divided into several projects, each headed by a project officer.

The Department of Defense used the weapons effects tests to attain the following objectives:

- Develop the vehicles for deploying the nuclear devices
- Design military equipment able to withstand the effects of a nuclear detonation
- Develop doctrine for better use of the weapons
- Determine the military requirements for future nuclear weapons designs.

The weapons effects tests were divided into three categories:

- Basic measurements of the output characteristics of nuclear devices, such as blast, thermal, and radiation measurements
- Tests to determine blast, thermal, and radiation effects on living animal tissues, structures, equipment, and material
- Operational tests to develop and evaluate techniques and equipment unique to nuclear warfare, such as Indirect Bomb Damage Assessment (IBDA).

This section details the objectives and general procedures employed for each project, first of the Operation BUSTER shots and then of the Operation JANGLE shots. Because each operation had different scientific programs and projects associated with it, they are discussed separately. In several instances, similar projects were conducted at both operations. In some cases, the project had one number for BUSTER and a different number for JANGLE. The pertinent multi-shot volumes contain information regarding participants' activities at a particular shot.

4.1.1 Operation BUSTER Programs and Projects

During the BUSTER phase, the Weapons Effects Test Unit conducted projects that were part of seven programs fielded by

various military and civilian DOD laboratories and contractors. Table 4-1 lists the programs and projects conducted at each shot. This table is an index to project descriptions in this chapter and in the multi-shot volume, Shots ABLE to EASY, the First Five Tests of the BUSTER-JANGLE Series.

The sources used to compile table 4-1 are the weapons test reports generated by each project. These sources describe actual rather than planned shot participation. Although other documents are available listing project participation by shot, they indicate planned participation only. Table 4-1 shows the projects that actually were conducted at each shot.

Program 2, Thermal and Nuclear Radiation, investigated the military significance of nuclear and thermal phenomena associated with nuclear detonations. Table 4-2 lists the Program 2 projects conducted during Operation BUSTER, including the shots at which the project was performed and the fielding agencies (48).

Project 2.2, Thermal and Blast Effects on Idealized Forest Fuels, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the Division of Fire Research of the Forest Service. The objective was to study the effects of a nuclear detonation on forests. Project participants arranged forest fuels, such as pine needles, hardwood leaves, and grass, in trays, the tops of which were flush with the ground to approximate natural conditions. Before each detonation, they installed the trays at six stations ranging 630 to 4,400 meters from ground zero. At stations 2,130 and 2,740 meters from ground zero, Naval Radiological Defense Laboratory personnel installed high-speed cameras to record ignition and combustion behavior. They also took preshot and postshot photographs and studied the natural vegetation of the NPG before and after each detonation (17).

**Table 4-1: WEAPONS EFFECTS TESTS CONDUCTED AT
OPERATION BUSTER**

Program \ Shot	ABLE	BAKER	CHARLIE	DOG	EASY	Estimated DOD Personnel
Program 2, Thermal and Nuclear Radiation		2.2	2.2	2.2	2.2	10
		2.3		2.3		5
		2.4a		2.4a		5
		2.4b		2.4b		5
	2.4-1	2.4-1	2.4-1	2.4-1	2.4-1	8
		2.4-2		2.4-2		8
Program 3, Blast Effects on Structures and Equipment		3.5	3.5	3.5	3.5	9
				3.8	3.8	3
					3.9	6
Program 4, Bio-medical		4.1	4.1	4.1	4.1	5
		4.2		4.2		8
		4.2a		4.2a		8
		4.3	4.3	4.3		17
Program 6, Test of Service Equipment and Operations		6.1b	6.1b	6.1b		6
		6.4	6.4	6.4	6.4	*
				6.5	6.5	*
			6.9	6.9	6.9	*
Program 7, Long-range Detection		7.1	7.1	7.1	7.1	30
		7.2	7.2	7.2	7.2	*
	7.3	7.3	7.3	7.3	7.3	28
	7.5	7.5	7.5	7.5	7.5	14
		7.6	7.6	7.6	7.6	*
Program 8, Supporting Measurements	8.2	8.2	8.2	8.2	8.2	90
				8.4	8.4	*
Program 9, Personnel Shelter Evaluation		9.1a	9.1a	9.1a		10
		9.1b	9.1b	9.1b	9.1b	10

*Unknown

Table 4-2: WEAPONS EFFECTS TESTS OF PROGRAM 2, OPERATION BUSTER

Project	Title	Objective	Shots	Participants
2.2	Thermal and Blast Effects on Idealized Forest Fuels	To study the effects of a nuclear detonation on forests	BAKER, CHARLIE, DOG, EASY	Division of Fire Research, Forest Service
2.3	Effects of Geometry on Flash Thermal Damage	To determine the effects of exposure configuration on thermal damage	BAKER, DOG	Naval Material Laboratory
2.4a	Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation	To determine the protective value of clothing materials exposed to thermal radiation	BAKER, DOG	Office of the Quartermaster General; Quartermaster Board; Engineer Research and Development Laboratories
2.4b	Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics	To determine thermal effects on various materials	BAKER, DOG	Engineer Research and Development Laboratories
2.4-1	Basic Thermal Radiation Measurements	To obtain thermal radiation measurements at various distances from a nuclear detonation	ALL	Naval Radiological Defense Laboratory
2.4-2	The Effect of Thermal Radiation on Materials	To determine thermal effects on various materials	BAKER, DOG	Naval Material Laboratory
2.6	Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux	To determine the protection afforded by field fortifications against the radiation from a nuclear detonation	BAKER, CHARLIE, DOG	Engineer Research and Development Laboratories

Project 2.3, Effects of Geometry on Flash Thermal Damage, was conducted at Shots BAKER and DOG by the Naval Material Laboratory. The objective was to determine the effect of a target's size, shape, and thermal properties on the thermal damage resulting from a nuclear detonation. In the days preceding each shot, Project 2.3 and 2.4 participants installed wooden materials at three stations 610 to 1,520 meters from the BAKER ground zero and 1,220 to 1,830 meters from the DOG ground zero. They returned to the shot area after the detonation to examine the effects of the detonation on each of the materials (96).

Project 2.4a, Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation, was conducted at Shots BAKER and DOG by the Office of the Quartermaster General, the Quartermaster Board, and the Engineer Research and Development Laboratories. This project was to evaluate the protective value of clothing materials exposed to thermal radiation. Before each detonation, project participants placed various fabrics at four stations 650 to 2,180 meters from the BAKER ground zero and at three stations 1,240 to 2,150 meters from the DOG ground zero. They returned to the shot area following the detonation to evaluate and photograph damage to the fabrics (31).

Project 2.4b, Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics, was conducted at Shots BAKER and DOG by the Engineer Research and Development Laboratories. The objective was to determine the effects of a nuclear detonation on various paints, plastics, and fabrics. Project participants applied paints to steel, aluminum, and wood surfaces before each detonation. They positioned these painted samples, along with plastic and fabric specimens, in the shot area at various distances from ground zero. After the detonation, they monitored the specimens for radiation and photographed and retrieved the samples for laboratory analysis (77).

Project 2.4-1, Basic Thermal Radiation Measurements, was performed at Shots ABLE, BAKER, CHARLIE, DOG, and EASY by the Naval Radiological Defense Laboratory. The objective was to conduct thermal measurements at distances from a nuclear detonation where significant thermal damage was expected. Project personnel used thermal detectors to detect and record the thermal pulse. They placed the instruments and samples of cloth, wood, and paint at stations 500 to 3,660 meters from ground zero (15).

Project 2.4-2, The Effect of Thermal Radiation on Materials, was conducted at Shots BAKER and DOG by the Naval Material Laboratory. The objective was to study the physical characteristics of thermal radiation and its effects on various materials. The study continued a similar experiment conducted during Operation GREENHOUSE that investigated thermal damage to materials. Participants placed panels of different materials and thermal indicators at various ranges from each ground zero (79).

Project 2.6, Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux, was conducted at Shots BAKER, CHARLIE, and DOG by the Engineer Research and Development Laboratories. The objective was to evaluate the protection afforded by field fortifications against the radiation from a nuclear detonation.

Project personnel constructed two-man foxholes in Area 7 at 275-meter intervals and at distances of 90 to 2,000 meters southwest of the intended ground zero. They also constructed one-man foxholes adjacent to the two-man foxholes located 365, 915, and 1,465 meters from ground zero. Before each detonation, project personnel instrumented each foxhole with gamma film detectors. They also placed neutron detectors in the two-man foxholes located within 920 meters of ground zero. Project participants retrieved the gamma and neutron detectors within two hours of each detonation. The detectors were then flown to LASL for analysis (113).

Program 3, Blast Effects on Structures and Equipment, investigated the effects of airburst nuclear weapons on selected military equipment. The program involved the projects shown in table 4-3.

Table 4-3: WEAPONS EFFECTS TESTS OF PROGRAM 3, OPERATION BUSTER

Project	Title	Objective	Shots	Participants
3.5	Minefield Clearance	To determine the ability of airburst nuclear devices to detonate antitank mines	BAKER, CHARLIE, DOG, EASY	Engineer Research and Development Laboratories
3.8	Effects of an Atomic Detonation on Aircraft Structures on the Ground	To determine thermal and blast effects on parked aircraft	DOG, EASY	Wright Air Development Center
3.9	Effects on Selected Water Supply Equipment	To determine blast, thermal, and radiation effects on water storage tanks	EASY	Engineer Research and Development Laboratories

Project 3.5, Minefield Clearance, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the Engineer Research and Development Laboratories. The objective was to determine the effects of a nuclear airburst on antitank and beach mines placed at various distances from ground zero. Project personnel used the Universal Indicator mine, which behaves similarly to antitank and beach mines. Scientists computed the probabilities of mine detonation based on the project results.

Participants designed a minefield pattern having 20 positions consisting of two rows of ten mines each. The pattern began 400 meters south of the BAKER, CHARLIE, and DOG ground zero and 900 meters southeast of the EASY ground zero and then extended 1,830 meters east. In preparing the minefield, participants bulldozed a path 20 meters wide in Area 7 (110).

Project 3.8, Effects of an Atomic Detonation on Aircraft Structures on the Ground, was conducted at Shots DOG and EASY by

the Wright Air Development Center. The objective was to determine the structural damage to parked aircraft that resulted from the thermal and blast energy of a nuclear detonation. Project personnel tested one B-17 and one F-47 aircraft at each shot. They placed the aircraft at specific ranges from ground zero based on predicted overpressures (89).

Project 3.9, Effects on Selected Water Supply Equipment, was performed at Shot EASY by the Engineer Research and Development Laboratories. The primary objectives were to determine the:

- Blast and thermal damage to 3,000-gallon tanks filled with water
- Radioactive contamination of water in the tanks
- Amount of induced radioactivity in canned samples of sea water in various dilutions and in bottles of assorted fresh water.

Before the detonation, project personnel placed water tanks and canned and bottled water samples 460 to 3,930 meters southwest of ground zero. After the detonation, they examined the tanks and water samples (71).

Program 4, Bio-medical, was to determine the nuclear and thermal effects of airburst nuclear devices. By exposing test animals and instruments to the detonations, program personnel hoped to gain information concerning these effects on the human body. Table 4-4 shows the projects in this program.

Project 4.1, Radiation Dosimetry, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the Naval Medical Research Institute. The objectives were to:

- Measure the ionization produced by gamma radiation at various depths in the ground and at various distances from ground zero
- Correlate laboratory measurements with field measurements.

Project personnel placed dosimeters and other radiation detection instruments at four stations located at various distances from ground zero. They recovered the instruments about three hours after each detonation (48; 86).

Table 4-4: WEAPONS EFFECTS TESTS OF PROGRAM 4, OPERATION BUSTER

Project	Title	Objective	Shots	Participants
4.1	Radiation Dosimetry	To measure gamma radiation exposure at various locations	BAKER, CHARLIE, DOG, EASY	Naval Medical Research Institute
4.2	Thermal Effects on Animals (Dogs)	To compare burns produced on dogs in the laboratory with those produced by a nuclear detonation	BAKER, DOG,	Medical College of Virginia; Office of the Surgeon General
4.2a	Thermal Effects on Animals (Rats)	To investigate burn damage to rats	BAKER, DOG	Naval Radiological Defense Laboratory
4.3	Flash Blindness	To determine visual difficulties resulting from witnessing the flash of a nuclear detonation	BAKER, CHARLIE, DOG	Air Force School of Aviation Medicine

Project 4.2, Thermal Effects on Animals (Dogs), was conducted at Shots BAKER and DOG by the Medical College of Virginia and the Office of the Surgeon General. The primary objective was to determine the biological relationship between burns produced on dogs in the laboratory and those caused by a nuclear detonation. The secondary objective was to determine the protection afforded against burns by military fabrics. Before each detonation, project personnel placed two anesthetized dogs, each clothed in a canvas jacket, 1,220 meters from the BAKER ground zero and six anesthetized and jacketed dogs 2,130 and 2,740 meters from the DOG ground zero. After the detonation, they recovered the animals for laboratory analysis (16; 86).

Project 4.2a, Thermal Effects on Animals (Rats), was conducted at Shots BAKER and DOG by the Naval Radiological

Defense Laboratory. The objective was to investigate burn damage to rat skin as a function of the energy delivered from a nuclear detonation. Before Operation BUSTER-JANGLE, test participants had used only dogs and pigs in investigating burns at nuclear tests. Prior to each detonation, project participants placed 60 anesthetized rats along a radial line 640 to 3,660 meters from ground zero. Two hours after the detonation, participants recovered the rats for laboratory analysis (100).

Project 4.3, Flash Blindness, was conducted at Shots BAKER, CHARLIE, and DOG by the Air Force School of Aviation Medicine. The objectives were to evaluate the:

- Visual handicap that might be expected if military personnel were exposed to the flash of a nuclear detonation
- Effectiveness of goggles developed to protect the eyes during exposure to a nuclear flash.

During each detonation, an estimated 17 volunteers orbited in a C-54 aircraft about 15 kilometers from ground zero, at an altitude of 15,000 feet. Beginning immediately after the detonation, project personnel performed a number of visual tasks. The aircraft then returned to Kirtland AFB (18).

Program 6, Test of Service Equipment and Operations, was designed to test equipment and techniques developed by three services to determine various effects of nuclear detonations. The program consisted of the projects listed in table 4-5.

Project 6.1b, Evaluation of Dosimetric Materials, was conducted at Shots BAKER, CHARLIE, and DOG by the Signal Corps Engineering Laboratories and the Bureau of Ships. The objective was to field-test several personnel dosimeters, including some that were and some that were not self-reading. Project participants placed the dosimeters inside aluminum shelters located at various distances from each ground zero (30).

Table 4-5: WEAPONS EFFECTS TESTS OF PROGRAM 6, OPERATION BUSTER

Project	Title	Objective	Shots	Participants
6.1b	Evaluation of Dosimetric Materials	To field-test personnel dosimeters	BAKER, CHARLIE, DOG	Signal Corps Engineering Laboratories; Bureau of Ships
6.4	Airborne Radiac Evaluation	To evaluate equipment used to detect radioactivity from aircraft	BAKER, CHARLIE, DOG, EASY	Bureau of Aeronautics; Wright Air Development Center; Air Research and Development Command
6.5	Operational Tests of Techniques for Accomplishing IBDA	To test radar and photographic equipment for use as an IBDA system	DOG, EASY	Wright Air Development Center
6.9	Effects of Atomic Detonations on Radio Propagation	To determine the effects of a nuclear detonation on radio communications	CHARLIE, DOG, EASY	Signal Corps Engineering Laboratories

Project 6.4, Airborne Radiac Evaluation, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the Bureau of Aeronautics, Wright Air Development Center, and Air Research and Development Command. The objective was to evaluate the capabilities of airborne radiation detection equipment in detecting the cloud resulting from a detonation and in indicating the cloud's position relative to the monitoring aircraft. The instruments evaluated were the AN/ADR-3 and Type F-1 ground survey meters and the AN/ADR-1 recording dosimeter. A Navy P2V-2 and an Air Force B-17 aircraft equipped with the radiac devices participated at each of the shots. During the detonation, the aircraft were about 30 kilometers from ground zero. After receiving permission from the tower, they proceeded in the direction of the cloud to determine the maximum distance from which the cloud could be detected (109).

Project 6.5, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment, was conducted at Shots DOG and EASY by the Wright Air Development Center, with support from Lookout Mountain Laboratory. The objective was to test, under

operational conditions, radar and photographic equipment as a means of determining ground zero, height of burst, and yield of a nuclear detonation. With measurements gathered by strike aircraft, it would then be possible to assess the effect of the nuclear detonation on enemy installations. For this project, two B-50 and one B-29 aircraft instrumented with radar equipment and cameras took photographs and recorded data following the detonations (65). Lookout Mountain Laboratory personnel participating in Project 8.4 did the photography (55; 65).

Project 6.9, Effects of Atomic Detonations on Radio Propagation, was conducted at Shots CHARLIE, DOG, and EASY by the Signal Corps Engineering Laboratories. The objective was to determine the effects of a nuclear detonation on the propagation of radio communications at various frequencies. Project personnel made measurements at the Nevada Proving Ground and at Alamo and Beatty, Nevada. The onsite station was 2.4 kilometers from the Control Point and about 14 kilometers from each ground zero (106).

Program 7, Long-range Detection, tested and evaluated various techniques used to detect nuclear detonations at long ranges. Table 4-6 indicates the Program 7 projects.

Project 7.1, Transport of Radiation Debris, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by Headquarters, Air Force, and the Air Weather Service. The objective was to determine the distribution of airborne debris from a nuclear detonation. The Air Weather Service tracked the debris at various distances from the Nevada Proving Ground (3). Cloud tracking is described in section 4.3 of this chapter, on Air Force support missions during Operation BUSTER-JANGLE.

Table 4-6: WEAPONS EFFECTS TESTS OF PROGRAM 7, OPERATION BUSTER

Project	Title	Objective	Shots	Participants
7.1	Transport of Radiation Debris	To determine the distribution of airborne radioactive debris resulting from a nuclear detonation	ALL	Headquarters, Air Force; Air Weather Service
7.2	Long-range Light Measurements	To study light transmission from a nuclear detonation	BAKER, CHARLIE, DOG, EASY	4925th Test Group; EG&G
7.3	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	To perform analysis of bomb debris collected in cloud-sampling missions	ALL	Headquarters, Air Force; 4925th Test Group
7.5	Seismic Waves from A-Bombs Detonated over a Land Mass	To determine the seismic waves resulting from a nuclear detonation	ALL	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
7.6	Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE	To evaluate acoustic equipment used to detect nuclear detonations at long ranges	BAKER, CHARLIE, DOG, EASY	Naval Electronics Laboratory; Signal Corps Engineering Laboratories; National Bureau of Standards

Project 7.2, Long-range Light Measurements, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the 4925th Test Group (Atomic) and by EG&G. The objective was to study light transmission from a nuclear detonation and to obtain data for the design of long-range detection systems. At shot-time, project participants operated cameras at several stations in Nevada, Arizona, and New Mexico (24).

Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was performed at all BUSTER shots by Headquarters, Air Force, in conjunction with sampling operations conducted by the 4925th Test Group (Atomic). Personnel made radiochemical analyses of nuclear weapon debris obtained close to the Nevada Proving Ground (103). Cloud-sampling operations are discussed in section 4.3 of this chapter.

Project 7.5, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted at all BUSTER shots by the 1009th Special Weapons Squadron, Naval Ordnance Laboratory, Acoustics Research Division of the Wright Air Development Center, and Coast and Geodetic Survey. The objective was to study seismic waves propagated by nuclear detonations. Personnel obtained data from five onsite and a number of offsite stations (29).

Project 7.6, Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the Naval Electronics Laboratory, Signal Corps Engineering Laboratories, and National Bureau of Standards. The objective was to determine the range and reliability of acoustic detection equipment for continental nuclear explosions of various yields. Project personnel worked at stations in Alaska, California, Florida, Hawaii, Kentucky, New Jersey, Texas, Washington, and Washington, D.C. (88).

Program 8, Supporting Measurements, obtained data for use by other projects in evaluating test results. The program consisted of two projects at BUSTER.

Project 8.2, Air Weather Service Participation in Operation BUSTER, was conducted at Shots ABLE, BAKER, CHARLIE, DOG, and EASY by the 2059th Air Weather Wing and one of its units, the 2060th Mobile Weather Squadron, from Tinker AFB. The objective was to gather and report information before each detonation regarding such weather factors as wind conditions, temperature, and humidity. Weather forecasts included estimates of the anticipated cloud cover, winds at the surface and up to 45,000 feet, and the precipitation projected within a radius of 500 kilometers of the target area.

Project personnel worked from a weather station at the Control Point and from outlying upper air observation stations at

Tonopah, Warm Springs, Carrant, Pioche, and Alamo, Nevada, and at St. George, Utah. Ninety personnel took part in Shots ABLE and BAKER, and 73 participated in each of the subsequent shots. Participants issued their first weather forecast on 15 October 1951. Thereafter, they issued daily forecasts throughout Operation BUSTER. Project personnel gave weather briefings at the Control Point at 0800, 2000, and 2400 hours on the day preceding each detonation in addition to a final summary just before shot-time (55).

Project 8.4, Technical Photography for IBDA Project, was conducted at Shots DOG and EASY by the Air Force Lookout Mountain Laboratory. The purpose was to provide technical and documentary photography of Project 6.5, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment. Lookout Mountain Laboratory personnel took photographs from two B-50 and one B-29 aircraft (55; 65).

Program 9, Personnel Shelter Evaluation, tested the design of shelters for protection against the effects of an airburst detonation. The program consisted of two projects, both of which evaluated family-size and larger shelters.

Project 9.1a, FCDA Family Shelter Evaluation, was performed at Shots BAKER, CHARLIE, and DOG by the Federal Civil Defense Administration. The project was designed to determine the effects of nuclear blasts on small shelters for family use. Before each shot, project personnel assembled 29 prefabricated shelters made of metal, wood, and brick at eight-meter intervals along an arc 370 meters east of zero. Since the project was a late addition to the test program, there was not time to instrument the structures completely. Improvised methods, including gamma film badges, deflection devices, and land mine fuses, were used to measure pressure inside the shelters (41).

Project 9.1b, AEC Communal Shelter Evaluation, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by the Los Alamos Scientific Laboratory. The objective was to determine the effects of a nuclear detonation on a prototype shelter constructed of conventional materials and buried under about three feet of earth. In the days before the first detonation, project personnel constructed a shelter about 250 meters southeast of the airburst ground zeroes. Before each shot, they instrumented the structure with gauges and gamma film badges. They evaluated damage to the shelter and retrieved the gauges and film badges after recovery hour was declared (26).

4.1.2 Operation JANGLE Programs and Projects

During Operation JANGLE, the Weapons Effects Test Unit conducted projects that were part of seven programs fielded by various military and civilian DOD laboratories and contractors. Table 4-7 lists the programs and projects conducted at each JANGLE shot. This table is an index to project descriptions in this chapter and in the multi-shot volume, Shots SUGAR and UNCLE, the Final Tests of the BUSTER-JANGLE Series. The sources used to compile this table are the weapons test reports generated by each project (5).

In addition to the projects listed in table 4-7, AFSWP personnel conducted ten Program 1 projects and one Program 2 project associated with Operation JANGLE but not directly involving a nuclear detonation. Project 1(8)a, Geologic, Hydrologic, and Thermal Features of the Sites, and Project 1(8)a-1, Seismic Refraction Survey for Nye County, Nevada, were geologic studies conducted outside the time frame of Operation JANGLE (90; 97). Four other Program 1 projects were theoretical studies of the effects of nuclear explosions (49; 50; 80; 98):

- Project 1.9, Theoretical Studies of Underground Shock Waves

**Table 4-7: WEAPONS EFFECTS TESTS CONDUCTED DURING
OPERATION JANGLE**

Program	SUGAR	UNCLE	Estimated DOD Personnel
Program 1, Blast and Shock	1.1	1.1	16
	1.2a-1	1.2a-1	4
	1.2a-2	1.2a-2	4
		1.2b	2
	1.3a	1.3a	4
	1.3b	1.3b	*
	1.3c		47
	1.4	1.4	4
	1.5a	1.5a	*
		1.5b	*
	1.6	1.6	*
	1.7	1.7	*
	1(8)-b	1(8)-b	*
		1(9)-a	*
	1(9)-b	*	
Program 2, Radiological Phenomena	2.1a	2.1a	7
	2.1b	2.1b	*
	2.1c-1	2.1c-1	15
	2.1c-2	2.1c-2	*
	2.1d	2.1d	*
	2.3-1	2.3-1	6
	2.3-2	2.3-2	6
	2.4a	2.4a	4
	2.4b	2.4b	4
	2.4c	2.4c	5
	2.5a-1	2.5a-1	25
	2.5a-2	2.5a-2	17
	2.5a-3	2.5a-3	*
	2.6a	2.6a	16
	2.6c-1	2.6c-1	*
	2.6c-2	2.6c-2	*
	2.6c-3	2.6c-3	*
	2.7	2.7	6
2.8	2.8	*	
Program 3, Blast Effects		3.1	*
		3.2	*
		3.3	*
		3.28	*
		3.29	*

*Unknown

**Table 4-7: WEAPONS EFFECTS TESTS CONDUCTED DURING
OPERATION JANGLE (CONTINUED)**

Program	SUGAR	UNCLE	Estimated DOD Personnel
Program 4, Special Phenomena	4.1	4.1	*
	4.1a-1	4.1a-1	2
	4.1a-2	4.1a-2	*
	4.2	4.2	*
		4.5	*
Program 6, Tests of Service Equipment and Operations	6.1	6.1	*
	6.2	6.2	*
	6.3-1	6.3-1	*
	6.3-2	6.3-2	*
		6.4	*
	6.7	6.7	*
	6.8	6.8	*
Program 7, Long-range Detection	7.1a	7.1a	10
	7.1b	7.1b	16
	7.2	7.2	*
	7.3	7.3	*
Program 8, Supporting Measurements		8.4	*

*Unknown

- Project 1.9-1, Application of the Kirtwood-Brinkley Method to the Theory of Underground Explosions
- Project 1.9-2, Notes on Surface and Underground Explosions
- Project 1.9-3, Predictions for the Underground Shot.

Other Program 1 projects were performed in conjunction with a series of high-explosive (HE) tests conducted between 25 August and 9 September 1951 (19; 20; 35; 116):

- Project 1(9)-1, Scaled HE Tests
- Project 1(9)-2, Composition of Clouds Formed by TNT Explosions
- Project 1(9)-3, Some HE Tests and Observations on Craters and Base Surges
- Project 1(9)-4, Base Surge Analysis--HE Tests.

The Program 2 experiment, Project 2.0, Predicted Scaling of Radiological Effects to Operational Weapons, lasted from March 1952 to June 1952. Its purpose was to use data obtained from Operation JANGLE to predict the radiological contamination that might result from fission bombs detonated near the earth's surface (99).

Program 1, Blast and Shock, was designed to:

- Measure blast pressures produced by surface and underground nuclear detonations and by high explosives
- Develop theories for predicting blast effects produced by surface and underground nuclear detonations
- Survey the geology of the NPG to determine its effect on the propagation of blast waves.

The program consisted of the projects indicated in table 4-8.

Table 4-8: WEAPONS EFFECTS TESTS OF PROGRAM 1, OPERATION JANGLE

Project	Title	Objective	Shots	Participants
1.1	Ground Acceleration Measurement	To measure ground acceleration from surface and underground detonations	SUGAR, UNCLE	Naval Ordnance Laboratory
1.2a-1	Peak Air Blast Pressures from Shock Velocity Measurements	To study air blast effects in relation to ground shock effects	SUGAR, UNCLE	Ballistics Research Laboratories
1.2a-2	Transient Ground Mechanical Effects from High Explosives (HE) and Nuclear Explosions	To measure ground shock from a nuclear detonation	SUGAR, UNCLE	Ballistics Research Laboratories
1.2b	Close-in Ground Measurements	To determine blast phenomena from an underground detonation	UNCLE	Naval Special Weapons Unit
1.3a	Free Air Shock Arrival Times	To determine the time of arrival of the blast wave	SUGAR, UNCLE	Brookhaven National Laboratory
1.3b	Peak Pressure versus Distance in Free Air Using Smoke and Rocket Photography	To determine peak pressure along the ground and in the air	SUGAR, UNCLE	Naval Ordnance Laboratory
1.3c	The Measurement of Free Air Atomic Blast Pressures	To measure blast pressures in free air	SUGAR	Air Force Cambridge Research Center; 6531st Flight Test Squadron
1.4	Free Air Pressure Measurements	To measure blast pressures at ground-level stations	SUGAR, UNCLE	Sandia Corporation
1.5a	Transient Ground Displacement Measurement	To measure the transient ground displacement caused by surface and underground detonations	SUGAR, UNCLE	Naval Ordnance Laboratory
1.5b	Detection of Time of Arrival of First Earth Motion	To determine the time of the first earth motion following an underground detonation	UNCLE	David Taylor Model Basin
1.6	Earth Displacement (Shear Shafts)	To measure permanent earth displacement following surface or underground detonations	SUGAR, UNCLE	Ohio River Division Laboratories; Office, Chief of Engineers
1.7	Ground Acceleration (Shock Pins)	To determine the amount of ground acceleration due to surface or underground detonations	SUGAR, UNCLE	Massachusetts Institute of Technology; Office, Chief of Engineers
1(8)b	Air Weather Service Participation in Operation JANGLE	To provide weather predictions prior to each detonation	SUGAR, UNCLE	2060th Mobile Weather Squadron
1(9)a	Ground Acceleration, Ground and Air Pressures for Underground Tests	To measure basic blast phenomena for an underground detonation	UNCLE	Stanford Research Institute
1(9)b	Base Surge Analysis for Nuclear Tests	To analyze the base surge resulting from an underground detonation	UNCLE	Naval Ordnance Laboratory

Project 1.1, Ground Acceleration Measurement, was conducted at Shots SUGAR and UNCLE by the Naval Ordnance Laboratory. The principal objective was to study the characteristics of ground acceleration resulting from a surface and an underground detonation. Project participants placed accelerometers and pressure gauges at an estimated 16 stations located 90 to 930 meters south-southwest of the SUGAR ground zero and 60 to 930 meters south-southwest of the UNCLE ground zero. A revetted trailer 2,480 meters south-southwest of each ground zero recorded information registered by the instruments (81).

Project 1.2a-1, Peak Air Blast Pressures from Shock Velocity Measurements, was conducted at Shots SUGAR and UNCLE by the Ballistics Research Laboratories. The objective was to study airblast effects in relation to ground shock effects. Blast switches and microphones were placed along a blast line at stations located 90 to 910 meters south of the SUGAR ground zero and 90 to 470 meters south of the UNCLE ground zero (37).

Project 1.2a-2, Transient Ground Mechanical Effects from HE and Nuclear Explosions, was conducted at Shots SUGAR and UNCLE by the Ballistics Research Laboratories. Project 1.2a-1 personnel also took part in this project. The objective was to measure ground shock phenomena. One phase of the experiment was to measure ground acceleration using self-recording instruments. Another phase was to measure ground pressure as a function of time and distance from the detonation. To obtain preliminary measurements for the SUGAR and UNCLE detonations, participants performed the experiment at two high-explosive underground tests conducted on 25 August and 3 September. For each of the two nuclear detonations, participants placed gauges for measuring ground acceleration and pressure at 12 stations 90 to 910 meters south of ground zero (4).

Project 1.2b, Close-in Ground Measurements, was conducted at Shot UNCLE by the Naval Special Weapons Unit. The objective was to measure, at close ranges, blast phenomena produced by an underground nuclear detonation. Project participants placed blast gauges and pressure switches in holes 17 feet deep, the same depth at which UNCLE was detonated. The instruments were at 31 stations located 1.5 to 100 meters from ground zero. Electrical cables transmitted data from each of these gauges to a recording station about 2,400 meters from ground zero (45).

Project 1.3a, Free Air Shock Arrival Times, was conducted at Shots SUGAR and UNCLE by the Brookhaven National Laboratory. The objective was to measure the time of arrival of the blast wave in free air resulting from surface and underground nuclear detonations. Project personnel took measurements with pressure gauges suspended from balloons. A telemetry system transmitted the pressure data from the gauges to a receiving station about eight kilometers from ground zero (92).

Project 1.3b, Peak Pressure versus Distance in Free Air Using Smoke and Rocket Photography, was conducted at Shots SUGAR and UNCLE by the Naval Ordnance Laboratory. The objective was to determine the peak overpressure along the ground and in the air above a surface and an underground detonation. Project personnel used high-speed photographs of smoke rocket trail distortions to measure blast pressures. The night before the detonation, they placed smoke rocket launchers at various locations in the shot area and positioned cameras 3,750 meters from the UNCLE ground zero and 4,570 meters from the SUGAR ground zero (83).

Project 1.3c, The Measurement of Free Air Atomic Blast Pressures, was conducted at Shot SUGAR by the Air Force Cambridge Research Center and the 6531st Flight Test Squadron. The objective was to measure free-air blast pressures using instrumented canisters deployed from aircraft. The operation was a preliminary

test of equipment and techniques anticipated for use in future tests. Two B-29 aircraft provided by the 6531st Flight Test Squadron, Rome Air Development Center, each dropped four canisters. On the ground, radar guided the two B-29s to the proper drop point, a telemetry station received pressure data from the canisters, and a tracking system monitored the location of the canisters (54).

Project 1.4, Free Air Pressure Measurements, was conducted at Shots SUGAR and UNCLE by the Sandia Corporation. The objective was to record blast pressures at ground-level stations for both surface and underground detonations. Before Shot SUGAR, project participants placed gauges 150 to 1,280 meters from ground zero. Before Shot UNCLE, they positioned the gauges 100 to 950 meters from ground zero (63).

Project 1.5a, Transient Ground Displacement Measurement, was conducted at Shots SUGAR and UNCLE by the Naval Ordnance Laboratory. The objective was to measure the transient ground displacement caused by a surface and an underground nuclear detonation and to correlate this displacement with ground acceleration and damage to structures.

Before each shot, project personnel placed markers in the ground at ten stations 90 to 580 meters south of ground zero. In addition, they oriented a camera station, located 1,530 meters east of ground zero, toward the markers. During the detonations, the camera filmed the markers' movement resulting from the shots. After the shot, participants retrieved the film and measured marker displacement (82).

Project 1.5b, Detection of Time of Arrival of First Earth Motion, was conducted at Shot UNCLE by the David Taylor Model Basin. The objective was to obtain information on the time of the first detectable earth motion at each of ten stations located

on a radial line 30 to 180 meters from ground zero. Before the detonation, project participants installed electric flash lamps at the ten stations and positioned a camera at a station 2,700 meters east of ground zero. During the detonation, the camera recorded the first earth motion at each station as the flash lamp was triggered by the earth motion. After the declaration of recovery hour, participants retrieved film from the camera (25).

Project 1.6, Earth Displacement (Shear Shafts), was conducted at Shots SUGAR and UNCLE by the Ohio River Division Laboratories and the Office, Chief of Engineers. The objective was to determine the limits and amounts of permanent displacement in areas surrounding earth craters caused by surface and underground nuclear detonations. Project participants installed instruments in a series of deep shafts 230 meters east and west and 300 meters south of ground zero. Several weeks after the detonations, they retrieved the data to determine permanent earth displacement (87).

Project 1.7, Ground Acceleration (Shock Pins), was conducted at Shots SUGAR and UNCLE by the Massachusetts Institute of Technology for the Office, Chief of Engineers. The objective was to determine if shock pins would furnish reliable data regarding the magnitude of ground shock associated with nuclear detonations.

Before each detonation, project personnel installed metal shock pins two feet into the ground at stations about 190 to 380 meters east and west of ground zero and 170 to 560 meters south of ground zero. Participants reentered the shot area after the detonation to examine the exterior of each shock pin station. Excavating crews later uncovered the shelters, enabling personnel to photograph the positions of the shock pins (52).

Project 1(8)b, Air Weather Service Participation in Operation JANGLE, was conducted at Shots SUGAR and UNCLE by the

2060th Mobile Weather Squadron of the Air Weather Service. The activity was a continuation of Project 8.2, Air Weather Service Participation in Operation BUSTER. The objective, like that of Project 8.2, was to gather and report information before each detonation regarding the weather, including wind conditions, temperature, and humidity. Project personnel worked from a weather station at the Control Point and from observation stations at Tonopah, Warm Springs, Currant, Pioche, and Alamo, Nevada, and at St. George, Utah (67).

Project 1(9)a, Ground Acceleration, Ground and Air Pressures for Underground Tests, was conducted at Shot UNCLE by the Stanford Research Institute. The objectives were to:

- Obtain data for comparing the phenomena of an underground nuclear detonation with the phenomena resulting from high-explosive tests
- Provide measurements for Projects 1.1, 1.2a-2, and 1.4.

Before the detonation, project personnel installed accelerometers in the shot area to measure movements of the earth. Following the detonation, they retrieved data and compared the information with data obtained at the high-explosive tests conducted from 25 August to 14 October 1951 (34).

Project 1(9)b, Base Surge Analysis for Nuclear Tests, was conducted at Shot UNCLE by the Naval Ordnance Laboratory. The objective was to compare base surge data from an underground nuclear detonation with base surge data from underground high-explosive tests. In conducting the experiment, project personnel analyzed photographs of both UNCLE and the high-explosive tests (117).

Program 2, Radiological Phenomena, was designed to determine the:

- Physical, chemical, and radioactive characteristics of fallout
- Distribution of fallout at various ranges
- Biological hazards resulting from the radiological contamination produced by underground and surface detonations.

Table 4-9 lists the Program 2 projects, all of which were conducted at both Shots SUGAR and UNCLE.

Project 2.1a, Gamma Radiation as a Function of Time and Distance, was conducted at Shots SUGAR and UNCLE by the Evans Signal Laboratory and the National Bureau of Standards. The objective was to measure gamma intensity in order to assess the radiation effects of underground and surface bursts.

Prior to the detonations, project personnel placed radiation detecting instruments at various distances from each ground zero. The instruments were designed to measure residual gamma radiation in the shot area up to 48 hours after the detonation. At shot-time, eight or nine project participants operated an instrument station five kilometers west of the SUGAR and UNCLE ground zeros. At various times after the detonation, project personnel entered the shot area to retrieve data from the instrument stations (27).

Project 2.1b, Gamma Radiation as a Function of Time with Droppable Telemeters, was conducted at Shots SUGAR and UNCLE by the Naval Air Development Center. The objective was to measure the initial gamma intensity and subsequent fallout intensity from each detonation and to measure the gamma intensity in and around the SUGAR and UNCLE craters following the burst. The night before the detonation, personnel installed telemetering instruments at eight-meter intervals 310 to 920 meters northeast

Table 4-9: WEAPONS EFFECTS TESTS OF PROGRAM 2, OPERATION JANGLE

Project	Title	Objective	Participants
2.1a	Gamma Radiation as a Function of Time and Distance	To measure gamma radiation intensities	Evans Signal Laboratory; National Bureau of Standards
2.1b	Gamma Radiation as a Function of Time with Droppable Telemeters	To measure gamma intensities with instrumented, droppable canisters	Naval Air Development Center
2.1c-1	Aerial Survey of Distant Contaminated Terrain	To use instrumented aircraft to measure distant fallout	Headquarters, Air Force
2.1c-2	Aerial Survey of Local Contaminated Terrain	To measure onsite fallout from aircraft	Bureau of Aeronautics; Air Research and Development Command; Wright Air Development Center
2.1d	Monitor Survey of Ground Contamination	To determine the extent and magnitude of the SUGAR and UNCLE radiation fields	Naval Radiological Defense Laboratory; Radiological Health and Safety Group of LASL; AFSWP
2.3-1	Total Gamma Radiation Dosage	To determine the gamma radiation exposure resulting from surface or underground detonations	Evans Signal Laboratory
2.3-2	Foxhole Shielding of Gamma Radiation	To determine the protection afforded by foxholes against gamma radiation	Engineer Research and Development Laboratories
2.4a	Beta-ray and Gamma-ray Energy of Residual Contamination	To evaluate the biological hazard of residual beta and gamma radiation	Naval Radiological Defense Laboratory
2.4b	Gamma Depth Dose Measurement in Unit-density Material	To evaluate the biological hazard of initial and residual radiation	Naval Medical Research Institute
2.4c	Gamma Ray Spectrum Measurements of Residual Radiation	To determine the energy spectrum of residual gamma radiation	Brookhaven National Laboratory
2.5a-1	Airborne Particle Studies	To determine airborne fallout hazards	Army Chemical Center
2.5a-2	Fallout Particle Studies	To determine the physical and distribution characteristics of fallout	Naval Radiological Defense Laboratory
2.5a-3	Radiochemical Studies of Large Particles	To study the chemical and radiological composition of fallout	Army Medical Service Graduate School

Table 4-9: WEAPONS EFFECTS TESTS OF PROGRAM 2, OPERATION JANGLE (CONTINUED)

Project	Title	Objective	Participants
2.6a	Remotely Controlled Sampling Techniques	To obtain samples of the crater lip shortly after each detonation	Evans Signal Laboratory; Coles Signal Laboratory
2.6c-1	Nature and Distribution of Residual Contamination I	To determine the nature of contamination in soil following surface or underground detonations	National Institutes of Health; Public Health Service
2.6c-2	Nature and Distribution of Residual Contamination II	To determine the characteristics of radioactive soil samples	Naval Radiological Defense Laboratory; Evans Signal Laboratory
2.6c-3	Retrievable Missiles for Remote Ground Sampling	To evaluate a method of obtaining soil samples from contaminated areas	National Institutes of Health; Public Health Service
2.7	Biological Injury from Particle Inhalation	To estimate the inhalation hazards associated with surface and underground detonations	National Institutes of Health
2.8	Analysis of Test Site and Fallout Material	To evaluate potential agricultural hazards associated with fallout	Department of Agriculture

of ground zero. The instruments transmitted data to the Program 1 station on shot-day. Project personnel entered this station several hours before the detonation and operated equipment during the detonation and for 15 to 25 minutes after the detonation. Two hours after the shot, a Navy P2V-2 aircraft dropped radiac telemetry units to monitor residual radiation in and around the craters. These instruments transmitted data to the aircraft and to a station at an unspecified location (21).

Project 2.1c-1, Aerial Survey of Distant Contaminated Terrain, was conducted at Shots SUGAR and UNCLE by Headquarters, Air Force. The objectives were to determine by instrumented aircraft the radiation levels of fallout from the cloud and to test the efficiency of various airborne instruments in detecting

radioactivity (53). The aircraft involved in the project were under the operational control of SWC and are discussed in section 4.3.

Project 2.1c-2, Aerial Survey of Local Contaminated Terrain, was conducted at Shots SUGAR and UNCLE by the Navy Bureau of Aeronautics, Air Force Air Research and Development Command, and Wright Air Development Center. The objective was to test the ability of airborne radiac equipment to detect gamma-emitting radioactive contamination on the ground.

For each detonation, two instrumented aircraft, a Navy P2V-2 and an Air Force B-17, orbited about eight kilometers away at altitudes of 8,000 feet and 10,000 feet, respectively. From shot-time to about one hour later, participants aboard the aircraft monitored and recorded radiation levels. After that, the aircraft surveyed the shot area by making numerous runs at altitudes of 500 to 2,000 feet over the crater and its vicinity. Upon completing their mission, the aircraft returned to Kirtland AFB (108).

Project 2.1d, Monitor Survey of Ground Contamination, was conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory, the Radiological Health and Safety Group of LASL, and AFSWP. The objective was to determine the extent and magnitude of the radiation fields in the SUGAR and UNCLE areas as measured by survey teams. At various times up to one month after each detonation, the teams monitored radiation in the shot areas from Project 2.1a and 2.1d stations (66).

Project 2.3-1, Total Gamma Radiation Dosage, was conducted at Shots SUGAR and UNCLE by the Evans Signal Laboratory. The objective was to use various types of dosimeters to determine gamma radiation exposure. Before each detonation, project

participants placed dosimeters at stations 300 meters to 15 kilometers in various directions from each ground zero. Two days after each detonation, participants recovered the dosimeters, which were sent to the laboratory for analysis (43).

Project 2.3-2, Foxhole Shielding of Gamma Radiation, was conducted at Shots SUGAR and UNCLE by the Engineer Research and Development Laboratories. The objective was to evaluate the protection afforded by foxholes against gamma radiation emitted from surface and underground nuclear detonations. Project personnel constructed one- and two-man foxholes 610 to 1,530 meters northeast of each ground zero. They placed dosimeters at various locations inside the foxholes and recovered the dosimeters after the detonation (113).

Project 2.4a, Beta-ray and Gamma-ray Energy of Residual Contamination, was conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory. The objective was to determine the energy spectra of residual beta and gamma radiation. Project personnel used film packets, ionization chambers, and survey meters for the study. They placed these dosimeters at stations in the field before each detonation and retrieved them at various times up to four days after the detonation (111).

Project 2.4b, Gamma Depth Dose Measurement in Unit-density Material, was conducted at Shots SUGAR and UNCLE by the Naval Medical Research Institute. The objective was to determine dose caused by initial and residual gamma radiation. Project participants placed instrumented phantoms (mannequins made of material approximating the density of human tissue) at five locations in each shot area. Four participants retrieved the phantoms one hour after the announcement of recovery hour (22).

Project 2.4c, Gamma Ray Spectrum Measurements of Residual Radiation, was conducted at Shots SUGAR and UNCLE by Brookhaven

National Laboratory. The objective was to determine the energy spectrum of residual gamma radiation resulting from an underground and a surface nuclear detonation. Project personnel drove a truck, containing a spectrometer and other supporting instrumentation, into a number of radiation areas at times ranging from two hours to four days after the detonation. Personnel remained at each location for about an hour taking measurements (5).

Project 2.5a-1, Airborne Particle Studies, was conducted at Shots SUGAR and UNCLE by the Army Chemical Center. The objective was to determine fallout particle characteristics associated with surface and underground nuclear detonations. Project participants placed several types of instruments, including samplers and fallout trays, at 46 stations located out to 15 kilometers northeast of ground zero. After the announcement of recovery hour, they retrieved the samples, which were shipped for analysis to the Army Chemical Center (95).

Project 2.5a-2, Fallout Particle Studies, was conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory. The objective was to determine the chemical and physical properties and the distribution of fallout associated with surface and underground detonations. Project participants placed aerosol and fallout collectors at distances of 610 to 6,100 meters northwest to northeast of ground zero. The instruments were activated by remote control five minutes before the detonation. Thirty minutes after the detonation, a helicopter flew to the instrument area to pick up fallout trays with grappling hooks. Project personnel then transported the trays from the helicopter transfer station to the Control Point. Other samples and trays were retrieved by ground parties after recovery hour. The samples were shipped for analysis to the Naval Radiological Defense Laboratory (91).

Project 2.5a-3, Radiochemical Studies of Large Particles, was conducted at Shots SUGAR and UNCLE by the Army Medical Service Graduate School. The objective was to study the size, radioactivity, and chemical composition of fallout particles resulting from both underground and surface nuclear detonations. Project 2.5a-1 personnel collected samples in fallout trays located out to 23 kilometers northeast of ground zero. Project 2.5a-3 personnel performed the analysis (75).

Project 2.6a, Remotely Controlled Sampling Techniques, was conducted at Shots SUGAR and UNCLE by Evans Signal Laboratory and Coles Signal Laboratory. The objective was to obtain samples from the crater lip soon after each detonation for radiochemical studies and spectrometer measurements. Samples were taken from areas around the crater and from about five meters within the crater using remotely controlled weasels, vehicles resembling tractors. Project participants controlled the activity from a tower about 1,830 meters from each crater (44).

Project 2.6c-1, Nature and Distribution of Residual Contamination I, was conducted at Shots SUGAR and UNCLE by the National Institutes of Health and the Public Health Service. The objective was to determine the characteristics of radioactivity in the soil, as a function of soil depth and distance. After each detonation, project participants used remotely controlled weasels to collect soil samples from the crater lips and retrievable rockets to collect samples from within the craters (73).

Project 2.6c-2, Nature and Distribution of Residual Contamination II, was conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory and Evans Signal Laboratory. The experiment was performed in conjunction with Project 2.6a. The objective was to determine the following characteristics of radioactive soil samples:

- The relative amounts of neutron-induced and fission product radionuclides

- The beta and gamma energies
- The gross decay rates
- The leaching behavior of radioactive elements.

After each detonation, Project 2.6c-2 participants analyzed the samples collected by Project 2.6a personnel (8).

Project 2.6c-3, Retrievable Missiles for Remote Ground Sampling, was conducted at Shots SUGAR and UNCLE by the National Institutes of Health and the Public Health Service. The objective was to develop and field-test an inexpensive method for obtaining soil samples from areas that personnel could not enter because of radiological conditions. The second day after each detonation, project participants went to a location about 320 meters from ground zero and launched several rockets with attached lines into the crater areas. The rockets penetrated the soil in the crater and took samples on impact. Participants then dragged the rockets out of the area by the attached lines and returned the samples to the laboratory for analysis. They repeated this procedure on the third day after Shot UNCLE (74).

Project 2.7, Biological Injury from Particle Inhalation, was conducted at Shots SUGAR and UNCLE by the National Institutes of Health. The objective was to estimate the inhalation of particles associated with surface and underground nuclear detonations. Project participants placed dogs and sheep at various distances from each detonation. To correlate internal with external exposure, they placed film badges with the animals. Following the detonation, personnel retrieved the animals. The animals were later studied to determine the amount of radioactivity inhaled (104).

Project 2.8, Analysis of Test Site and Fallout Material, was conducted at Shots SUGAR and UNCLE by the Department of Agriculture, under contract to the AEC. The objective was to evaluate

potential agricultural problems related to the fallout from surface and underground nuclear detonations. Project personnel collected soil samples in the shot area before both shots and again 72 hours after Shot SUGAR and 48 hours after Shot UNCLE (5).

Program 3, Blast Effects on Structures, studied blast effects on a variety of structures of interest to the Departments of the Army, Navy, and Air Force. One of the projects investigated the characteristics of soil in the vicinity of an underground nuclear detonation. Another project provided instrumentation for all of the structures so that project personnel could measure blast pressures for correlation with blast effects. Table 4-10 lists the Program 3 projects, which were conducted only at Shot UNCLE.

Table 4-10: WEAPONS EFFECTS TESTS OF PROGRAM 3, OPERATION JANGLE

Project	Title	Objective	Participants
3.1	Navy Underground and Surface Structures	To determine the response of various structures to blast pressures from an underground detonation	Bureau of Yards and Docks
3.2	Army Structures Test	To determine the response of various structures to an underground detonation	Office, Chief of Engineers; Massachusetts Institute of Technology
3.3	Air Force Structures	To determine the response of various structures to blast pressures from an underground detonation	Air Materiel Command; Armour Research Foundation
3.28	Structure Instrumentation	To install and instrument structures for Projects 3.1, 3.2, and 3.3	Sandia Corporation
3.29	Engineer Soil Mechanics Test	To determine soil characteristics in the vicinity of an underground detonation	Naval Civil Engineering Research and Evaluation Laboratory

Project 3.1, Navy Underground and Surface Structures, was conducted at Shot UNCLE by the Bureau of Yards and Docks. The objectives were to:

- Determine the response of different precast concrete structures to blast pressures resulting from an underground detonation
- Determine the response of a light steel building and two types of communication towers to airblast
- Observe the effect of ground shock on standard utility installations and sections of pavement.

Test structures, instrumented with gauges to document blast pressures, strain, and displacement, were located south to southwest of ground zero. Project personnel recorded the data supplied by the gauges, while LASL personnel photographed these structures before and after the detonation (56).

Project 3.2, Army Structures Test, was conducted at Shot UNCLE by the Office, Chief of Engineers, and the Massachusetts Institute of Technology. The experiment tested eight structures to determine the dynamic loads produced by the detonation and to obtain data for the design of structures that could resist the effects of such a detonation. Project participants built one underground structure 70 meters from ground zero and seven surface structures 130 to 270 meters from ground zero. They instrumented the structures to measure accelerations, pressures, displacements, and strains. LASL personnel photographed the structures both before and after the detonation (51).

Project 3.3, Air Force Structures, was conducted at Shot UNCLE by the Air Materiel Command and the Armour Research Foundation. The objective was to determine the effectiveness of an underground detonation in destroying military, industrial, and commercial structures. The project tested 11 different structures, including reinforced concrete retaining walls and circular concrete cells. Project personnel erected the structures 100 to

320 meters from ground zero. They instrumented the structures with devices for measuring blast pressure and strain (6).

Project 3.28, Structure Instrumentation, involved a crew of Sandia Corporation personnel who supported the structure projects conducted during Shot UNCLE. The crew installed instruments, operated the instruments by remote control during the detonation, and prepared records of the activities for other project teams.

Before the detonation, project personnel laid cables between test structures and shelters, installed power equipment, mounted relay and timer panels, tested and installed components, and calibrated systems for electronic and recording instruments. They completed their work one day prior to the detonation. At shot-time, they were working from facilities located near the structures area and to the southwest of ground zero. After the declaration of recovery hour, participants collected data and retrieved test equipment (70).

Project 3.29, Engineer Soil Mechanics Test, was conducted at Shot UNCLE by the Naval Civil Engineering Research and Evaluation Laboratory. The project was designed to determine the characteristics, properties, and behaviors of the soil types located in the vicinity of the detonation. Several weeks after the detonation, project personnel made 57 soil borings near ground zero. Fourteen of these borings were within 90 meters of ground zero. To obtain profiles of the soil, project personnel conducted laboratory analyses of the samples (12).

Program 4, Special Phenomena, was to determine the visible phenomena resulting from underground and surface nuclear detonations. Program personnel relied extensively on photographs to evaluate these phenomena. Table 4-11 indicates the Program 4 projects conducted at JANGLE.

Table 4-11: WEAPONS EFFECTS TESTS OF PROGRAM 4, OPERATION JANGLE

Project	Title	Objective	Shots	Participants
4.1	Aerial Technical Photography	To provide technical and documentary films of phenomena during Operation JANGLE	SUGAR, UNCLE	Wright Air Development Center
4.1a-1	Ground Technical Photography Material Operations	To document cloud formation, crater development, and blast damage	SUGAR, UNCLE	Wright Air Development Center
4.1a-2	Photographic Analysis	To analyze photographs taken for Project 4.1a-1	SUGAR, UNCLE	Wright Air Development Center
4.2	Cratering Effects of Underground-surface Detonated Atomic Bombs and Influence of Soil Characteristics on Crater	To determine the physical characteristics of craters and lips formed by surface and underground detonations	SUGAR, UNCLE	Naval Civil Engineering Research and Evaluation Laboratory
4.5	Characteristics of Missiles from Underground Nuclear Explosions	To determine damage produced by debris projected from an underground detonation	UNCLE	Stanford Research Institute

Project 4.1, Aerial Technical Photography, was conducted at Shots SUGAR and UNCLE by the Technical Photographic Service Branch of the Wright Air Development Center. The objective was to provide technical and documentary films of physical phenomena associated with Operation JANGLE. Project personnel at Wright-Patterson AFB, Ohio, outfitted three C-47 aircraft with special cameras and controls for the activity. The first aircraft was to photograph base surge and shock wave phenomena, the second was to cover the initial cloud growth and shock wave phenomena, and the third was to photograph the entire development of the cloud with respect to target layout. The aircraft staged from Indian Springs AFB (28).

Project 4.1a-1, Ground Technical Photography Material Operations, was conducted at Shots SUGAR and UNCLE by the Technical Photographic Service Branch of the Wright Air Development Center. The objective was to document basic physical phenomena associated

with the detonations. At Shot SUGAR, the specific purpose was to photograph the cloud formation. At Shot UNCLE, the purpose was to photograph blast damage phenomena and crater development. Personnel placed cameras in towers and on the surface at various ranges from ground zero (9).

Project 4.1a-2, Photographic Analysis, was conducted at Shots SUGAR and UNCLE by the Technical Photographic Service Branch of the Wright Air Development Center. The objective was to analyze the photographs taken by Project 4.1a-1 to determine the cloud and column dimensions and the time of disintegration, damage, or movement of structures.

Project 4.2, Cratering Effects of Underground-surface Detonated Atomic Bombs and Influence of Soil Characteristics on Crater, was performed at Shots SUGAR and UNCLE by the Naval Civil Engineering Research and Evaluation Laboratory. The project was to determine the precise dimensions of the craters. Project personnel took soil samples 15, 30, 60, and 90 meters from ground zero at radii of 45 degrees (11).

Project 4.5, Characteristics of Missiles from Underground Nuclear Explosions, was conducted at Shot UNCLE by the Stanford Research Institute. The objective was to obtain data on the damage produced by debris ejected by an underground nuclear detonation. At least 28 days before the test, project personnel constructed a group of concrete highway strips and an array of walls. The highway strips each contained a specific substance, such as aluminum nails or crushed red brick. Project participants laid out the highway slabs at distances of five to 90 meters west of ground zero. They built the wall sections on a different line extending six to 16 meters from ground zero. After the detonation, they tracked down the fragmentary missiles and recorded the direction and distances traveled (112).

Program 6, Tests of Service Equipment and Operations, was to evaluate the operational suitability of techniques and equipment developed for use in conjunction with the military deployment of nuclear weapons. These techniques included indirect bomb damage assessment and decontamination methods, and the equipment included radiac instruments and air filtration systems. The projects that were part of the program at JANGLE are shown in table 4-12.

Project 6.1, Evaluation of Military Radiac Equipment, was conducted at Shots SUGAR and UNCLE by the Evans Signal Laboratory and the Bureau of Ships. The purpose was to field-test military radiac equipment. Project and radiological safety personnel used the radiac instruments in their operations and then prepared evaluation reports (42).

Project 6.2, Protection and Decontamination of Land Targets and Vehicles, was conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory, the Engineer Research and Development Laboratories, the Army Chemical Center, and the Office, Chief of Engineers. The project consisted of ten experiments designed generally to determine the effectiveness of various decontamination methods. These experiments, identified by titles and described in the next ten paragraphs, constituted the first extensive field test of decontamination procedures (36).

Land Reclamation by Surface Techniques was conducted at Shot SUGAR by the Naval Radiological Defense Laboratory. The objectives were to determine the effectiveness of standard earth-moving techniques in reducing the radiation intensity in radioactively contaminated undeveloped land areas and to provide basic data for evaluating exposures of operating crews.

Land Reclamation by Barrier Techniques was conducted at Shot SUGAR by the Engineer Research and Development Laboratories.

Table 4-12: WEAPONS EFFECTS TESTS OF PROGRAM 6, OPERATION JANGLE

Project	Title	Objective	Shots	Participants
6.1	Evaluation of Military Radiac Equipment	To field-test military radiac equipment	SUGAR, UNCLE	Evans Signal Laboratory; Bureau of Ships
6.2	Protection and Decontamination of Land Targets and Vehicles	To field-test decontamination procedures	SUGAR, UNCLE	Naval Radiological Defense Laboratory; Engineer Research and Development Laboratories; Army Chemical Center; Office, Chief of Engineers
6.3-1	Evaluation of Military Individual and Collective Protection Device and Clothing	To determine the adequacy of protective equipment	SUGAR, UNCLE	Army Chemical Center
6.3-2	Evaluation of Potential Respiratory Hazards Associated with Vehicular Operations in a Radioactively Contaminated Area	To estimate the inhalation hazard for personnel in armored vehicles	SUGAR, UNCLE	Ballistics Research Laboratories; Army Field Forces Board Number 2 Test Team; Army Chemical Center
6.4	Operational Tests of Techniques for Accomplishing IBDA	To field-test radar and photographic equipment for IBDA use	UNCLE	Wright Air Development Center
6.7	Clothing Decontamination and Evaluation of Laundry Methods	To test the suitability of a laundry method for decontaminating clothing	SUGAR, UNCLE	9135th Test Support Unit; Office of the Quartermaster General; Evans Signal Laboratory
6.8	Evaluation of U.S. Army Field Water Supply Equipment and Operations	To determine blast, thermal, and radiation effects on water storage tanks	SUGAR, UNCLE	Engineer Research and Development Laboratories

This test was to measure the reduction of radiation intensity within radioactively contaminated regions in areas protected by earth barriers.

Flame Decontamination was conducted at Shot UNCLE by the Naval Radiological Defense Laboratory. This experiment involved testing a flame decontamination unit on surfaces of wood, asphalt, and concrete contaminated by fallout from the detonation.

Decontamination of Paved Areas was performed at Shots SUGAR and UNCLE by the Army Chemical Center. The objective was to determine the merits of various decontamination methods and equipment in removing superficial contamination from paved roads. Figure 4-1 shows personnel measuring radiation intensities on asphalt.

Decontamination of Test Structures was conducted at Shot UNCLE by the Naval Radiological Defense Laboratory. The test was designed to determine the effectiveness of three cleaning methods in decontaminating buildings: water washing with a fire hose; hot liquid cleaning with a mixture of steam, hot water, and detergent; and vacuum cleaning.

Decontamination of Construction Materials was performed at Shots SUGAR and UNCLE by the Office, Chief of Engineers. The test was designed to determine the decontaminability of coated and uncoated surfaces of construction materials used by the Army Corps of Engineers.

Contamination-Decontamination Phenomenology was conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory. The objective was to study the effects of structure orientation and surface condition on the amount of contamination deposited and subsequently removed in decontamination operations.



Figure 4-1: PROJECT 6.2 PARTICIPANTS MEASURING RADIATION INTENSITIES ON ASPHALT

Test of Materials was conducted at Shot UNCLE by the Chemical and Radiological Laboratory of the Army Chemical Center. The purpose was to study the decontaminability of materials commonly used for military purposes. The Army Chemical Center, the Corps of Engineers, and the Signal Corps supplied materials for this test.

Decontamination of Vehicles was conducted at Shots SUGAR and UNCLE by the Engineer Research and Development Laboratories. The purpose was to evaluate methods and techniques used to decontaminate military vehicles, including trucks and tanks. Another objective was to study the amount of shielding afforded personnel by these vehicles.

Measurement experiments were conducted at Shots SUGAR and UNCLE by the Naval Radiological Defense Laboratory. The objective was to evaluate equipment and methods used to monitor the progress of decontamination operations (36).

Project 6.3-1, Evaluation of Military Individual and Collective Protection Device and Clothing, was conducted at Shots SUGAR and UNCLE by the Army Chemical Center. The objective was to determine the adequacy of protective equipment for use in radioactive areas. Project participants positioned racks of protective clothing in the forward area. They also positioned two tanks with their hatches open and placed clothing in the personnel positions within the tanks (62).

Project 6.3-2, Evaluation of Potential Respiratory Hazards Associated with Vehicular Operations in a Radioactively Contaminated Area, was performed at Shots SUGAR and UNCLE by the Ballistics Research Laboratories, the Army Field Forces Board Number 2 Test Team, and the Army Chemical Center. The objective was to gain data for estimating the potential inhalation hazard for personnel in armored vehicles exposed to a nuclear detonation or operating in areas contaminated with fission product fallout

from a nuclear detonation. Two M26 tanks and one M59 personnel carrier were positioned in the shot area (38).

Project 6.4, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment, was conducted at Shot UNCLE by the Wright Air Development Center. (The project was numbered 6.5 for Operation BUSTER.) The objective was to test, under operational conditions, radar and photography equipment as a means of determining ground zero, height-of-burst, and yield of a nuclear detonation. With measurements gathered by strike aircraft, it would then be possible to assess the effect of the nuclear detonation on enemy installations. For this project, two B-50 and one B-29 aircraft, instrumented with radar equipment and cameras, took photographs and recorded data following the detonation. The aircraft were attached to Project 8.4 (55; 65).

Project 6.7, Clothing Decontamination and Evaluation of Laundry Methods, was conducted at Shots SUGAR and UNCLE by the following:

- 12 participants from Detachment 7, 9135th Test Support Unit, Fort Lee, Virginia
- Two participants from the Office of the Quartermaster General
- One participant from the Evans Signal Laboratory.

The main objective was to test the suitability of a laundry formula developed during Operation GREENHOUSE for the removal of radioactive contamination from clothing. A second objective was to field-test experimental survey instruments used to monitor levels of clothing contamination. Project personnel surveyed and washed the clothing used by personnel from Projects 6.2 and 6.3 (64).

Project 6.8, Evaluation of U.S. Army Field Water Supply Equipment and Operations, was conducted at Shots SUGAR and UNCLE by the Engineer Research and Development Laboratories. The

objective was to determine the resistance of water storage tanks to the blast and thermal effects of a nuclear detonation. In addition, the project investigated the potential problem of radioactive contamination of field water supplies.

For the first part of the project, participants placed filled water tanks at various distances from the SUGAR ground zero. The closest tank was 460 meters northeast of the shot. For the second part, participants monitored the water in the tanks for radioactive contamination. Because water tanks were not used at UNCLE, project personnel calculated the contamination that water in tanks would have received had tanks been located in the path of the fallout (72).

Program 7, Long-range Detection, tested equipment used in detecting nuclear detonations at long ranges. The equipment included seismographs and acoustic sensors. As shown in table 4-13, the program involved four projects. Each of these projects was conducted at both Shots SUGAR and UNCLE.

Table 4-13: WEAPONS EFFECTS TESTS OF PROGRAM 7, OPERATION JANGLE

Project	Title	Objective	Participants
7.1a	Transport of Radiation Debris	To determine the distribution of airborne radioactive debris	Headquarters, Air Force; Air Weather Service
7.1b	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	To analyze debris obtained in cloud-sampling missions	Headquarters, Air Force; 4925th Test Group
7.2	Seismic Waves from A-Bombs Detonated over a Land Mass	To study seismic wave propagation from nuclear detonations	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
7.3	Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE	To evaluate acoustic detection equipment	Naval Electronics Laboratory; Signal Corps Engineering Laboratories; National Bureau of Standards

Project 7.1a, Transport of Radiation Debris, was conducted at Shots SUGAR and UNCLE by Headquarters, Air Force, and the Air Weather Service. The objective was to determine the distribution of airborne debris from a nuclear detonation. Aircraft tracked the debris at various distances from the Nevada Proving Ground (103). Cloud tracking is described in section 4.3 of this chapter, on Air Force support missions during Operation BUSTER-JANGLE.

Project 7.1b, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was performed at Shots SUGAR and UNCLE in conjunction with sampling operations conducted by Headquarters, Air Force, and the 4925th Test Group (Atomic) (103). Cloud-sampling operations are discussed in section 4.3 of this chapter.

Project 7.2, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted at Shots SUGAR and UNCLE by the 1009th Special Weapons Squadron, the Naval Ordnance Laboratory, the Acoustics Research Division of the Wright Air Development Center, and the Coast and Geodetic Survey. The objective was to study seismic waves propagated by nuclear detonations. Project personnel obtained data from six onsite stations, as well as from a number of offsite stations (29).

Project 7.3, Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE, was conducted at Shots SUGAR and UNCLE by the Naval Electronics Laboratory, Signal Corps Engineering Laboratories, and National Bureau of Standards. The objective was to determine the range and reliability of acoustic detection equipment for continental nuclear explosions of various yields (88).

Program 8, Supporting Measurements, provided technical support to AFSWP personnel. This program included one project at Operation JANGLE.

Project 8.4, Technical Photography for IBDA Project, was conducted at Shot UNCLE by the Air Force Lookout Mountain Laboratory. The purpose was to provide technical and documentary photography for Project 6.4, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment. Lookout Mountain Laboratory personnel took photographs from two B-50 and one B-29 aircraft (55; 65).

4.2 DEPARTMENT OF DEFENSE INVOLVEMENT IN PROGRAMS OF THE WEAPONS DEVELOPMENT TEST UNIT

The test organization coordinated the activities of the Weapons Development Test Unit, as well as those of the Weapons Effects Test Unit. The Weapons Development Test Unit experiments were primarily conducted by LASL. LASL fielded one program with an unknown number of projects during Operation BUSTER-JANGLE. Department of Defense participation was limited to Project 10.4, Radiochemical Results.

Project 10.4 was conducted at all BUSTER-JANGLE shots. The project required the collection of cloud samples, performed by the 4925th Test Group (Atomic) (105). Cloud-sampling missions are discussed in the next section.

4.3 AIR FORCE SUPPORT MISSIONS AT OPERATION BUSTER-JANGLE

The Air Force, particularly the Special Weapons Command, played a major operational and support role in many of the scientific and military test programs. Based at Kirtland AFB in Albuquerque, New Mexico, SWC used Kirtland AFB and Indian Springs AFB in Nevada as its principal staging areas during the testing. Figure 4-2 presents a photograph of Indian Springs AFB in 1951. SWC provided most of the aircraft and personnel required for bomb-drop missions, cloud-sampling missions, cloud-tracking missions, aerial surveys, and other air support as requested by

the test organization. The principal SWC units involved in Operation BUSTER-JANGLE were the 4925th Test Group (Atomic) and the 4901st Support Wing. SWC participation is summarized in table 4-14 (40; 47; 55; 107).

Table 4-14: SWC MISSION SUPPORT AT OPERATION BUSTER-JANGLE

Mission	ABLE	BAKER	CHARLIE	DOG	EASY	SUGAR	UNCLE
Bomb Drop		•	•	•	•		
Cloud Sampling	•	•	•	•	•	•	•
Courier Service	•	•	•	•	•	•	•
Cloud Tracking		•	•	•	•	•	•
Aerial Survey		•	•	•	•	•	•

The 4925th Test Group (Atomic) exercised operational control over all military aircraft participating in Operation BUSTER-JANGLE. Stationed at the Control Point, an operations officer from the 4925th assumed control of the aircraft in NPG airspace. Specific duties of the 4925th included:

- Providing and operating the B-45 and B-50 bomb delivery aircraft and the spare aircraft for bomb delivery
- Assigning aircraft and crews for cloud-sampling, cloud-tracking, and aerial survey operations.

The 4901st Support Wing (Atomic), composed of the 4905th Maintenance and Supply Group, 4901st Air Base Group, and the 4920th Medical Group, was responsible for most of the logistics



Figure 4-2: INDIAN SPRINGS AIR FORCE BASE, 1951

and maintenance activities required for air operations.

Responsibilities of the 4901st included (55):

- Providing and operating C-47 disaster aircraft to accompany bomb-drop aircraft
- Providing and operating courier aircraft.

In addition, the 4901st was responsible for decontamination operations at Indian Springs AFB, as discussed in chapter 5. A total of 307 personnel from the 4901st participated at BUSTER-JANGLE (55).

Bomb Drop

A B-50 aircraft operated by personnel from the 4925th Test Group (Atomic) delivered the nuclear bombs for Shots BAKER, CHARLIE, and DOG. The aircraft, staging from Kirtland AFB, arrived over the NPG two hours before each shot. Flying at a height of 19,000 feet over Area 7, each aircraft made three practice bomb runs before releasing the bomb. The bomb runs were from east to west over the ground zero area.

A B-45 manned by personnel from the 4925th Test Group (Atomic) delivered the nuclear device for EASY. Staging out of Kirtland AFB, it probably arrived over the NPG two hours before shot-time. It made two practice bomb runs. The bomb run was from east to west at a height of 24,000 feet over Area 7 (55).

Each drop aircraft was accompanied by a C-47 disaster aircraft from the 4901st Support Wing (Atomic). Staging from Kirtland AFB, the C-47 maintained contact with the drop aircraft during its flight to the NPG. In the event that the drop aircraft crashed or was forced to jettison the bomb, the C-47 would attempt to land or parachute its team of radiological safety, salvage, and security personnel as near as possible to the accident site. The disaster team would secure the area, provide first aid, and salvage the nuclear component of the weapon (55).

Cloud Sampling

An important objective of Operation BUSTER-JANGLE was to obtain samples of fission products from nuclear detonations so that the yield and efficiency of the nuclear devices could be determined. The 4925th Test Group (Atomic) assigned aircraft and personnel to collect samples of particulate debris from clouds following a detonation. The 57th Strategic Reconnaissance Squadron (Weather) of Hickam AFB, Hawaii, provided the B-29 sampler aircraft, their crews, and their maintenance personnel. The Air Proving Ground of Eglin AFB, Florida, provided the T-33 samplers, their crews, and their maintenance personnel. Cloud samples were collected for the Weapons Effects Test Unit Project 7.3 of the BUSTER shots and Project 7.1b of the JANGLE events, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris. Samples were also obtained for the Weapons Development Test Unit Project 10.4, Radiochemical Results (55).

The plan was to obtain the best possible samples with the lowest crew exposure. Since the allowable exposure for BUSTER-JANGLE was 3.9 roentgens per individual, a maximum of 0.75 roentgen was allowed for participation at each shot.

While B-29s were the primary cloud sampling aircraft, T-33 aircraft were used experimentally. The T-33s, jet aircraft, were considered more effective samplers for several reasons (40; 55):

- Fewer people were exposed to nuclear radiation because of the reduction in the size of the crew (eight to ten crew members in a B-29 versus a crew of two in a T-33).
- The higher speed resulted in quicker collection of the necessary samples with less radiation exposure to the aircrew, thus allowing a sampling team to accomplish more before it reached its maximum allowable radiation exposure.
- The higher altitude capability resulted in the collection of samples that formerly could not be obtained because of altitude limitations of the propeller-driven aircraft.

- Fresher samples were available for analysis because of the shorter time necessary to return the samples to the landing strip for removal and subsequent air shipment to the research laboratory.
- It was easier to decontaminate the T-33 because it had only one engine to decontaminate instead of the four engines of the B-29.

Procedures to ready the aircraft for cloud penetration were modified during Operation BUSTER-JANGLE. For most of the BUSTER shots, the B-29 aircraft were depressurized before the initial cloud penetration. The depressurized condition caused the windshield to frost over, which limited visual reference to the cloud. The depressurized condition also allowed a rapid drop in temperature, which made the crew uncomfortable and reduced its efficiency. To resolve these problems, SWC personnel experimented with a filter pressurization system at Shot EASY. With this system, the B-29 sampler remained pressurized during its entire mission. After the mission, the crew space registered no contamination (40; 55).

The standard procedures for cloud sampling are described in the following paragraphs, while shot-specific information on sampling is in the BUSTER-JANGLE multi-shot volumes.

The B-29 and T-33 sampling crews received briefings about two hours before their flights. A radiological safety officer, who worked with the pilot in determining the flight pattern and altitude of the aircraft, flew on each sampling mission (40; 55).

After reaching its altitude, each B-29 held a counterclockwise racetrack pattern eight kilometers wide and 48 kilometers long, with the south end of the pattern over Indian Springs. Each T-33 held a counterclockwise circular pattern above a point 16 kilometers west of Indian Springs AFB (40; 55).

From the Control Point, the Air Operations Officer vectored the B-29s toward the cloud. The T-33s left base after the B-29s had determined the location of the cloud. Because the T-33s had a limited flying range, it was necessary to direct them to the exact cloud location (40; 55).

In general, the first pass at the cloud was tangential. If exposures, as read from pocket dosimeters, were less than 0.6 roentgens, the samplers made a second pass through the center of the visible cloud. If the exposure readings on the first pass were between 0.6 and 1 roentgen, the aircraft delayed the second pass for 15 minutes. Samplers made successive passes through the cloud center until their pocket dosimeters read 1.2 roentgens. The pocket dosimeter readings, as indicated by past experience, were about twice as high as film badge readings. When the pocket dosimeters showed 1.2 roentgens per hour (R/h), the aircraft returned to Indian Springs AFB. At Indian Springs, sample removal teams used long-handled tongs to remove filters from the aircraft and to place them in lead containers for delivery to LASL and other laboratories for analysis (40; 47; 55; 107).

Courier Service

The purpose of the SWC courier service was to deliver cloud samples and experimental material from BUSTER-JANGLE research projects to laboratories for analysis. The 4901st Support Wing (Atomic) provided B-25 and C-47 aircraft for the flights. In addition, Carco, an AEC contractor, supplied a C-54 and two twin-engine aircraft for the missions (40; 55; 61).

Cloud Tracking

Cloud tracking was another program conducted by the Special Weapons Command. Its objective was to record the path of the cloud and to monitor its radiation intensity in order to expedite airway clearance for commercial aircraft. The 57th Strategic Reconnaissance Squadron (Weather) provided the B-29 cloud

trackers, their crews, and their maintenance personnel. Each aircraft was fitted with standard radiological instruments and dosimeters, along with a B-21 air-conductivity ionization chamber and a B-35 scintillation counter. The Air Operations Officer issued flight instructions from the Control Point (40; 55).

Cloud-tracking procedures were standard for every shot, with some modifications caused by differences between the estimated and actual yield of a detonation. Before the detonation, one B-29 orbited in a counter-clockwise pattern eight kilometers wide and 48 kilometers long, with the north end of the pattern over Indian Springs. Orbit altitude was 16,000 feet. Twenty minutes after the detonation, the B-29 was cleared to follow the cloud by visual means, staying away from the radioactive debris and approaching no closer than 32 kilometers to the cloud (40; 55).

A second B-29 was at Indian Springs AFB at shot-time. Upon command from the Air Operations Center, this B-29 relieved the first B-29, which returned to Kirtland AFB (40; 55; 61).

Another B-29 cloud tracker remained at Kirtland AFB on standby. It flew as a third cloud tracker if the first or second cloud tracker had to abort. Also, it conducted a cloud-tracking mission if the cloud was dissipating rapidly and had relatively high radiation intensities (40; 55; 61).

The cloud trackers radioed information on cloud altitude and position to the Air Operations Officer. The data were plotted on a large plexiglass display board in the Air Operations Center. The board showed a map of the area surrounding the Nevada Proving Ground. The Test Manager, the Test Director, the Onsite Civil Aeronautics Administration representative, and the AEC Public Information Officer used this display to follow the movement of the cloud. Offsite radiological safety monitors were informed of the cloud movement so they could make ground readings (39).

Upon completion of their missions, the cloud trackers returned to Kirtland AFB and parked in the decontamination area. There, the crew members remained near their aircraft until they had been monitored for radiological contamination and released by the officer in charge of the decontamination crew (40; 47; 55; 107).

Aerial Surveys

Following each nuclear event, several support aircraft made radiological surveys of the terrain in and around the Nevada Proving Ground. These surveys helped determine radiation levels along the path of the cloud for the test organization and for Project 2.1c-1, Aerial Survey of Distant and Contaminated Terrain, at Shots SUGAR and UNCLE. The 4901st Support Wing (Atomic) provided two C-47 aircraft for offsite surveying, and the 1009th Special Weapons Squadron from McClellan AFB, California, supplied a third C-47. Each aircrew consisted of a pilot and copilot and two aerial survey technicians, probably from the 57th Strategic Reconnaissance Squadron (Weather) (40).

Helicopters, based at Indian Springs AFB, surveyed the NPG, particularly the immediate area around ground zero. They reported their findings to the Air Operations Center, where the information was marked on a plexiglass map of the NPG. After the mission, the helicopters returned to Indian Springs AFB (39).

The aerial survey began approximately two hours after the detonation, when the C-47 aircraft flew crosswind patterns over the path of the cloud at heights of about 600 feet. Using various instruments on board, the crew determined radiation levels and radioed the findings to the Control Point. After the mission, the aircraft returned to Indian Springs AFB (40; 102).

CHAPTER 5

RADIATION PROTECTION AT OPERATION BUSTER-JANGLE

In addition to the thermal and blast phenomena associated with a conventional explosive device, a nuclear detonation also produces ionizing radiation. To protect BUSTER-JANGLE personnel from the radiation associated with the detonation of a nuclear device, the Atomic Energy Commission developed procedures to ensure the radiological safety of all participants. The purpose of the various radiation protection procedures was to minimize individual exposure to ionizing radiation while still allowing participants to accomplish their test objectives.

The missions of Exercises Desert Rock I, II, and III, the test units, and the Air Force Special Weapons Command required different types of participation. Despite those differences, many of the radiation protection procedures for these groups were similar. These procedures included (41; 57; 60; 101; 102):

- Orientation and training: preparing radiological monitors for their work and familiarizing other participants with radiological safety procedures
- Personnel dosimetry: issuing, exchanging, developing, and evaluating film badges to determine gamma exposure
- Use of protective equipment: providing clothing, respirators, and other protective equipment
- Monitoring: performing radiological surveys and controlling access to radiation areas
- Briefing: informing observers and project personnel of radiation characteristics and the current radiation intensities in the test area
- Decontamination: removing contaminated material from personnel, vehicles, and equipment.

Sections 5.1, 5.2, and 5.3 of this chapter discuss, respectively, the radiological safety plans of the Desert Rock exercises, the test organization, and SWC. Each section addresses maximum permissible levels of exposure, the structure of the radiological organization, and the procedures used by each organization to control individual exposure to ionizing radiation.

5.1 RADIATION PROTECTION FOR EXERCISES DESERT ROCK I, II, AND III

The Atomic Energy Commission established safety criteria to protect Exercise Desert Rock participants from the thermal, blast, and radiation effects of nuclear detonations at the Nevada Proving Ground. The AEC established a maximum radiation exposure limit of 1 roentgen for the participants in Desert Rock I and a total exposure of 3 roentgens for participants in Desert Rock II and III. Based on these limits, the AEC set minimum distance criteria for positioning troops and troop observers during Operation BUSTER-JANGLE. During the detonations, troops were 11 kilometers from ground zero for Desert Rock I, 9.2 kilometers from ground zero for Desert Rock II, and 9.6 kilometers from ground zero for Desert Rock III (57; 60; 102).

5.1.1 Organization and Responsibilities

Desert Rock exercises were conducted so that the troop maneuvers did not interfere with the technical and diagnostic studies conducted by the test units. Subject to these limitations, the Joint Chiefs of Staff assigned to the Commanding General, SWC, the mission of coordinating military participation in BUSTER-JANGLE. To ensure the coordination of Desert Rock activities with technical test activities, and to ensure compliance with instructions issued by the Test Director, the Deputy Test Director supervised the plans and operations of the Exercise Director of Desert Rock I, II, and III (55; 57; 60; 101).

The Exercise Director was responsible for implementing radiological safety procedures for military participants in Desert Rock activities. The AEC Radiological Safety Technical Advisor assisted the Exercise Director in fulfilling this responsibility. The AEC also provided 16 trained monitors to the Exercise Director. For Desert Rock I, the Exercise Director provided 45 additional monitors to perform radiological safety surveys. The number of monitors provided for Desert Rock II and III is unknown (57; 60; 69).

5.1.2 Orientation and Briefing

The Armed Forces Special Weapons Project Advisory Group, which was attached to Camp Desert Rock, provided educational programs for observers and exercise and support troops, covering basic weapons characteristics and effects. In addition, the Advisory Group accompanied participating troops and observers on their tours of the shot area after the detonation. The general purpose of the orientation was to allay misconceptions about the effects of nuclear weapons (60).

5.1.3 Personnel Dosimetry

Desert Rock personnel entering the forward area wore film badges to record their exposure to ionizing radiation. The film badges were DuPont #533 with a range of 0.1 to 50 roentgens. The Radiological Safety Unit issued the badges, and an Army Signal Corps photography unit processed them, determining individual exposure to radiation (57; 60).

Three Desert Rock personnel received gamma exposures exceeding 3 roentgens. These exposures ranged from 4 to 6 roentgens. It is not known whether these individuals participated in Desert Rock I, II, or III (32; 93).

5.1.4 Monitoring

After the monitors had completed an initial survey of the shot area, they accompanied Army Chemical, Biological, and Radiological monitors in advance of the troops to survey routes of approach to and through radiation areas. The monitors notified the Exercise Director by radio when it was safe for troops to advance toward ground zero. The forward limit for Desert Rock I personnel was 1 R/h (57; 60).

5.1.5 Decontamination

The objective of decontamination procedures at Exercises Desert Rock I, II, and III was to ensure that no participants or vehicles contaminated in excess of established limits left the forward area. For all shots, the established limit for gamma-emitting contamination on personnel or vehicles was 0.02 R/h, as measured with the AN/PDR-27A survey meter (57; 60).

An eight-man decontamination team, directed by the Camp Desert Rock Radiological Safety Officer, assisted AEC personnel in operating a decontamination facility in the vicinity of exercise activities. The initial decontamination procedure involved brushing clothing, equipment, and vehicles to remove contaminated dust and debris. If brushing failed to reduce radiation intensities to the established limit or lower, individuals showered and were provided with a change of clothing, and vehicles and equipment were either washed or isolated until radiation intensities decayed to permissible levels. No personnel or vehicles participating in Exercise Desert Rock I were found to be contaminated above the 0.02 R/h limit (57). Specific information on decontamination is not available for Exercises Desert Rock II and III.

5.2 RADIATION PROTECTION FOR THE TEST ORGANIZATION

The Test Director was responsible for the radiological safety of all members of the test organization at the Nevada Proving Ground. The Radiological Health and Safety Group, composed of personnel from LASL, from the armed services, and from various civilian groups, performed onsite and offsite radiological safety operations. The Radiological Safety Officer, who was appointed by the Test Director, headed the group (102).

The Radiological Health and Safety Group worked within guidelines set by the AEC, which established an exposure limit of 3 roentgens of gamma radiation for all personnel involved in test organization activities except sampling pilots, who were permitted to receive up to 3.9 roentgens of gamma exposure. The operational responsibilities of the group were to (40; 55; 102):

- Provide training and guidance in radiological procedures and situations
- Provide radiac equipment and maintenance services
- Conduct radiological surveys and plot isointensity maps
- Provide monitors to projects as required
- Decontaminate personnel and vehicles
- Maintain dosimetry and records service for all organizations participating in activities coordinated by the test organization.

5.2.1 Organization and Responsibilities

The Radiological Health and Safety Group consisted of 187 personnel, as indicated in the following listing (102):

	LASL Health Division	Military	Other	Total
Administration	8	2		10
Monitoring	9	52	20	81
Fallout study	14	1	17	32
Dosimetry and records	10	3		13
Supply	3	2		5
First aid	5	1		6
Safety	1			1
Vehicle decontamination		18		18
Meteorology	3			3
Transportation	1			1
Instrument repair	5	4		9
Aerial survey	2			2
Pilots		4	2	6
Total	61	87	39	187

The activities performed by the Radiological Health and Safety Group, the headquarters of which were at Nellis AFB, included (102):

- Furnishing ground and aerial monitoring both onsite and offsite
- Providing current radiological situation charts and maps showing on- and offsite data obtained by ground and aerial surveys
- Issuing, processing, and maintaining records of all personnel dosimeters
- Operating personnel, vehicle, and equipment decontamination facilities
- Tracking clouds resulting from the detonations to advise the Test Director on closing air lanes
- Packaging radioactive material for shipment offsite.

JANGLE Program 2, Radiological Phenomena, monitored fallout less than 16 kilometers from ground zero. The Fallout Study of the Radiological Health and Safety Group provided monitoring 16 to 320 kilometers from ground zero. Study personnel were primarily interested in SUGAR and UNCLE; they regarded the BUSTER shots basically as training for the two JANGLE detonations. To obtain data, they used numerous air-sampling and dust-collecting instruments (102).

5.2.2 Personnel Dosimetry

Film badges and pocket dosimeters were issued to test organization personnel to record their exposure to ionizing radiation. During Operation BUSTER-JANGLE, the Radiological Health and Safety Group issued 10,589 personnel film badges and processed 9,623 of these badges. Group personnel distributed and collected the badges and dosimeters at the Control Point and Indian Springs AFB. SWC personnel issued and collected badges at Kirtland AFB (102).

5.2.3 Protective Equipment

Radiological Health and Safety Group personnel at the Control Point issued respirators to the radiological safety team making the initial survey. If radiation intensities in the shot area were 0.02 R/h or greater, as measured by the initial survey, they distributed respirators, cloth caps, coveralls, booties, and gloves to all participants entering the shot area. Participants were required to use masking tape to seal their booties and gloves to their coveralls (102).

5.2.4 Monitoring

Onsite and offsite monitoring operations were conducted after each shot. Onsite operations were officially based at

Indian Springs AFB, but the monitoring teams worked out of the Control Point. Members of various mobile offsite teams were based in outlying communities.

Onsite monitors began the initial ground surveys soon after each detonation. The initial survey party at each shot probably consisted of three or four monitors, who radioed the intensity readings to the Control Point. Monitors resurveyed the shot area at various times after each detonation (102).

Ten offsite teams, each consisting of two men in a radio-equipped vehicle, surveyed out to a distance of 320 kilometers from each ground zero. They maintained radio and telephone contact with radiological safety personnel at the Control Point and LASL. The day before each detonation, the teams proceeded to small communities in the region where weather forecasts indicated the cloud from the detonation would pass. The teams determined preshot background radiation levels in each of these areas. After each shot, they continued to monitor radiation levels.

In addition to the on- and offsite surveying activities, monitors accompanied recovery parties into the shot area. Entry into the forward area on shot-days required the approval of the Test Director. Each project requiring entry into the shot area submitted a list of names to the Test Director at least 24 hours before shot-time. Working from this list, the Test Director assigned a monitor to accompany each recovery party. The monitor was responsible for informing the party leader of the radiological conditions within the recovery area. When a predetermined radiation exposure was reached, the monitor informed the party leader, and the group left the area. The monitor was to allow for exposures anticipated during withdrawal from the area (102).

5.2.5 Decontamination

The Radiological Health and Safety Group operated a decontamination station near the Control Point. At the station, personnel checked project participants and vehicles leaving the shot area for radioactive contamination. They began decontamination procedures if they detected gamma levels greater than 0.007 R/h on the outer garments of participants or on the surface of vehicles (102).

Personnel

To decontaminate test participants, Radiological Health and Safety Group personnel used brooms to brush dust and dirt from the surface of clothing. Participants then removed respirators and protective clothing and gave film badges and pocket dosimeters to radiological safety personnel. Group personnel then checked each individual for radioactive contamination. If 0.007 R/h or more of gamma radiation was detected on the outer garments, the individual was required to remove all clothing and take a shower. After showering, the individual was reexamined, and when radiation readings were less than 0.002 R/h at the surface of the skin, he was issued clean clothing and released (102).

Vehicles

To decontaminate vehicles, Radiological Health and Safety Group personnel used vacuum cleaners to brush loose dust and dirt from all surfaces, including running boards, floorboards, and the under-surface of fenders. They then remonitored the vehicles. If still contaminated, the vehicles were rinsed with water, then sprayed and washed with a liquid detergent. When radiation intensities were reduced to less than 0.002 R/h, the vehicles were returned to service. Records indicate that 275 vehicles were decontaminated during Operation BUSTER-JANGLE (102).

5.3 RADIATION PROTECTION FOR THE SPECIAL WEAPONS COMMAND

During Operation BUSTER-JANGLE, SWC provided two types of air support to the test units: test air operations and support air operations. The test air operations included all aircraft directly involved in test missions and projects, such as bomb drops, cloud sampling, cloud tracking, and terrain surveys. Support air operations included all other aircraft not directly involved in these test missions, such as sample couriers.

The radiological safety of air and ground personnel involved in SWC test and support operations was the responsibility of the Test Director. Implementing radiological safety procedures was the responsibility of the SWC Radiological Safety Group.

5.3.1 Organization and Responsibilities

SWC was responsible for a number of tasks related to radiological safety at Indian Springs AFB and Kirtland AFB, including:

- Providing personnel trained in radiological safety for ground and air monitoring duties
- Providing protective equipment, film badges, dosimeters, and radiac instruments
- Operating decontamination areas for personnel, aircraft, and equipment.

The 4925th Test Group (Atomic) implemented safety procedures at Indian Springs AFB, while the 4901st Support Wing (Atomic) performed these activities at Kirtland AFB (40; 47; 55; 61).

5.3.2 Briefing

Before each mission, ground and air crews at Kirtland AFB and Indian Springs AFB attended briefings concerning the weather, the mission, and precautions to minimize exposures to radiation while performing the mission. These briefings, given by the

4925th Test Group at Indian Springs and the 4901st Support Wing at Kirtland, were usually presented the day before each shot. At the time of the briefings, crews received film badges and pocket dosimeters (40; 55).

5.3.3 Protective Equipment and Personnel Dosimetry

The primary requirement of the SWC radiation protection program was to ensure the radiological safety of SWC personnel by minimizing their exposure to radiation. Because exposure to ionizing radiation may be from internal or external sources, SWC developed procedures to minimize both types of exposure. To minimize internal exposure, which occurs primarily through inhalation of radioactive material, personnel wore respirators if they worked in enclosed spaces or in areas where there were high concentrations of radionuclides in the air, such as the area where cloud sample filters were removed from the aircraft. As described in chapter 4, procedures were tested during Operation BUSTER-JANGLE for minimizing the possibility that sampling pilots would inhale contaminated air.

To prevent the spread of contamination, participants wore protective clothing over their regulation clothing while in contaminated areas. Upon leaving these radiation areas, personnel removed this clothing.

The SWC Radiological Safety Group issued film badges to all SWC personnel. During BUSTER-JANGLE, the group distributed 1,065 film badges to SWC participants in the operation (40; 47; 84; 102).

5.3.4 Monitoring

The 4901st Support Wing (Atomic) provided three C-47 aircraft to support the offsite ground monitoring teams. These

aircraft, which were airborne at the time of each detonation, were responsible for tracking the cloud and conducting aerial surveys.

The Air Operations Officer, stationed at the Control Point, received information on the location of the cloud from the crews of the tracking aircraft. He then informed the Civil Aeronautics Administration of the cloud location so that commercial aircraft could be rerouted out of the path of the cloud. Information on the movement of the cloud was also used to guide ground monitoring teams to offsite fallout areas (40; 47; 102).

5.3.5 Decontamination

Radioactive contamination on personnel and aircraft at both Kirtland AFB and Indian Springs AFB was measured with portable radiation detection instruments. To prevent the spread of contamination, special control procedures were developed by SWC for aircrews, ground crews, and aircraft. These procedures are explained below.

Personnel

Ground personnel planning to enter radiation areas obtained protective clothing, film badges, and dosimeters from the Radiological Safety Group. Individuals with breaks in their skin could not enter radiation areas unless the breaks were covered. Proper wear of protective clothing included using masking tape to secure the cuffs of the coveralls to gloves and the legs to booties. Monitors accompanied individuals working in radiation areas. Personnel were monitored when departing these areas. If, after removing their protective clothing, personnel still registered radiation intensities greater than 0.007 R/h of gamma radiation, they showered and received clean clothing (40).

Aircraft

After landing, aircraft taxied to designated areas where they were met by radiation monitors, who surveyed the aircraft to determine the level of radioactive contamination. Figure 5-1 shows monitors checking radiation levels on a B-29 aircraft. After the preliminary survey, aircraft with radiation intensities greater than 0.01 R/h were decontaminated by repeated washings with detergent and water or were parked in designated areas, marked with radiation signs, and the radiation allowed to decay. Radiation monitors were present during all phases of the decontamination, and decontamination crews wore protective clothing, film badges, and pocket dosimeters.

T-33 aircraft used for cloud sampling posed a special decontamination problem since radioactive particles became impacted on the impeller blades of the jet engine. Washing the engines while they were still running with detergent and rinsing water from a high-pressure hose removed much of the contamination. Normal decay further reduced the level of radioactivity on the aircraft prior to their return to service (39; 40; 47).

Special procedures were developed to remove cloud sample filters from sampling aircraft. To prevent direct contact with the cloud samples, the filter removal team used long-handled tools to remove the particulate sample filters from the sample chambers. Radiological Safety Group personnel monitored the intensity of the samples, which were then placed in lead containers. The samples were taken by courier aircraft to laboratories for analysis. All samples were packaged in lead shielding sufficient to ensure that neither passengers nor crew in the courier aircraft would be exposed to radiation intensities exceeding 0.02 R/h (40; 47).



Figure 5-1: RADIOLOGICAL MONITORS CHECK RADIATION LEVELS ON A B-29 AIRCRAFT

CHAPTER 6

DOSIMETRY FOR DEPARTMENT OF DEFENSE PERSONNEL AT OPERATION BUSTER-JANGLE

This chapter summarizes the data available as of June 1982 regarding the radiation doses received by Department of Defense personnel during their participation in various military and scientific activities during Operation BUSTER-JANGLE. It is based on research that identified the participants, their unit of assignment, and their doses.

6.1 PARTICIPATION DATA

The identity of participants was determined from several sources:

- Final Report of Operations of the Exercise Director, Exercises Desert Rock I, II, and III provided information on unit participation and activities of Desert Rock organizations (57; 60).
- Weapons test reports for AFSWP and other scientific projects often identified personnel, units, and organizations that participated in the operation.
- After-action reports, security rosters, and vehicle loading rosters 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 transit for the purpose of participating in a nuclear weapons test.
- Official travel or reassignment orders provided information on the identity of transient or assigned personnel participating in the nuclear weapons tests.
- Discharge records, maintained by all services, aided in identification.

- The services' reserve personnel record centers provided information on participants still carried on inactive reserve rolls.
- A widely publicized national call-in campaign sponsored by the Department of Defense has identified many of the participants in the nuclear weapons tests.

6.2 SOURCES OF DOSIMETRY DATA

Most of the dosimetry data for Operation BUSTER-JANGLE were derived from film badge records. As stated in chapter 5, dosimetry records for Desert Rock and test organization personnel were maintained by the Radiological Health and Safety Unit.

During Operation BUSTER-JANGLE, the film badge was the primary device used to measure the radiation dose received by individual participants. A film badge was apparently issued to each test organization and Desert Rock participant (57; 60; 102). The film badge, normally worn at chest level on the outside of clothing, was designed to measure the wearer's exposure to gamma radiation from external sources. The film badges were insensitive to neutron radiation, however, and did not measure the amount of radioactive material, if any, that might have been inhaled or ingested.

Both the test organization and Exercises Desert Rock I, II, and III had their own radiological safety personnel who issued, received, developed, and interpreted film badges during Operation BUSTER-JANGLE. The Dosimetry and Records Section of the Radiological Health and Safety Unit handled the film badges for test organization personnel. The film badge program for Desert Rock I participants was administered by the Desert Rock Radiological Safety Unit and the Army Signal Corps Photographic Unit. The Chemical Section and the Army Signal Corps Photographic Unit administered the film badge program for Desert Rock II and III

participants. Film badge records for both test organization and Desert Rock participants were maintained by the Radiological Health and Safety Unit (57; 60; 102).

Film badge records were compiled into several documents after Operation BUSTER-JANGLE. These records were the basis for the aggregate exposure data included in the Exercise Desert Rock I Final Report (57), Report of Test Exercises Desert Rock II and III (60), Report of Radiological Safety, Indian Springs AFB (84), and Radiological Safety, Operation BUSTER-JANGLE (102). The film badge data summarized in this chapter were obtained from these reports and two other sources:

- Historical files of the Reynolds Electrical and Engineering Company (REECo), the prime support contractor to the Department of Energy (and previously to the AEC Nevada Operations Office). REECo has provided support at the Nevada Proving Ground since 1952. REECo assumed responsibility for onsite radiological safety in July 1955 and subsequently collected available dosimetry records for nuclear test participants at all nuclear testing operations from 1945 to the present. REECo has the available exposure records for individuals working under the test organization at Operation BUSTER-JANGLE (93; 94).
- Military medical records, maintained at the National Personnel Records Center, St. Louis, Missouri, for troops separated from military service, or at the Veterans Administration for individuals who have filed for disability compensation or health benefits. Unfortunately, many records were destroyed in a fire at the St. Louis repository in July 1973. That fire destroyed 13 to 17 million Army records for personnel discharged through 31 December 1959, and for members of the Army Air Corps/Air Force discharged through 31 December 1963.

6.3 DOSIMETRY DATA FOR OPERATION BUSTER-JANGLE PARTICIPANTS

This section presents data on the external gamma radiation exposures received by test organization and Desert Rock personnel by military service and unit.

6.3.1 External Gamma Exposure Data

Tables 6-1 through 6-6* present the gamma exposure data available from film badge records for DOD participants at Operation BUSTER-JANGLE. The tables indicate the following information by service or unit (32; 93):

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

Table 6-1 summarizes all exposures for each service affiliation. In addition to the Army, Navy, Marine Corps, and Air Force designations, the table includes data for scientific personnel, contractors, affiliates, and participants whose service affiliation is unknown. Tables 6-2 through 6-6 provide information about the gamma exposures received by the various participants. In these tables, distributions and averages are given by unit. For a unit to be represented in the table, it must meet at least one of the following criteria:

- Records are available for ten or more individuals from the unit.
- At least one individual in the unit had a gamma exposure of 1 roentgen or more.

Units not meeting these criteria are consolidated in tables 6-2 through 6-6 in the "other" category, and a distribution of cumulative and average exposures is provided for them. Tables 6-2a through 6-6a list the individual units constituting the "other" category in tables 6-2 through 6-6.

*All tables can be found at the end of the chapter.

6.3.2 Instances of Gamma Exposure Exceeding Prescribed Limits

As stated in chapter 5, the gamma exposure limit for most BUSTER-JANGLE participants was 3 roentgens. Participants in Desert Rock I, however, were limited to 1 roentgen. Cloud-sampling pilots and crews at Operation BUSTER-JANGLE were authorized to receive exposures of 3.9 roentgens (55; 57; 60; 102). Inconsistent and inconclusive information in the Radiological Safety Report indicates that from 50 to 67 individuals at the operation received gamma exposures in excess of the established limits. The exposures of 28 of these individuals have been found in the film badge records. Table 6-7 lists these exposures and the units or organizations of the individuals (32; 93; 102). The 3 roentgen limit is used for Desert Rock units since it is not possible to determine whether an individual participated specifically in Desert Rock I, II, or III.

Several of the overexposed personnel listed in table 6-7 participated in Weapons Effects Test Unit projects and entered radiation areas to retrieve instruments and data. These participants were from the following units and organizations (32; 93; 94):

- Armed Forces Special Weapons Project
- Bureau of Medicine
- Bureau of Ships
- Engineer Research and Development Laboratories
- Evans Signal Laboratory
- Naval Research Laboratory.

Personnel from the Engineer Research and Development Laboratories participated in project activities studying blast effects on various water tanks and the extent of radioactive contamination of the water in these tanks. Personnel entered the shot area soon after the detonation to examine the water tanks and obtain water samples. These personnel could have received

overexposures, since some of the water tanks were within 700 meters of ground zero (71; 72). The activities of the individuals from AFSWP, the Bureau of Medicine, the Bureau of Ships, the Evans Signal Laboratory, and the Naval Research Laboratory are not known.

Members of the Radiological Health and Safety Unit provided radiological safety monitors for all shots. These monitors accompanied AFSWP project personnel on many of the recovery missions. In addition, radiological safety personnel surveyed the shot area after each detonation. Members of the radiological safety group spent more time in or near radiation areas than other personnel, especially because they repeated their activities during several shots (102).

The 4925th Test Group gathered radioactive samples from clouds for analysis by personnel from various test projects. Because this task required the crews to fly near or through the clouds formed by the detonations, the potential for exposure was increased (40; 47).

Documentation has not been found for the activities of representatives from Desert Rock, Lackland AFB, Special Weapons Command at Kirtland AFB, the Technical Operations Squadron, the 3200th Target Drone Squadron, and the 97th Bombardment Wing.

Table 6-1: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR OPERATION BUSTER-JANGLE PARTICIPANTS BY AFFILIATION

Service	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Army	5443	1836	0.251	1343	358	117	16	2
Navy	203	181	0.729	33	97	48	3	0
Marine Corps	115	90	0.041	88	0	2	0	0
Air Force	863	329	0.539	156	115	41	17	0
Scientific Personnel, Contractors, and Observers	185	185	0.261	93	80	12	0	0
Service Unknown*	21	21	0.116	13	8	0	0	0
Total	6830	2642	0.312	1726	658	220	36	2

* Film badge data are available, but service affiliation is not known.

Table 6-2: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR ARMY PARTICIPANTS, OPERATION BUSTER-JANGLE

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
AP-36 (sic)*	1	1	2.480	0	0	1	0	0
Army Chemical Center, Edgewood Arsenal Edgewood, MD	45	45	1.213	5	17	23	0	0
Ballistic Research Laboratories, Aberdeen Proving Ground, Aberdeen, MD	15	15	0.511	2	11	2	0	0
Buster-Jangle (sic)*	2	2	4.140	0	0	0	2	0
Camp Desert Rock, NV	4084	1535	0.114	1263	257	12	2	1
Camp Gordon Observer Unit	20	0						
Engineer Research and Development Laboratories Fort Belvoir, VA	29	29	1.251	3	14	9	3	0
Evans Signal Laboratory, Fort Monmouth, NJ	31	31	1.437	1	8	21	0	1
Los Alamos Scientific Laboratory	1	1	3.190	0	0	0	1	0
Observers	18	18	0.122	4	14	0	0	0
Office of the Chief of Engineers, Washington, D.C.	5	5	0.660	1	0	4	0	0
PRF Sens R-S (sic)*	1	1	2.270	0	0	1	0	0
Provisional Company	329	21	0.023	21	0	0	0	0
Radiological Safety and Health Unit	27	27	2.038	1	5	14	7	0
Stanford Research Institute	9	9	0.799	1	5	3	0	0
U.S. Army, Effects Test Group	12	12	1.122	1	4	7	0	0
U.S. Army Detachment, Naval Research Laboratory Project 10.9	1	1	1.210	0	0	1	0	0
U.S. Army Detachment, Special Weapons Command Kirtland AFB, NM	3	3	2.233	0	1	1	1	0
U.S. Army Program Personnel	35	35	0.558	14	12	9	0	0
U.S. Army, Vehicle Decontamination	11	11	1.292	0	2	9	0	0
III Corps Artillery, Fort Lewis, WA	10	0						
III Corps Headquarters, Camp Roberts, CA	10	0						
11th Airborne Division, 188th Airborne Infantry Regiment, 1st Battalion, Camp Campbell, KY	26	0						
231st Engineer Combat Battalion, Fort Lewis, WA	34	0						

* "Sic" indicates that the unit appears in the table just as it was entered in the source documentation.

Table 6-2: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR ARMY PARTICIPANTS, OPERATION BUSTER-JANGLE (CONTINUED)

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				< 0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
303rd Signal Service Battalion Detachment Headquarters and Headquarters Company, Camp Cooke, CA	19	0						
314th Signal Construction Battalion (Detachment) Headquarters and Headquarters Company and Company "B", Camp Cooke, CA	10	0						
369th Engineer Amphibious Support Regiment, Fort Worden, WA	19	0						
505th Military Police Battalion, Camp Roberts, CA	13	0						
Other**	304	7	0.234	0	7	0	0	0
Unit Unknown***	319	27	0.038	26	1	0	0	0
Total	5443	1836	0.251	1343	358	117	16	2

** For list of units in this category, see table 6-2a.
 *** Unit information unavailable.

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION BUSTER-JANGLE

NUMBERED UNITS

Second Army (G-2 Section), Fort Meade, MD
Second Army, Headquarters, Fort Meade, MD
Third Army, Deputy Surgeon
Third Army, Headquarters, Fort McPherson, GA
Fifth Army Team
Sixth Army, Corps of Engineers (sic)*
Sixth Army, Headquarters (G-3 Section), Presidio of San Francisco, CA
Sixth Army, Headquarters, Presidio of San Francisco, CA
Sixth Army, 452nd Transportation Company (sic) [Inactivated 1950, per Adjutant General's letter, dated 4 October 1950]**

III Corps, Chemical Section
V Corps, Fort Lewis, TDY (sic) [V Corps, Bad Nauheim, Germany]***

1st Armored Division, Fort Hood, TX
1st Helicopter Company (sic) [13th Transportation Helicopter Company, Fort Sill, OK]
1st Technical Squad, Army Chemical Center, Baltimore, MD (sic)
2nd Armored Division [Sandhofen, Germany]
2nd Armored Division, 41st Armored Infantry, Company "C" [Mannheim, Germany]
2nd Armored Division, 82nd Reconnaissance [Company, Idar, Germany]
2nd Signal Battalion (sic)
2nd Signal Photographic (sic)
3rd Armored Division, 23rd Engineer Battalion [Fort Knox, KY]
3rd Infantry Regiment, Fort Myer, VA
4th Armored Division, 22nd Field Artillery, Battery "A" (sic) [22nd Antiaircraft Artillery Battalion, Okinawa]
4th Transportation Truck Company, Camp Stoneman, CA
5th Infantry Division, 10th Infantry Regiment, Company "D" [Indiantown Gap, PA]
5th Transportation Truck Battalion, Headquarters Company [Fort Story, VA]

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

**Unit files in Organizational History Branch, Office Chief of Military History.

***Unit and/or home station verification based on the "Directory and Station List of the US Army" for November 1951. Additional information from the Station List is provided in brackets.

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY
PARTICIPANTS, OPERATION BUSTER-JANGLE
(Continued)

6th Armored Division, Fort Leonard Wood, MO
6th Infantry Division, Fort Ord, CA

11th Armored Cavalry Regiment [Camp Carson, CO]
13th Antiaircraft Artillery Group (sic)
16th Signal Operation Battalion [Camp Cooke, CA]

23rd Transportation Truck Company (sic)
29th Regimental Combat Team, Fort McNair, Washington, D.C.

30th Engineer Helicopter Unit (sic)
30th Ordnance [Battalion, 30th Ordnance Company, Taegu, Korea]
30th Tank Battalion, Fort Knox, KY
31st Infantry Division [Camp Mackall, NC, to return to
Fort Jackson, SC, on or about 3 November 1951]
36th Engineer Construction Combat Brigade [36th Engineer
Combat Group, Pusan, Korea]

42nd Medium Tank Battalion [Camp Breckinridge, KY]
46th Engineer Construction Battalion [Fort Sill, OK]
47th Infantry Division, 136th Infantry [Regiment,
Camp Rucker, AL]

50th Chemical Service Platoon (sic)
53rd Quartermaster Base Depot Company, Ogden, UT
63rd Sec/Engr TRA/Fort Leonard Wood (sic)
76th Field Artillery, Fort Knox, KY
76th Signal Service Battalion (sic)
82nd Airborne Division [Fort Bragg, NC]
82nd Airborne Division, 325th Airborne Infantry Regiment
[Fort Bragg, NC]
82nd Airborne Division, 504th Airborne Infantry Regiment
[Fort Bragg, NC]
82nd Airborne Division, 505th Airborne Infantry Regiment
[Fort Bragg, NC]

90th Engineer Water Supply Company [Fort Lewis, WA]
92nd Transportation Car Company, 2nd Platoon, Camp Roberts, CA
94th Veterinary Food Inspection Service, Detachment,
Fort Lewis, WA
95th Infantry Battalion, Fort Campbell, KY
96th Engineer Combat Battalion (sic) [95th Engineer Combat
Battalion, Fort Lewis, WA, to Camp Desert Rock]

101st Signal Corps [Battalion, Chunchon, Korea]
115th Counterintelligence Detachment [Presidio of
San Francisco, CA]
122nd Special Weapons Unit [Sandia Base, NM]
127th Airborne Engineer, Company "A" [Fort Campbell, KY]

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION BUSTER-JANGLE (Continued)

144th Transportation Truck Company [Camp Rucker, AL]
 161st Ordnance Depot Company [Camp Cooke, CA]
 164th Infantry [Regiment] Company "I" [Camp Rucker, AL]
 169th Amphibious Company, Fort Story, VA
 179th Antiaircraft [Artillery Detachment, Fort Bliss, TX]
 194th Tank Battalion, Company "A" [Camp Rucker, AL]
 195th Field Artillery [Battalion, Fort Lewis, WA]

226th [Antiaircraft] Artillery Group [Fort Bliss, TX]
 237th Engineer Combat Battalion (sic) [231st Engineer Combat Battalion, Fort Lewis, WA, to Exercise Desert Rock]
 278th Regimental Combat Team (National Guard)

301st Logistics Command [Camp Rucker, AL]
 307th Military Police Battalion [Fort Sam Houston, TX]
 317th Signal Construction Battalion [Camp Cooke, CA]
 325th Transportation Staging Area Company (sic)
 359th Engineer Utility Detachment, Camp Roberts, CA
 369th Signal Detachment, Fort Flagler, WA (sic)
 371st Evacuation Hospital, Fort Lewis, WA
 374th Convalescent Center, Fort Lewis, WA
 375th Military Police Battalion [Company, Camp Cooke, CA]
 390th Chemical Laboratory [Army Chemical Center, MD]
 393rd Ordnance Battalion, HQS and HQS Detachment, Camp Cooke, CA

412th Engineer Construction Battalion [Yuma Test Station, AZ]
 449th Field Artillery (Observation) [Battalion, Fort Bragg, NC]

504th Military Police Battalion, Detachment [Camp Gordon, GA]
 504th Signal Base Maintenance Company, Detachment [Sacramento Signal Depot, CA]
 508th Airborne Regimental Combat Team [Fort Benning, GA]
 523rd Quartermaster Subsistence Depot Company,
 1st Platoon, Ogden, UT
 539th Quartermaster Laundry Company, 1st Platoon [Fort Lewis, WA]
 540th Field Artillery Battalion, Fort Lewis, WA
 546th Field Artillery Battalion, Battery "C," Fort Lewis, WA
 562nd Transportation Staging Area Company [Camp Stoneman, CA]
 597th Engineer Light Equipment Company, Detachment,
 Fort Huachuca, AZ

621st Quartermaster Subsistence Company, Fort Lewis, WA
 631st Ordnance Depot Company (sic)
 631st Quartermaster Subsistence Company, Fort Devens, MA
 653rd Field Artillery Battalion (Observation) [Fort Sill, OK]
 685th Field Artillery [Battalion], Battery "C" [Camp Edwards, MA]
 690th Field Artillery [Battalion], Battery [Fort Campbell, KY]

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY
PARTICIPANTS, OPERATION BUSTER-JANGLE
(Continued)

701st Armored Infantry Battalion, Fort Hood, TX
701st Engineer Maintenance Company Detachment (sic)
705th Engineer Maintenance Company, Maintenance Platoon,
Fort Huachuca, AZ
708th [Antiaircraft] Gun Battalion [Camp Stewart, GA]
747th Amphibious Tank Battalion [Camp Cooke, CA]

806th Army Postal Unit [Fort Lewis, WA]
836th Signal Radio Relay Outfit [Company, Fort Lewis, WA]
900th Mobile Army Surgical Hospital [Camp Atterbury, IN]

2101st Area Service Unit, Fort Meade, MD
2114th Area Service Unit, Company "E" [Camp Pickett, VA]
2128th Area Service Unit, Fort Knox, KY
2151st Area Service Unit [Aberdeen Proving Ground, MD]
3069th Engineer Amphibious Support Replacement Unit (sic)
3623rd Ordnance Medium Maintenance Company, Camp Cooke, CA

4004th Area Service Unit, Fort Sam Houston, TX
4052nd Area Service Unit, Fort Hood, TX
5021st Area Service Unit, Station Complement [Fort Riley, KS]
6020th Area Service Unit, Camp Desert Rock (sic)
8287th Area Service Unit, Station Complement (sic)
9135th Technical Service Unit, Fort Lee, VA
9710th Technical Service Unit, Army Chemical Center, MD
9778th Rad-Safe Unit, Fort McClellan, AL

DEPARTMENT OF THE ARMY

Headquarters, Department of the Army
Judge Advocate General Corps
OCA/SG.1 Sec D/A (sic)
Office, Chief of Information
Office, Chief Signal Officer
Office, Deputy Chief of Staff, G-2
Office, Quartermaster General, Program 2
Surgeon General's Office, Program 4; Project 4.2

COMMANDS

Headquarters, Army Antiaircraft Artillery Command, Ent AFB, CO
Headquarters, Western Area Antiaircraft Artillery Command

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION BUSTER-JANGLE
(Continued)

SCHOOLS AND TRAINING CENTERS

Antiaircraft Artillery Replacement Training Center,
Fort Bliss, TX
The Armored School and Training Center, Fort Knox, KY
Army General Staff School, Fort Riley, KA
Aviation Training School, Fort Sill, OK (sic) [6th and 13th
Transportation Helicopter Companies, Fort Sill, OK]
Command and General Staff College, Fort Leavenworth, KA
Training Center 6.3 (sic)
Transportation School, Fort Eustis, VA

LOCATIONS

Camp Cooke, CA
Camp Roberts, CA
Fort Benning, GA
Fort Bliss, TX
Fort Campbell, KY
Fort Chaffee, Ark
Fort Eustis, VA
Fort Hood, TX
Fort Leonard Wood, MO
Fort Tilden, NY
Fort Worden, WA
Indian Springs Air Force Base, NV
Sandia Base, NM

MISCELLANEOUS

Antiaircraft Artillery Brigade [47th], Fort MacArthur, CA
Arlington Hall Station, Army Security Agency, Detachment
Armed Forces Special Weapons Project
Armored Engineer Battalion (sic)
Army Pictorial Center, Long Island, NY
Chemical Corps Atomic Monitoring (sic)
Chemical Corps, Fort Benning, GA (sic)
Chemical Corps, Fort Carson, CO (sic)
Chem Corps Radiological Survey (sic)
Dispersing 6001 (sic)
Explosive Disposal Center (sic)
Firing Party (sic)
Hampton Roads Virginia, Port of Embarkation [OCAFF]
Headquarters, Ivy Flats, CA (sic)
Headquarters, Military District of Washington
Los Alamos Scientific Laboratory
Military Police Detachment, Walter Reed Army Medical Center,
Washington, D.C.

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY
PARTICIPANTS, OPERATION BUSTER-JANGLE
(Continued)

National Guard Unit, Buffalo, NY
Naval Radiological Defense Laboratory, Program 2
Naval Research Laboratory, Program 5
New York Port of Embarkation
Radiological Survey Team
Research and Development Board, Washington, D.C.
Sandia Base, AFSWP, Project 3.28
Signal Corps (sic)
Signal Corps Engineering Laboratories, Fort Monmouth, NJ
Task Group 3.2

Table 6-3: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR NAVY PARTICIPANTS, OPERATION BUSTER-JANGLE

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				< 0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Armed Forces Special Weapons Project	8	7	1.430	1	1	5	0	0
Bureau of Medicine	5	5	2.032	1	0	3	1	0
Bureau of Ships	4	4	1.227	2	0	1	1	0
Los Alamos Scientific Laboratory	6	6	0.828	0	5	1	0	0
Naval Attachment, Kirtland AFB	18	17	0.684	2	11	4	0	0
Naval Attachment, Sandia Base	2	2	1.145	0	1	1	0	0
Naval Ordnance Laboratory	28	23	0.463	4	16	3	0	0
Naval Research and Development Laboratory	112	103	0.690	16	57	30	0	0
Naval Research Laboratory	3	2	1.965	0	1	0	1	0
Others*	11	6	0.289	3	3	0	0	0
Unit Unknown**	6	6	0.100	4	2	0	0	0
Total	203	181	0.729	33	97	48	3	0

* For list of units in this category, see table 6-3a.

** Unit information unavailable.

Table 6-3a: DETAILED LISTING OF "OTHER" CATEGORY, NAVY PARTICIPANTS, OPERATION BUSTER-JANGLE

Aberdeen Proving Ground, Aberdeen, MD
Atomic Energy Commission, Washington, D.C.
Bureau of Docks, Washington, D.C.
Commander Amphibious Group 3
David Taylor Model Basin, Washington, D.C.
Directorate Weapons Effects Test
Office of Naval Research, Washington, D.C.
Naval Civil Engineering Laboratory, Port Hueneme, CA

Table 6-4: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR MARINE CORPS PARTICIPANTS, OPERATION BUSTER-JANGLE

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				< 0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Marine Corps Recruitment Depot, Parris Island, SC – Observers	16	14	0.001	14	0	0	0	0
Marine Corps Recruitment Depot, San Diego, CA – Observers	14	12	0.001	12	0	0	0	0
Others*	36	27	0.001	27	0	0	0	0
Unit Unknown – Observers**	49	37	0.100	35	0	2	0	0
Total	115	90	0.041	88	0	2	0	0

* For list of units in this category, see table 6-5a.

** Unit information unavailable.

Table 6-4a: DETAILED LISTING OF "OTHER" CATEGORY,
MARINE CORPS PARTICIPANTS, OPERATION
BUSTER-JANGLE

1st Amphibious Tractor Battalion, Fleet Marine Force, Pacific
1st Signal Operations Company, Fleet Marine Force, Pacific--
Observers

Headquarters and Service Company, Supply School Battalion
155 mm Gun Battalion, Fleet Marine Force, Pacific--Observers
Company A, Headquarters Battalion, Marine Corps Schools,
Quantico, VA--Observers

Headquarters and Maintenance Squadron 13, Marine Aircraft Group
13, Aircraft, Fleet Marine Force, Pacific--Observers

Headquarters Company, Fleet Marine Force, Atlantic, Norfolk, VA--
Observers

Headquarters Company, Fleet Marine Force, Pacific--Observers

Headquarters Company, Headquarters Battalion, Marine Corps
Schools, Quantico, VA--Observers

Headquarters, Field Command, Armed Forces Special Weapons Project

Headquarters, Marine Base, Camp Pendleton, CA--Observers

Headquarters, Marine Corps, Washington, D.C.--Observers

Marine Aircraft Maintenance Squadron 15, Marine Aircraft Group
15--Observers

Marine All-Weather Fighter Squadron 235, Marine Aircraft Group
25--Observers

Marine All-Weather Fighter Squadron 451, Marine Aircraft Group 13

Marine Corps Schools, Quantico, VA--Observers

Marine Attack Squadron 261, Marine Aircraft Group 13, Aircraft,
Fleet Marine Force, Pacific--Observers

Marine Night Fighter Squadron 542, Marine Aircraft Group 15--
Observers

Marine Observation Squadron 2, Fleet Marine Force, Pacific--
Observers

Marine Training Squadron 2, Aircraft, Fleet Marine Force,
Pacific--Observers

Marine Tactical Air Control Squadron 3, Marine Aircraft Control
Group 3, Aircraft, Fleet Marine Force, Pacific

Station Maintenance Squadron 1, Marine Corps Air Station,
El Toro, CA

Table 6-5: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR AIR FORCE PARTICIPANTS, OPERATION BUSTER-JANGLE

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Air Force Special Weapons Command	61	39	0.566	12	19	8	0	0
Armed Forces Special Weapons Project	12	6	1.470	2	1	2	1	0
Cambridge Research Center	24	24	0.070	19	5	0	0	0
Headquarters, U.S. Air Force	10	8	0.295	5	2	1	0	0
Headquarters, Wright Air Development Center	100	10	0.393	4	5	1	0	0
Headquarters, 1090th Special Reporting Group	19	11	0.009	11	0	0	0	0
Headquarters, 4901st Support Wing	40	1	0.001	1	0	0	0	0
Lackland AFB, Texas	1	1	3.570	0	0	0	1	0
Technical Operations Squadron (Provisional)	11	4	2.120	0	1	2	1	0
7th Bombardment Wing	16	0						
57th Reconnaissance Squadron	60	2	0.085	1	1	0	0	0
97th Bombardment Wing	1	1	3.140	0	0	0	1	0
136th Communication Security Squadron	17	0						
338th Strategic Reconnaissance Squadron	32	0						
1090th Special Reporting Squadron	17	11	0.001	11	0	0	0	0
1131st Special Activity Squadron	4	3	1.064	1	0	2	0	0
2060th Mobile Weather Squadron	5	1	1.230	0	0	1	0	0
3200th Target Drone Squadron	7	5	0.698	2	2	0	1	0
4901st Support Wing	19	13	0.149	3	10	0	0	0
4909th Organizational Maintenance Squadron	46	7	0.380	2	4	1	0	0
4911th Air Police Squadron	26	1	0.180	0	1	0	0	0
4925th Test Group	104	67	1.207	16	26	13	12	0
6531st Test Squadron	22	1	0.050	1	0	0	0	0
Other*	88	30	0.155	13	17	0	0	0
Unit Unknown**	121	83	0.299	52	21	10	0	0
Total	863	329	0.539	156	115	41	17	0

* For list of units in this category, see table 6-4a.

** Unit information unavailable.

Table 6-5a: DETAILED LISTING OF "OTHER" CATEGORY, AIR FORCE PARTICIPANTS, OPERATION BUSTER-JANGLE

1st Tactical Support Squadron
3rd Aviation Field Squadron
27th Fighter Wing
35th Food Service Squadron
42nd Bombardment Squadron
49th Bombardment Squadron
53rd Fighter Bomber Squadron
97th Aviation Squadron

140th Maintenance and Supply Squadron
187th Fighter Bomber Squadron
545th Aviation Squadron
561st Fighter Escort Squadron

1009th Special Weapons Squadron
1083rd Special Reporting Squadron
1095th Special Reporting Squadron
1096th Special Reporting Squadron
1352nd Motion Picture Squadron
3061st Support Squadron
3595th Medical Group
3596th Air Base Squadron
3599th Training Group

4905th Maintenance and Supply Group, Headquarters
4906th Field Maintenance Squadron
4907th Supply Squadron
4908th Motor Vehicle Squadron
4909th Support Squadron
4910th Air Base Group
4910th Air Base Group Headquarters
4914th Flight Operations Squadron
4915th Installation Squadron
4920th Medical Group

Armament Test Division
Headquarters Squadron, 4910th Air Base Group
Headquarters, Air Proving Ground
Headquarters, Air Research Development Command
Headquarters, Air Weather Service
Headquarters, School of Aviation Medicine
Headquarters, Strategic Air Command
Headquarters, Tactical Air Command
Headquarters, Technical Training Detachment 8407th AAU
Lookout Mountain Laboratory, Hollywood, CA
Naval Research Laboratory, Washington, D.C.
Radiological Defense School

Table 6-6: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR SCIENTIFIC PERSONNEL, CONTRACTORS, AND OBSERVERS, OPERATION BUSTER-JANGLE

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<0.1	0.1-1.0	1.0-3.0	3.0-5.0	5.0+
Headquarters, Weapons Effects Test Unit	10	10	0.589	5	2	3	0	0
Radiological Safety	79	79	0.309	27	47	5	0	0
Stanford Research Institute	26	26	0.204	11	14	1	0	0
Test Director's Panel (Staff)	6	6	0.318	3	2	1	0	0
University of Rochester, NY	16	16	0.232	12	3	1	0	0
Weapons Effects Test Unit	33	33	0.124	28	4	1	0	0
Other*	15	15	0.202	7	8	0	0	0
Total	185	185	0.261	93	80	12	0	0

* For list of units in this category, see table 6-6a.

Table 6-6a: DETAILED LISTING OF "OTHER" CATEGORY
FOR SCIENTIFIC PERSONNEL, CONTRACTORS,
AND OBSERVERS, OPERATION BUSTER-JANGLE

North American Aviation
Observers

Table 6-7: FILM BADGE READINGS EXCEEDING ESTABLISHED LIMITS FOR PARTICIPANTS IN OPERATION BUSTER-JANGLE

Unit	Number of Personnel	Total Exposures (Roentgens)*
Armed Forces Special Weapons Project	1	3.8
Bureau of Medicine	1	3.1
Bureau of Ships	1	3.2
Buster-Jangle (sic)**	2	3.6, 4.7
Desert Rock	3	4.7, 4.9, 5.8
Engineer Research and Development Laboratories	3	3.3, 4.9, 4.9
Evans Signal Laboratory	1	5.7
Lackland AFB, TX	1	3.6
Los Alamos Scientific Laboratory	1	3.2
Naval Research Laboratory	1	3.5
Radiological Safety and Health	7	3.0, 3.1, 3.1, 3.2, 3.2, 3.5, 3.5
Technical Operations Squadron	1	5.0
United States Army, Special Weapons Command, Kirtland AFB	1	3.5
97th Bombardment Wing	1	3.1
3200th Target Drone Squadron	1	3.1
4925th Test Group***	2	4.0, 4.4
TOTAL	28	

* Exposures rounded to nearest tenth of a roentgen.

** "Sic" indicates that this unit appears just as it was entered in the source documentation.

*** Subject to 3.9 roentgen exposure limit.

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Exec Ofc of The President
Management & Budget Off Lib
ATTN: Librn

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

National Atomic Museum
ATTN: Historian

Department of Commerce
National Bureau of Standards
ATTN: Librn

Occupational Safety & Health Admin
ATTN: Library

Office of Health & Disability (ASPER)
ATTN: R. Copeland

Ofc of Workers Compensation Program
Department of Labor
ATTN: R. Larson

U.S. Coast Guard Academy Library
ATTN: Librn

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

OTHER GOVERNMENT AGENCIES (Continued)

U.S. House of Representatives
Committee on Interstate & Foreign Commerce
ATTN: Subcommittee on Health & Envir

U.S. Military Academy
ATTN: Director of Libraries

U.S. Senate
Committee on Armed Services
ATTN: Committee on Veterans Affairs

U.S. Senate
ATTN: Committee on Veterans Affairs

Veterans Administration-RO
Providence, RI
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

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
Denver, CO
ATTN: Director

Veterans Administration-RO
Hartford, CT
ATTN: Director

Veterans Administration-RO
Wilmington, DE
ATTN: Director

Veterans Administration-OFC Central
Washington, D. C.
ATTN: Dept Veterans Benefit, Central Ofc
ATTN: Director
ATTN: Board of Veteran Appeal

Veterans Administration-RO
St. Petersburg, FL
ATTN: Director

Veterans Administration-RO
Atlanta, GA
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Honolulu, HI
ATTN: Director

Veterans Administration-RO
Chicago, IL
ATTN: Director

Veterans Administration-RO
Seattle, WA
ATTN: Director

Veterans Administration-RO
Indianapolis, IN
ATTN: Director

Veterans Administration-RO
Des Moines, IA
ATTN: Director

Veterans Administration-RO
Wichita, KS
ATTN: Director

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

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

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
Ft. Harrison, MT
ATTN: Director

National Archives
ATTN: Librn

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Lincoln, NE
ATTN: Director

Veterans Administration-RO
Reno, NV
ATTN: Director

Veterans Administration-RO
Manchester, NH
ATTN: Director

Veterans Administration-RO
Newark, NJ
ATTN: Director

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

Veterans Administration-RO
Portland, OR
ATTN: Director

Veterans Administration-RO
Pittsburgh, PA
ATTN: Director

Veterans Administration-RO
Philadelphia, PA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

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

OTHER GOVERNMENT AGENCIES (Continued)

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

Veterans Administration-RO
Nashville, TN
ATTN: Director

The White House
ATTN: Domestic Policy Staff

DEPARTMENT OF ENERGY CONTRACTORS

Lawrence Livermore National Lab'
ATTN: Tech Info Dept Library

Los Alamos National Lab
ATTN: Library
2 cy ATTN: ADPA MMS 195

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

Reynolds Electrical & Engr Co., Inc
ATTN: CIC
ATTN: W. Brady

OTHER

Adams State College
ATTN: Gov Pubs Library

Akron Public Library
ATTN: Gov Pubs Library

Alabama State Dept of Archives & History
ATTN: Military Records Div

University of Alabama
ATTN: Reference Dept/Documents

University of Alaska Library at Anchorage
ATTN: Gov Pubs Library

University of Alaska
ATTN: Dir of Libraries

Albany Public Library
ATTN: Librn

Alexander City State Jr College
ATTN: Librn

Allegheny College
ATTN: Librn

Allen County Public Library
ATTN: Librn

Altoona Area Public Library
ATTN: Librn

American Statistics Index
Congressional Info Service, Inc
ATTN: Cathy Jarvey

Anaheim Public Library
ATTN: Librn

College of Wooster
ATTN: Gov Docs

Angelo State University Library
ATTN: Librn

Angelo Iacoboni Public Library
ATTN: Librn

Anoka County Library
ATTN: Librn

Appalachian State University
ATTN: Library Docs

Arizona State University Library
ATTN: Librn

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

Arkansas College Library
ATTN: Library

Brooklyn College
ATTN: Doc Div

OTHER (Continued)

Arkansas Library Comm
ATTN: Library

Arkansas State University
ATTN: Library

University of Arkansas
ATTN: Gov Docs Div

Austin College
ATTN: Librn

Atlanta Public Library
ATTN: Ivan Allen Dept

Atlanta University
ATTN: Librn

Auburn University Library at Montgomery (Reg)
ATTN: Librn

C. W. Post Ctr Long Island University
ATTN: Librn

Bangor Public Library
ATTN: Librn

Bates College Library
ATTN: Librn

Baylor University Library
ATTN: Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

State University College
ATTN: Gov Docs

Akron University
ATTN: Gov Docs

Boston Public Library (Reg)
ATTN: Docs Dept

Bowdoin College
ATTN: Librn

Bowling Green State University
ATTN: Lib Gov Docs Services

Bradley University
ATTN: Librn

Brandeis University Library
ATTN: Docs Section

Brigham Young University
ATTN: Librn

Brigham Young University
ATTN: Docs Collection

Brookhaven National Laboratory
ATTN: Tech Library

OTHER (Continued)

Broward County Library Sys
ATTN: Librn

Brown University
ATTN: Librn

Bucknell University
ATTN: Reference Dept

Buffalo & Erie Co Public Library
ATTN: Librn

State University Library of California at Fresno
ATTN: Library

University Library of California at Los Angeles
ATTN: Pub Affairs Serv U.S. Docs

University of California at San Diego
ATTN: Docs Dept

State College Library of California at Stanislaus
ATTN: Library

California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Librn

California State University at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Librn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Librn

California University Library
ATTN: Gov Docs Dept

California University Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN: Librn

Kearney State College
ATTN: Gov Docs Dept

Carleton College Library
ATTN: Librn

OTHER (Continued)

Carnegie Library of Pittsburgh
ATTN: Librn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Missouri State Univ
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN: Librn

Charleston County Library
ATTN: Librn

Charlotte & Mecklenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Librn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

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

Cincinnati University Library
ATTN: Librn

Claremont Colleges Libraries
ATTN: Doc Collection

Clemson University
ATTN: Dir of Libraries

OTHER (Continued)

Cleveland Public Library
ATTN: Docs Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: Docs Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: Docs Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

OTHER (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College So Cpus
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: Docs Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN: Librn

Burlington Library
ATTN: Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: Docs Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN: Librn

East Islip Public Library
ATTN: Librn

OTHER (Continued)

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

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN: Librn

Eastern Kentucky University
ATTN: Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Docs Dept/D-103

Fond Du Lac Public Library
ATTN: Librn

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

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

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

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

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

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

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

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

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

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

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

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

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

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

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

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

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Manchester City Library
ATTN: Librn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
ATTN: Librn

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

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
ATTN: Librn

Murray State University Library
ATTN: Lib

OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN: Librn

Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

University of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

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

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Control Cultural Ed Ctr

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

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

State University of New York
ATTN: Lib Docs Sec

North Texas State University Library
ATTN: Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN: Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State
University
ATTN: Librn

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

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
ATTN: Docs Librn

University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

OTHER (Continued)

Northeast Missouri State University
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
ATTN: Librn

Northwestern Michigan College
ATTN: Librn

Northwestern State University
ATTN: Librn

Northwestern State University Library
ATTN: Librn

Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN: Librn

Oakland Public Library
ATTN: Librn

Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN: Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librn

Oklahoma City University Library
ATTN: Librn

OTHER (Continued)

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

University of Oklahoma
ATTN: Docs Div

Old Dominion University
ATTN: Doc Dept Univ Lib

Olivet College Library
ATTN: Librn

Omaha Public Library Clark Branch
ATTN: Librn

Onondaga County Public Library
ATTN: Gov Docs Sec

Oregon State Library
ATTN: Librn

University of Oregon
ATTN: Docs Sec

Ouachita Baptist University
ATTN: Librn

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN: Librn

Portland Public Library
ATTN: Librn

Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN: Librn

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN: Librn

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College Library
ATTN: Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
ATTN: Gov Pubs Ofc

University of Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
ATTN: Librn

OTHER (Continued)

Richland County Public Library
ATTN: Librn

Riverside Public Library
ATTN: Librn

University of Rochester Library
ATTN: Docs Sec

University of Rutgers Camden Library
ATTN: Librn

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