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PROJECT TRINITY

1945-1946

by

Carl Maag and Steve Rohrer

United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

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

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC Atomic Energy Commission
DOD Department of Defense
LASL Los Alamos Scientific Laboratory
MAUD [Committee for the] Military Application of Uranium Detonation
MED Manhattan Engineer District
R/h roentgens per hour
UTM Universal Transverse Mercator

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TRINITY

Los Alamos Scientific Laboratory

Alamogordo Bombing Range

Manhattan Engineer District

Manhattan Project

Personnel Dosimetry

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20. ABSTRACT: This report describes the activities of an estimated 1,000 personnel, both military and civilian, in Project TRINITY, which culminated in detonation of the first nuclear device, in New Mexico in 1945. Scientific and diagnostic experiments to evaluate the effects of the nuclear device were the primary activities engaging military personnel.

FACT SHEET

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Subject: Project TRINITY

Project TRINITY, conducted by the Manhattan Engineer District (MED), was designed to test and assess the effects of a nuclear weapon. The TRINITY nuclear device was detonated on a 100-foot tower on the Alamogordo Bombing Range in south-central New Mexico at 0530 hours on 16 July 1945. The nuclear yield of the detonation was equivalent to the energy released by detonating 19 kilotons of TNT. At shot-time, the temperature was 21.8 degrees Celsius, and surface air pressure was 850 millibars. The winds were nearly calm at the surface; at 10,300 feet above mean sea level, they were from the southwest at 10 knots. The winds blew the cloud resulting from the detonation to the northeast. From 16 July 1945 through 1946, about 1,000 military and civilian personnel took part in Project TRINITY or visited the test site. The location of the test site and its major installations are shown in the accompanying figures.

Military and Scientific Activities

All participants in Project TRINITY, both military and civilian, were under the authority of the MED. No military exercises were conducted. The Los Alamos Scientific Laboratory (LASL), which was staffed and administered by the University of California (under contract to the MED), conducted diagnostic experiments. Civilian and military scientists and technicians, with assistance from other military personnel, placed gauges, detectors, and other instruments around ground zero before the detonation. Four offsite monitoring posts were established in the towns of Nogal, Roswell, Socorro, and Fort Sumner, New Mexico. An evacuation detachment consisting of 144 to 160 enlisted men and officers was established in case protective measures or evacuation of civilians living offsite became necessary. At least 94 of these personnel were from the Provisional Detachment Number 1, Company "B," of the 9812th Technical Service Unit, Army Corps of Engineers. Military police cleared the test area and recorded the locations of all personnel before the detonation.

A radiological monitor was assigned to each of the three shelters, which were located to the north, west, and south of ground zero. Soon after the detonation, the monitors surveyed the area immediately around the shelters and then proceeded out the access road to its intersection with the main road, Broadway. Personnel not essential to postshot activities were transferred from the west and south shelters to the Base Camp, about 16 kilometers southwest of ground zero. Personnel at the north shelter were evacuated when a sudden rise in radiation levels was detected; it was later learned that the instrument had not been accurately calibrated and levels had not increased as much as the instrument indicated. Specially designated groups conducted onsite and offsite radiological surveys.

Safety Standards and Procedures

The safety criteria established for Project TRINITY were based on calculations of the anticipated dangers from blast pressure, thermal radiation, and ionizing radiation. The TR-7 Group, also known as the Medical Group, was responsible for radiological safety. A limit of 5 roentgens of exposure during a two-month period was established.

The Site and Offsite Monitoring Groups were both part of the Medical Group. The Site Monitoring Group was responsible for equipping personnel with protective clothing and instruments to measure radiation exposure, monitoring and recording personnel exposure according to film badge readings and time spent in the test area, and providing for personnel decontamination. The Offsite Monitoring Group surveyed areas surrounding the test site for radioactive fallout. In addition to these two monitoring groups, a small group of medical technicians provided radiation detection instruments and monitoring.

Radiation Exposures at Project TRINITY

Dosimetry information is available for about 815 individuals who either participated in Project TRINITY activities or visited the test site between 16 July 1945 and 1 January 1947. The listing does not indicate the precise military or unit affiliation of all personnel. Less than six percent of the Project TRINITY participants received exposures greater than 2 roentgens. Twenty-three of these individuals received exposures greater than 2 but less than 4 roentgens; another 22 individuals received between 4 and 15 roentgens.

PREFACE

From 1945 to 1962, the U.S. Government, through the Manhattan Engineer District (MED) and its successor agency, the Atomic Energy Commission (AEC), conducted 235 tests of nuclear devices 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. Project TRINITY, the war-time effort to test-fire a nuclear explosive device, was the first atmospheric nuclear weapons test.

* The MED, which was part of the Army Corps of Engineers, administered the U.S. nuclear testing program until the AEC came into existence in 1946. Before DOD was established in 1947, the Army Corps of Engineers was under the War Department.

In 1977, 15 years after the last above-ground nuclear weapons test, the Centers for Disease Control** noted a possible leukemia cluster among a small group of soldiers present at Shot SMOKY, a test of Operation PLUMBBOB, the series of atmospheric nuclear weapons tests conducted in 1957. Since that initial report by the Centers for Disease Control, the Veterans Administration has received a number of

claims for medical benefits from former military personnel who believe their health may have been affected by their participation in the weapons testing program.

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

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

- o Identify DOD personnel who had taken part in the atmospheric nuclear weapons tests
- o Determine the extent of the participants' exposure to ionizing radiation
- o Provide public disclosure of information concerning participation by military personnel in Project TRINITY.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report on Project TRINITY is based on historical and technical documents associated with the detonation of the first nuclear device on 16 July 1945. The Department of Defense compiled information for this volume from documents that record the scientific activities during Project TRINITY. These records, most of which were developed by participants in TRINITY, are kept in several document repositories throughout the United States.

In compiling information for this report, historians, health physicists, radiation specialists, and information analysts canvassed document repositories known to contain materials on atmospheric nuclear weapons tests conducted in the southwestern United States. These repositories included armed services libraries, Government agency archives and libraries, Federal repositories, and libraries of scientific and technical laboratories. Researchers examined classified and unclassified documents containing information on the participation of personnel from the MED, which supervised Project TRINITY, and from the Los Alamos Scientific Laboratory (LASL), which developed the TRINITY device. After this initial effort, researchers recorded relevant information concerning the activities of MED and LASL personnel and catalogued the data sources. Many of the documents pertaining specifically to MED and LASL participation were found in the Defense Nuclear Agency Technical Library and the LASL Records Center.

Information on the fallout pattern, meteorological conditions, and nuclear cloud dimensions is taken from Volume 1 of the General Electric Company-TEMPO's "Compilation of Local Fallout Data from Test Detonations 1945-1962, Extracted from DASA 1251," unless more specific information is available elsewhere.

ORGANIZATION OF THIS VOLUME

The following chapters detail MED and LASL participation in Project TRINITY. Chapter 1 provides background information, including a description of the TRINITY test site. Chapter 2 describes the activities of MED and LASL participants before, during, and after the detonation. Chapter 3 discusses the radiological safety criteria and procedures in effect for Project TRINITY, and chapter 4 presents the results of the radiation monitoring program, including information on film badge readings for participants in the project.

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

CHAPTER 1

INTRODUCTION

Project TRINITY was the name given to the war-time effort to produce the first nuclear detonation. A plutonium-fueled implosion device was detonated on 16 July 1945 at the Alamogordo Bombing Range in south-central New Mexico.

Three weeks later, on 6 August, the first uranium-fueled nuclear bomb, a gun-type weapon code-named LITTLE BOY, was detonated over the Japanese city of Hiroshima. On 9 August, the FAT MAN nuclear bomb, a plutonium-fueled implosion weapon identical to the TRINITY device, was detonated over another Japanese city, Nagasaki. Two days later, the Japanese Government informed the United States of its decision to end the war. On 2 September 1945, the Japanese Empire officially surrendered to the Allied Governments, bringing World War II to an end.

In the years devoted to the development and construction of a nuclear weapon, scientists and technicians expanded their knowledge of nuclear fission and developed both the gun-type and the implosion mechanisms to release the energy of a nuclear chain reaction. Their knowledge, however, was only theoretical. They could be certain neither of the extent and effects of such a nuclear chain reaction, nor of the hazards of the resulting blast and radiation. Protective measures could be based only on estimates and calculations. Furthermore, scientists were reasonably confident that the gun-type uranium-fueled device could be successfully detonated, but they did not know if the more complex firing technology required in an implosion device would work. Successful detonation of the TRINITY device showed that implosion would work, that a nuclear chain reaction would result in a powerful detonation, and that effective means exist to guard against the blast and radiation produced.

1.1 HISTORICAL BACKGROUND OF PROJECT TRINITY

The development of a nuclear weapon was a low priority for the United States before the outbreak of World War II. However, scientists exiled from Germany had expressed concern that the Germans were developing a nuclear weapon. Confirming these fears, in 1939 the Germans stopped all sales of uranium ore from the mines of occupied Czechoslovakia. In a letter sponsored by group of concerned scientists, Albert Einstein informed President Roosevelt that German experiments had shown that an induced nuclear chain reaction was possible and could be used to construct extremely powerful bombs (7; 12)*.

* All sources cited in the text are listed alphabetically in the reference list at the end of this volume. The number given in the text corresponds to the number of the source document in the reference list.

In response to the potential threat of a German nuclear weapon, the United States sought a source of uranium to use in determining the feasibility of a nuclear chain reaction. After Germany occupied Belgium in May 1940, the Belgians turned over uranium ore from their holdings in the Belgian Congo to the United States. Then, in March 1941, the element plutonium was isolated, and the plutonium-239 isotope was found to fission as readily as the scarce uranium isotope, uranium-235. The plutonium, produced in a uranium-fueled nuclear reactor, provided the United States with an additional source of material for nuclear weapons (7; 12).

In the summer of 1941, the British Government published a report written by the Committee for Military Application of Uranium Detonation (MAUD). This report stated that a nuclear weapon was possible and concluded that its construction should begin immediately. The MAUD report, and to a lesser degree the discovery of plutonium, encouraged American leaders to think more seriously about developing a nuclear weapon. On 6 December 1941, President Roosevelt appointed the S-1 Committee to determine if the United States could construct a nuclear weapon. Six months later, the S-1 Committee gave the President its report, recommending a fast-paced program that would cost up to \$100 million and that might produce the weapon by July 1944 (12).

The President accepted the S-1 Committee's recommendations. The effort to construct the weapon was turned over to the War Department, which assigned the task to the Army Corps of Engineers. In September 1942, the Corps of Engineers established the Manhattan Engineer District to oversee the development of a nuclear weapon. This effort was code-named the "Manhattan Project" (12).

Within the next two years, the MED built laboratories and production plants throughout the United States. The three principal centers of the Manhattan Project were the Hanford, Washington, Plutonium Production Plant; the Oak Ridge, Tennessee, U-235 Production Plant; and the Los Alamos Scientific Laboratory in northern New Mexico. At LASL, Manhattan Project scientists and technicians, directed by Dr. J. Robert Oppenheimer,* investigated the theoretical problems that had to be solved before a nuclear weapon could be developed (12).

* This report identifies by name only those LASL and MED personnel who are well-known historical figures.

During the first two years of the Manhattan Project, work proceeded at a slow but steady pace. Significant technical problems had to be solved, and difficulties in the production of plutonium, particularly the inability to process large amounts, often frustrated the scientists. Nonetheless, by 1944 sufficient progress had been made to persuade the scientists that their efforts might succeed. A test of the plutonium implosion device was necessary to determine if it would work and what its effects would be. In addition, the scientists were concerned about the possible effects if the conventional explosives in a nuclear device, particularly the more complex implosion-type device, failed to trigger the nuclear reaction when detonated over enemy territory. Not only would the psychological impact of the weapon be lost, but the enemy might recover large amounts of fissionable material.

In March 1944, planning began to test-fire a plutonium-fueled implosion device. At LASL, an organization designated the X-2 Group was formed within the Explosives Division. Its duties were "to make preparations for a field test in which blast, earth shock, neutron and gamma radiation would be studied and complete photographic records made of the explosion and any atmospheric phenomena connected with the explosion" (13). Dr. Oppenheimer chose the name TRINITY for the project in September 1944 (12).

1.2 THE PROJECT TRINITY SITE

The TRINITY site was chosen by Manhattan Project scientists after thorough study of eight different sites. The site selected was an area measuring 29 by 39 kilometers* in the northwest corner of the Alamogordo Bombing Range. The Alamogordo Bombing Range was located in a desert in south-central New Mexico called the Jornada del Muerto ("Journey of Death"). Figure 1-1 shows the location of the bombing range. The site was chosen for its remote location and good weather and because it was already owned by the Government. MED obtained permission to use the site from the Commanding General of the Second Air Force (Army Air Forces) on 7 September 1944 (12). Figure 1-2 shows the TRINITY site with its major installations.

* 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. Vertical distances are given in feet; altitudes are measured from mean sea level, while heights are measured from surface level, unless otherwise noted.

Ground zero for the TRINITY detonation was at UTM coordinates 630266.** Three shelters, located approximately 9,150 meters (10,000 yards) north, west, and south of ground zero, were built for the protection of test personnel and instruments. The shelters had walls of reinforced concrete and were buried under a few feet of earth. The south shelter was the Control Point for the test (12). The Base Camp, which was the headquarters for Project TRINITY, was located approximately 16 kilometers southwest of ground zero. The principal buildings of the abandoned McDonald Ranch, where the active parts of the TRINITY device were assembled, stood 3,660 meters southeast of ground zero. Seven guard posts, which were simply small tents or parked trucks like the ones shown in figures 1-3 and 1-4, dotted the test site (9).

** 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.

1.3 THE PROJECT TRINITY ORGANIZATION

The organization that planned and conducted Project TRINITY grew out of the X-2 Group. LASL, though administered by the University of California, was part of the Manhattan Project, supervised by the Army Corps of Engineers Manhattan Engineer District. The chief of MED was Maj. Gen. Leslie Groves of the Army Corps of Engineers. Major General Groves reported to both the Chief of Engineers and the Army Chief of Staff. The Army Chief of Staff reported to the Secretary of War, a Cabinet officer directly responsible to the President. Figure 1-5 outlines the organization of Project TRINITY.

The director of the Project TRINITY organization was Dr. Kenneth Bainbridge. Dr. Bainbridge reported to Dr. J. Robert Oppenheimer, the director of LASL. A team of nine research consultants advised Dr.

Bainbridge on scientific and technical matters (3).

The Project TRINITY organization was divided into the following groups (3):

- o The TRINITY Assembly Group, responsible for assembling and arming the nuclear device
- o The TR-1 (Services) Group, responsible for construction, utilities, procurement, transportation, and communications
- o The TR-2 Group, responsible for air-blast and earth-shock measurements
- o The TR-3 (Physics) Group, responsible for experiments concerning measurements of ionizing radiation
- o The TR-4 Group, responsible for meteorology
- o The TR-5 Group, responsible for spectrographic and photographic measurements
- o The TR-6 Group, responsible for the airblast-airborne condenser gauges
- o The TR-7 (Medical) Group, responsible for the radiological safety and general health of the Project TRINITY participants.

Each of these groups was divided into several units. Individuals were also assigned special tasks outside their groups, such as communications and tracking the TRINITY cloud with a searchlight (3).

1.4 MILITARY AND CIVILIAN PARTICIPANTS IN PROJECT TRINITY

From March 1944 until the beginning of 1946, several thousand people participated in Project TRINITY. These included not only the LASL scientists, but also scientists, technicians, and workmen employed at MED installations throughout the United States. According to entrance logs, film badge data, and other records, about 1,000 people either worked at or visited the TRINITY site from 16 July 1945 through 1946 (1; 3; 8; 15; 16).

Although supervised by Major General Groves and the Army Corps of Engineers, many Manhattan Project personnel were civilians. Military personnel were assigned principally to support services, such as security and logistics, although soldiers with special skills worked with the civilians (7; 12). Most of the military personnel were part of the Army Corps of Engineers, although Navy and other Army personnel were also assigned to the project (4; 12).

CHAPTER 2

THE ACTIVITIES AT PROJECT TRINITY

The TRINITY nuclear device was detonated on a 100-foot tower (shown in figure 2-1) at UTM coordinates 630266 on the Alamogordo Bombing Range, New Mexico, at 0530 Mountain War Time, on 16 July 1945. The detonation had a yield of 19 kilotons and left an impression 2.9 meters deep and 335 meters wide. The cloud resulting from the detonation rose to an altitude of 35,000 feet (5). The TRINITY detonation is shown in figure 2-2.

At shot-time, the temperature was 21.8 degrees Celsius, and the surface air pressure was 850 millibars. Winds at shot-time were nearly calm at the surface but attained a speed of 10 knots from the southwest at 10,300 feet. At 34,600 feet, the wind speed was 23 knots from the southwest. The winds blew the cloud to the northeast (5).

2.1 PRESHOT ACTIVITIES

Construction of test site facilities on the Alamogordo Bombing Range began in December 1944. The first contingent of personnel, 12 military policemen, arrived just before Christmas. The number of personnel at the test site gradually increased until the peak level of about 325 was reached the week before the detonation (2; 12).

On 7 May 1945 at 0437 hours, 200 LASL scientists and technicians exploded 100 tons of conventional high explosives at the test site. The explosives were stacked on top of a 20-foot tower and contained tubes of radioactive solution to simulate, at a low level of activity, the radioactive products expected

from a nuclear explosion. The test produced a bright sphere which spread out in an oval form. A column of smoke and debris rose as high as 15,000 feet before drifting eastward. The explosion left a shallow crater 1.5 meters deep and 9 meters wide. Monitoring in the area revealed a level of radioactivity low enough to allow workers to spend several hours in the area (3; 12).

The planned firing date for the TRINITY device was 4 July 1945. On 14 June 1945, Dr. Oppenheimer changed the test date to no earlier than 13 July and no later than 23 July. On 30 June, the earliest firing date was moved to 16 July, even though better weather was forecast for 18 and 19 July. Because the Allied conference in Potsdam, Germany, was about to begin and the President needed the results of the test as soon as possible, the TRINITY test organization adjusted its schedules accordingly and set shot-time at 0400 hours on 16 July (3; 12; 14).

The final preparations for the detonation started at 2200 on 15 July. To prevent unnecessary danger, all personnel not essential to the firing activities were ordered to leave the test site. During the night of 15 July, these people left for viewing positions on Compania Hill,* 32 kilometers northwest of ground zero. They were joined by several spectators from LASL (3; 12).

* "Compania" also appears as "Compana," "Campagne," or "Compagna" in various sources.

Project personnel not required to check instruments within the ground zero area stationed themselves in the three shelters or at other assigned locations. The military police at Guard Posts 1, 2, and 4 blocked off all roads leading into the test site, and the men at Guard Post 8, the only access to the ground zero area from the Base Camp, ensured that no unauthorized individuals entered the area (9; 12).

At 0100 hours on 16 July, military policemen from Guard Posts 3, 5, 6, and 7 met to compare their logs of personnel authorized to be in the ground zero area. The guards then traveled along the access roads to clear out all project personnel. As individuals left for their assigned shelters or stations, their departures from the test area were recorded in the military police logs. By 0200 the area sweep was completed, and the military police went to their shelters and stations. A final check of personnel was made in each shelter (3; 9; 12).

At the time of detonation, 99 project personnel were in the three shelters: 29 in the north shelter, 37 in the west shelter, and 33 in the south shelter. Dr. Oppenheimer, Dr. Bainbridge, and other key personnel awaited the firing at the south shelter, which served as the Control Point. Figure 2-3 shows the exterior of the south shelter; figure 2-4 gives an interior view of one of the shelters, most likely the south. Although most of the shelter occupants were civilians, at least 23 military participants were spread among the three shelters (1; 12).

The remainder of the test site personnel were positioned at the Base Camp 16 kilometers south-southwest of ground zero, or on Compania Hill, or at the guard posts. Important Government officials, such as General Groves and Dr. Vannevar Bush, Director of the U.S. Office of Scientific Research and Development, viewed the detonation from a trench at the Base Camp. The Base Camp is depicted in figure 2-5.

The military police of Guard Posts 1 and 2 were instructed to be in foxholes approximately five kilometers west and north, respectively, from their posts. The military police of Guard Posts 3 and 4 were instructed to be in foxholes south of Mockingbird Gap. A radiological safety monitor was assigned to the group from Guard Post 4. Guard Post 5 personnel were to be in the south shelter, Guard Post 6 personnel in the west shelter, and Guard Post 7 personnel in the north shelter. The military police of Guard Post 8 remained at that post, 400 meters east of the Base Camp (9).

An evacuation detachment of between 144 and 160 officers and enlisted men was stationed near Guard Post 2, about 14 kilometers northwest of ground zero. These men were on standby in case ranches and towns beyond the test site had to be evacuated. Five radiological safety monitors were assigned to this detachment. Ninety-four men of the evacuation detachment belonged to Provisional Detachment Number 1, Company "B," of the 9812th Technical Service Unit, Army Corps of Engineers, from LASL. The identity of the remaining evacuation personnel has not been documented (3; 4; 8; 10; 15).

With the exception of the shelter occupants (99 personnel) and evacuation detachment (between 144 and 160 men), the number of personnel at the test site at the time of detonation has not been documented. Film badge records show that approximately 355 people were at the test site at some time during 16 July. The shelter occupants and 44 men of the evacuation detachment are on this list. It has not been possible to pinpoint the location of many of the remaining personnel. Some were at the Base Camp or on Compania Hill. Since many of these people returned to the test site after shot-time to work

on experiments, their film badges registered exposures from residual radioactivity on 16 July. Based on the documented personnel totals, at least the following 263 individuals were at the test site when the device was detonated (1; 4; 8-10; 13; 15):

- o 99 shelter occupants at shelters 9,150 meters north, south, and west of ground zero
- o 144 to 160 officers and enlisted men of the evacuation detachment, located 14 kilometers northwest of ground zero near Guard Post 2
- o Five radiological safety monitors assigned to the evacuation detachment to perform offsite monitoring of nearby towns and residences
- o One radiological safety monitor assigned to Guard Post 4
- o Two military policemen at each of the seven guard posts (indicated by photographs such as figures 1-3 and 1-4).

2.2 DETONATION AND POSTSHOT ACTIVITIES

Because of bad weather, the Project TRINITY director (Dr. Bainbridge) delayed the detonation, which had been scheduled for 0400 hours. By 0445, however, the forecast was better, and shot-time was set for 0530. This gave the scientists 45 minutes to arm the device and prepare the instruments in the shelters. The final countdown began at 0510, and the device was detonated at 0529:45 Mountain War Time from the Control Point in the south shelter (3; 12).

No one was closer than 9,150 meters to ground zero at the time of the detonation. With the exception of a few men holding the ropes of barrage balloons or guiding cameras to follow the fireball as it ascended, all shelter personnel were in or behind the shelters. Some left the shelters after the initial flash to view the fireball. As a precautionary measure, they had been advised to lie on the ground before the blast wave arrived. Project personnel located beyond the shelters, such as at the Base Camp and on Compania Hill, were also instructed to lie on the ground or in a depression until the blast wave had passed (1). However, the blast wave at these locations was not as strong as had been expected.

In order to prevent eye damage, Dr. Bainbridge ordered the distribution of welder's filter glass. Because it was not known exactly how the flash might affect eyesight, it was suggested that direct viewing of the fireball not be attempted even with this protection. The recommended procedure was to face away from ground zero and watch the hills or sky until the fireball illuminated the area. Then, after the initial flash had passed, one could turn around and view the fireball through the filter glass. Despite these well-publicized instructions, two participants did not take precautions. They were temporarily blinded by the intense flash but experienced no permanent vision impairment (1; 17).

People as far away as Santa Fe and El Paso saw the brilliant light of the detonation. Windows rattled in the areas immediately surrounding the test site, waking sleeping ranchers and townspeople. To dispel any rumors that might compromise the security of Project TRINITY, the Government announced that an Army munitions dump had exploded. However, immediately after the destruction of Hiroshima, the Government revealed to the public what had actually occurred in the New Mexico desert (12; 13).

Immediately after the shot, Medical Group personnel began the radiological monitoring activities described in section 3.1.2. At 0815, when most of the monitoring activities were completed, preparations began for entrance into the ground zero area. To regulate entry into the area, a "Going-in Board" was established, consisting of Dr. Bainbridge, the Chief of the Medical Group, and a special scientific consultant. Its purpose was to determine whether a party had a valid reason for entering the ground zero area. The board functioned for three days.

Military police at Guard Post 4 and at three roadblocks set up along Broadway controlled entry into the area. Guard Posts 3, 5, 6, and 7 were within 3,000 meters of ground zero and thus remained unmanned. At the south shelter, the Medical Group set up a "going-in" station where personnel were required to stop to put on protective clothing (coveralls, booties, caps, and cotton gloves) and pick up monitoring equipment before entering the ground zero area. Since it was not known how much radioactive material might be suspended in the air, all personnel entering the ground zero area wore complete protective covering and respirators for the first three days after the detonation. Figure 2-6 shows two Project TRINITY personnel wearing protective clothing (1).

On the day of the shot, five parties entered the ground zero area. One party consisted of eight members of the earth-sampling group. They obtained samples by driving to within 460 meters of ground zero in a tank specially fitted with rockets to which retrievable collectors were fastened in order to gather soil samples from a distance. This group made several sampling excursions on 16 and

17 July. The tank carried two personnel (a driver and a passenger) each trip. No member of this party received a radiation exposure of more than 1 roentgen (1).

Five other men from the earth-sampling group entered the ground zero area in a second tank, lined with lead for radiation protection. The tank, carrying the driver and one passenger, made five trips into the ground zero area to retrieve soil samples on 16 and 17 July. On two trips, the tank passed over ground zero; on the others, it approached to within about 90 meters of ground zero. The men scooped up soil samples through a trap door in the bottom of the tank. One driver who made three trips into the ground zero area received the highest exposure, 15 roentgens (1).

This lead-lined tank was also used by ten men to observe the radiation area. These men, traveling two at a time, made five trips into the area on shot-day but never approached closer than 1,370 meters to ground zero. The highest exposure among these ten men was 0.3 roentgens (1).

The next party to approach ground zero consisted of a photographer and a radiological safety monitor. Wearing protective clothing and respirators, the two men were about 730 meters northwest of ground zero photographing "JUMBO" from 1100 to 1200 hours. "JUMBO," shown in figure 2-7, was a massive container built to contain the high-explosive detonation of the TRINITY device and to allow recovery of the fissionable material if the device failed to produce a nuclear detonation. The plan to use "JUMBO," however, was abandoned when the scientists concluded that a fairly large nuclear explosion was certain. The container remained on the ground near the shot-tower during the detonation. Both the photographer and the monitor received an estimated radiation exposure between 0.5 and 1 roentgen (1; 7).

The last party to "go in" on shot-day consisted of six men retrieving neutron detectors. They entered the test area at 1430 hours. Three of the men went to a point 730 meters south of ground zero to pull out cables carrying neutron detectors located 550 meters south of ground zero. The group wore protective clothing and respirators and spent about 30 minutes in the area. The remaining three men drove as close as 320 meters southwest of ground zero to retrieve neutron detectors. They got out of their vehicle only once, at about 460 meters from ground zero, and spent a total of about ten minutes making this trip through the area. Each man's radiation exposure measured less than 1 roentgen (1).

Most of the soldiers of the evacuation detachment remained in their bivouac area near Guard Post 2. According to a report written by the detachment commander, a reinforced platoon was sent to the town of Bingham, about 29 kilometers northeast of the test site, while offsite radiological safety monitors surveyed the area. The evacuation detachment was dismissed at 1300 hours on shot-day when it became evident from offsite monitoring that evacuations would not be undertaken. The detachment returned to LASL at 0400 on 17 July (15).

Two B-29 aircraft from Kirtland Field, Albuquerque, New Mexico, participated in post-shot events. Their planned mission was to pass over the test area shortly before the explosion to simulate a bomb drop. After the TRINITY device had been detonated, the aircraft would circle near ground zero, while the men onboard would measure the atmospheric effects of the nuclear explosion. This would enable them to determine whether a delivery aircraft would be endangered. However, because of bad weather on shot-day, Dr. Oppenheimer canceled the aircraft's flight in the ground zero area. Instead, the two B-29s, each with 12 men onboard, flew along the perimeter of the bombing range and observed the shot from a distance of 19 to 29 kilometers. Among those observers was a Navy captain who was also the MED Chief of Ordnance (6; 12; 13).

2.3 ACTIVITIES AFTER 16 JULY 1945

On 17, 18, and 19 July, all personnel and visitors had to receive permission to approach ground zero from the "Going-in Board." On these three days, 21 groups were authorized to go beyond the Broadway roadblocks. Most of those who sought this authorization were scientists and military support personnel whose job required that they work near ground zero. Except for a group of two military men and three civilians who went to ground zero on 16 and 17 July and a group of two civilians who approached as close as 90 meters on 18 July, the reentry personnel came no closer than 180 meters to ground zero. Of these personnel, the individual who received the highest exposure during the three days was an Army sergeant who received 15 roentgens. During the same period, two civilians received 10 roentgens and 7.5 roentgens, respectively. All other personnel received exposures of 5 roentgens or less (1; 3).

After the "Going-In Board" was disbanded on 19 July, permission to enter the ground zero area had to be obtained from Dr. Bainbridge or one of his deputies. Many scientists entered the ground zero area after 19 July to retrieve instruments or to perform experiments. The population of the TRINITY test site was diminishing, however, as the emphasis shifted to preparing the devices that were to be dropped on Japan (1).

On 23 July, a week after the shot, chain barricades with prominent signs warning against trespassing were placed 910 meters north, south, and west of ground zero. These barricades were supplemented with two concentric circles of red flags 1,830 and 2,740 meters from ground zero. Except during bad weather, the entire ground zero area was visible from the roadblocks. No unauthorized person was ever detected entering the ground zero area (1).

On 10 August, the Broadway roadblocks were removed, and mounted military policemen began patrolling around ground zero at a distance of 730 meters. Each guard was assigned to a daily six-hour shift for a period of two weeks; in the third week, the guard was assigned tasks away from the ground zero area. The mounted guards and their horses wore film badges. No exposure greater than 0.1 roentgen was registered. On 1 September, the mounted patrol moved to a distance of 460 meters from ground zero, just outside a fence installed a week earlier to seal off the area. The same rotating patrol schedule was used. The guards' film badge readings showed an average daily exposure of 0.02 roentgens. The mounted patrol at the fence continued until early 1947 (1).

Between 20 July 1945 and 21 November 1945, 67 groups entered the ground zero area. Most of these parties entered in the month after shot-day. These were the scientists and technicians conducting experiments or retrieving data. By the beginning of September, most of those who entered the ground zero area were invited guests (1).

Also during the period 20 July through 21 November, at least 71 soldiers were at the TRINITY test site. Twenty-five of these men were support personnel who never went within 460 meters of ground zero. The remaining 46 men were technical personnel, laborers who erected the 460-meter fence, or military policemen who served as guides. Eleven of these men, probably members of the fence detail, spent several days at about 460 meters from ground zero. Working three to five hours per day between 9 August and 25 August, they would have been the only group to stay longer than one hour in the ground zero area. Of the remaining personnel who approached within 460 meters from ground zero, 25 spent 15 minutes and ten spent between 30 minutes and one hour in the ground zero area. Only 11 people received exposures of 3 to 5 roentgens between 20 July and 21 November. Most received less than 1 roentgen. After 21 November 1945, no one approached closer than the fence which was 460 meters from ground zero, although about 200 civilian and military personnel worked at or visited the TRINITY site through 1946 (1; 16).

According to dosimetry data, entrance logs, and other records, about 1,000 individuals were at the test site at some time between 16 July 1945 and the end of 1946. This number includes not only the scientists, technicians, and military personnel who were part of Project TRINITY but also many visitors. Some of the scientists took their wives and children on a tour of the area near ground zero, particularly to view the green glass called "trinitite," which covered the crater floor. Trinitite was the product of the detonation's extreme heat, which melted and mixed desert sand, tower steel, and other debris (1; 8; 9; 16).

CHAPTER 3

RADIATION PROTECTION AT PROJECT TRINITY

The TR-7 or Medical Group, shown in the figure 1-5 organizational chart, was responsible for radiological safety at Project TRINITY. Many of the physicians and scientists in the Medical Group had worked with radioactive materials before and were trained in radiological safety procedures. The Chief of the Medical Group supervised the radiological safety operations and reported to the TRINITY director. In addition to providing medical care to TRINITY personnel, this group established radiological safety programs to:

- o Minimize radiation exposure of personnel on the test site and in offsite areas
- o Provide monitors to conduct radiological surveys onsite and offsite
- o Provide and maintain radiation detection instruments
- o Provide protective clothing and equipment.

An exposure limit of 5 roentgens during a two-month period was established. Personnel were provided with radiation detection instruments to determine their exposures (1).

3.1 ORGANIZATION

The Medical Group consisted of physicians, scientists, and administrators, as well as radiological monitors. Many of these personnel were nonmilitary, but all worked on the Manhattan Project under the administration of the Army Corps of Engineers Manhattan Engineer District.

The Medical Group was divided into two monitoring groups, the Site Monitoring Group, which was responsible for onsite monitoring, and the Offsite Monitoring Group. Each reported to the Chief of the Medical Group, and each communicated with the other during the monitoring activities. In addition to these two groups, a small group of medical technicians provided radiation detection instruments to Medical Group personnel (1; 10).

3.2 SITE MONITORING GROUP

The Site Monitoring Group consisted of a chief monitor, three other monitors, and several medical doctors. This group had the following functions (1; 10):

- o Conduct ground surveys of the test area and mark areas of radioactivity
- o Conduct surveys of the Base Camp and roads leading into the test area
- o Provide protective clothing and equipment, including film badges and pocket dosimeters, to personnel
- o Monitor all personnel for radioactive contamination and provide for their decontamination
- o Maintain a record of radiation exposures received by personnel.

The Site Monitoring Group monitored the radiation exposures of personnel in the test area. The time spent by personnel in radiation areas was limited, and radiation detection instruments were provided to permit continuous monitoring of exposure rates. In many cases, a monitor from the Site Monitoring Group accompanied project personnel into the test area to monitor exposure rates (1; 10).

Two members of the Site Monitoring Group, a monitor and a physician with radiological safety training, were assigned to each shelter. The supervising monitor was stationed at the Base Camp and was in radio and telephone communication with all three shelters and the offsite ground and aerial survey teams. Before any personnel were allowed to leave the shelter areas, a radiological safety monitor and a military policeman from each shelter advanced along the roads to Broadway to check radiation levels. They wore respirators to prevent them from inhaling radioactive material (1; 10).

Since it was expected that any dust from the cloud would fall on one of the shelter areas within 30 minutes of the shot, plans had been made to evacuate personnel as soon as the monitors completed their initial survey. Because the cloud moved to the northeast, the south shelter (the Control Point) was not completely evacuated, although nonessential personnel were sent to the Base Camp. The west shelter was emptied of all personnel except a searchlight crew spotlighting the cloud as it moved away (1; 10).

Only at the north shelter did an emergency evacuation occur. About 12 minutes after the shot, a detection instrument indicated a rapid rise in the radiation levels within the shelter. At the same time, a remote ionization monitoring device detected a rapid increase in radiation. Because of these two readings, all north shelter personnel were immediately evacuated to the Base Camp, 25 kilometers to the south. Film badges worn by personnel stationed at the north shelter, however, showed no radiation exposure above the detectable level. It was later discovered that the meter of the detector in the north shelter had not retained its zero calibration setting, and radiation at the north shelter had not reached levels high enough to result in measurable exposures of the personnel who had been positioned there. However, fallout activity was later detected in the north shelter area, proof that part of the cloud did head in that direction. This also explains why the monitoring device detected rising radiation levels (1; 12).

After ascertaining that radiation levels along the roads leading from the shelters to Broadway were within acceptable limits, the radiological safety monitors and military police established roadblocks at important intersections leading to ground zero. The north shelter monitor and military police set up a post where the North Shelter Road ran into Broadway. The west shelter monitor and a military policeman blocked Vatican Road where it intersected Broadway. The south shelter monitor and military police set up a roadblock where Broadway intersected Pennsylvania Avenue (1).

The monitor assigned to Guard Post 4 surveyed the Mockingbird Gap area to ensure that it was safe for the guards to return to their post. This position controlled access to the McDonald Ranch Road, which led directly to ground zero (1).

At 0540 hours, the chief monitor departed from the Base Camp with a military policeman to monitor the entire length of Broadway. They first checked the roadblock at Pennsylvania Avenue and Broadway. Next they drove to the roadblock at Vatican Road and Broadway. Upon the chief monitor's arrival, the west shelter monitor traveled about nine kilometers west on Vatican Road to monitor Guard Post 1 so that the military police could reoccupy the post. The monitoring excursion to Guard Post 1 continued until the chief monitor had returned from Guard Post 2, located 17 kilometers northwest of the Vatican Road roadblock on Broadway (1; 18).

The chief monitor arrived at Guard Post 2 at about 0550 hours and found the post empty. He then continued five kilometers north along Broadway to the foxholes from which the military police had watched the detonation. There he found the guards, the five radiological safety monitors assigned to the evacuation detachment, and the Commanding Officer of the evacuation detachment (1; 18).

The military policemen refused to return to Guard Post 2, insisting that they had received orders over their two-way radio from the Base Commander to evacuate their post and head for San Antonio, New Mexico, a town 28 kilometers northwest of the Guard Post. The Base Commander had noted that portions of the cloud were heading northwestward and, fearing that fallout from the cloud would contaminate Guard Post 2, had ordered the military police to evacuate. The chief monitor, however, had found no significant radiation levels anywhere along the northern part of Broadway nor around Guard Post 2. The Base Commander, after being contacted by the chief monitor, drove to the foxholes and ordered the guards to return to their post. This was the only unplanned incident during the onsite monitoring (1).

After Guard Post 2 was reoccupied, the chief monitor returned to the roadblock at the intersection of Broadway and the North Shelter Road. The north shelter monitor informed the chief monitor of the sudden evacuation of the north shelter, whereupon the chief monitor surveyed the north shelter area and found intensities of only 0.01 and 0.02 roentgens per hour (R/h). The chief monitor then contacted the south shelter and informed Dr. Bainbridge that the north shelter region was safe for those who needed to return, that Broadway was safe from the Base Camp to Guard Post 2, and that Guard Post 2 was now manned so that personnel leaving for LASL could be checked out (1).

The chief monitor then returned to the south shelter and assembled the monitors from the three roadblocks and Guard Post 4 to prepare for entrance into the ground zero area. The time was about 0815 hours. The military police at the roadblocks were given radiation meters to survey the adjoining area. Broadway from the south shelter to Guard Post 2 was remonitored occasionally to reassure the military police that there was no radiation problem. Monitors also surveyed the Base Camp for 24 hours after the detonation. No radiation above background levels was detected there (1).

The following brief description of the radiological environment in the TRINITY test area is based primarily on the results of the remote gamma recorders situated in the test area and on results of the road surveys conducted after the detonation (1).

Within about 1,400 meters of ground zero (except to the north), radiation intensities between 0.2 and 1.3 R/h were detected during the first few minutes after the detonation. These readings decreased to less than 0.1 R/h within a few hours. At greater distances to the east, south, and west, radiation levels above background were not detected (1).

The cloud drifted to the northeast, and higher gamma readings due to fallout were encountered in this direction. About five minutes after the detonation, a reading of 3 R/h was recorded 1,400 meters north of ground zero. Several minutes later, the intensity there had increased to greater than 7 R/h, and it continued to increase for several more minutes. Gamma detectors 9,150 meters north of ground zero, however, recorded no radiation above background levels. This indicated that the cloud had passed over or near the 1,400-meter area and only partially over the 9,150-meter area where the north shelter was located. Subsequent ground surveys of this area found no gamma intensities higher than 0.02 R/h (1).

Gamma radiation levels at and around ground zero were much higher than in other onsite areas because of induced activity in the soil. Twenty-four hours after the detonation, the gamma intensity at ground zero was estimated to be 600 to 700 R/h. This estimate was based on data provided by the tank crew that drove to ground zero to obtain soil samples. The intensity decreased to about 2 R/h at 725 meters from ground zero. Gamma intensities of 0.1 R/h or more were confined within a circular area extending about 1,100 meters from ground zero (except in areas of fallout). One week after the shot, the gamma intensity at ground zero was about 45 R/h. After 30 days, intensities at ground zero had decreased to 15 R/h, and intensities of 0.1 R/h or more were not encountered beyond about 365 meters from ground zero. Gamma intensities of 3 to 10 R/h were found at ground zero three months after the detonation (1; 19).

3.3 OFFSITE MONITORING GROUP

Four two-man teams and one five-man team supervised by the chief offsite monitor constituted the Offsite Monitoring Group. Before the detonation, the four two-man teams established monitoring posts in towns outside the test area. These towns were Nogal, Roswell, Fort Sumner, and Socorro, all in New Mexico. The five-man team remained at Guard Post 2 to assist in evacuation of nearby residences if the TRINITY cloud drifted in that direction. These residences, the Fite house and the homes in the town of Tokay, were 24 and 32 kilometers northwest of ground zero, respectively. Since the cloud drifted to the northeast, evacuation was not required. All offsite monitoring teams were in radio or telephone contact with personnel at the Base Camp (11).

Offsite monitoring teams in areas northeast of ground zero encountered gamma readings ranging from 1.5 to 15 R/h two to four hours after the detonation. Three hours after the detonation, surveys taken in Bingham, New Mexico (located 30 kilometers northeast of ground zero) found gamma intensities of about 1.5 R/h. Radiation readings at the town of White, nine kilometers southeast of Bingham, were 6.5 R/h three hours after the detonation and 2.5 R/h two hours later. Another team monitoring in a canyon 11 kilometers east of Bingham found a gamma intensity of about 15 R/h. Five hours later, the intensity had decreased to 3.8 R/h. It was estimated that peak intensities of gamma radiation from fallout on shot-day were about 7 R/h at an occupied ranch house in this canyon area (1; 11; 19).

Monitoring teams resurveyed these towns about one month after the TRINITY detonation. At Bingham, gamma readings of 0.003 R/h and 0.0001 R/h were found at ground level outdoors and at waist level inside a building, respectively. At the town of White, the highest outdoor gamma reading was 0.008 R/h. Inside a building, the highest reading was 0.0005 R/h (11).

Surveys taken in the canyon area one month after the detonation indicated that gamma intensities at ground level had decreased to 0.032 R/h. The occupied ranch house was also surveyed, both inside and outside. The highest reading outdoors was 0.028 R/h, and the highest reading indoors was 0.004 R/h (11; 19).

Monitoring was also conducted in offsite areas other than those to the north and northeast of ground zero. Monitors found no radiation readings above background levels (11).

Significant fallout from the TRINITY cloud did not reach the ground within about 20 kilometers northeast of ground zero. From this point, the fallout pattern extended out 160 kilometers and was 48 kilometers wide. Gamma intensities up to 15 R/h were measured in this region several hours after the detonation. One month later, intensities had declined to 0.032 R/h or less (11).

CHAPTER 4

DOSIMETRY ANALYSIS OF PARTICIPANTS IN PROJECT TRINITY

This chapter summarizes the radiation doses received by participants in various activities during Project TRINITY. The sources of this dosimetry information are the safety and monitoring report for personnel at TRINITY, which includes a compilation of film badge readings for all participants up to 1 January 1946, and film badge data from the records of the Reynolds Electrical and Engineering Company, which contain readings through 1946 (1; 16). These sources list individual participants with their cumulative gamma radiation exposures.

4.1 FILM BADGE RECORDS

During TRINITY, the film badge was the primary device used to measure the radiation dose received by individual participants. The site monitoring plan indicates that film badges were to be issued to participants. The film badge was normally worn at chest level on the outside of clothing and was designed to measure the wearer's exposure to gamma radiation from external sources. These film badges were insensitive to neutron radiation and did not measure the amount of radioactive material that might have been inhaled or ingested (1).

Personnel from the Medical Group had responsibility for issuing, receiving, processing, and interpreting film badges for Project TRINITY. The Site Monitoring Group compiled the film badge records for both onsite and offsite personnel. Radiological safety personnel and military police recorded the names and identification numbers of individuals as they entered the test area. This information was recorded in an entry logbook and on a personal exposure data card. Upon leaving the test area,

individuals returned their film badges to the check station. When the film badges were processed and interpreted, the reading was entered on the individuals exposure data card. In this manner, the number of times an individual entered the test area and his cumulative exposure history were recorded and maintained (1).

4.2 GAMMA RADIATION EXPOSURE

The safety and monitoring report lists film badge readings for about 700 individuals who participated in Project TRINITY from 16 July 1945 to 1 January 1946 (1). This list includes both military and nonmilitary personnel who were involved with the TRINITY operation and postshot activities. However, records are available for only 44 of the 144 to 160 members of the evacuation detachment (1). In addition, some of these film badge listings may be for personnel who were only peripherally involved with TRINITY activities, such as family members and official guests who visited the site.

According to the safety and monitoring report, by 1 January 1946, 23 individuals had received cumulative gamma exposures greater than 2 but less than 4 roentgens. An additional 22 individuals received gamma exposures between 4 and 15 roentgens. Personnel who received gamma exposures exceeding 2 roentgens represent less than six percent of the Project TRINITY participants with recorded exposures. As described below, these exposures generally resulted when personnel approached ground zero several times (1).

Information is available regarding the activities of some of these personnel. One of the drivers of the earth-sampling group's lead-lined tank, an Army sergeant who traveled three times to ground zero, received an exposure of 15 roentgens. A second tank driver, also an Army sergeant, received an exposure of 3.3 roentgens. Three members of the earth-sampling group, all of whom traveled in the tank to ground zero, received exposures of 10, 7.5, and 5 roentgens. An Army photographer who entered the test area six times between 23 July and 20 October received 12.2 roentgens (1).

Four individuals involved with excavating the buried supports of the TRINITY tower from 8 October to 10 October 1945 received gamma exposures ranging from 3.4 to 4.7 roentgens. Film badge readings for this three-day period indicate that the two individuals who operated mechanical shovels received 3.4 and 4.3 roentgens, while the two who supervised and monitored the excavation received exposures of 4.2 and 4.7 roentgens. The individual receiving 4.7 roentgens during the excavation operation had received 1.3 roentgens from a previous exposure, making his total exposure 6 roentgens (1).

An Army captain who accompanied all test and observer parties into the ground zero area between 1 September and 11 October 1945 received a total gamma exposure of 2.6 roentgens (1). The activities and times of exposure are not known for other personnel with exposures over 2 roentgens.

According to the dosimetry records for 1946, about 115 people visited the test site that year. No one ventured inside the fence surrounding ground zero, and no one received an exposure greater than 1 roentgen (1; 16).

REFERENCE LIST

The following list of references represents the documents consulted in preparation of the Project TRINITY volume.

AVAILABILITY INFORMATION

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