

Operation UPSHOT-KNOTHOLE

Note: For information related to claims, call the Department of Veterans Affairs (VA) at 800-827-1000 or the Department of Justice (DOJ) at 800-729-7327. For all other information, call the Nuclear Test Personnel Review (NTPR) Program at 800-462-3683.

Operation UPSHOT-KNOTHOLE, the ninth series of atmospheric nuclear tests, was conducted by the Atomic Energy Commission (AEC) at the Nevada Proving Ground (NPG) from March 17, 1953, to June 4, 1953. The series consisted of 11 nuclear tests. One detonation was an atomic artillery projectile fired from a 280-mm cannon, three were airdrops, and seven were detonated on towers ranging from 100 to 300 feet in height. The operation involved an estimated 20,100 Department of Defense (DoD) personnel participating in observer programs, tactical maneuvers, scientific studies, and support activities. UPSHOT-KNOTHOLE was intended to test nuclear devices for possible inclusion in the U.S. arsenal, to improve military tactics, equipment, and training, and to study civil defense needs.

Historical Background

During UPSHOT-KNOTHOLE, the largest DoD participation was in Exercise Desert Rock V, a program involving members of all four armed services. Exercise Desert Rock V included troop orientation and training, a volunteer officer observer program, tactical troop maneuvers, operational helicopter tests, and damage effects evaluation. Orientation and training generally included lectures and briefings on the effects of nuclear weapons, observation of a nuclear detonation, and a subsequent visit to a display of military equipment damaged by the detonation. In the volunteer officer observer program, trained staff officers calculated the effects of a nuclear detonation to determine a minimum safe distance for observing the blast; they later watched the detonation from the calculated position. Tactical maneuvers were designed to train troops and to test military tactics for the nuclear battlefield. The operational helicopter tests performed by the Marine Corps were designed to investigate the capability of helicopters and their crews to withstand a nuclear burst and its effects. The damage effects evaluation enabled the services to determine the amount of damage sustained by military vehicles and equipment at various distances from nuclear detonations.

In addition to Desert Rock activities, scientific experiments were conducted by three test groups of the Joint Test Organization (JTO). The Military Effects Group consisted of personnel from Field Command, Armed Forces Special Weapons Project (AFSWP). The Weapons Development Group comprised personnel from the Los Alamos Scientific Laboratory (LASL) and the University of California Radiation Laboratory (UCRL), the two AEC weapons development laboratories. The Civil Effects Group was established by the Federal Civil Defense Administration to assess the effects of nuclear detonations on civilian structures and food products. Although the Military Effects Group was the only DoD-sponsored test group, DoD personnel also assisted in the experiments conducted by the other two test groups. Participants in scientific experiments placed data-collection instruments around the point of detonation before the scheduled nuclear test. They returned to the test area to recover equipment and gather data after the detonation, when the Test Director had determined that the area was safe for limited access.

During UPSHOT-KNOTHOLE, approximately 2,000 troops, primarily from the Sixth Army, were present at Camp Desert Rock to provide support services for both Exercise Desert Rock V and the JTO. These services included radiological safety, communications, medical care, transportation, security, and construction. The Radiological Safety Section was composed mainly of personnel from the 50th Chemical Service Platoon. Other support elements included men from the 505th Signal Service Group (Composite Company); Detachment 371st Evacuation Hospital; 26th Transportation Truck Battalion; Company C, 505th Military Police Battalion; and the 412th Engineer Construction Battalion.

The Air Force Special Weapons Center (AFSWC) from Kirtland Air Force Base, N.M., provided aircraft and pilots for delivery of the airdropped devices, pre-shot security sweeps, cloud sampling, cloud tracking, and aerial radiation surveys. Over 400 air and ground crew personnel at Indian Springs Air Force Base, Nev., and about 2,000 at Kirtland Air Force Base participated in AFSWC operations during UPSHOT-KNOTHOLE. The principal AFSWC unit was the 4925th Test Group (Atomic). Other participating units included the 4935th Air Base Squadron, the 4901st Support Wing, and the 55th Weather Reconnaissance Squadron.

Summaries of UPSHOT-KNOTHOLE Nuclear Events

The 11 UPSHOT-KNOTHOLE events are summarized in the accompanying table, and their locations are shown on the accompanying map. Shots ANNIE, NANCY, BADGER, SIMON, ENCORE, and GRABLE involved larger numbers of DoD participants than the other five shots and are described below in some detail.

Shot ANNIE, a 300-foot tower detonation, was fired with a yield of 16 kilotons at 5:20 a.m. Pacific Standard Time (PST) on March 17, 1953, in Area 3 of Yucca Flat. The AEC designated ANNIE an "open shot," which meant that reporters were allowed to view the detonation from News Nob, 12 kilometers south of the shot-tower. In addition, 20 reporters were selected to accompany the troops to the trenches, located 3,200 meters southwest of the tower.

Exercise Desert Rock V activities at Shot ANNIE included troop maneuvers, troop orientation and indoctrination, operational helicopter tests, and damage effects evaluation. Of the 1,700 personnel involved in these projects, 1,181 troops, divided into two Battalion Combat Teams (BCTs), participated in the tactical maneuver. Unlike the maneuver troops at other UPSHOT-KNOTHOLE events who were assigned to units all over the United States, the troops at Shot ANNIE had been specifically assigned to provide support at Camp Desert Rock. After the pre-shot orientation and rehearsal, which were conducted before each shot with Desert Rock participation, maneuver troops observed the shot with other observers in the trenches. After the shot, the two BCTs, each preceded by a radiological safety monitor, attacked an objective located about one kilometer west of ground zero. Once they reached their objective, the troops went to the display area and inspected the displays up to the 2.5 roentgen per hour (R/h) radiation intensity line. This line was 460 to 640 meters from ground zero.

Besides the tactical maneuver troops, an estimated 505 personnel from various services participated in the orientation and indoctrination program, which consisted of instruction in nuclear weapons, observation of the detonation, and a post-shot tour of the display areas. In addition, approximately 10 Marines and three helicopters from the Helicopter Atomic Test Unit, 2nd Marine Corps Provisional Atomic Exercise Brigade, participated in a test of the effects of overpressure. The helicopters were parked on the side of a hill 17 kilometers from ground zero at the time of the ANNIE detonation.

About 45 minutes after the shot, the helicopters airlifted some troops from the trench area to a location two kilometers south of ground zero. The helicopters flew to the decontamination station after the exercise, which was standard procedure in the UPSHOT-KNOTHOLE helicopter tests.

For the damage effects evaluation, the 412th Engineer Construction Battalion placed barbed wire obstacles and excavated trenches, bunkers, and foxholes in the display area, which extended 3,200 meters south of ground zero. The chemical team placed film badges in the open and in the fortifications, and the 3623rd Ordnance Company placed military equipment in the display area. After the shot, the engineer team and the ordnance team returned to the display area to assess the damage to the fortifications, and the chemical team retrieved the film badges.

DoD personnel at Shot ANNIE also participated in scientific experiments and air support activities. About 300 DoD personnel were involved in projects performed by the test groups, and another 80 AFSWC personnel provided air support.

Shot NANCY, a 300-foot tower detonation, was fired with a yield of 24 kilotons at 5:10 a.m. PST on March 24, 1953, in Area 4 of Yucca Flat. A shift in wind direction at shot-time caused fallout in an area between the Desert Rock maneuver troops and their objective, and the Shot NANCY cloud approached the troop trenches before it was carried to the west and north. The peak intensity noted at the trenches was 0.018 R/h.

At NANCY, Exercise Desert Rock V activities included troop maneuvers, the volunteer officer observer program, troop orientation and indoctrination, operational helicopter tests, and damage effects evaluation. Of the approximately 2,860 personnel involved, about 2,350 participated in the tactical troop maneuver.

The maneuver troops, divided into two BCTs, first underwent an orientation program and then observed the shot from trenches 3,660 meters south-southwest of ground zero. After the detonation, the BCTs, accompanied by radiological safety monitors, began an attack on objectives about 1,000 and 2,000 meters northwest of ground zero. As the two BCTs headed toward their objectives, the radiological safety monitors nearest ground zero reported levels of radiation approaching 2.0 R/h. As a result, one BCT was ordered to shift its advance to the west. That BCT then moved on a northwest course, away from ground zero, to avoid the radiation area. Neither BCT was able to approach closer than 460 to 640 meters to its objective. At that distance, one of the BCTs encountered a radiation intensity of 14 R/h. The troops returned to the display area, where they viewed the effects of the detonation on military equipment, field fortifications, and sheep.

The estimated 490 observers formed the next largest group of Desert Rock participants at NANCY. Observers witnessed NANCY from trenches located 3,660 meters from ground zero. After the shot, they toured the display area up to about 910 meters from ground zero. The 2.5 R/h radiation intensity line, which was the forward limit of the observers' advance, was located about 780 meters south of ground zero.

The nine volunteer officer observers at Shot NANCY positioned themselves in trenches located 2,300 meters south-southwest of ground zero. These officers were the first participants in this program. After the shot, the officers evacuated their trenches when a wind shift blew part of the cloud stem toward their position and they observed a radiation intensity reading of 0.09 R/h on their radiac instruments.

Also at Shot NANCY, an estimated nine Marines and four helicopters were involved in an operational helicopter test. Three helicopters hovered about 18 kilometers southeast of ground zero to experience the shock wave. A fourth helicopter was parked 15 kilometers southeast of ground zero. Two of these helicopters then flew toward ground zero and one attempted to land and check the radiation intensities in the area around ground zero. However, thick dust and residual radiation intensities prevented it from landing.

Finally, as part of Exercise Desert Rock V, damage effects evaluation teams compared the pre-shot and post-shot conditions of fortifications and materiel placed in the display area before the shot by the 412th Engineer Construction Battalion and the 3623rd Ordnance Company. The medical team examined the condition of sheep that had been placed 90 to 2,740 meters from ground zero, and the chemical team retrieved film badges placed in fortifications and on stakes in the display area.

In addition to the Desert Rock projects, the scientific experiments conducted by the test groups had an estimated 400 DoD participants. An additional 80 AFSWC personnel provided air support during Shot NANCY.

Shot BADGER, a 300-foot tower detonation, was fired with a yield of 23 kilotons at 4:35 a.m. PST on April 18, 1953, in Area 2 of Yucca Flat. About 2,800 DoD personnel participated in five Desert Rock programs: troop maneuvers, volunteer officer observers, troop orientation and indoctrination, operational helicopter tests, and damage effects evaluation.

The largest DoD activity at Shot BADGER was the troop maneuver, a Marine exercise that included a test of the ability of helicopters to transport troops in an attack after the employment of a nuclear weapon. The 2nd Marine Corps Provisional Atomic Exercise Brigade (MCPAEB) conducted the exercise. The brigade, which included 2,167 Marines, consisted of four major units:

- Brigade Headquarters
- 1st Battalion, 8th Marine Regiment, 2nd Marine Division
- 2nd Battalion, 3rd Marine Regiment, 3rd Marine Division
- Marine Helicopter Transport Group 16 (MAG (HR) 16)

The evening before the shot, MAG (HR) 16 flew 39 helicopters to the staging area at Yucca Airstrip, 20 kilometers from ground zero, and remained there overnight. Before dawn on April 18, the other participants had assembled to observe the shot from the trench area, located 3,660 meters south-southwest of ground zero. After the shock wave passed, the participants began the maneuver, which involved an attack on objectives 1,830 meters south-southwest of ground zero. Radiological monitoring teams preceded and accompanied the Marines. A wind shift blew the stem of the cloud over the display area and over some of the observer trenches, resulting in contamination. During the ground attack, the 1st Battalion advanced less than 460 meters before these Marines were ordered to halt, presumably because dosimeter readings exceeded 3.0 roentgens, half the allowable dose of 6.0 roentgens. The battalion withdrew to the trench area and was not permitted to continue the maneuver or to tour the display area. By the time the battalion had left the trench area, some Marines exceeded the allowable dose of 6.0 roentgens, with film badge readings as high as 7.1 roentgens. The 2nd Battalion reached its objective and toured the display area.

The helicopter airlift began 11 minutes after the shot. Two pathfinder helicopters preceded the other helicopters to measure radiation intensities near the objectives. The remaining 37 helicopters flew

one Marine company to the area of the objectives. After arriving at the objectives, the Marines toured the display area.

Also at Shot BADGER, six Army and six Marine Corps officers took part in the volunteer officer observer program. These observers witnessed the shot from a trench 1,830 meters from ground zero. Because radiation intensities in the trench after the shot were between 30 and 50 R/h, the officers evacuated this area. They walked to a road about 180 meters west of the trenches, where they met vehicles which took them to the main trench area, 3,660 meters from ground zero. About 590 other observers, drawn from all the armed services, witnessed the shot from the main trench area, walked to the display area, and there inspected the equipment and animals up to the display located 910 meters from ground zero.

In the operational helicopter test at BADGER, four helicopters were airborne at shot-time. Two helicopters were about 14 kilometers southeast of the shot, flying toward ground zero. Two others were hovering at a point 13 kilometers southeast of ground zero. After the shot, the helicopters followed different flight paths toward ground zero and landed at different points determined by radiological conditions in the area. Two of the helicopters encountered radiation intensities greater than 50 R/h before they could take evasive action.

For the Desert Rock damage effects evaluation, the Sixth Army and the Marine Corps established displays at various distances from ground zero. The Marine Corps display consisted of extensive arrays of field equipment and uniformed mannequins, while the Army display included animals and emplacements such as bunkers, trenches, and foxholes. Army personnel placed test animals and dosimetry instruments in these emplacements to evaluate shielding effectiveness. After the shot, Army and Marine Corps personnel returned to the display area to assess the effects of the detonation.

In addition to the Desert Rock participants at Shot BADGER, another 360 DoD personnel participated in scientific projects conducted by the three JTO test groups. An additional 125 AFSWC personnel provided air support.

in Area 1 of Yucca Flat. The SIMON device produced a nuclear yield of 43 kilotons, significantly larger than expected. Because the wind shifted at the time of detonation, radiation levels in the Desert Rock trench area were higher than anticipated. The Test Director established offsite roadblocks as a result. These were placed on U.S. Highway 91 between Las Vegas and Alamo, Nevada, and on U.S. Highway 93 between Las Vegas and St. George, Utah.

At SIMON, Exercise Desert Rock V activities involved more than 3,000 personnel in tactical troop maneuvers, troop observer and volunteer officer observer programs, operational helicopter tests, and damage effects evaluation.

The tactical troop maneuver, the largest Desert Rock program at SIMON, engaged 2,450 Army personnel. The exercise, designed to provide realistic combat training under the conditions of a nuclear battlefield, was preceded by an orientation and rehearsal. The exercise itself consisted of observing the shot, conducting a ground attack, and inspecting the display areas. For the attack, troops were divided into two BCTs, which were to capture an objective about 750 meters west of ground zero. Two radiological monitoring teams preceded the troops to the objective and display areas, and additional monitors accompanied each BCT during the attack. The BCT to the east, which was closer to ground zero, was halted 1,830 meters from ground zero when the monitors detected radiation intensities of 2.5 R/h. The other BCT, approaching on the west, continued to advance and

presumably reached the objective. After the ground attack, troops viewed the display area south of ground zero. Because SIMON produced more widespread contamination than most of the previous UPSHOT-KNOTHOLE shots, several displays were inaccessible; forward movement was halted at the 1,830-meter display line, where the radiation intensity was near the limit of 2.5 R/h.

The troop observer program involved an estimated 550 observers drawn from all of the armed services. After an extensive pre-shot orientation, the observers viewed the shot from trenches 3,660 meters south of ground zero. They then toured the display area, approaching as close as 1,830 meters from ground zero before walking back to the trenches.

Seven Army officers and one Navy officer participated in the volunteer observer program at Shot SIMON. These volunteers chose to occupy trenches 1,830 meters from ground zero. Seconds after the burst, one officer measured a radiation intensity of 100 R/h, which dropped to about 20 to 25 R/h within one minute. As the volunteers left the trenches and walked away from ground zero, radiation levels steadily declined, except when the officers stopped to tour the display area. The group walked about 400 meters before they were met by trucks and driven to the main trench area.

Elements of the 2nd MCPAEB conducted the operational helicopter test at Shot SIMON. At shot-time, three Marine helicopters were near Yucca Lake Airstrip, southeast of the detonation. Two of these helicopters were hovering 11 kilometers from ground zero, while the other, about 17 kilometers from ground zero, was proceeding toward the shot. After the shock wave passed, all helicopters flew to the shot area. One skirted the SIMON dust column, encountering radiation intensities of 50 R/h before completing evasive action. Another landed about 1,830 meters west of ground zero, where a radiation monitor walked to a location about 870 meters from ground zero and noted intensities of 10 R/h about 30 minutes after the shot. The third helicopter flew around the upwind side of the dust column and landed 2,000 meters northwest of ground zero.

For the damage effects evaluation, personnel from the 412th Engineer Construction Battalion and the 3623rd Ordnance Company prepared a display area 230 to 3,200 meters south-southeast of ground zero. Equipment, sheep, and film badges were placed in fortifications and in the open. After the shot, engineer and ordnance teams inspected equipment and fortifications to assess the damage caused by the detonation. A medical team retrieved the sheep, and a chemical team retrieved the film badges for analysis.

In addition to the Desert Rock participants, an estimated 400 DoD personnel participated in scientific projects conducted by the test groups at Shot SIMON. An additional 120 AFSWC participants provided air support.

Shot ENCORE, an airdropped nuclear device, had a yield of 27 kilotons. A B-50 from Kirtland Air Force Base delivered the ENCORE device, which was detonated 2,423 feet above Area 5 of Frenchman Flat at 8:30 a.m. Pacific Daylight Time (PDT) on May 8, 1953. The bomb was off-target by 250 meters. Shot ENCORE was a military effects test, and the Military Effects Group conducted many projects, involving about 720 DoD personnel. Perhaps another 40 took part in activities of the Weapons Development Group and the Civil Effects Group.

Although the scientific activities at ENCORE were extensive, even more DoD personnel were involved in the Desert Rock activities at the shot. More than 3,000 individuals took part in observer programs, troop maneuvers, operational helicopter tests, and damage effects evaluation. Desert Rock troop maneuvers, the largest single program conducted at ENCORE, involved about 2,475 men.

Participants were organized into two BCTs, composed of provisional units from the First, Third and Fourth Armies and from individual Air Force units.

For several days before the shot, maneuver troops attended classes and practiced their shot-day activities. They observed the shot with the other troops in trenches 9,400 meters from the intended ground zero. The trenches were far enough from the shot that troops and other observers were allowed to rise and look at the fireball before the arrival of the shock wave, a change from previous policy.

After the shot, the two BCTs began the ground assault on two objectives, about 5,000 meters south-southwest and 1,400 meters south-southeast of ground zero. While the ground troops were marching from the trenches to the objectives, seven H-19 helicopters were airlifting one 30-man platoon from each BCT to the closer objective. The first group to arrive at that objective was a pathfinder team, which included a radiological safety monitor. This monitor took a reading of 0.26 R/h about one hour after the detonation in the vicinity of ground zero. By 10:45 a.m., the ground troops had secured both objectives. After spending about seven hours in the forward area, the troops returned to Camp Desert Rock.

Desert Rock observers, including representatives from each of the armed services, watched Shot ENCORE from trenches 9,400 meters from the intended ground zero and then toured the equipment display area. They spent about five hours and 20 minutes at the test site.

For the Marine Corps operational helicopter test, four HRS helicopters were tested, each operated by a crew of three from the 2nd MCPAEB. At shot-time, three helicopters were 20 kilometers from ground zero at a height of 400 feet, while the fourth was hovering 10 feet above the ground at a point 15.5 kilometers from ground zero. After the shock wave passed, two helicopters returned to Camp Desert Rock. The other two flew to a position 1,000 meters south of ground zero and landed briefly to allow monitors to survey the immediate area. The radiation levels that they measured 20 to 30 minutes after shot-time did not exceed 1.4 R/h.

For the Desert Rock damage effects evaluation, the 412th Engineer Construction Battalion excavated bunkers, trenches, and foxholes and built two sections of bridging. The 3623rd Ordnance Company placed equipment in the display area, which extended 3,200 meters to the southeast of ground zero. In addition, a medical evaluation team placed sheep in the area the day before the shot, and a chemical team placed film badges in the fortifications. After the shot, evaluation teams entered the display area to assess damage and to retrieve the animals and film badges for analysis.

In addition to test group and Desert Rock participants at Shot ENCORE, about 80 AFSWC personnel, including the crew for the airdrop mission, provided air support.

Shot GRABLE, the tenth test of UPSHOT-KNOTHOLE, was detonated with a yield of 15 kilotons at 8:30 a.m. PDT on May 25, 1953. A 280-mm cannon fired the atomic artillery projectile, which detonated 524 feet above Area 5 (Frenchman Flat). GRABLE was the only nuclear device fired from a cannon during the test series. The Artillery Test Unit from the Artillery Center, Fort Sill, Oklahoma, fired the cannon. Like Shot ENCORE, Shot GRABLE had extensive test group activities; an estimated 650 DoD personnel participated in the Military Effects Group projects. DoD personnel also assisted in Weapons Development Group and Civil Effects Group projects.

Although the scientific program was extensive, many more DoD personnel were involved in the Desert Rock exercises. More than 2,600 exercise troops and over 700 observers participated in GRABLE. Observers, including members of each of the armed services, witnessed the shot from trenches 4,570 meters west of ground zero. After the shot, observers were to inspect the equipment display area, but because of a dust storm, they were unable to approach closer than 1,370 meters to ground zero.

After observing the shot with other Desert Rock participants, the exercise troops were to attack two objectives located 2,400 meters southeast of ground zero and 2,800 meters east-southeast of ground zero. High winds and dust forced the troops to turn back about an hour after the attack began, although some troops did approach as close as 700 meters to the south of ground zero and were subsequently able to view the equipment display up to 450 meters from ground zero.

For the damage effects evaluation at GRABLE, the 412th Engineer Construction Battalion excavated trenches, bunkers, and foxholes and constructed sections of bridging in the display area southeast of ground zero. The 3623rd Ordnance Company also placed military equipment in the area. Army personnel placed sheep and dosimetry instruments in these fortifications for use in medical and shielding evaluations. After the shot, engineer, ordnance, chemical, medical, and quartermaster teams evaluated the damage to equipment, animals, and fortifications. A veterinary officer and technician evaluated the effects of the detonation on the sheep, and a chemical team retrieved dosimetry instruments.

In addition to the test group and Desert Rock participants, about 70 AFSWC crewmembers provided air support.

Radiation Protection Standards

Exercise Desert Rock V, the JTO, and AFSWC each developed its own organization and procedures for ensuring the safety of its members. Based on safety criteria established by the AEC, the radiological safety plans developed by each organization were designed to minimize individual exposures to ionizing radiation while allowing participants to accomplish their missions.

During UPSHOT-KNOTHOLE, the safety of Desert Rock participants was the responsibility of the Army. Subject to AEC approval, the Office, Chief of Army Field Forces (OCAFF), set the external gamma radiation exposure criterion for Desert Rock V troops as a maximum of 6.0 roentgens (R) during Operation UPSHOT-KNOTHOLE, with no more than 3.0 R of prompt radiation. To protect Desert Rock participants from the thermal and blast effects of nuclear detonations, OCAFF also established exposure limits for blast pressure and thermal radiation:

- Five pounds per square inch of overpressure
- One calorie per square centimeter of thermal radiation.

Based on these exposure limits and the mode of delivery, OCAFF set minimum distances from ground zero for the positioning of Desert Rock troops and observers.

In addition, OCAFF authorized a special volunteer observer program for Exercise Desert Rock V. Small groups of officer volunteers were positioned in trenches closer to ground zero than the standard distances. The exposure limits for this special program were:

- 10 R of gamma radiation, with no more than 5 R of prompt radiation per test, and a total of no more than 25 R for the exercise
- Eight pounds per square inch of overpressure
- One calorie per square centimeter of thermal radiation

The Test Manager was responsible for the radiological safety of all JTO personnel at the NPG and individuals residing within 320 kilometers of the test site. Onsite radiological safety operations were performed by the AFSWP Radiological Safety Support Unit, composed of Army personnel from Fort McClellan, Alabama, and directed by AFSWP. The Radiological Safety Support Unit worked within guidelines recommended by the AEC, Division of Biology and Medicine, and accepted by the Test Manager. An exposure limit of 3.9 R of gamma radiation for the series was established for personnel involved in JTO activities. Because UPSHOT-KNOTHOLE lasted almost 12 weeks, this limit approximated the then-current occupational exposure limit of 3.9 R for each 13-week period recommended by the National Committee on Radiation Protection and the International Commission on Radiological Protection.

AFSWC was responsible for the radiation protection of its units. The AFSWC exposure limit was 3.9 R of gamma radiation for the entire operation, unless otherwise specified.

Although the missions of Desert Rock, the JTO, and AFSWC required different types of 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 and developing film badges for participants and evaluating gamma radiation exposures recorded on these badges
- 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 radiological conditions in the test area
- Decontamination – detecting and removing contamination from personnel and equipment

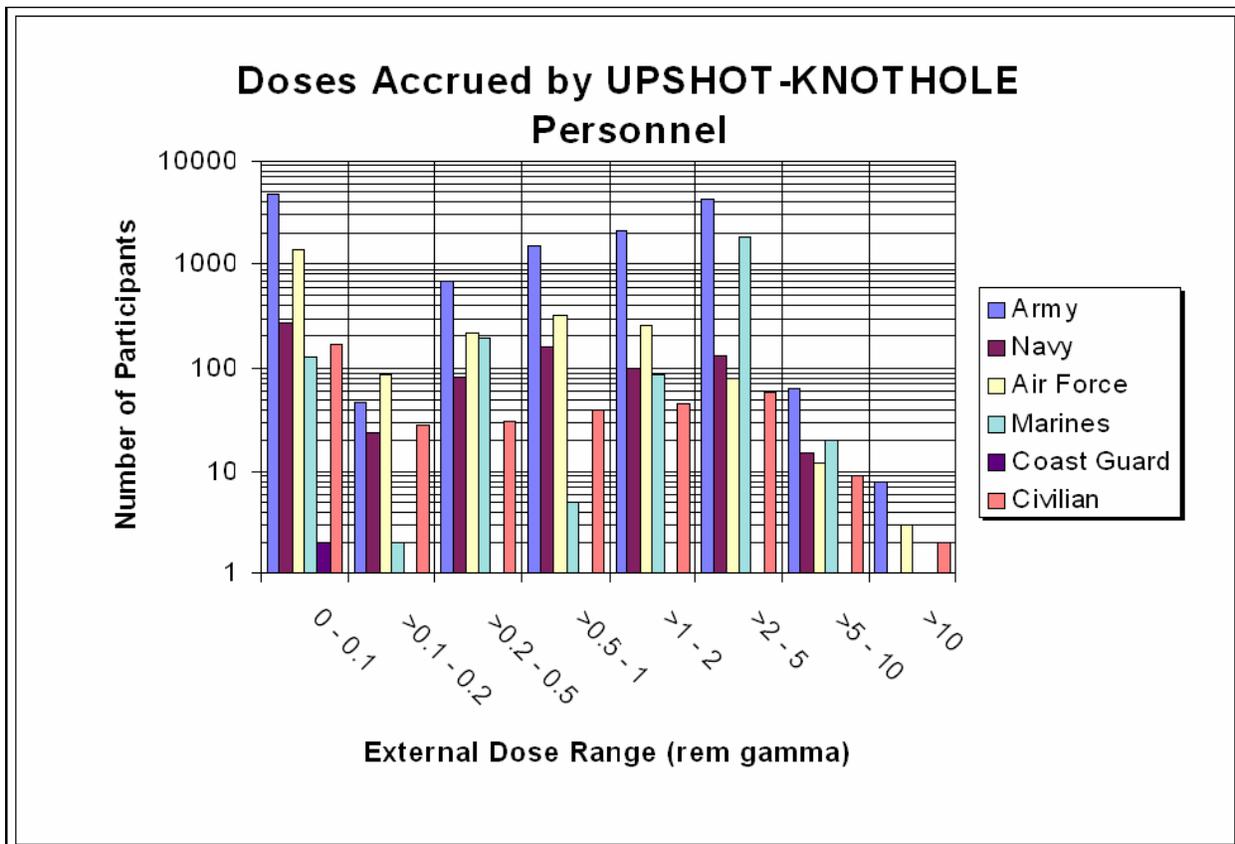
Radiation Doses at Operation UPSHOT-KNOTHOLE

Film badge data are available for mostly the JTO personnel among the DoD participants of UPSHOT-KNOTHOLE. While film badge data for individual Desert Rock participants are generally not available, dosimetry information is available for the volunteer officer observers who participated at Shots NANCY, BADGER, and SIMON. Each volunteer observer wore a pocket dosimeter and at least one film badge. Film badge records show that the nine volunteer officer observers at Shot NANCY received doses between 0.3 and 0.79 rem.* The 12 officer observers at Shot BADGER received doses ranging from 5.2 to 9.5 rem. At Shot SIMON, the eight volunteers received doses of 9.5 to 17.5 rem; seven of these doses exceeded the 10 rem limit for one shot. One of the volunteer observers witnessed all three shots, and his total gamma dose for all three was 26.6 rem.

Because the volunteer officer observers were relatively close to Shots NANCY, BADGER, and SIMON, the potential also existed for exposure to neutron radiation. The calculated mean neutron

doses for the volunteer observers have been reconstructed as 0.63 rem for Shot NANCY, 2.4 rem for Shot BADGER, and 28 rem for Shot SIMON.

For JTO personnel as well, the number of overexposures at UPSHOT-KNOTHOLE was unusually large. This resulted in part from the heavy fallout and the unanticipated directions in which it was deposited on the ground. Even the doses over 10 rem were from many different activities and distributed among the services. The highest dose (and the only one exceeding 20 rem, apart from the volunteer observers) was 22 rem to a Marine. Two of the Army radsafe monitors for the JTO received over 16 rem while not operating their radiac meters in an unexpectedly contaminated area. The totals of reconstructed and film badge doses for UPSHOT-KNOTHOLE participants are depicted below.



** A rem is a radiation protection unit of measure that quantifies the risk of biological effects resulting from exposure to ionizing radiation. Ionizing radiation is any radiation (gamma, x-ray, beta, neutron or alpha) capable of displacing electrons from atoms or molecules, thereby producing ions. According to the National Council on Radiation Protection and Measurements (NCRP, Report No. 93, Table 8.1), the general U.S. population receives about 0.36 rem per year from natural background radiation sources (radon, cosmic rays and rocks) and man-made radiation sources (medical diagnostic x-rays and consumer products).*

For more information on reconstructed doses, see the reports “Analysis of Radiation Exposure for Troop Observers” (DNA 5742F), “Analysis of Radiation Exposure 2nd Marine Corps Provisional Atomic Exercise Brigade” (DNA-TR-82-03), and “Analysis of Radiation Exposure for Maneuver

Units” (DNA-TR-84-303), available online at http://www.dtra.mil/rd/programs/nuclear_personnel/pubs.cfm.

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For more information, see the report “Operation WIGWAM 1955” (DNA 6000F), available online at http://www.dtra.mil/rd/programs/nuclear_personnel/atr.cfm.

Also see the report “Operation UPSHOT-KNOTHOLE 1953” (DNA 6014F), available online at http://www.dtra.mil/rd/programs/nuclear_personnel/atr.cfm.

July 2007