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LOW LEVEL INTERNAL DOSE SCREEN—CONUS TESTS

Nuclear Test Personnel Review

Science Applications International Corporation
P.O. Box 1303
McLean, VA 22102-1303

22 December 1986

Technical Report

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Nuclear Test Personnel Review**

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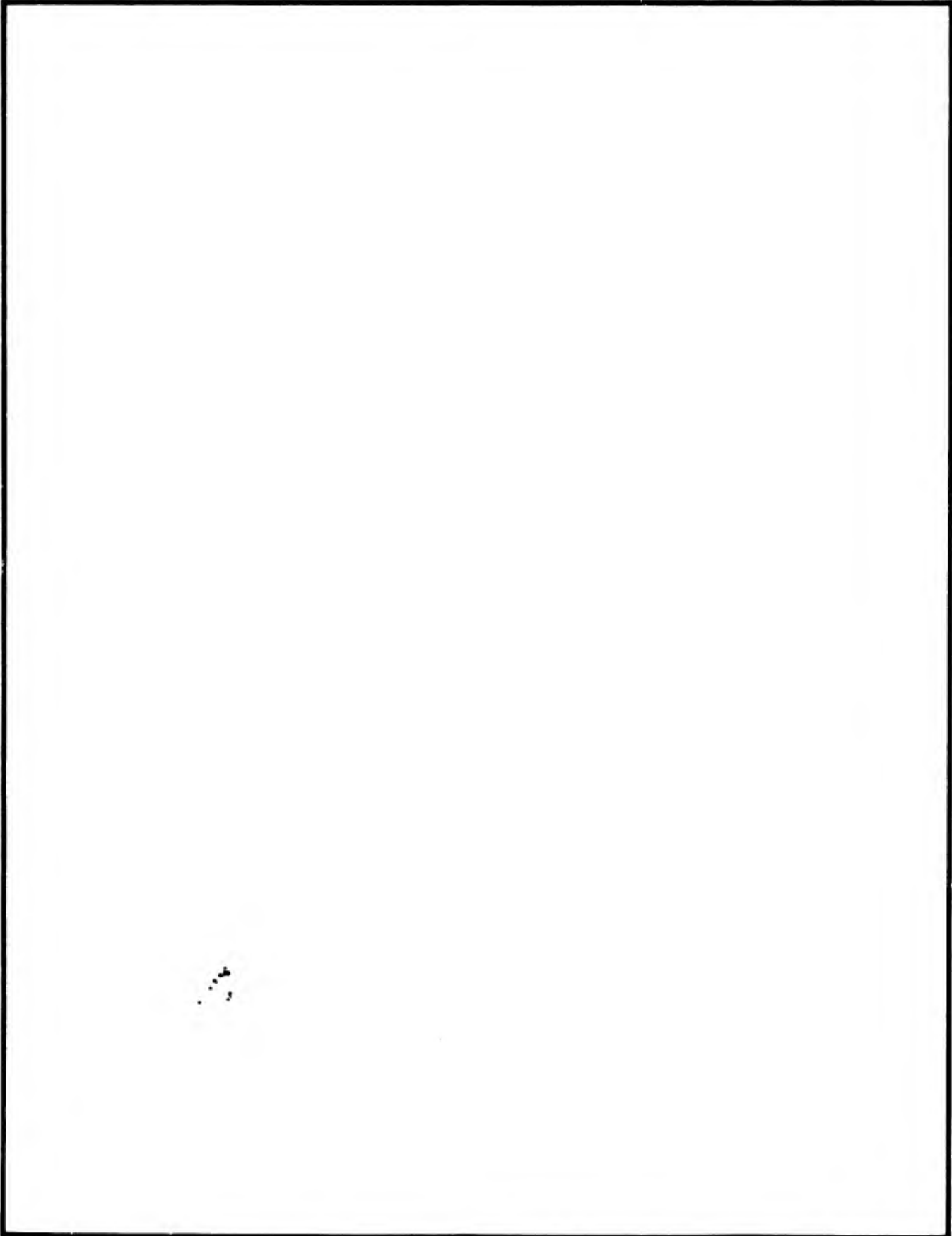
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SECTION 1 INTRODUCTION AND SUMMARY

From 1945 through 1962, the Atomic Energy Commission tested more than 250 nuclear weapons/devices primarily at sites in Nevada and in the Pacific Ocean. Over 200,000 Department of Defense (DoD) personnel were involved in these tests. As a result of concern over alleged adverse health effects resulting from exposure to ionizing radiation among these participants, the DoD initiated the Nuclear Test Personnel Review (NTPR) program in 1977. One of the objectives of this program is to compile a roster of all DoD personnel involved in these tests and to ascertain the radiation doses they received.

Considerable progress has been made in the effort to identify the test participants and determine their doses; however, data gaps still exist. It was standard practice to issue film badges to all test participants or representative members of groups to measure their "external" radiation (primarily gamma) doses. Much film badge dosimetry data has been located and entered into the NTPR data base. Only a few assessments (e.g. Reference 7) have been made to determine "internal" doses resulting from intake of radioactive material. Therefore, such doses must be calculated to supplement external dose information in the data base.

Detailed calculation of the internal dose for each test participant would be an overwhelming task; therefore, a method is needed to quickly screen groups of participants who were exposed to similar radiological conditions and eliminate those who most likely did not receive a significant internal dose. This report describes such a method for the pertinent exposure pathways and lists those participants (by project or unit) who did not receive a dose greater than a specified screen threshold. This method allows for rapid reassessment of internal dose level should additional information surface as to participant activities.

For purposes of this report, a committed dose equivalent (50-year) of 150 millirem to the bone is used for the screen threshold. This dose is 1 percent of radiation protection guideline (annual limit) for occupational exposure currently

recommended by the National Council on Radiation Protection and Measurements (NCRP). The choice of bone as the indicator organ is reasonable because, according to NCRP Report 39, "bone has a unique position as a limiting organ because of the experience with radium depositions and the fact that many radionuclides give a much higher dose to the skeleton than to other body parts." Radium is the longest studied of the "bone-seekers," which include many nuclear fuel and fission product radionuclides. Had red bone marrow, the critical organ for leukemia induction, been selected as the indicator organ, the results would be essentially the same. The composite bone dose conversion factor (rem per microcurie inhaled) based on data presented in Reference 1 is slightly higher than the composite red marrow factor based on Reference 2.

This report addresses DoD participation in the atmospheric nuclear tests conducted within the continental United States (CONUS) at the Nevada Test Site (NTS), and in New Mexico. The oceanic tests that occurred principally at the Pacific Proving Ground (PPG) will be covered in a subsequent report. A distinction between the continental and oceanic tests is that residence ships and islands in the PPG were sometimes subjected to fallout. Therefore, the PPG assessments consider the "chronic" exposures due to residence in contaminated areas as well as the "acute" exposures that resulted from activities on contaminated shot islands and target ships. Since foodstuffs could be contaminated from fallout on the residence islands/ships, both ingestion and inhalation pathways must be considered in the oceanic internal dose assessments. In contrast, the residence areas of the NTS were virtually free of contamination, and eating was prohibited in contaminated test areas; therefore, this report considers only the inhalation pathway. If exceptions to the eating prohibition are noted, the analysis must be augmented.

The results contained in this report are summarized as follows:

- Most DoD participants in continental nuclear testing received a 50-year bone dose commitment less than the screen threshold of 150 mrem.
- Airbursts provided the least potential for internal dose, followed by tower shots.

- Participants at near-surface and shallow underground bursts who encountered the high concentration of contaminants in the shot area may have received bone dose commitments greater than the screen threshold.
- Almost all activities conducted in the radiation fields of very low yield bursts resulted in a potential for internal dose in excess of the screen threshold.

SECTION 2 METHODOLOGY

2.1 INTRODUCTION.

Few body burden measurements, bioassays, or air sampling data are available to calculate the committed dose equivalent (hereafter termed "dose commitment") to specific body organs resulting from inhaled radioactive material. Therefore, an indirect approach is necessary. Usually, the only indicators of the radiological environment to which test participants were exposed are gamma radiation intensities as measured by a survey meter or integrated external doses determined from film badges. Fortunately, such measurements can be related to an airborne activity concentration of radioactive material that can be used to calculate an internal organ dose commitment using the following equation:

$$D = AA \times BR \times T \times DF \quad (1)$$

where:

- D = 50-year internal dose commitment (rem) to the organ
- AA = Airborne activity concentration (Ci/m³) of radioactive material
- BR = Breathing rate (m³/hr)
- T = Duration of exposure (hr)
- DF = Inhalation Dose Conversion Factor* (rem/Ci) for the organ.

There are three basic scenarios for the inhalation of radioactive material by nuclear test personnel:

- Inhalation of fallout particles that were deposited on the ground or other surfaces and resuspended by mechanical or natural disturbances.
- Inhalation of neutron-induced radioactivity in the soil (or other material) that had been lofted into the air by mechanical or natural disturbances.

*Dose conversion factors have been published to convert the intake of various radionuclides to a 50-year dose commitment to specific body organs. The particle size and the chemical and metabolic properties of the specific radionuclide are considered in the calculation of inhalation dose factors (References 1 and 2).

- Inhalation of radioactive material contained in the nuclear cloud or descending fallout. Obviously the former case would be limited to aircrews who flew through the cloud.

2.2 INHALATION OF RESUSPENDED FALLOUT.

In the case of inhalation of resuspended fallout, the airborne concentration of radioactive material is calculated through the application of a resuspension factor, $K(m^{-1})$ which correlates the airborne activity concentration, $AA (Ci/m^3)$, to the amount of radioactive material on the ground or other surface, $SA (Ci/m^2)$, under a given set of conditions. The surface activity (SA) is not directly measured; however, it can be related to a gamma radiation intensity, $I (R/hr)$, measured at a given distance (1 meter) above the surface. The ratio $SA/I (Ci/m^2 \text{ per } R/hr)$ is a function of the gamma energy spectrum of the time-dependent mixture of radionuclides on the surface. Substituting these relationships into the basic equation (Equation 1) for calculating organ dose commitments and generalizing to mixed nuclear debris yields the following equation:

$$D = I \times \frac{SA}{I}(t) \times K \times BR \times T \times DF(t) \quad (2)$$

where:	D	=	Fifty-year dose commitment to the organ (rem)
	I	=	Gamma radiation intensity (R/hr)
	$\frac{SA}{I}(t)$	=	Surface activity--intensity ratio ($Ci/m^2 \text{ per } R/hr$)*
	K	=	Resuspension factor ($Ci/m^3 \text{ per } Ci/m^2$, or m^{-1})
	BR	=	Breathing rate (m^3/hr)
	T	=	Duration of exposure (hr)
	DF(t)	=	Activity-weighted average (composite) dose conversion factor for the organ for the mixture of radionuclides in the fallout (rem/Ci)*
	t	=	Time after detonation of exposure (hr).

Equation (3) relates the product of the free-field gamma radiation intensity (I) and the duration of exposure (T) to a time integrated dose (D_{FB}) in roentgens (or rem)

*Note that, while the quantities SA/I and DF are independent of radiation levels, they are functions of time after detonation because of the changing radionuclide inventory due to radiological decay.

that should be indicated by a film badge worn by a person standing in a uniform fallout field (Reference 3).

$$D_{FB} = 0.7 \times I \times T \quad (3)$$

Therefore, the internal dose commitment to a particular organ can be related to the external film badge dose an individual receives at the same time from the same source.

Equations (2) and (3) are combined to calculate the external film badge dose that is equivalent to an internal bone dose commitment of 150 millirem as follows:

$$D_{FB} = \frac{0.150 \times 0.7}{\frac{SA}{I}(t) \times K \times BR \times DF(t)} \quad (4)$$

If the film badge dose, calculated using values for breathing rate, resuspension factor, and time after the detonation that can be related to the various activities performed by nuclear test participant, is more than the known or upper limit external dose received by a category of participants, the corresponding internal bone dose commitment is less than 150 millirem.

Due to the complexity of the calculation, in particular the determination of values for the time dependent parameters SA/I and DF, the computer code FIIDOS (Reference 4) is used for this task. The code considers the production and radiological decay of all radionuclides (fission products, neutron activation products, and actinide elements including unfissioned nuclear fuel) present in unfractionated fallout. Values of SA/I* and DF** are shown in table 1 for the three principal fission reactions--fast*** neutron fission of U-235 and Pu-239, and 14 MeV neutron fission of U-238. The tabulated values pertain only to the fission product radionuclides. Contributions of other radionuclides vary with the design and efficiency of individual nuclear devices and surrounding materials (such as shot tower cabs). If the activities of non-fission

*Surface is modeled to approximate empirical ground roughness factor of 0.7 for desert terrain.

** Composite bone dose conversion factor for aerosol (oxide clearance classification) having an Activity Median Aerodynamic Diameter (AMAD) of 1.0 μm .

*** Unmoderated fission neutron spectrum.

product radionuclides are known or estimable, these may be used to augment the fission product information below. Only if present in great activity could other radionuclides significantly perturb the tabulated values of SA/I. However, certain radionuclides may influence the aggregate DF far out of proportion to their activity.

Table 1. Surface activity to radiation intensity ratios and composite bone dose factors for fission products from selected fission reactions.

TIME AFTER DETONATION	SA/I (Ci/m ² per R/hr)			DF (rem/Ci)		
	U-235	U-238	Pu-239	U-235	U-238	Pu-239
	FAST NEUTRON	14MeV NEUTRON	FAST NEUTRON	FAST NEUTRON	14MeV NEUTRON	FAST NEUTRON
3 Min	0.100	0.100	0.117	3.86	3.20	3.20
9 Min	0.095	0.089	0.095	8.22	7.18	6.91
30 Min	0.083	0.078	0.081	18.4	16.3	14.6
1 Hr	0.069	0.067	0.067	34.6	30.8	27.8
2 Hr	0.065	0.063	0.064	68.6	62.0	56.2
4 Hr	0.085	0.082	0.085	125	113	101
6 Hr	0.112	0.109	0.113	169	148	133
9 Hr	0.139	0.137	0.139	222	189	170
12 Hr	0.150	0.149	0.151	269	226	201
18 Hr	0.154	0.157	0.160	367	301	263
1 Day	0.155	0.161	0.164	471	375	323
2 Day	0.158	0.166	0.169	907	669	556
3 Day	0.155	0.162	0.163	1350	963	785
4 Day	0.151	0.157	0.156	1770	1250	1020
5 Day	0.147	0.153	0.152	2170	1530	1240
6 Day	0.145	0.151	0.147	2540	1790	1450
7 Day	0.143	0.148	0.145	2910	2050	1650
10 Day	0.142	0.148	0.141	3890	2810	2240
14 Day	0.147	0.154	0.146	5050	3740	2890
21 Day	0.161	0.168	0.159	6640	5090	3750
1 Mon	0.179	0.185	0.176	8250	6430	4540
2 Mon	0.225	0.227	0.221	12500	9700	6620
3 Mon	0.240	0.243	0.241	15800	12000	8290
4 Mon	0.240	0.244	0.245	18600	14000	9810
1 Yr	0.415	0.422	0.459	62200	39600	25400
2 Yr	1.18	0.775	0.840	150000	83700	49400

Table 2 presents the calculated external film badge doses that are equivalent to a bone dose commitment of 150 millirem for exposures received at various times after most* CONUS nuclear detonations resulting in significant on-site fallout. A resuspension factor of $1 \times 10^{-5} \text{ m}^{-1}$, a breathing rate of $1.2 \text{ m}^3/\text{hr}$, and dose conversion

*BUSTER-JANGLE Shot Able and HARDTACK II Shots Tamalpais and Blanca are excluded due to insufficient radiochemistry data.

Table 2. External film badge dose (rem) equivalent to internal bone dose commitment of 150 millirem.

OPERATION - SHOT	1 HOUR		4 HOURS		9 HOURS		1 DAY		2 DAYS		4 DAYS		1 WEEK		2 WEEKS		1 MONTH		2 MONTHS		4 MONTHS		1 YEAR	
	HOURS	DOSE	HOURS	DOSE	HOURS	DOSE	DAY	DOSE	DAY	DOSE	DAY	DOSE	WEEK	DOSE	WEEK	DOSE	MONTH	DOSE	MONTH	DOSE	MONTH	DOSE	MONTH	DOSE
TRINITY	2900	520	170	63	32	17	10	4.1	1.6	0.64	0.26	0.029												
BJ - Sugar	2800	610	230	120	77	45	24	7.3	2.4	0.96	0.43	0.044												
BJ - Uncle	2600	540	210	120	79	47	24	6.6	1.9	0.74	0.32	0.033												
TS - Easy	3100	640	200	74	35	18	11	5.5	2.3	0.94	0.41	0.042												
TS - Fox	3400	720	240	96	50	27	16	7.4	3.1	1.3	0.58	0.063												
TS - George	3600	760	260	110	55	30	18	8.5	3.7	1.6	0.73	0.081												
TS - How	3200	670	210	77	36	19	11	5.9	2.6	1.1	0.46	0.048												
UK - Annie	3600	780	250	110	56	31	18	8.8	2.9	1.7	0.78	0.093												
UK - Nancy	3500	750	250	100	53	29	17	8.2	3.5	1.5	0.69	0.078												
UK - Ruth	3600	780	270	120	70	40	23	9.9	4.2	1.9	0.93	0.11												
UK - Ray	3600	780	270	120	70	40	23	9.9	4.2	1.9	0.91	0.10												
UK - Badger	3600	780	270	120	66	37	22	9.9	4.1	1.8	0.82	0.097												
UK - Simon	3600	790	270	110	57	31	19	9.2	4.1	1.8	0.88	0.10												
UK - Harry	3700	820	280	120	64	35	21	10	4.5	2.0	1.0	0.12												
T - Moth	1800	320	94	31	14	6.7	4.0	1.9	0.75	0.28	0.11	0.011												
T - Tesla	1200	200	57	19	8.5	4.3	2.4	1.1	0.40	0.15	0.057	0.0057												
T - Turk	3700	800	270	110	53	28	18	9.2	4.2	1.8	0.89	0.11												
T - Hornet	2900	590	200	74	34	16	9.7	4.8	2.0	0.78	0.33	0.035												
T - Bee	2800	550	170	61	28	14	8.3	4.1	1.7	0.68	0.28	0.029												
T - Ess	2600	540	220	120	80	47	24	6.6	1.9	0.74	0.32	0.034												
T - Apple I	3000	610	190	71	34	17	10	5.1	2.1	0.86	0.38	0.039												
T - MST	3900	880	300	130	66	36	23	12	5.9	2.9	1.7	0.26												
T - Apple II	3400	720	240	91	45	23	14	7.2	3.1	1.3	0.61	0.067												
T - Zucchini	3500	730	240	91	44	23	14	7.2	3.2	1.4	0.62	0.068												
P - Boltzmann	3200	670	220	81	38	19	11	5.8	2.5	1.0	0.45	0.048												
P - Franklin	3600	770	260	99	47	24	15	8.2	3.9	1.8	1.0	0.19												
P - Wilson	2900	580	180	64	29	15	8.9	4.5	1.9	0.77	0.33	0.034												
P - Priscilla	3900	890	310	130	67	35	23	12	6.1	3.1	1.8	0.30												
P - Diablo	3200	650	210	82	41	21	13	5.9	2.5	1.0	0.44	0.047												
P - Kepler	2300	430	130	44	20	10	5.9	2.8	1.1	0.42	0.17	0.019												
P - Shasta	3200	650	210	81	40	21	12	5.8	2.4	0.98	0.43	0.046												
P - Smoky	3900	870	310	130	67	36	22	12	5.8	2.8	1.6	0.24												
P - Galileo	2300	420	130	50	25	13	7.2	3.0	1.1	0.43	0.18	0.028												
P - Fizeau	2900	570	180	65	30	15	8.8	4.4	1.9	0.73	0.31	0.032												
P - Whitney	3200	650	210	82	42	22	13	5.8	2.4	0.96	0.41	0.045												
HII - Quay	160	23	6.2	1.8	0.77	0.37	0.21	0.1	0.04	0.015	0.006	<0.001												
HII - Hamilton	0.84	0.12	0.032	0.01	0.004	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001												
HII - Rio Arriba	3600	790	280	120	69	39	23	10	4.4	2.0	1.0	0.12												
HII - Humboldt	5.7	0.79	0.22	0.064	0.029	0.014	0.008	0.004	0.001	<0.001	<0.001	<0.001												
DII - Johnnie Boy	3700	890	380	190	95	39	23	13	6.2	3.1	1.9	0.32												
DII - Small Boy	790	120	33	11	4.7	2.3	1.3	0.6	0.23	0.086	0.033	0.003												
DII - Little Feller I,II	18	2.5	0.69	0.21	0.09	0.043	0.025	0.012	0.004	0.002	<0.001	<0.001												

factors for aerosols (oxide clearance classification) with an Activity Median Aerodynamic Diameter (AMAD) of 1.0 μm are used in the calculations. The breathing rate (1.2 m^3/hr) corresponds to that of a typical adult male during light activity (Reference 5). For strenuous activities, the external doses corresponding to a 150 millirem bone dose commitment are approximately two-thirds of those indicated in the table. Table 2 shows that the relationship between the external dose and the internal bone dose commitment changes rapidly with time after the detonation and varies from shot to shot. These variations result from radiological decay and shot specific differences in the mixture of radionuclides in the fallout, in particular the amount of long-lived radionuclides generated and/or left over (unfissioned) from the detonation. Several radionuclides that contribute to the bone dose commitment have half-lives well in excess of the human life span, and thus are not radiologically depleted in the environment or the body. Because these nuclides are principally beta and alpha particle emitters, they contribute little to the external dose; however, they increasingly dominate the relationship between bone dose commitment and external doses as most of the short half life gamma emitters decay away.

For utility, table 3 presents a "worst-case composite" of information for a large number of NTS shots. (TEAPOT Shots Moth and Tesla, all HARDTACK II Shots except Rio Arriba, and DOMINIC II Shots Small Boy, Little Feller I and II are excluded; discussion will follow.) Information is presented for three values of the resuspension factor ($K = 1 \times 10^{-3}$, 10^{-4} , and 10^{-5}m^{-1}) for selected times after the detonation.

Table 3 is used to determine whether or not a participant in any of the shots covered (see exceptions mentioned above) received a bone dose commitment of less than 150 millirem as follows:

- Step 1: Select an appropriate resuspension factor. The scientific literature provides a basis for selecting resuspension factors that are applicable to various activities performed by DoD participants in the nuclear test program. For example, table 4 is a summary of experimentally determined resuspension factors for a variety of activities and environmental settings (Reference 6). Using this information, the resus-

Table 3. Composite* external film badge dose (rem) equivalent to internal (bone) dose commitment of 150 millirem.

K (m ⁻¹)	Time After Detonation								
	H+4 hrs	H+9 hrs	H+24 hrs (1 day)	H+48 hrs (2 days)	H+96 hrs (4 days)	H+168 hrs (1 week)	H+336 hrs (2 weeks)	H+720 hrs (1 month)	H+1440 hrs (2 months)
1x10 ⁻³	4.2	1.3	0.44	0.20	0.10	0.059	0.028	0.011	0.0042
1x10 ⁻⁴	42	13	4.4	2.0	1.0	0.59	0.28	0.11	0.042
1x10 ⁻⁵	420	130	44	20	10	5.9	2.8	1.1	0.42

*Composite NTS shots minus BUSTER-JANGLE Shot Able, TEAPOT Shots Moth and Tesla, and most HARDTACK II and DOMINIC II shots.

Table 4. Resuspension factors* reported in reactor safety study.

Arid/Desert	Semi-arid/Grassland	Urban/Suburban	Interiors
<p>4×10^{-7} near road graded in fallout field (a)</p> <p>3×10^{-5} in Land Rover during travel to work site and outside during work; fission products (5-18 hr) (a)</p> <p>3 to 10×10^{-4} downwind of crater (a) } UO_2</p> <p>1×10^{-3} mechanical disturbance (a) } UO_2</p> <p>5×10^{-4} dust from vehicles } PuO_2</p> <p>10^{-4} to 10^{-6} dust from pedestrians (a) }</p> <p>3×10^{-7} particles of 7 μm MMD on 6-m circles (sandy) furnished and rocky with sand base (dry) (b)</p> <p>1×10^{-7} to 3×10^{-7} (wet) (b)</p> <p>1.2×10^{-7} in $1000\text{-}\mu g/m^2$ isopleth } PuO_2</p> <p>1.4×10^{-7} in $100\text{-}\mu g/m^2$ isopleth } Safety test (c)</p> <p>1.6×10^{-6} in $10\text{-}\mu g/m^2$ isopleth } Safety test (c)</p> <p>-35 day half-time air concentration decay</p> <p>1 to 3-μm median aerosol size</p> <p>38-day half-time for resuspension of fission products from Schooner (d)</p> <p>76-day half-time for resuspension of fission products from Banberry (e)</p> <p>3×10^{-10} for 8- to 10-year Pu aged deposit (c)</p> <p>2×10^{-9} for direction of strongest wind (e)</p>	<p>5×10^{-6} (ZnS) walking and loading boxes (f)</p> <p>1×10^{-5} (-0.5 $\times 10^{-5}$) limestone, rock, sand, grass, bushes; fission products (a)</p> <p>0.8 to 2×10^{-7} crater of tower shot; fission products; road graded from soil disturbance (a)</p> <p>2×10^{-5} to 4×10^{-6} in vehicle on road graded through fallout (a)</p> <p>8×10^{-6} to 4 μm U_3O_8 undisturbed</p> <p>5×10^{-7} to 12 μm U_3O_8 sandy soil with desert grasses (a)</p> <p>8×10^{-9} to 10^{-11} Y-91 aqueous solution on sandy soil-rain weathering small plot (a)</p> <p>1×10^{-7} for particles of 7 μm MMD on 6-m circles, grass plot (dry) (b)</p> <p>4×10^{-8} for particles of 7 μm MMD on 6-m circles, grass plot protected by snow fence (dry) (b)</p> <p>2×10^{-7} both cases, above, wet (b)</p>	<p>2.5×10^{-6} sandblasting for I-131 removal (k)</p> <p>2×10^{-6} 0- to 4-μm U_3O_8 particles on concrete slabs (a)</p> <p>1.5×10^{-7} 0- to 12-μm U_3O_8 particles on concrete (a)</p> <p>10^{-4} to 10^{-2} fraction resuspended per pass through particles (b)</p> <p>2×10^{-2} to 2×10^{-4}; initially very rapid half-time of a few days</p> <p>-2×10^{-5} to 2×10^{-3} at 4 days</p>	<p>1×10^{-5} heavy work (l) ZnS (3.1 μm)</p> <p>7×10^{-4} light work (a) CaO (2 μm)</p> <p>2×10^{-3} operations (j)</p> <p>0.4 to 7×10^{-3} clothes change and other activity (k)</p> <p>1.2×10^{-4} people waiting in change room (k)</p> <p>5×10^{-5} PuO_2, many steps (l)</p> <p>3×10^{-6} PuO_2, many steps (l)</p> <p>2×10^{-4} to 4×10^{-5} in enclosed space, I-131 in brick dust (a, g)</p>

For references, see continuation.
*Reciprocal meters (m^{-1})

Table 4. Resuspension factors reported in reactor safety study -
References (Concluded).

- (a) Stewart, K., 1964, "The Resuspension of Particulate Material from Surfaces," in Proc. Symp. Surface Contamination, Gatlinburg, Tenn. 1964, Pergamon Press.
- (b) Healy, J. W., and J. J. Fuguoy, 1959, "Wind Pickup of Radioactive Particles from the Ground," Progress in Nuclear Energy, Series 12, Vol. 1, pp. 427-436.
- (c) Wilson, R. H., R. G. Thomas, and J. N. Stannard, 1960, Biomedical and Aerosol Studies Associated with a Field Release of Plutonium, WT-1511.
- (d) Anspaugh, L. R., P. L. Phelps, N. C. Kennedy, and H. G. Booth, "Wind-Driven Redistribution of Surface-Deposited Radioactivity," in Proc. IAEA Symp. Environmental Behavior of Radionuclides Released In the Nuclear Industry, Aix-en-Provence, May 14-18, 1973.
- (e) Anspaugh, L. R., 1973, Relationship Between Resuspended Plutonium in Air and Soil, NVC-T40.
- (f) Schwendiman, L., 1958, Health Physics, 1, p. 352.
- (g) Chamberlain, A. C., and R. C. Chadwick, 1951, Transport of Iodine from Atmosphere to Ground, United Kingdom Atomic Energy Authority, Report AERE-R 4870.
- (h) Anspaugh, L. R., J. H. Shinn, and D. W. Wilson, 1974a, "Evaluation of the Resuspension Pathway Towards Protective Guidelines for Soil Contamination with Radioactivity," in Proc. IAEA/WHO Symp. on Radiological Safety Evaluation of Population Doses and Application of Radiological Safety Standards to Man and the Environment, Portorez, Yugoslavia, May 20-24, 1974.
- (i) Fish, B. R., et al., 1965, Redispersion of Settled Particulates, Oak Ridge National Laboratory Report ORNL-TM-1049.
- (j) Bailey, J. C., and R. C. Rohr, 1953, Airborne Contamination, Oak Ridge National Laboratory Report K-1088.
- (k) Brunskill, 1964, "The Relationship Between Surface and Airborne Contamination," in Proc. Symp. Surface Contamination, Gatlinburg, Tenn. 1964, Pergamon Press, Oxford.
- (l) Jones, I. S., and S. F. Pond, 1964, "Some Experiments to Determine the Resuspension Factor of Plutonium from Various Surfaces," in Proc. Symp. Surface Contamination, Gatlinburg, Tenn. 1964, Pergamon Press.

pension factors shown in table 5 are selected for typical activities involving DoD test participants. Note that the resuspension factor could change during an activity; for example, radioactive fallout material is resuspended only when the surface is disturbed during digging operations.

- Step 2: Determine period of exposure. From appropriate references, the approximate time that the activity in question occurred is determined. For example, many exposures received by scientific project personnel were incurred by H+4 hours. Most observer and maneuver troop activities took place on shot day and were completed by at least H+9 hours, however, in some cases these troops visited contaminated display areas on subsequent days or may have rehearsed in an "old" fallout field.
- Step 3: Estimate breathing rate of test participants. For most activities, a breathing rate of $1.2 \text{ m}^3/\text{hr}$ is assumed. This breathing rate is used in the calculations for the preparation of tables 2 and 3. For strenuous activities, the calculated external doses are reduced by one-third.
- Step 4: Compare "actual" external film badge doses with table 3. The maximum external film badge dose received by the category of test participants in question is determined from appropriate references. This dose is then compared with the dose indicated in table 3 for the appropriate value of the resuspension factor and time after the detonation as determined in Steps 1 and 2. If the actual dose is less than that indicated in table 3, the internal bone dose commitment is less than 150 millirem. For example, according to Reference 7, the upper limit external film badge dose received by the service observers at Shot Nancy (Operation UPSHOT-KNOTHOLE) was 0.32 rem. The observer activities were completed on shot day (prior to H+9 hrs); therefore, assuming that the resuspension factor associated with their activities was 10^{-5} , their external dose could have been as high as 130 rem before an internal bone dose commitment of 150 millirem would have resulted. Even if the resuspension factor had been as high as 10^{-4} , the 13 rem external dose corresponding to a 150 millirem

Table 5. Resuspension factors for typical DoD participant activities in contaminated areas.

<u>Participant Category</u>	<u>Activity</u>	<u>Resuspension Factor (m⁻¹)</u>
Observers & Maneuver Troops	Touring display area after shot (on foot, or inside vehicle)	10 ⁻⁵
Maneuver Troops	Maneuvers involving helicopter landings/take off	10 ⁻³
	Assaults or marches behind armored vehicles or marches	10 ⁻³
	Crawl through open terrain	10 ⁻⁴
	Dig foxholes, etc.	10 ⁻⁴
	Ground assaults (no vehicle)	10 ⁻⁵
	Trucking	10 ⁻⁵
Project Troops	Dig out buried instrumentation/equipment	10 ⁻⁴ - 10 ⁻⁵
	Equipment/data recovery	10 ⁻⁴ - 10 ⁻⁵
	Decontamination projects (Bulldozing, etc.)	10 ⁻⁴
	Visit project area (on foot or vehicle)	10 ⁻⁵
Support Troops - Engineers/Ordinance - Communications - Decontamination - Transportation - MP's - Rad-Safe	Dig trenches, install/dismantle displays	10 ⁻⁴
	Lay wire (communications network)	10 ⁻⁴
	Equipment/personnel decontamination	10 ⁻⁴
	Trucking	10 ⁻⁵
	Traffic control, security sweep	10 ⁻⁵
	Survey area on foot or from vehicle	10 ⁻⁵

bone dose commitment still greatly exceeds their actual dose of 0.32 rem; therefore, it is highly unlikely that these observers received a bone dose commitment in excess of 150 millirem.

As stated earlier, table 3 is based on a worst-case composite of a large number of CONUS detonations. The same methodology can be applied to the shots not covered by the table (see exceptions) by using the shot-specific values in table 2 with appropriate adjustments for the value of the resuspension factor (K). For example, the H+4 hour, external film badge dose values for Shot Small Boy (DOMINIC II) would be 120 rem, 12.0 rem, and 1.2 rem for $K = 1 \times 10^{-5}$, 10^{-4} , and 10^{-3} , respectively. The equivalent film badge doses for DOMINIC II Shots Little Feller I and II and most HARDTACK II shots with significant on-site fallout are considerably less. The fallout from these low-yield nuclear shots tended to be rich in unfissioned nuclear material, which leads to a high potential for internal bone dose.

In many cases, specific information regarding categories of troop participants is not available; however, the information in table 3 allows certain conclusions to be drawn. For example, it is evident that any activity that would result in an internal bone dose commitment of 150 millirem on the day of most shots would also be accompanied by an extremely high external dose (over 130 rem during activities where a resuspension factor of 1×10^{-5} is applicable; 13 rem where moderately high levels, $K = 1 \times 10^{-4}$, of resuspended material are encountered). For activities that are completed by H+4 hours, the corresponding external doses are more than three times higher. Since few external doses of this magnitude were recorded during any operation, most participants who were involved in activities on shot day only, can be assigned an internal bone dose commitment of less than 150 millirem unless they were involved in activities where unusually high ($K \geq 1 \times 10^{-3}$) levels of resuspended material were present.

External (film badge) dose limits for most DoD participants ranged from 3.0 to 6.0 rem, depending on the operation. Taking the higher value (6.0 rem), table 3 shows that an internal bone dose commitment of less than 150 millirem could be assigned to any person exposed to resuspended fallout material, ($K = 1 \times 10^{-5}$) up to almost 1 week

after most shots, provided that he did not receive an external dose over-exposure during that period. Obviously, the exposure period is shorter for higher values of the resuspension factor. Nevertheless, since test participant external doses were controlled and over-exposures documented, exposure limits can be used as worst case values of the external dose when specific information is not available.

Variants of the methodology are required when information is lacking for one or more of the scenario-related parameters in Equations 2 and 3. In order to make any internal dose evaluation for personnel in a fallout field, the resuspension factor must be estimable; this is accomplished from qualitative project descriptions that are generally available. Film badge dose, especially on a project basis, is typically unavailable. While a high-sided value of the operation dose limit is useful as a constraint on early time exposures, it aids late-time determinations only rarely, as attaining the dose limit would require unrealistic exposure durations at late times. Also, the time after burst of exposure, the implicit but important parameter of Equation 2, is often unspecified. This is particularly problematic when the poorly documented removal of test equipment well after the shot requires more time or involves greater resuspension than the better documented, early-time data recoveries.

When external dose and time-after-burst information are lacking, the internal dose can be evaluated if the innermost location (to GZ, or nearest the fallout hotline) of the participant is identified. For a given exposure duration at a specific location, the bone dose commitment is high-sided by the earliest possible exposure; the early fission product contribution decays, leaving long-lived weapon debris to dominate the internal dose from late-time exposures. Exposure durations, where not stated, are estimable with reasonable accuracy; normally, the order of 1 hour or 10 hours is appropriate to cleanup activities. For the high-sided weapon debris content represented by the composite shot described above, there is a time-dependent relation to radiation intensity. Radiation survey measurements have been used to determine the gamma intensity fields associated with nuclear fallout. These, as reported in Reference 8 (with many refinements in other DNA documents) were usually normalized with the $t^{-1.2}$ decay rule to one hour after burst. Thus, the H+1 hour intensity, as read from published contour plots for a known location, provides a useful measure for internal dose evaluation when other data are lacking.

For a known location or where the radiation intensity can be upper-limited, the bone dose commitment is directly proportional to resuspension factor, exposure time, and H+1 hour intensity; it declines weakly with time after burst and thus correlates poorly with film badge dose or intensity measured during the exposure. In terms of Equation 2, variation in intensity with time after burst is largely compensated by the time-dependence of the composite dose conversion factor. In order to implement a procedure using H+1 hour intensities, the external-internal dose relationship depicted in table 3 is adapted. For each pair of resuspension factor and exposure duration values, the earliest possible exposure time after burst, consistent with operational film badge dose limits, is chosen. The film badge dose is used to calculate (Equation 3) an intensity, which is normalized to H+1 hour ($t^{-1.2}$ decay). For example, with $K = 10^{-4} \text{ m}^{-1}$ and $T = 10 \text{ hr}$, the 4.4 rem value in the table for D+1 is used as an approximate value for the various operational dose limits. The corresponding intensity is 0.63 R/hr, which implies 29 R/hr at H+1. With the same resuspension factor but a one-hour exposure duration, 290 R/hr at H+1 would have been permissible. Other resuspension factors permit attainment of the operational external dose limit at different times: for 10^{-3} m^{-1} , at about H+4 hours; for 10^{-5} m^{-1} , at about 1 to 2 weeks. (Note that at later exposure times in each case, the external dose limits would not have been reached.) This procedure results in the following results for limiting intensities (R/hr) at H+1:

$K(\text{m}^{-1})$	Exposure Duration (T in hours)			
	1	10	100	1000
10^{-3}	32	3.2	N/A	N/A
10^{-4}	290	29	2.9	N/A
10^{-5}	4000	400	40	4

The last two columns apply primarily to personnel resident in contaminated areas, where chronic, low-level exposure resulted from routine activities over periods as long as several months. This situation occurred during oceanic, but not continental testing. Only realistic combinations of T and K are tabulated.

These values do not account for the decay that actually occurs during extended exposures; they are high-sided by this consideration. The small variation in the lead

digits (as opposed to order of magnitude) is solely the result of the variation in earliest reasonable reentry time; all entries would start with 29 if reentry were on D+1. It would be expected that D-day reentry would have the lowest lead digits because of the greater fission product activity then present; it is the composite-shot origin of table 3 that happens to perturb the values pertinent to a single shot.

Both military rehearsals and technical project fielding were often conducted in fallout fields remnant from earlier shots. The above limiting H+1 hour intensities are also useful for assessing these situations. Personnel activities in old high-intensity (H+1 hour) areas were limited because of shot positioning and timing practices. Tower and surface/underground shots, which accounted for almost all significant fallout, were conducted at distinct GZs during an operation. The heavily contaminated areas around such GZs were not used in preparations for subsequent shot activities. When tower GZs were reused during later operations, one or two years later, the resuspension factor would have diminished by at least an order of magnitude through weathering (Reference 6) and the potential for internal dose thus would have greatly diminished.

All CONUS fallout fields are examined to determine their potential impact on internal dose for activities during subsequent shots. The shots impacting other shot areas with H+1 intensities exceeding each major threshold tabulated above are indicated as follows. Through Operation PLUMBBOB, no tower shot had associated H+1 intensities as great as 4000 R/hr anywhere in the field; consequently, no activity characterized by $K = 10^{-5} \text{ m}^{-1}$ and $T = 1 \text{ hr}$ results in a 150 mrem dose commitment to bone. Only the cratering shots (BUSTER-JANGLE Sugar and Uncle, and TEAPOT Ess in the period of significant DoD participation at NTS) exceeded 4000 R/hr, and then not distant from the crater; no other shot areas were impacted at this level. Even at the 290 R/hr level, no shot impacted another with the exception of TEAPOT Tesla. Tesla has an internal dose potential considerably above that of the composite shot; therefore, part of its fallout field about 1 km northwest of Shot Post "effectively" exceeds 290 and 400 R/hr.

The shots impacting other areas at 29 R/hr or above are as follows:

	<u>1st Shot</u>	<u>2nd Shot</u>	<u>H+1 Hour Intensity (R/hr)</u>	<u>Location from 2nd Shot</u>
BUSTER-JANGLE	Sugar	Uncle	30 > 100	GZ Several hundred meters S and SE
TUMBLER-SNAPPER	Easy	Fox	50	2+ km S
UPSHOT-KNOTHOLE	Nancy	Ray	100	500 m WSW
	Nancy	Badger	75	Widespread
	Badger	Harry	50	2 km N; narrow strip
	Badger	Climax	50	2 km W to S; narrow strip
	Simon	Harry	200	Widespread
TEAPOT	Moth	Hornet	40*	1 km NE
	Tesla	Post	290-400*	1 km NW
PLUMBBOB	Diablo	Smoky	50	Widespread

Only a few additional shots impacted other areas at 3.2 R/hr or above:

TEAPOT	Turk	Apple I	10	3 km NW	
PLUMBBOB	Boltzmann	Smoky	10	Widespread	
	Boltzmann	Lassen	20	Widespread	
	Boltzmann	Wilson	20	Widespread	
	Boltzmann	Owens	20	Widespread	
	Boltzmann	Wheeler	20	Widespread	
	Boltzmann	Charleston	20	Widespread	
	Shasta	Smoky	15	Widespread	
	Smoky	Wheeler	} 6	GZ	
	Smoky	Charleston		} 20	1 km N
	Smoky	Morgan			

The only case in which a shot in a previous operation moderately impacted an area is TEAPOT Tesla on the colocated PLUMBBOB balloon. Shots Lassen, Wilson, Hood, Owens, Wheeler, Charleston, and Morgan. The "effective" Tesla intensity, corrected for reduced resuspension factor after 2 years, is about 10 R/hr (H+1 hour) at the balloon GZ; it rises to about 30 R/hr within 1 km to the southwest, before the immediate vicinity of the Tesla GZ is reached.

While several of the HARDTACK II shots were also impacted by earlier shots, consideration of their radiation levels was not required for the screening. Since many

*"Effective" intensity.

of the HARDTACK II shots had an internal dose potential much greater than the composite shot, non-remote participants fail to pass the screen regardless. None of the DOMINIC II shots significantly impacted subsequent shots during the operation or were meaningfully impacted by shots from previous operations.

The above shot-specific information is considered in estimating internal dose levels but, for simplicity, no designation regarding previous shots is shown on the lists of projects/units identified as receiving bone dose commitments of less than 150 millirem presented in Section 3. Those projects or units failing to qualify for the list on this account do not appear. Where qualification is marginal on one account and multiple exposures or sources of internal dose exist, the sum is considered. Even if there is qualification on all separate accounts, the sum must qualify for the unit to make the list. For a given shot, only the qualification based on the leading contributing exposure is displayed; this may well involve a late cleanup activity rather than a documented data recovery.

No ground maneuver troops or observers fail to qualify for the list (under 150 mrem bone dose) based on activities (e.g., rehearsals) in old radiation areas. In fact, almost every such unit also qualifies when post-shot activities are also included. The reasons revolve around the pertinent resuspension factors, exposure times and durations, and distances from GZs. The great majority of maneuver troops and observers were operating at $K = 10^{-5} \text{ m}^{-1}$ by virtue of walking or being trucked. Most of their post-shot activities were accomplished on D-day, exposure durations were 10 hours or less, and no part of a fallout field with H+1 intensity as great as 400 R/hr was entered. Therefore, all walking and riding maneuver and observer troops qualify. Most instances of higher resuspension factors are considered in dose reconstruction reports. Task Force BIG BANG (DNA 4772F) crawling in fallout, Task Force RAZOR (DNA-TR-83-07) resuspending fallout with tanks, and marines breathing helicopter-lofted contamination (4th MCPAEB--DNA 5774F) all qualify. However, certain activities of Task Force WARRIOR (Reference 3), for which internal dose has not previously been analyzed, do not clearly qualify; therefore, TF WARRIOR does not appear on the list.

2.3 INHALATION OF LOFTED NEUTRON-ACTIVATED MATERIAL.

Numerous nuclear test devices were detonated sufficiently high above the ground so that minimal on-site fallout occurred. However, in many cases, the neutrons

emitted from these detonations produced considerable radioactivity in the soil through activation by neutron capture. Any lofting or suspension of this activated soil by mechanical or natural means creates a potential inhalation hazard to those who enter the area.

The methodology for calculating internal organ dose commitments resulting from the inhalation of neutron-induced activity is basically the same as that for resuspended fallout as presented in Section 2.2. Again, the airborne concentration is determined by the application of a (re)suspension factor that relates the surface activity to that in the air above. The surface activity is determined from gamma radiation intensities measured above the surface.

As described in Reference 7, the relationship between activity in soils and gamma intensity is developed from field data on known activation products, generalized to other soil constituents through theoretical considerations of neutron capture. All reported constituents in NTS soil have been analyzed to determine relative contributions to both gamma intensity and internal bone dose commitment at relevant times of exposure. As shown in Reference 7, Na-24 dominates both the gamma intensity and bone dose commitment in the first few days after detonation. After Na-24 decays (half-life of 15 hours), Ca-45 (half-life of 163 days) is left as the dominant contributor to bone dose commitment.

Results in Reference 7 are expressed for time zero in terms of a unit radiation intensity (R/hr) from Na-24, a unit (re)suspension factor (m^{-1}), a unit breathing rate (m^3/hr), and a unit exposure duration (hr): 2.2 rem to the bone from Na-24 and 0.2 rem from Ca-45. The top centimeter of soil is considered to be available for suspension, and a suspension factor of $1 \times 10^{-3} m^{-1}$ demonstrates the implications of severe surface disturbances. Internal doses from Na-24 are directly proportional to external dose accrued during the interval that Na-24 dominates the radiation intensity. With a breathing rate of $1.2 m^3/hr$ and use of Equation (2), a bone dose commitment of 0.15 rem from Na-24 corresponds to a film badge dose of 40 rem. Thus, adherence to external dose limits in early days after the detonation would preclude a significant bone dose commitment from inhalation of activated soil.

At late times, it is theoretically possible to accrue a bone dose commitment from Ca-45 in excess of 0.15 rem without exceeding operational limits on film badge dose; however, this could be accomplished in extremely limited areas only, consistent with a reasonable exposure time. From the previous paragraph it is seen that Na-24, before decay, leads to 11 times the internal bone dose commitment from Ca-45. Thus, for 0.15 rem from Ca-45, the corresponding film badge dose based on undecayed Na-24 is >440 rem. Radiation intensities at H+1 in excess of 100 R/hr, coupled with a several-hour exposure and the extreme suspension factor of $1 \times 10^{-3} \text{ m}^{-1}$ throughout, would lead to values of this magnitude. Reference 8 indicates that such H+1 intensities did exist from induced activity, for a few shots, within a few hundred meters of ground zero. However, no military activities are known to have occurred under the combined set of circumstances that would lead to a bone dose commitment exceeding 0.15 rem from inhalation of suspended, activated soil. Consequently, a shot having a radiation field from neutron-induced activity is taken to imply, without further analysis, bone dose commitments of less than 0.15 rem for all participants at that shot.

2.4 INHALATION OF CLOUD DEBRIS.

A limited number of nuclear test personnel had the potential for exposure to internal dose while performing missions in aircraft or helicopters. Exposure to airborne nuclear debris was either planned, as in the case of cloud samplers, or inadvertent, as in the case of Marine helicopter exercises in Operation UPSHOT-KNOTHOLE. As in the case of ground personnel, radiation exposure was usually indicated by film badge dose or meter readings of gamma intensity.

The analysis of exposure to nuclear cloud debris differs from that of grounded debris through the variation in radiation source geometry. The volumetric radiation source geometry relates differently to gamma intensity than does a planar source. No consideration analogous to a resuspension factor is required; worst-case analysis takes the ambient airborne activity concentration without reduction. The other condition required for simple analysis is that the exposure and associated meter readings and film badge readings are from immersion in a cloud of uniform activity concentration over the range of gamma radiation. Equation (1) is applied as follows:

$$D = I \times \frac{AA}{I}(t) \times BR \times T \times DF, \quad (5)$$

where the new quantity AA/I is the ratio of airborne activity concentration to gamma intensity (Ci/m^3 per R/hr). Derived from an energy balance in Reference 7, AA/I is only weakly time-dependent from the small variation in average gamma emissions energy, E (MeV per disintegration):

$$\frac{AA}{I} = 5 \times 10^{-4}/E \quad (6)$$

This expression is based on sea level air density; AA/I is directly proportional to air density at altitude. However, the breathing rate tends to vary inversely with air density; consequently, no overall corrections for altitude are made in Equation (5).

The overall expression for worst-case exposure to nuclear cloud debris aloft is obtained from substitution of Equations (6) and (3) into Equation (5). Because of the intensity variations encountered in flight, the condition stated above is imperfectly met; however, deviations almost invariably high-side the internal dose. With Equation (3) used in its time-integral form, the following result is obtained:

$$D = 7 \times 10^{-4} \times D_{FB} \times BR \times DF/E \quad (7)$$

For the 0.15 rem bone dose commitment, the limiting film badge dose is:

$$D_{FB} = 210 \times E/(BR \times DF) \quad (8)$$

At early times after detonation, $t \approx 1$ hr, $E = 0.8$ MeV is approximately correct for all fission types. With the usual breathing rate of $1.2 \text{ m}^3/\text{hr}$,

$$D_{FB} = 140/DF \quad (9)$$

At early times, fission products dominate the dose conversion factor for many shots; thus, values of DF (the largest, from fission of U-235) from Section 2.2 are used to determine the following limiting film badge doses:

t(hr)	0.5	1	2	4
D_{FB} (rem)	7.6	4.0	2.0	1.1

Worst-shot values of D_{FB} , in the manner of (and excluding the same shots as in) table 3, are obtained by multiplying the above D_{FB} by worst-shot to best-shot ratios from table 2. Approximate results are:

t(hr)	0.5	1	2	4
D_{FB} (rem)	5.0	2.4	1.1	0.5

The limiting film badge doses given above apply in the absence of protective devices. They do not apply, for example, to aircrews breathing 100 percent oxygen. However, they are appropriate, at least as a reasonable upper limit, where the activity concentration within an aircraft does not correspond to ambient values. Even the slow infiltration of outside air and contaminants does not necessarily reduce the potential for internal dose; long after departure from the nuclear cloud, an aircraft may retain contamination within. In fact, the internal dose commitment is independent of infiltration rate under the following conditions: the rate is constant, exposure continues until the contamination has effectively exited the aircraft, particles are of inhalable sizes and remain in suspension within the aircraft, personnel negligibly deplete the contaminants, and radiological decay may be neglected during the period of exposure. In practice, only rapid infiltration permits these conditions to be met; otherwise, incomplete exposure to or degradation of the radioactive source occurs.

Film badge doses as used above tend to yield a conservatively high internal dose commitment because badge readings typically overrepresent the immediate radiation environment aloft; aircraft avoid the regions of highest activity concentration that nevertheless contribute to the gamma intensity at a distance. This phenomenon is most familiar when no local contamination is present; a gamma reading from distant contamination is referred to as cloud "shine."

2.5 INHALATION OF DESCENDING FALLOUT.

The inhalation of descending fallout can be considered the ground-based analog of the inhalation of cloud debris. However, the analysis of internal dose from this pathway develops quite differently because the common type of radiation measurement has a different interpretation. Except for the onset of fallout or for very fine

particles, the radiation intensity is dominated by fallout already deposited. This follows from the deposition velocities of fallout particles, the range of gamma radiation, and the duration of fallout deposition at a given position.

The airborne activity concentration must be represented in terms of the gamma intensity. This is accomplished through the following product: $I \times (SA/I) \times (AA/SA)$, in which SA/I is obtained from Section 2.2 for the time after detonation of exposure, t . For an airborne activity concentration AA that persists for a duration T , during which a deposition velocity V applies, the resulting surface activity $SA = AA \times V \times T$. In effect, a column of height $V \times T$ is deposited on the surface. Clearly, the corresponding radiation intensity is that at the termination of fallout deposition.

The above analysis is equally valid where AA and V are time-dependent, as realistically occurs; the integral representation obtains equivalent results. Because $AA/SA = 1/(V \times T)$, substitution into Equation (1) eliminates T . However, T has an impact when radiological decay is considered. If $T \ll t$, the above analysis is rigorous; otherwise, internal dose is high-sided by determining the largest time-normalized value of I and taking the exposure to have occurred at time t corresponding to the end of fallout deposition. In practice, the peak reported intensity and associated time adequately correspond to this limiting case, as t is typically a small multiple of T . Where multiple fallout episodes occur, the internal dose is readily high-sided by conversion of the combined late intensity to an H+1 hour value.

The deposition velocity is not commonly reported, but is simply estimated as follows. In order to reach the surface at time t from the nuclear cloud, the average fall speed is the stabilized altitude divided by t . For most nuclear tests, fallout particles descended on the order of 10 km. As the deposition velocity at the surface approximates the average fall speed, $V \approx 10 \text{ km}/t$. Thus, $AA/SA = t/(T \times 10^4 \text{ m})$. Substitution into Equation (1) in consistent units yields:

$$D = I \times \frac{SA}{I} \times 10^{-4} \times t \times BR \times DF \quad (10)$$

Further simplifications of this equation are possible. Most exposures involving particles small enough to be fully inhalable were from about H+10 hours onward. At

such times, Reference 4 indicates that SA/I has a nearly constant value of 0.16 Ci/m² per R/hr. For the typical breathing rate of 1.2 m³/hr, Equation (10) reduces to:

$$D = 2.0 \times 10^{-5} \times I \times t \times DF \quad (11)$$

To obtain the peak intensity that for any time t corresponds to a bone dose commitment of 150 mrem requires knowledge of the composite dose factor. The analysis of Section 2.2 using H+1 hour intensities provides a means of limiting the bone dose commitments. A comparison of Equation (10) with Equation (2) shows that the coefficient 10^{-4} is formally equivalent to a resuspension factor, and that time after detonation t replaces exposure duration T . Interpolating from the limiting values of H+1 intensity displayed in Section 2.2 for various combinations of K and T yields approximately 30 R/hr for $t=10$ hr and 3 R/hr for $t=100$ hr. Fallout arriving at earlier times was either not of inhalable size or fell out from lower altitudes in the cloud stem. Without special knowledge of particle size, the limiting H+1 intensity is reasonably held at 30 R/hr, rather than increased, for $t < 10$ hr.

In order for the internal dose evaluation from descending fallout to be accurate, the measured intensities must correspond to the deposited fallout, and personnel exposure must correspond to the full period of deposition. The presumption of full exposure when not otherwise known reasonably high-sides the internal dose, but the use of film badge readings would lead to inappropriate high-siding; exposure to external radiation continued long after fallout deposition ceased.

Few nuclear test participants received a bone dose commitment in excess of 150 mrem from the inhalation of descending fallout; most at NTS received far less.

SECTION 3
UNITS/PROJECTS WITH BONE DOSE COMMITMENT
LESS THAN 150 MILLIREM

Based on a review of the activities performed by DoD participants in the atmospheric nuclear weapons tests program as presented in DNA reports* and application of the methodologies presented in Section 2, the project/unit personnel listed in the following tables received an internal bone dose commitment of less than 150 millirem. The codes listed below are used to explain the rationale for the inclusion of a project/unit on these tables; operation and shot abbreviations are defined in the Appendix.

- | <u>CODE</u> | <u>RATIONALE</u> |
|-------------|--|
| Blank | Stated participation does not apply to given shot, or non-participant in (and not impacted by) shot. |
| IA | Participated in shot activities before, during, or after shot, but not exposed to airborne radioactivity. |
| IB | Exposed or potentially exposed to airborne activity but provided absolute respiratory protection. |
| II | Exposed to resuspended fallout but received an external film badge dose (rem) less than that indicated for the conditions characterized by the matrix below: |

	1	2	3	4	5	6	7	8	9
A	4.2	1.3	0.44	0.20	0.10	0.059	0.028	0.011	0.0042
B	42	13	4.4	2.0	1.0	0.59	0.28	0.11	0.042
C	420	130	44	20	10	5.9	2.8	1.1	0.42

Where: A = Resuspension Factor (K) of $1 \times 10^{-3} m^{-1}$
 B = Resuspension Factor (K) of $1 \times 10^{-4} m^{-1}$
 C = Resuspension Factor (K) of $1 \times 10^{-5} m^{-1}$
 1 = Up to 4 hours after the detonation
 2 = Up to 9 hours after the detonation

* DNA-6001F through DNA-6028F and DNA-6032F through DNA-6040F.

- 3 = Up to 1 day after the detonation
- 4 = Up to 2 days after the detonation
- 5 = Up to 4 days after the detonation
- 6 = Up to 1 week after the detonation
- 7 = Up to 2 weeks after the detonation
- 8 = Up to 1 month after the detonation
- 9 = Up to 2 months after the detonation

For example, Code IIB2 indicates that the unit was exposed to moderately high levels of resuspended fallout ($K = 1 \times 10^{-4} m^{-1}$) during the period up to 9 hours after the detonation and received an external film badge dose of 13 rem or less. Table 3 equates such an external dose to an internal bone dose commitment of less than 150 mrem. Note that when this code is applied, the actual or reconstructed film badge dose from residual radiation received by the project/unit is entered under " D_{FB} " in the table. For some cases where the actual external dose is unknown but the other parameters are known, the maximum permissible dose limit for the operation is applied. If further research indicates that external doses exceeded the limits, the corresponding bone dose commitment must be reconsidered.

II Exposed to resuspended fallout in areas where the H+1 hour gamma radiation intensity (R/hr) was less than that indicated for the exposure parameters listed below:

	a	b	c	d
A	32	3.2	N/A	N/A
B	290	29	2.9	N/A
C	4000	400	40	4

Where:

- A = Resuspension factor (K) of $1 \times 10^{-3} m^{-1}$
- B = Resuspension factor (K) of $1 \times 10^{-4} m^{-1}$
- C = Resuspension factor (K) of $1 \times 10^{-5} m^{-1}$
- a = Exposure duration of up to 1 hour
- b = Exposure duration of up to 10 hours
- c = Exposure duration of up to 100 hours
- d = Exposure duration of up to 1000 hours

For example, Code IIAb indicates that the unit operated up to 10 hours in an area where the H+1 hour intensity was 3.2 R/hr or less and the level of resuspended material was extremely high ($K = 1 \times 10^{-3} \text{m}^{-1}$). According to Section 2.2, such exposure conditions would result in an internal bone dose commitment of less than 150 mrem. Note that film badge information is not required for assignment of these codes.

III Exposed to suspended neutron-activated material in the absence of a fallout field. According to Section 2.3, it is virtually impossible to obtain an internal bone dose commitment in excess of 150 mrem from exposures in an induced activity field. Some shots had induced activity fields supplemented by on-site fallout deposition, restricted to the downwind direction. Of the shots listed in table 2, Annie, Harry, Bee, Apple I, Wilson, and Priscilla are of this type. Where participants are known to have operated only in the induced activity portion of the field, Code III is assigned.

IV Exposed to nuclear cloud debris while in flight but received an external film badge dose (rem) less than that indicated for the conditions characterized by the matrix below:

1	2	3	4
5.0	2.4	1.1	0.5

Where: 1 = Up to 0.5 hours after the detonation
 2 = Up to 1 hour after the detonation
 3 = Up to 2 hours after the detonation
 4 = Up to 4 hours after the detonation

For example, Code IV2 indicates that the participant flew through the nuclear cloud or fallout within the first hour after the detonation and received an external film badge dose of 2.4 rem or less for the duration of his immersion in the cloud. His exposure to airborne

contaminants may have persisted until he exited the aircraft. No personal protective gear is assumed. According to Section 2.4, such exposure conditions would result in an internal bone dose commitment of less than 150 mrem.

V Exposed to descending fallout from a nuclear cloud where the H+1 hour radiation intensity (R/hr) corresponding to completed fallout deposition on the surface was less than that indicated for the conditions listed below:

1	2	3	4
30	15	7.5	3

Where: 1 = Up to 10 hours after the detonation
 2 = Up to 20 hours after the detonation
 3 = Up to 40 hours after the detonation
 4 = Up to 100 hours after the detonation

For example, Code V2 indicates that fallout from the nuclear cloud reached the participant's site and attained a peak radiation intensity within 20 hours after the detonation. Negligible fallout deposition occurred after that time. The peak intensity, adjusted to H+1 hour according to $t^{-1.2}$, was less than 15 R/hr. According to Section 2.5, the participant, even if unprotected, would have received an internal bone dose commitment of less than 150 mrem.

A few of the code entries in the tables are asterisked because the shot involved was an exception to the conditions of code derivation (Section 2). Based on shot-specific information (table 2), effective values of film badge dose or radiation intensity are determined prior to application of codes.

For projects/units with multiple activities, the rules regarding inclusion in the list are according to the differentiability of project participants.

- Numbered subprojects are considered separately.
- If all project personnel were rotated at known intervals, each interval is considered separately.

- Air and ground participants are considered separately.
- If an individual could have performed all activities, the aggregate exposure is considered.
- For concurrent activities, activity sets are determined, each to be considered in the aggregate. Any set not satisfying code criteria excludes the entire project/unit from the list, except as noted above.

It must be emphasized that the assessments are based on the conditions reflected by the codes and stated activity. If additional information surfaces to indicate that the code does not accurately portray the exposure conditions (e.g., if the unit was exposed at a later time than that indicated or an individual participated in multiple activity sets), the dose must be re-evaluated. It should also be noted that unlisted project/unit personnel did not necessarily receive a bone dose commitment greater than 150 millirem. In many cases, units are excluded from the list because uncertainties in scenario or exposure conditions allow the possibility of the dose exceeding the threshold, pending further research. Also, the upper-limiting inherent in the generalized code definitions affects some cases. More detailed analyses of these cases may indicate that they qualify for inclusion in these tables.

Table 6. Project TRINITY participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>CODE (See Section 3 text)</u>
Official Observers	Observed detonation from Base Camp or Comana Hills.		IA
Military Intelligence	Performed intelligence functions and measurements with recording barographs in towns and cities up to 100 miles from site.		IA
Evacuation Detachment (-Reinforced Platoon)	Observed detonation from bivouac area approximately 14 km NW of GZ. Evacuation contingency not exercised.		IA
Reinforced Platoon, Evac. Detachment	Observed detonation from bivouac area approximately 14 km NW of GZ. Deployed to Bingham (H+1.5 to H+7.5) Evacuation contingency not exercised.	4.0	IIC2
TR-1B Timing and Remote Control	Manned N, W, and S 10,000 yd shelters on shot day.		IA
	Visited W 800 yd station on D+1.	0.1	IIC3
TR-1C Stock	Miscellaneous activities at Base Camp.		IA
TR-1E Radio-communications	Operated radiocommunication equipment in 10,000 yd shelters.		IA
TR-2A Piezo Gauges	Retrieved gauges from shot area on D+1.	0.1	IIB3
TR-2C Excess Velocity Measurements	Conducted measurements at N and W 10,000 yd shelters on shot day.		IA
	Visited N and W 800 yd stations on D+1.	0.15	IIC3
TR-2D Impulse Gauges	Manned W 10,000 yd shelter on shot day. One member made re-entry to W-800 yd station on D+1.	1.38	IIC3
TR-2E Maximum Pressure Gauges	Recovered instruments as close as W 300 yd station on D+1. Involved digging.	2.8	IIB3
TR-2H Displacement Seismographs	Manned N 10,000 yd shelter and several off-site stations on shot day.		IA
TR-4 and 4D Meteorology	Gathered weather data at Base Camp.		IA
TR-6 Airborne Condenser Gauges	Project to drop canisters from B-29 over GZ cancelled at last minute due to weather.		IA
TR-7B Searchlight Crews	Tracked cloud with searchlights from N and W 10,000 yd shelters (L-2 and L-3).		IA
	Tracked cloud with searchlights and made radiation measurements at stations (L-7 and L-8) approximately 20 miles NE of GZ.		V1

Table 7. Operation RANGER, scientific project participants with bone dose commitment less than 150 millirem.

<u>PROJECT/ UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>E*</u>	<u>B2*</u>	<u>F*</u>
Field Fortifications	Inspected field fortifications (trenches foxholes, etc.) and retrieved film badges from GZ area.		III	III	III	III	III
Thermal Effects Program	Retrieved test samples from GZ area.		III	III	III	III	III
Thermal and Ionizing Radiation Measurements	Retrieved test samples (fabrics) from GZ area.		III				
Radiation Measurements	Retrieved ion chambers and test samples from GZ area.				III	III	III
Fireball Growth	Retrieved film from camera stations 3.2 km NE and SE of GZ on shot day.		IA	IA	IA	IA	IA
Gamma Radiation as Function of Distance	Retrieved film badges from GZ area on shot day.		III	III	III	III	III

* See Appendix for shot abbreviation.

Table 8. Operation RANGER, Air Force support participants with bone dose commitment less than 150 millirem.

<u>PROJECT/ UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>E*</u>	<u>B2*</u>	<u>F*</u>
4925th Special Weapons Group	Dropped nuclear device from B-50.		IA	IA	IA	IA	IA
4925th Special Weapons Group	Conducted aerial radiation survey of GZ area from helicopters.		IA	IA	IA	IA	IA
4925th Special Weapons Group	Flew disaster assistance missions in C-47 and provided general support (except decon).		IA	IA	IA	IA	IA
Strategic Air Command	Photographed mission from B-50 trailing drop aircraft.		IA	IA	IA		IA
374th Recon Sq.	Flew cloud sampling missions in B-29s (Aircrews breathed 100% oxygen).		IB	IB	IB	IB	IB
374th Recon Sq.	Flew cloud tracking mission in B-29s (Did not penetrate cloud).		IA	IA	IA	IA	IA
Cambridge Research Lab and Air Force Weather Service	Flew aerial radiation survey missions in B-17 and C-47 aircraft.		IA	IA	IA	IA	IA
4901st Support Wing (Atomic)	Flew courier missions in B-25 aircraft.		IA	IA	IA	IA	IA
1009th Special Weapons Squadron	Manned off-site control center.		IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

Table 9. Operation BUSTER, Desert Rock support participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>DFB</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>
AFSWP Advisory Group	Provided advice to Desert Rock personnel. Accompanied observers and maneuver troops in forward area.						III
III Corps Hqs and Hqs Co	Command functions.						III
III Corps Arty, Hqs and Hqs Bty	Command functions.						III
Control Group	Supervised troop operations in forward area.						III
806th Army Postal Unit	General support at CDR.						
90th Engr Water Supply Co	General support at CDR.						
231st Engr Cbt Bn	Recovered equipment and materials from display area.						III
359th Engr Util Det	General support at CDR.						
597th Engr Lt Equip Co, Det	Forward area support to troop units.						III
705th Engr FM Co, Det Med	General support at CDR.						
94th Vet Food Ins Det	General support at CDR.						
374th Conv Cen Dets A&B	Established medical aid station and provided ambulances at forward parking area.						
161st Ord Depct Co (-)	General support at CDR.						
393d Ord Bn	General support at CDR.						
3623d Ord Co	Forward area support.						III
505th MP Bn	Controlled traffic to shot area, accompanied troops into forward areas as part of Control Group.						III
53d QM Base Depot Co Hqs & Hqs Co, Det	General support at CDR.						

* See Appendix for shot abbreviations.

Table 9. Operation BUSTER, Desert Rock support participants with bone dose commitment less than 150 millirem (Concluded).

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>DyB</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>
523d QM Subs Co (-) Det	General support at CDR.						
539th QM Ldry Co	General support at CDR.						
621st QM Svc Co	General support at CDR.						
303d Sig Svc Bn Hqs & Hqs Co Det	General support at CDR.						
314th Sig Svc Bn, Co B, Det	Forward area support.						III
504th Sig Base Maint Co Det	General support to CDR.						
4th Trans Trk Co	Transported observers, maneuver troops and evaluation teams to forward area.						IA
92d Trans Trk Co	Transported observers, maneuver troops and evaluation teams to forward area.						IA
562d Trans Staging Area Co	Transported observers, maneuver troops and evaluation teams to forward area.						IA
Chemical Corps School	Provided rad-safe support (radiological surveys, accompanied observer and evaluation teams).						III
Hqs Sixth Army Chem Section	Provided rad-safe support (radiological surveys, accompanied observer and evaluation teams).						III
Evaluation Teams	Evaluated damage to equipment in display area; teams included Desert Rock support troops.						III

* See Appendix for shot abbreviations.

Table 10. Operation BUSTER, Air Force support participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>
4925th Test 6p (Atomic)	Dropped nuclear device from aircraft.			IA	IA	IA	IA
57th Strategic Recon Sq (B-29)	Flew cloud sampling missions in support of Projects 7.3 and 10.4 (Crew breathed 100% oxygen).		IB	IB	IB	IB	IB
APG, Eglin (T-33)	Flew cloud sampling missions in support of Projects 7.3 and 10.4 (Crew breathed 100% oxygen).		IB	IB	IB	IB	IB
4901st Support Wing (Atomic)	Flew disaster control mission in C-47.		IA	IA	IA	IA	IA
57th Strategic Recon Sq (weather)	Flew cloud tracking missions (did not penetrate cloud).			IA	IA	IA	IA
4901st Support Wing	Flew aerial radiation survey missions in C-47s.			IA	IA	IA	IA
1009th Support Weapons Sq	Flew aerial radiation survey missions in C-47s.			IA	IA	IA	IA
57th Strategic Recon Sq	Flew aerial radiation survey missions in C-47s.			IA	IA	IA	IA
4901st Support Wing (Atomic)	General support at ISAFB (except decontamination).						

* See Appendix for shot abbreviations.

Table 11. Operation BUSTER, maneuver troops and observers with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>
Maneuver Troops (Desert Rock I)	Observed shot from point 11 km south of GZ. Advanced on foot to objective near GZ; toured display area on shot day.						III
Service Observers (Desert Rock I)	Observed shot from point 11 km south of GZ. Toured 4 of 5 display areas on shot day.						III
	Observed shot from observation area more than 10 km S of GZ.					IA	IA

* See Appendix for shot abbreviations.

Table 12. Operation BUSTER, AFWSP project participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>DFB</u>	<u>SHOTS/CODE (See Section 3 text)</u>					
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>	
2.3 Effects of Geometry on Flush Thermal Damage	Inspected test samples (wood) in GZ area on shot day. Recovery on D+1.			III			III	
2.4a Protective Value and Ignition of Textile Materials	Inspected test fabrics in GZ area on shot day.			III			III	
2.4b Thermal Effects on Paints, Plastics, and Coated Fabrics	Inspected, photographed and recovered samples on shot day.			III			III	
2.4-1 Basic Thermal Measurements	Retrieved thermal detectors and samples of cloth, wood, and paint from GZ area on shot day.			III	III		III	III
2.4.2 Effects of Thermal Radiation on Materials	Inspected and recovered samples from GZ area on shot day.			III			III	
2.6 Field Fortification Protection against Gamma and Neutron Radiation	Recovered dosimeters from foxholes in GZ area on shot day.			III	III		III	
3.5 Minefield Clearance	Inspected minefield in GZ area. Recovered some fuses and replaced others.			III	III		III	III
3.8 Vulnerability of Parked Aircraft	Inspected and recovered instruments from test A/C parked in GZ area.						III	III
3.9 Effects on Water Supply Equipment	Inspected and photographed water tanks in GZ area on shot day.							III
4.1 Radiation Dosimetry	Recovered radiation detectors (some buried) from GZ area on shot day.			III	III		III	III
4.2 Thermal Effects on Animals	Recovered test animals (dogs) from GZ area on shot day.			III			III	
4.2a Thermal Effects on Animals	Recovered test animals (rats) from GZ area on shot day.			III			III	
4.3 Flash Blindness	Observed shot from C-54, at 15,000 ft altitude, 15 km south of GZ.			IA	IA		IA	
6.1b Dosimetric Materials	Recovered dosimeters from shelters in GZ area on shot day.			III	III		III	
6.4 Airborne Radiac Evaluation	Conducted radiation measurements from aircraft.			IA	IA		IA	IA

* See Appendix for shot abbreviations.

Table 12. Operation BUSTER, AFWSP project participants with bone dose commitment less than 150 millirem (Concluded).

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>				
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>
6.5 IBDA	Tested airborne radar for IBDA.					IA	IA
6.9 Effects on Radio Propagation	Tested radio communications at off-site locations.					IA	IA
7.1 Transport of Radiation Debris	Analyzed cloud tracking information. (See Air Force Support).			IA	IA	IA	IA
7.2 Long Range Light Measurements	Operated cameras from off-site locations.			IA	IA	IA	IA
7.3 Radiochemical Analysis	Analyzed samples obtained by cloud samplers. (See Air Force Support).		IA	IA	IA	IA	IA
7.5 Seismic Waves	Recovered records from stations located 10-20 km south of GZ.		IA	IA	IA	IA	IA
7.6 Airborne Low Frequency Sound	Operated remote stations.			IA	IA	IA	IA
8.2 Air Weather Service	Operated weather station at CP and several off-site locations.		IA	IA	IA	IA	IA
8.4 Technical Photography	Photographed test from Project 6.5 aircraft.					IA	IA

* See Appendix for shot abbreviations.

Table 13. Operation JANGLE, Desert Rock support participants with bone dose commitment less than 150 millirem.

<u>PROJECT/ UNIT</u>	<u>ACTIVITY</u>	<u>DFB</u>	<u>SHOTS/CODE (See Section 3 text)</u>	
			<u>S*</u>	<u>U*</u>
III Corps Arty, Hq and Hq Btry	Command functions at CDR.			
Control Group	Supervised troop operations in forward area.	0.195	IIC3	IIC4
359th Engr Util Det	General support at CDR.			
90th Engr Water Sup Co	General support at CDR.			
705th Engr Fed Maint Co, Maint Plt	General support at CDR.			
393rd Ord Bn, Hq and Hq Det	General support at CDR.			
161st Ord Depot Co	General support at CDR.			
303rd Sig Svc Bn Hq and Hq Co, Det (1)	General support at CDR.			
314th Sig Svc Br, Hq and Hq Co and Co "B"	General support at CDR.			
504th Sig Base Maint Co (Det)	General support at CDR.			
505th MP Bn, Co "A"	Controlled traffic to shot area, accompanied troops to forward area.	0.053	IIC3	
505th MP Bn, Co "C"	Controlled traffic to shot area, accompanied troops to forward area.	0.195	IIC3	IIC4
621st QM Svc Co	General support at CDR.			
523rd QM Sub Dep Co, 1 Plt (-)	General support at CDR.			
53rd QM Base Depot Co (Det)	General support at CDR.			
539th QM Ldry Co, 1 Plt	General support at CDR.			
4th TC Trk Co	Transported observers and Evaluation Teams to forward area. Drove observers through Sugar display area.	0.053	IIC3	
92nd TC Car Co, 2 Plt	General support at CDR.			
806th APU	General support at CDR.			
94th VFID	General support at CDR.			
562nd Staging Area Co, 4 Sections	General support at CDR.			
Food Service Personnel	General support at CDR.			

* See Appendix for shot abbreviations.

Table 14. Operation JANGLE, Air Force support participants with bone dose commitment less than 150 millirem.

<u>PROJECT/ UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>	
			<u>S*</u>	<u>U*</u>
4925th Test Gp (A)	Flew cloud sampling mission in B-29s (breathed 100% oxygen).		IB	IB
57th Strategic Recon Sq	Flew cloud tracking mission. Did not penetrate cloud.		IA	IA
4901st Support Wing (A)	Flew Project 2.1c-1 missions and other aerial survey missions.		IA	IA
4901st Support Wing (A)	Flew courier mission from ISAFB.		IA	IA

Table 15. Operation JANGLE, Desert Rock observers with bone dose commitment less than 150 millirem.

<u>PROJECT/ UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>	
			<u>S*</u>	<u>U*</u>
Service Observers (DR II)	Observed shot from 9 km south of GZ. Toured display area in bus on D+1.	0.053	IIC3	
Service Observers (DR III)	Toured display area in bus on D-1. Observed shot from 9 km south of GZ. Toured display area in bus on D+2.	0.142		IIC4

* See Appendix for shot abbreviations.

Table 16. Operation JANGLE, AFSWP project participants with bone dose commitment less than 150 millirem.

<u>PROJECT/ UNIT</u>	<u>ACTIVITY</u>	<u>D_{FB}</u>	<u>SHOTS/CODE (See Section 3 text)</u>	
			<u>S*</u>	<u>U*</u>
1.3a Free Air Shock	Suspended gauges from balloons in shot area prior to shot. Manned telemetry station approximately 13 km S of Sugar GZ.		IA	IA
1.3c Measurement of Free Air Blast Pressures	Dropped canisters from B-29s. Recorded data from telemetry station 8 km SW of GZ.		IA	
1.5b Time of Arrival of Earth Movement	Placed flash lamps at stations 30 to 180 m from GZ prior to shot. Photographed lamps from camera stations 2700 m E of GZ. Recovered film from cameras after R-hour.	3.0		IIC3
1.8b Air Weather Service Participation	Operated weather station at CP and several off-site locations.		IA	IA
1.9b Base Surge Analysis	Analyzed photos of test.			IA
2.1c-1 Aerial Survey of Distant Contaminated Terrain	Tested airborne radiac for terrain surveys.		IA	IA
2.1c-2 Aerial Survey of Local Contaminated Terrain	Tested airborne radiac for terrain surveys.		IA	IA
2.3-1 Total Gamma Radiation Dosage	Recovered dosimeters from stations 300 m to 15 km in various directions from GZ on D+2	3.0	IIB4**	IIB4**
2.3-2 Foxhole Shielding of Gamma Radiation	Recovered dosimeter from foxholes, 610-1530 m NE of GZ on D+2.	3.0	IIB4**	IIB4**
2.4b Gamma Depth Dose in Unit Density Material	Recovered instrumented phantoms from stations 690-1070 m SW of Sugar GZ and 460-910 m WSW of Uncle GZ on shot day.	3.0	IIC2	IIC2
2.5a-2 Fallout Particle Studies	Recovered samples from fallout trays and air samples 610-6100 m NE of GZ.	3.0	IIB3**	IIB3**
	Recovered samples from GZ area using grappling hooks from helicopters.	3.0	IIA1	IIA1
2.5a-3 Radiochemical Studies of Large Particles	Analyzed Project 2.5a-1 samples.		IA	IA
2.6a Remotely Controlled. Sampling Techniques	Collected soil samples from crater and lip area with weasel controlled remotely from station 1830 m from GZ. Removed samples from weasel at shield 4 miles upwind from GZ on shot day.	3.0	IIB2	IIB2

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 16. Operation JANGLE, AFSWP project participants with bone dose commitment less than 150 millirem (Concluded).

PROJECT/ UNIT	ACTIVITY	D _{FB}	SHOTS/CODE (See Section 3 text)	
			S*	U*
2.6c-2 Nature and Distribution of Residual Contamination II	Analyzed samples collected by Project 2.6a.		IA	IA
2.7 Biological Injury from Particle Inhalation	Recovered dogs and sheep from stations 760, 1530, and 2440 m NE to NW of GZ at H+6.	3.0	IIB2	
	Recovered dogs and sheep from stations 760, 1530, and 2440 m N to NW of GZ (some at H+6, rest at H+24).	3.0		IIB3
4.1 Aerial Technical Photography	Took photos from C-47 aircraft.		IA	IA
4.1a-1 Ground Technical Photography	Recovered film and cameras from the following stations beginning at H+3 and H+23.5: 4570 m SE, 3000 m NE, 2470 m E, 2440 m NW, and 1520 m SE.	3.0		IIC3
	Recovered film and cameras from the following stations beginning at H+3: 4570 m SW, 4270m SE, 3000 m NE, 2740 m SE, 1520 m SE, 1460 m SE, 1370 m SE, and 640m S.	3.0	IIC3	
4.1a-2 Photographic Analysis	Analyzed photos at remote location.		IA	IA
6.1 Evaluation of Military Radiac	Evaluated various radiac equipment on shot day.	3.0	IIC2	IIC2
6.4 Indirect Bomb Damage Assessment	Recorded data from aircraft over shot area.			IA
6.8 Evaluation of Field Water Supply	Retrieved water sample from open tank 460 m NE of Sugar GZ at H+6. Collected 70 pounds of dirt from crater lip at H+26 and used it to contaminate water for test.	4.99	IIB3**	
7.1a Transport of Radiation Debris	Tracked radioactive cloud using data received from B-29 cloud tracker (see Air Force Support).		IA	IA
7.1b Radiochemical Chemical, and Physical Analysis of Bomb Debris	Analyzed samples collected by cloud samplers (see Air Force Support).		IA	IA
7.3 Airborne Low-Frequency Sound	Manned off-site stations.		IA	IA
8.4 Technical Photography for IBDA (Project 6.4)	Took photos from Project 6.4 aircraft.			IA

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 17. Operation TUMBLER-SNAPPER, Desert Rock support personnel with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	DPR	SHOTS/CODE (See Section 3 text)								
			A*	B*	C*	D*	E*	F*	G*	H*	
CDR Headquarters	Command functions.	0.106**	III	III	III	III	III	III	III	III	IIA2
Instructor Gp	Presented orientation course. Accompanied troops through display areas.		III	III							
AFSMP Instructor Gp	Presented orientation courses, accompanied observer and maneuver troops in trenches. Conducted tours of display area on shot day.	3.0							IIC2	IIC2	
Hq & Hq Svc Co, 369th Engr Amph Spt Rgt***	General support at CDR.										
Shore Bn, 369th Engr Amph Spt Rgt (Co D-F)***	Construction of display areas (passed through fallout from Shot Easy).	0.056	IA	IA	IA	IA	IA	IA	IA	IA	IA
562nd TSAC (-Plt)	Provided transportation for observers to and from forward area.		IA	IA	IA	IA	IA	IA	IA	IA	IA
23rd Trans Trk Co	Provided transportation for maneuver troops and observers to and from forward area.		IA	IA	IA	IA	IA	IA	IA	IA	IA
31st Trans Trk Co***	Provided transportation for maneuver troops and observers to and from forward area.		IA	IA	IA	IA	IA	IA	IA	IA	IA
505th MP Bn, Co A	Controlled traffic on shot day.		IA	IA	IA	IA	IA	IA	IA	IA	IA
314th Sig Constr Bn Det	Installed wire and radiocommunications system in trench area. (Exposured to Easy fallout during preparation for Shot Fox.)	0.056	IA	IA	IA	IA	IA	IA	IA	IA	IA
504th Sig Base Maint Co Det	Operated PA systems in display area during tours on shot day.	3.0	III	III	III	III	III	III	III	III	IIC2 IIC2
Med Det, Sixth Army	Established first aid station in forward area parking lot.		IA	IA	IA	IA	IA	IA	IA	IA	IA
360th Army Band	General support at CDR.										

* See Appendix for shot abbreviations.

** For Shot George.

*** Participated in Shot George troop maneuver.

Table 18. Operation TUMBLER-SNAPPER, Air Force support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	DTB	SHOTS/CODE (See Section 3 text)										
			A*	B*	C*	D*	E*	F*	G*	H*			
4925th Test Gp (A)	Dropped nuclear device from aircraft.		IA	IA	IA	IA	IA						
4925th Test Gp (A)	Flew cloud sampling missions (crews breathed 100% oxygen) in support of Program 13.		IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB
4925st Test Gp (A)	Flew aerial survey missions.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4925th Test Gp (A)	General support at ISAFB (except decon).		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4925th Test Gp (A)	Trained Task Group 132.4 pilots in cloud sampling techniques (crews breathed 100% oxygen).		IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB
4901st Support Wg (A)	Flew cloud tracking missions. (Did not penetrate cloud.)		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
55th Weather Recon Sq	Flew cloud tracking missions. (Did not penetrate cloud.)		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4901st Support Wg (A)	Flew courier missions.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4901st Support Wg (A)	Flew disaster control missions in support of drop aircraft.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4901st Support Wg (A)	General support at Kirtland AFB (except decon).		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

Table 19. Operation TUMBLER-SNAPPER, maneuver troops and observers with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	D _{FB}	SHOTS/CODE (See Section 3 text)								
			A*	B*	C*	D*	E*	F*	G*	H*	
Maneuver Troops (Shot Charlie)	Observed shot from trenches 6400 m S of GZ. Advanced on foot to display area SW of GZ, then to paratroop drop area NNW of GZ.				III						
Paratroops (82d AB Div) (Shot Charlie)	Parachuted to area NNW of GZ. Advanced south on foot and joined BCT.				III						
Maneuver Troops (Shot Dog)	Observed shot from trenches 6400 m S of GZ. Toured display areas 2 and 3. Maneuver cancelled due to high radiation levels.				III						
Maneuver Troops (Shot George)	Observed shot from trenches 6400 m S of GZ. Advanced on foot behind tanks to 0.5 M/hr line S of GZ, then toured display area on shot day.	0.106									IIA2
Service Observers (Shot Charlie)**	Observed shot from trenches 6400 m S of GZ. Toured display area on shot day.				III						
Service Observers (Shot Dog)**	Observed shot from trenches 6400 m S of GZ. Toured display areas 2 and 3 on shot day.				III						
Service Observers (Shot Fox)**	Observed shot from trenches 6400 m SE of GZ. Performed rifle tests and completed psychological tests and toured display area on shot day.	0.126									IIC2
Service Observers (Shot George)**	Observed shot from trenches 3200 m SW of GZ and toured display area on shot day.	0.028									IIC2
CDR Observers	Observed shot from point near CP.				IA						
Strategic Air Command Observers	Viewed shot from B-50 aircraft.		IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

** Some CDR support troops also participated.

Table 20. Operation TUMBLER-SNAPPER, AFSWP project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)								
		A*	B*	C*	D*	E*	F*	G*	H*	
1.1 Measurements of Free Air Blast Pressures	Dropped instrumented canisters from B-29s over GZ.					IA				IA
1.1 Measurements of Free Air Blast Pressures	Manned telemetry/tracking stations least 11 km S, SE, and SW of GZ.					IA				IA
1.1 Measurements of Free Air Blast Pressures	Recovered instruments from underground station 1830 m E of GZ on D+1. (Retrieval of canisters not considered).									IA
1.2 Air Pressure vs Time	Recovered blast gauges from blast line on shot day and D+1.	III	III	III	III					
1.3 Ground-level Pressure Measurements	Recovered data from instrument trailer and blast gauges from blast line on shot day and D+1.	III	III	III	III					
1.5 Free-Air Pressure Measurements	Photographed rocket trails from remote location, inspected, retrieved rocket launchers after shot.	III	III	III	III					
1.6 Ground Acceleration Measurements	Recovered buried accelerometers from blast line on shot day and D+1.	III	III	III	III					
1.7 Earth Acceleration vs Time	Recovered buried accelerometers from blast line of shot day and D+1.	III	III	III	III					
1.9 Pre-Shock Dust	Recovered air samplers from GZ area on shot day.	III	III	III	III					
1.13 Measurement of Air Blast Pressure vs Time	Recovered gauges and film from GZ area.		III	III	III					
2.1 Total Gamma Exposure vs Distance	Retrieved film packets from GZ area on shot day.	III	III	III	III	III	III	III	III	IIC2 IIC2 IIC2
2.2 Gamma Energy Spectrum of Residual Contamination	Took measurements with radiac meters in radiation fields up to 1.3 R/hr on shot day, D+1 and D+2.									IIC4 IIC4 IIC4 IIC4

* See Appendix for shot abbreviations.

Table 20. Operation TUMBLER-SNAPPER, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	Dyb	SHOTS/CODE (See Section 3 text)										
			A*	B*	C*	D*	E*	F*	G*	H*			
2.3 Neutron Flux and Energy Measurements	Retrieved neutron detectors from line 200-1030 m from GZ and assisted Project 17.1 personnel.			III	III	III	III						IICb
3.1 Vulnerability of Parked Aircraft	Recovered film and instrument data and inspected damage to aircraft in test area.		III	III	III	III							
3.3 Blast Damage to Trees	Inspected damage to trees planted in GZ area.			III	III	III	III						
3.4 Minefield Clearance	Inspected mine field in GZ area, replaced mines for next shot. Removed undetonated mines after Dog.			III	III	III	III						
4.2 Biomedical Exposure Equipment	Recovered film, test animals, and instruments from GZ area on shot day.				III	III	III						
4.2 Biomedical Exposure Equipment	Recovered film from cameras in Easy GZ area and inspected cages 90-180 m from GZ on shot day.	3.0										IIC2	
4.2 Biomedical Exposure Equipment	Recovered film from stations 550, 640, and 790 m SE of GZ on shot day.	3.0											IIC2
4.3 Biological Effectiveness of Neutron Radiation	Recovered mice from stations 90-1010 m from Charlie GZ and 780-1330 m from Dog GZ on shot day.				III	III	III						
4.3 Biological Effectiveness of Neutron Radiation	Recovered mice and neutron detectors from station 870 m SE of GZ on shot day.	3.0											IIB2
4.4 Gamma Depth Dose Measurements in Unit Density Material	Recovered dosimeters placed in lucite spheres not less than 1 km from GZ on shot day.	3.0			III	III	III	IIC2					IIC2
4.5 Flash Blindness	Witnessed detonation from trailer 15 km SW of GZ.				IA	IA							
6.1 Evaluation of Military Radiac	Recovered dosimeters from stations 910-2750 m from GZ on shot day.	3.0	III		III	IIC2	IIC2	IIC2	IIC2	IIC2	IIC2	IIC2	IIC2

* See Appendix for shot abbreviations.

Table 20. Operation TUMBLER-SNAPPER, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	D ₇₅	SHOTS/CODE (See Section 3 text)										
			A*	B*	C*	D*	E*	F*	G*	H*			
6.1 Evaluation of Military Radiac	Took radiation measurements on D+1 in areas where intensity was 8.0 R/hr on shot day.	3.0									IIC3	IIC3	
6.1 Evaluation of Military Radiac	Performed aerial survey of shot area from LC-126 about 30 minutes after the detonation.												IA
6.3 Evaluation of Filtration System for Pressurized Aircraft	Flew through clouds in pressurized B-29s. (Removal of filters by ground crews not included).					IB	IB	IB	IB	IB			IB
6.4 IBDA	Flew simulated bomb runs in formation with drop aircraft. One aircraft intentionally penetrated cloud at Shot Fox (crew breathed 100% oxygen).		IA	IA	IA	IA	IA	IA	IA	IA			IB
6.7 Evaluation of Air Monitoring Instruments	Recovered air samplers from stations 8-10.5 km from GZ. Radiation intensities ranged from background to 5.0 R/hr during recovery at H+8 hr.	3.0										IIC2	IIC2 IIC3
7.1a Electromagnetic Effects	Manned on-site stations at Yuoca Lake and off-site stations throughout world.								IA	IA	IA	IA	IA IA
7.1b Long-range Light Measurements	Manned off-site stations throughout US.								IA	IA	IA	IA	IA IA
7.2 Detection of Low Frequency Sound	Manned off-site stations throughout US.								IA	IA	IA	IA	IA IA
7.3 Radiochemical and Physical Analysis of Atomic Bomb Debris	Analyzed samples collected by cloud samplers (see Air Force Support).								IA	IA	IA	IA	IA IA
8.1 Effects on Forest Fuels	Recovered samples from GZ area.												III III
8.2 Air Temperatures in Vicinity of Detonation	Recovered thermal detectors from stations along blast line.												III III III III

* See Appendix for shot abbreviations.

Table 20. Operation TUMBLER-SNAPPER, AFSWP project participants with bone dose commitment less than 150 millirem (Concluded).

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)												
		A*	B*	C*	D*	E*	F*	G*	H*	D _{FB}				
8.3 Thermal Radiation from Nuclear Detonation	Recovered instruments from stations along blast line.	III	III	III	III									
8.3a Thermal Radiation Measurements Using Passive Detectors	Recovered detectors from stations along blast line.			III										
8.4 Atmospheric Transmissions and Weather Measurements	Collected meteorological data prior to shot. Collected data from receiving station at BJJ after shot. Assisted Project 8.3a retrieve instruments.		IA	III	IA									
8.5 Incendiary Effects on Building Sections	Inspected and recovered structures located in Gz area.			III	III									
8.6 Sound Velocity Changes Near Ground	Retrieved instruments from Gz area.	III	III	III	III									
8.7 Thermal Radiation Measurements	Trained UCLA personnel in use of thermal radiation measurement equipment and collected data recorded in Bldg. 400, near Cp.									IA	IA	IA	IA	
9.1 Technical and Training Photography	Provided photographic support to technical projects.	III	III	III	III					IICb	IICb	IICb	IICb	
9.2 Air Weather Service Participation	Operated on-site and off-site weather stations and compiled data for forecasts in support of operation.	IA	IA	IA	IA					IA	IA	IA	IA	IA
9.2 Air Weather Service Participation	Recovered data from wind and humidity measurement stations on blast line on shot day. Recovered instruments on D+1.	III	III	III	III					3.0	IIB3	IIB3	IIB3	
9.4 Effects on the Ionosphere	Operated on-site transmitter station 910 m N of Cp and other transmitter/receiver stations off-site.	IA	IA	IA	IA					IA	IA	IA	IA	
9.5 Electromagnetic Radiation Over the Radio Spectrum	Operated two on-site stations 16-25 km from Gz and two off-site stations.	IA	IA	IA	IA					IA	IA	IA	IA	

* See Appendix for shot abbreviations.

Table 21. Operation TUMBLER-SNAPPER, other project participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>DTB</u>	<u>SHOTS/CODE (See Section 3 text)</u>							
			<u>A*</u>	<u>B*</u>	<u>C*</u>	<u>D*</u>	<u>E*</u>	<u>F*</u>	<u>G*</u>	<u>H*</u>
10.2 Test of Scintillator Optical Path Technique	Took measurements from remote location.						IA	IA		
18.1 Total Thermal Radiation and Atmospheric Transmission	Recovered brightness meter from Area 2.						II Ca	II Ca	IA	II Ca
18.3 Color Temperatures	Took measurements at CP.						IA		IA	IA
18.4 High-Resolution Spectroscopy	Took measurements at CP.						IA	IA	IA	IA
19.2a+b Blast-wave Material Velocity Measurements	Recovered 90 mm gun from GZ area.						II Ba			II Ba

* See Appendix for shot abbreviations.

Table 22. Operation UPSHOT-KNOTHOLE, Desert Rock support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)											
		D _{7B}	A*	N*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C
CDR Headquarters	Command functions.	6.0	III	IIC2			IIC2	IIC2	III				III
Control Group	Supervised troop activities in forward area on shot day.	6.0	III	IIC2			IIC2	IIC2	III	III			III
Instructor Group	Accompanied observers in display area on shot day.	6.0	III	IIC2			IIC2	IIC2	III	III			III
26th Trans Trk Br** (Hq and Hq Co)	General support at CDR.												
23rd Trans Trk Co**	Transported observers, maneuver troops and control group to and from forward area on shot day.	6.0	III	IA			IIC2	IIC2	IA	IA			IA
31st Trans Trk Co**	Transported observers, maneuver troops and control group to and from forward area on shot day.	6.0	III	IA			IIC2	IIC2	IA	IA			IA
38th Trans Trk Co** (Det)	Transported observers, maneuver troops and control group to and from forward area on shot day.	6.0	III	IA			IIC2	IIC2	IA	IA			IA
53rd Trans Trk Co** (Det)	Transported observers, maneuver troops and control group to and from forward area on shot day.	6.0	III	IA			IIC2	IIC2	IA	IA			IA
50th Chem Serv Plt	Conducted radiological surveys and other rad-safe functions on shot day and subsequent re-entries into display areas no closer than 500 m from GZ.		III	IICb									III
77th Army Band**	General support at CDR.												
93rd Army Band	General support at CDR.												
94th Med Det (Food Insp)	General support at CDR.												
163rd QM Ldry Det**	General support at CDR.												

* See Appendix for shot abbreviations.

** Provided participants for troop maneuver at Shot Annie (see table 25).

NOTE: Some CDR Support troops observed Shots Encore and Harry (see table 24).

Table 22. Operation UPSHOT-KNOTHOLE, Desert Rock support participants with bone dose commitment less than 150 millirem (Concluded).

PROJECT/UNIT	ACTIVITY	SHOTS/CODES (See Section 3 text)											
		Dys	A*	M*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C
371st Evac Hosp** (SNBL)	Established forward area aid station in parking area. Airmen accompanied service observers.	6.0	III	IIC2				IIC2	IIC2	III	III	III	III
505th MP Bn (Co C)**	Controlled traffic to and from forward area on shot day. Accompanied Control Group in forward area.	1.4	III	IIC2				IIC2	IIC2	III	III	III	III
705th Eng'r Pld* Maint Plt	General support at CDR.												
762nd QM Sub Sup* Co	General support at CDR.												

* See Appendix for shot abbreviations.

** Provided participants for troop maneuver at Shot Annie.

Table 23. Operation UPSHOT-KNOTHOLE, Air Force support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODES (See Section 3 text)											
		Dys	A*	M*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C
4925th Test Gp (Atomic)	Dropped nuclear device from aircraft.					IA					IA		IA
4925th Test Gp (Atomic)	Flew cloud sampling missions in support of Projects 7.5 and 13.1 (breathed 100% oxygen).		IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB
55th Weather Recon Sq	Flew cloud tracking missions. Did not penetrate cloud.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4901st Support Wing	Flew courier and aerial survey missions.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4935th Air Base Sq.	General support at ISAFB (except decon).												
4905th Maint and Sup Sq.	Maintained UK project aircraft at Kirtland AFB (except sampler).												
4910th Air Base Gp	General support at Kirtland AFB (except decon).												

* See Appendix for shot abbreviations.

Table 24. Operation UPSHOT-KNOTHOLE, observers with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)												
		DP	A°	M°	Bu°	D°	Ra°	B°	S°	E°	E°	G°	C	
Service Observers (Shot Annie)	Observed shot from trenches 3200 m SSW of GZ. Toured display area on shot day.		III											
Service Observers (Shot Nancy)	Rehearsed and toured Annie display on D-2 (Annie + 5 days).		III											
Volunteer Observers (Shot Nancy)	Observed shot from trenches 3360 m SSW of GZ and toured Nancy display on shot day.	0.32		IIC2										
Volunteer Observers (Shot Nancy)	Observed shot from trenches 2290 m from GZ.	0.01		IIC1										
Service Observers (Shot Dixie)	Observed shot from Hees Mob (10 miles S of GZ).					IA								
Service Observers (Shot Ray)	Observed shot from Hees Mob (11 miles S of GZ).					IA								
Service Observers (Shot Badger)	Rehearsed and toured Nancy display area on D-1 (Nancy + 23 days).	0.04		IIC8										
Volunteer Observers (Shot Badger)	Observed shot from trenches 3660 m SSW of GZ. Toured Badger display on shot day.	1.4						IIC2						
Service Observers (Shot Simon)	Observed shot from trench 1830 m from GZ.	4.1						IIC1						
Service Observers (Shot Simon)	Toured Badger display area on D-2 (Badger + 5 days).	0.01						IIC6						
Volunteer Observers (Shot Simon)	Observed shot from trenches 3660 m S of GZ. Toured Simon display area on shot day.	0.5								IIC2				
Service and CDR Observers (Shot Encore)	Observed shot from trench 1830 m from GZ.	3.6						IIC1						
Service and CDR Observers (Shot Harry)	Observed shot from trenches 9420 m SSW of GZ. Toured display area on shot day.									III				
Service Observers (Shot Harry)	Observed shot from trenches 3660 m SSW of GZ. Toured display area on shot day.												III	
Service Observers (Shot Grable)	Toured Marty display area on D-2 (Marty + 3 days).												III	
	Observed shot from trenches 4570 m SSW of GZ. Toured display area on shot day.													III

* See Appendix for shot abbreviations.

Table 25. Operation UPSHOT-KNOTHOLE, maneuver troops with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)											
		D ₇₅	A*	M*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C
Maneuver Troops (Shot Annie)	Observed shot from trenches 3200 m SSW of GZ. Advanced on foot to objective 1 km W of GZ and toured display area S of GZ on shot day.	0.6	III										
Maneuver Troops (Shot Nancy)	Observed shot from trenches 3660 m SSW of GZ. Advanced on foot toward objective 1-2 km W of GZ and toured display area SW of GZ on shot day.	2.2		IIC2									
1stBn, 8th Marines (Shot Badger)	Observed shot from trenches 3660 m SSW of GZ. Advanced toward objective until halted due to high radiation exposures shortly after detonation.	4.7										IIC1	
2dBn, 3rd Marines (-"E" Co) (Shot Badger)	Observed shot from trenches 3660 m SSW of GZ. Advanced to objective 2000 yd N of trenches toured display area before H+4.	3.0										IIC1	
2MCPAEB HQ (Shot Badger)	Led troops through display area by H+2.25.	3.7				IA	IA					IIC1	
Maneuver Troops (Shot Simon)	Observed shot from trenches 3660 m S of GZ. Advanced on foot toward objectives 1-2 km W of GZ and toured display area S of GZ on shot day.	3.1											IIC2
Maneuver Troops (Shot Encore)	Observed shot from trenches 9420 m SW of GZ. Advanced on foot and in helicopters to objective 1.5 km SE of GZ, advanced on foot to GZ and toured display area on shot day.												III
Maneuver Troops (Shot Grable)	Visited Harry display area on D-3 (Harry + 3 days).												III
USMC Helicopter Atomic Test Unit	Observed shot from trenches 4570 m W of GZ. Advanced on foot toward objectives 2-3 km SE of GZ and toured portion of display area on shot day.												III
USMC Helicopter Atomic Test Unit	Observed detonation from locations 8.5 to 20 km from GZ. Flew to GZ area shortly after shot. Conducted radiological survey.	2.6	IIAI	IIAI		III	IIAI	IIAI	IIAI	III	IIAI	IIAI	III

* See Appendix for shot abbreviations.

Table 26. Operation UPSHOT-KNOTHOLE, AFSWP project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)												
		Dyb	A	N*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C	
1.1a/1.2 Air Blast Measurements	Recovered data from underground recording stations 2130 + 3500 m from GZ on shot day. Recovered gauges later.								III					III
	Recovered rocket launchers from GZ area.		III			III							III	III
1.1a-1 Evaluation of Miancho & Vibrotron Gauges	Recovered data from underground recording stations 2130 + 3500 m from GZ on shot day. Recovered gauges later.								III				III	III
1.1b Air Pressure & Ground Shock Measurements	Recovered records from instrument station on blast line on shot day. Recovered gauges on shot day.	3.9			IIB2	III							III	III
1.1c-1 Air Shock Pressure/Time vs Distances	Recovered gauges/data from stations 210 to 2380 m NNM of Annie GZ and 500 and 700 m N, NE and E of Simon GZ.		III						IIBa**					
1.1c-2 Air Shock as Affected by Hills and Dales	Recovered data from instrument station 6 km west of GZ on shot day.												IA	
1.1d Dynamic Pressure versus Time	Retrieved records from recording stations on shot day.												III	III
1.3 Free-air Blast Measurements	Dropped instrument canisters from B-29 aircraft upwind from shot.					IA							IA	
1.3 Free-air Blast Measurements	Manned receiver stations east of Yucca Lake and north of CP during shot. Retrieved canister several days after shot.												III	
1.4 Free-field Measurements of Earth Stress/Motion	Retrieved data from recording station on blast line on shot day. Retrieved gauges later.		III										III	III
2.2a Gamma Spectrum of Residual Contamination	Took measurements with radiac instruments in radiation field.				IICb	IICb			IICb	IICb			IICb	III
2.2b Residual Ionizing Depth Dose Measurements in Unit Density Material	Placed dosimeters in radiation field and retrieved them no later than D+2.	3.9							IIC4	IIC4			IIC4	III

* See Appendix for shot abbreviations

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 26. Operation UPSHOT-KNOTHOLE, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)											
		D _{7B}	A*	N*	Ru*	D*	Ru*	B*	S*	E*	B*	C*	C
2.3 Neutron Flux Measurements	Recovered neutron detectors from cable dragged from GZ area and from stakes at least 700 m from GZ on shot day.									III	III	III	III
3.1 Loading of Building and Equipment Shapes	Inspected structures and equipment in GZ area for damage and recovered instrument records.									III			III
3.1a Shock Diffraction in Vicinity of Structures	Recovered instrument readings from GZ area.									III			III
3.3 Tests on Loading of Horizontal Cylinder Shapes	Inspected cylinders located at least 1460 m from GZ and recorded gauge data.									III			III
3.4 Tests on Loading of Truss Systems	Inspected structures located at least 670 m from GZ and retrieved gauge data.									III			III
3.5 Tests on Response of Wall & Roof Panels	Inspected structures located at least 670 m from GZ and retrieved gauge data.									III			III
3.6 Loading and Response of Railroad Equipment	Inspected railroad equipment (locomotive and cars) located 460-2010 m from GZ.												III
3.7 Air Blast Effects on Entrances and Intakes on Underground Structures	Inspected entrances, intakes and filters in underground structure located 290 m from GZ.									III			III
3.8 Air Blast Effects on Underground Structures	Inspected three underground structures located 280 m from GZ.									III			III
3.9 Field Fortification	Inspected field fortifications and retrieved data from stations 150-2440 m from GZ.									III			III
3.11-3.16 Navy Structures	Inspected buildings and retrieved data 820-6100 m from GZ.									III			III

* See Appendix for shot abbreviations.

Table 26. Operation UPSHOT-KNOTHOLE, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)												
		D _{YB}	A*	N*	Ru*	D*	Ra*	B*	S*	E*	H*	C*	C	
3.18 Minefield Clearance	Inspected minefield 820 m from GZ. Detonated undetonated mines.												III	
3.19 Blast Damage to Tree Stands	Inspected tree stand 2000 m from GZ and tree line 460-2440 m from GZ. Recovered gauge data.								III				III	
3.20 Blast and Thermal Effects on Tactical Communications Equipment	Inspected communications equipment (poles, lines, radios, etc) 90-4570 m from GZ.								III				III	
3.21 Statistical Estimation of Damage to Ordnance Equipment	Inspected tanks, trucks, jeeps and guns 270-2000 m from GZ. Recovered and uprighted equipment on D-2.								III				III	
3.22 Effects on Engineer Bridging Equipment	Inspected bridge spans 320-1340 m from GZ. Retrieved gauge data.								III				III	
3.24 Effects on Tracked Landing Vehicles	Inspected and recovered film badges from vehicles 240-1370 m from GZ.								III				III	
3.76 Effects on POL Installations	Inspected various POL equipment (drums, tanks, etc) 70-3110 m from GZ.								III				III	
3.27 Effects on Field Medical Installations and Equipment	Inspected medical installation and equipment located 1270-4570 m from GZ.								III				III	
3.28.1 Structures Instrumentation	Retrieved and reduced blast data from Program 3 projects.								III				III	
3.28.2 Pressure Measurements for Program 3 Projects	Retrieved and reduced pressure data for Program 3 projects.								III				III	
3.28.3 Pressure Measurements on Structures	Retrieved data from underground recording station (Project 3.1) 1500 m from GZ.								III				III	

* See Appendix for shot abbreviations.

Table 26. Operation UPSHOT-KNOTHOLE, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	D ₇₈	SHOTS/CODE (See Section 3 text)														
			A*	N*	RU*	D*	RA*	B*	S*	E*	H*	G*	C				
3.29 Blast Effects on Walls and Partitions	Inspected structures located 1340 and 2020 m from GZ.													III			
4.2 Direct Air Blast Exposure Effects in Animals	Recovered test animals and equipment from GZ area (290-470 m) on shot day.	3.9												III	IIB2	III	III
4.5 Ocular Effects of Thermal Radiation	Viewed detonation from trailer at least 10 km from GZ.		IA	IA											IA		
	Recovered test animals (rabbits) from site at least 3 km from GZ on shot day.	3.9	IIB2	IIB2											IIB2		
4.7 Beta-Gamma Skin Hazard in Pout Shot Contaminated Area	Took radiation measurements in GZ area on shot day using thin-walled ion chamber.	3.9													IIC2	III	III
4.8 Bio-effects of Neutrons	Recovered test animals (mice) from 14 stations 450-1800 m SSE of GZ on shot day.																III
5.1 Effects on AD Aircraft in Flight	Flew over detonation (did not penetrate cloud).		IA	IA											IA	IA	IA
	Manned ground control station near CP. Recovered test panels 1.2-2.2 km from GZ on shot day (Encore).		IA	IA											IA	III	IA
5.2 Effects on B-50 Aircraft in Flight	Two B-50s flew in formation with drop aircraft.														IA		
5.3 Blast Effects on B-36 Aircraft in Flight	Flew B-36 in formation with drop aircraft. Did not penetrate cloud.														IA		
6.2 Indirect Bomb Damage Assessment (IBDA)	B-29 aircraft orbited at least 8 km from GZ. Did not fly through or under cloud.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Manned radar transmitter/receiver stations 9-11 km from GZ. Shut down un-manned stations after shot no later than D+1.	3.9	IA	IIC3	IIC3	III	IIC3	IIC3	IIC3	IIC3	IIC3	IIC3	IIC3	III	IIC3	III	III
6.3 Interim IBDA Capabilities of SAC	Flew over test site (did not fly through or under cloud).		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

Table 26. Operation UPSHOT-KNOTHOLE, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	D ₇₀	SHOTS/CODE (See Section 3 text)														
			A*	N*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C				
6.4 Evaluation of Chemical Dosimeters	Recovered dosimeters from 8 stations (location unknown) not later than D+1.	3.9										IIB3				IIB2	
6.8 Evaluation of Military Radiac Equipment	Performed radiation surveys with experimental radiac equipment on shot day.	3.9	IIC2	IIC2		III		IIC2	IIC2	III						IIC2	
6.8a Initial Gamma Exposure versus Distance	Recovered dosimeters at varying distances from Gz on shot day.	3.9	IIC2	IIC2	IIC2		IIC2	IIC2	IIC2	III						IIC2	III
6.9 Evaluation of Naval Airborne Radiac Equipment	Took radiation measurements from aircraft. Dropped dosimeters with telemetry into area. (Retrieval not documented.)		IA	IA	IA		IA	IA								IA	IA
6.10 Evaluation of Rapid Aerial Radiological Survey Technique	Took radiation measurements from aircraft.		IA	IA			IA	IA	IA	IA	IA					IA	IA
6.11 Indoctrination of TAC Aircrews	Flew T-33s in formation with drop aircraft.								IA							IA	
6.12 Determination of Height of Burst and Ground Zero	Operated various sensors located 13-60 km from GZ from station at least 13 km from GZ.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.13 Effectiveness of Fast Scan Radar for Fireball Studies	Operated radar from station approximately 11 km from GZ.									IA	IA	IA	IA	IA	IA		
7.1 Electromagnetic Effects of Nuclear Explosions	Manned stations on-site (14-22 km from GZ) and off-site throughout US.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
7.3 Detection of Airborne Low Frequency Sound	Operated remote stations throughout world.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
7.4 Seismic Measurements	Manned stations throughout US. Turned off equipment and recovered records from un-manned station in Yucca Flat on shot day.	3.9	IA	IA	IA	IA	IA	IA	IA	IIC2	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

Table 26. Operation UPSHOT-KNOTHOLE, AFSWP project participants with bone dose commitment less than 150 millirem (Concluded).

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)											
		D _{7B}	A*	M*	Ru*	D*	Da*	B*	S*	E*	H*	C*	
8.11a Incendiary Effects on Building and Interior Kindling	Inspected demonstration houses and test material in GZ area on shot day.									III			III
8.11b Ignition and Persistent Fires	Inspected test materials in GZ area on shot day.				III					III			III
8.12a Sound Velocities Near Ground	Inspect and collect data from instruments in GZ area on shot day.	3.9						IIB2	III				III
8.12b Supplementary Pressure Measurement	Retrieved data from GZ area (460-920 m) on shot day.									III			III
8.13 Study of Fire Retardant Paint	Inspected test panels in GZ area several days after shot.									III			
9.1 Technical Photography	Took photographs in support of projects.		IICb	IICb	IICb	III	IICb	IICb	IICb	III	IICb	III	III
9.6 Product Stabilization	Inspected treated area near GZ on shot day.									III			III
9.7 Experimental Soil Stabilization	Inspected treated area near GZ on shot day.									III			III

* See Appendix for shot abbreviations.

Table 27. Operation UPSHOT-KNOTHOLE, other project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)												
		D _{7B}	A*	N*	Ru*	D*	Ra*	B*	S*	E*	H*	G*	C	
13.1 Radiochemistry Sampling	Flew through clouds to collect samples (crew on 100% oxygen).		IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB
18.3 Spectroscopy	Operated spectrometers in Bldg. 400 near CP. Retrieved film from close in station (3 km from GZ) on shot day.	3.9	IA	IA	IA	IA	IA	IIC2	IA	IA	IA	IA	IA	
23.1 Biological Effectiveness of Ionizing Radiation within Shelters	Retrieved test animals from earth protected shelters near GZ on shot day.	3.9	III		IIB2	III				III	IIB2		III	
23.2 Bacteriological Studies on Animals Exposed to Neutron Radiation	Retrieved test animals from earth protected shelters near GZ on shot day.	3.9	III		IIB2	III				III	IIB2		III	
23.3 Long-Term Studies on Dogs Exposed to Neutron	Retrieved test animals from earth protected shelters near GZ on shot day.	3.9	III		IIB2	III				III	IIB2		III	
23.17 Neutron Flux Measurements in AEC Shelters and Lead Hemispheres	Retrieved detectors from shelter used for Projects 23.1, 23.2, and 23.3, and other stations in GZ area on shot day.	3.9	III		IIB2	III				III	IIB2	III	III	
27.1 Distribution and Characteristics of Fallout at Distances Greater Than 10 Miles	Collected samples and conducted radiological surveys.	3.9		IIB3	IIB3	IA		IIB3	IIB3					
29.1 Comparison and Evaluation of Dosimetric Methods - Gamma	Took radiation measurements in and retrieved dosimeter from shot area.	3.9				III	IIC3	IIC5	IIC5	III	IIC3	III	III	

* See Appendix for shot abbreviations.

Table 28. Operation TEAPOT, Desert Rock support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)														
		D _{TR}	W*	Mo*	Te*	Tu*	H*	B*	E*	A1*	W1*	HA*	P*	ME*	A2*	Z*
CDR Headquarters	Command functions.															
Control Gp	Supervised troop activities in forward area.	6.0	IA	IA	IIC1**	IIC3	III	IA	III	III				IA	IIC1	
Instructor Gp	Presented orientation courses and accompanied troops during tours of display areas.	6.0	IA	IA	IIC1**	IIC3	III	IA	III	III				IA	IIC1	
505th MP Bn	Controlled traffic to and from forward area on shot day.	0.15	IA	IA	IIC1**	IIC3	III	IA	III					IA	IIC1	
95th Engr Bn	Pre-shot trench and test structure construction. Inspected/evaluated test structures after Shot MET (D-5 to 11).	0.123													IIB7	
26th Trans Bn	General support at CDR.															
23rd Trans Trk Co	Provided transportation for maneuver troops, observers and technical project personnel to and from forward area.	6.0	IA	IA	IIC1**	IIC3	IA	III	IA	III	IA	IA	IA	IA	IIC1	
31st Trans Trk Co	Provided transportation for maneuver troops, observers and technical project personnel to and from forward area.	6.0	IA	IA	IIC1**	IIC3	IA	III	IA	III	IA	IA	IA	IA	IIC1	
2nd Trans Trk Co	Provided transportation for maneuver troops, observers and technical project personnel to and from forward area.	5.0	IA	IA	IIC1**	IIC3	IA	III	IA	III	IA	IA	IA	IA	IIC1	
Evacuation Hosp (-)	General support at CDR and established aid station in observer trench area.	6.0	IA	IA	IA	IIC3	IA	IA	IA	IA	IA	IA	IA	IA	IA	
94th Med Det	General support at CDR.															
90th Repl Bn, Hq & Hq Det	General support at CDR.															
71st Repl Co	General support at CDR.															
53rd QM Co	General support at CDR.															
163rd QM Co	General support at CDR.															
433rd Army Band	General support at CDR.															

* See Appendix for shot abbreviations.
 ** Elements of category matrix are adjusted to shot specific values from table 2.
 NOTE: CDK Support troops may have witnessed one or more shots as CDR Observers (see table 30).

Table 29. Operation TEAPOT, Air Force support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)															
		DYR	W*	Mo*	Te*	Tu*	H*	B*	E*	Al*	W1*	HA*	P*	ME*	A2*	I*	
4925th Test Gp (A)	Dropped nuclear device from aircraft.		IA														
4935th Air Base Sq	Flew pre-shot security sweeps and provided general support at ISAFB (Aircraft decon not considered).																
4926th Test Sq (S)	Flew cloud sampling missions in support of Projects 11.2, 21.2 and 40.8 (Crew breathed 100% oxygen).	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB	IB
55th Weather Recon Sq	Flew cloud tracking missions in B-29s and B-50s. Did not penetrate cloud.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
4901st AB Wing**	Flew courier missions.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Flew terrain survey missions.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Flew cloud tracking missions in B-25s. Did not penetrate cloud.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

** Deceased 4900th Air Base Group on 5 May 1955.

Table 30. Operation TEAPOT, observers with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	D _{FB}	SHOTS/CODE (See Section 3 text)															
			M*	Mo*	Te*	Tu*	H*	B*	E*	A1*	M**	BA*	P*	ME*	A2*	Z*		
Service and CDR Observers (Shot Wasp)	Observed shot from News Mob, tour of display area cancelled.		IA															
Service and CDR Observers (Shot Moth)	Observed shot from trenches 2290 m SW of GZ. Returned to CDR shortly thereafter.		IA															
Service and CDR Observers (Shot Tesla)	Observed shot from trenches 2190 m SW of GZ. Toured portion of display area by H+2.	1.1			IIC1**													
Service and CDR Observers (Shot Turk)	Observed shot from trenches 5030 m SE of GZ. Toured display area on D+1.	1.24				IIC3												
Service Observers (Shot Bee)	Observed shot from trenches 3200 m SW of GZ. Toured display area shortly after shot.						III											
Service and CDR Observers (Shot Ess)	Observed shot from open area 8230 m SW of GZ. (Area was contaminated by Shot Turk fired 16 days earlier.) Returned to CDR after shot.	0.043							IA									
Service and CDR Observers (Shot Apple I)	Observed shot from trenches 3200 m SSW of GZ. Toured display area immediately after shot.									III								
CDR Observers (Shot MET)	Observed shot from open area 9330 m SW of GZ. Returned to CDR shortly after shot.												IA					
Service and CDR Observers (Shot Apple II)	Observed shot from trenches 3200 m S of GZ. Toured display area shortly after shot.	0.34																IIC1
VIP Observers (Shot Apple II)	Observed shot from trenches 4700 m SW of GZ. Did not tour display area.																	IA
Volunteer Observers (Shot Apple II)	Observed shot from trenches 2380 m S of GZ. May have toured display area after shot with service observers.	0.34																IIC1

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 31. Operation TEAPOT, maneuver and troop test participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)															
		D ₇₈	W*	Mo*	Te*	Tu*	H*	B*	E*	Al*	W*	HA*	P*	ME*	A2*	Z*	
40.16 Army Demolition Munitions	Emplaced and detonated the device. No post shot recovery/inspection activities documented. (May have observed shot with Service observers).																
40.18 Location of Atomic Bursts	Manned stations at least 8 km SE to SW of GZ during shot.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA		
41.1 Infantry Regimental Communications Test	Observed shot with Apple II Service observers. Went to posts located between 1.3 and 1.7 km S of GZ, 0.8 and 1.1 km E of GZ, and 2.2 km W of GZ shortly after shot to test and repair communications equipment. Returned to CDR at H+2 hours.	6.0															IYB1
41.2 Task Force RAZOR	Conducted helicopter supported armored (tanks and armored personnel carriers) maneuver and toured display area by H+4 hours.	1.8															IYAI
41.6 Marine Brigade Exercise (3rd MCPAEB)	Conducted air (helicopter airlift) and ground maneuver in old (Turk + 15 days) fallout field on shot day.	0.001												IA			
	Toured Bee display area on shot day.																III

* See Appendix for shot abbreviations.

Table 32. Operation TEAPOT, AFSWP project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)														
		D _{2R}	W*	Mo*	Te*	Tu*	H*	B*	E*	Al*	W1*	HA*	P*	ME*	A2*	Z*
1.1 Measurement of Free Air Blast Pressures	Recovered instrument canisters dropped from aircraft over shot area. (Turk & RA recoveries on shot day; Apple 1 recovery time presumed to be also.)	3.9				IIC2				IIC2		IA				
1.2 Shock Wave Photography	Recovered film from cameras placed at various distances from GZ.	3.9	III		IIB2**	IIB3		IIB2	IIBa	IIB	III	IA	IIBa	IIB2		
1.3 Microbarographic Pressure at Ground Level	Recovered data from recording stations near surface zero.											IA				
1.9 Material Velocity Measurements	Aircraft produced smoke trails just prior to detonation. Ground crews photographed distortion in trails due to shock wave.											IA				
1.11 Special Measurements of Dynamic Pressure	Recovered data and instruments from stations at least 4 km S and 6 km E of Turk GZ and 0.4-2.4 km W, W, and S of MET GZ. Recovery took approximately two days.					IIBb										IIBb
1.12 Drag Force Measurements	Recovered data and instruments from stations between 600 m and 1350 m south of GZ on shot day.	3.9														IIB2
1.13 Dust Density vs. Time & Distance	Recovered data and instruments from stations located 760 and 910 m S and W of GZ and 610 to 910 m S of GZ. Recovery activities took approximately 2 days.															IIBb
1.14a Transient Drag on Spherical Models	Performed activities similar to Project 1.12. Data and equipment recovery lasted approximately 10 days.															IIBc
2.1 Gamma Exposure vs. Distance	Recovered dosimeters (film packets) from several stations upwind from GZ on shot day. Recovered canisters dropped through cloud (Shot RA only).	3.9	III	IIC2*	IIC2**	IIC2	III	IIC2	IIC2	III	IA	III	III	IIC2		
2.2 Neutron Flux Measurements	Removed neutron detectors from stakes in GZ area and cable dragged from GZ area shortly after shot. Recovered canisters dropped through cloud (RA only).	3.9***	III	IIB1**	IIBa**		IIB1	IIB1		IIB1	III	IA	III	IIB1		

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values derived from table 2.

*** Does not include Shot Tesla dose. Code used for Tesla does not require specific dose information.

Table 32. Operation TEAPOT, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SHOTS/COCK (See Section 3 text)													
		Dm	W*	Mo*	Ts*	Tu*	B*	E*	A1*	W1*	BA*	P*	MS*	A2*	E*
2.2b Gamma Radiation Fields Above Contaminated Ground	Took radiation measurements at station 2300 m SE of GZ on D-9 and along NE-SW access road on D-16.														IICb
2.6 Radiation Absorbed by Human Phantoms	Placed instrumented mannequins in radiation fields up to 3.5 R/hr. Retrieved later.		III			IICa									IICa IICa
2.8a Contact Radiation Hazard from Contaminated Aircraft	Took radiation measurements at various distance from aircraft surfaces and removed film taped to aircraft surface.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA IA IA IA IA IA
2.8b Manned Penetration of Atomic Clouds	Flew T-33s through cloud. Crew breathed 100% oxygen.						IB								IB IB IB
3.2 Study of Drag Loading of Structures in Precursor Zone	Recovered data/instruments from concrete buildings located 1200-1800 m South of GZ on shot day.														IIC2
3.6 Evaluation of Earth Cover	Inspected and recovered data/instruments from 8 underground shelters located 460-900 m from GZ.														IIBb
3.7 Effect of Positive Phase Length of Blast	Inspected, photographed and recovered data from test structures at 4 locations, 1100-1750 m south of GZ.														IICb
3.8 Test of Concrete Panels	Inspected and recovered data from concrete panels located 1070 and 1480 m from GZ.														IICb
3.9 Response of Small Petroleum Tanks	Photographed and inspected damage to tanks.														IICb**
3.10 Structures Instrumentation	Recovered data/instruments from 16 test structures located 1000-1800 m south of GZ.														IIBb
5.1 Destructive Loads on Aircraft in Flight	Tracked aircraft from radar sites 18-27 km S of GZ. Flew CP-80 drones (unmanned) near Shots Bee & HBT detonation. Drones did not penetrate cloud; recovered at Indian Springs.						IA				IA				IA IA IA
5.2 Effects on Fighter Type A/C in Flight	Flew F-84 aircraft near detonation (slant range 4-8 km) aircraft did not penetrate cloud. Project 5.1 personnel tracked aircraft from ground station near CP.						IA	IA	IA	IA	IA				IA IA IA IA IA IA

* See Appendix for shot abbreviations.

** Elements of category code are adjusted to shot specific values from table 2.

Table 32. Operation TEAPOT, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)															
		D ₁	W ^o	Mo ^o	Te ^o	Tu ^o	H ^o	B ^o	E ^o	Al ^o	W ¹	HA ^o	P ^o	ME ^o	A2 ^o	I ^o	
6.1.1a Evaluation of Military Radiac Equipment	Field tested radiac equipment and recovered dosimeters from stations 900-2700 m from Gz on shot day.	3.9	III			IIC2	IIC2	IIC2	IIC2	IIC2							IIC2
6.1.1b Evaluation of Radiological Defense Warning System	Recovered detector systems from stations located outside of contaminated areas.		IA	IA	IA	IA	IA	IA									
	Tested radiac equipment in 5-10 R/hr field on shot day and D+1.	3.9					IIC3			IIC3							
6.1.2 Accuracy of Military Radiacs	Tested radiac equipment in 3-4 R/hr fields on shot day.	3.9								IIC2	IIC2						IIC2
6.2 Effects on Selected Components and Systems	Recovered test equipment from positions 400-500 m from Gz.										IICb						IICb
6.3 Missile Detonation Locator	Manned station in California.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.4 Test of IBDA Equipment	Tested IBDA equipment in aircraft near shot area. Did not penetrate cloud.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.5 Test of Airborne Naval Radars for IBDA	Tested IBDA equipment in aircraft near shot area. Did not penetrate cloud.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
8.1 Measurement of Direct and Ground-Reflected Thermal Radiation	Flew aircraft in vicinity of shot (slant range at least 3.4 km). Turned away from shot shortly after detonation. Ground crews tracked aircraft from radar station south of Gz.																
8.4a Thermal Measurements from Aircraft in Flight	Took thermal radiation measurements in delivery aircraft. Aircraft did not penetrate cloud.																IA
8.4b Thermal Measurements from Fixed Ground Installations	Recovered data/instruments from stations near Gz.		III	IIBa**	IIBa**					IIBa	IIBa						IIBa
8.4c Thermal Measurements Prior to First Minimum	Took measurements from delivery aircraft and/or Bldg. 410 near Control Point.		IA														IA
8.4d Spectrometer Measurements	Took measurements in Bldg. 410 near CP except at Shot Apple 1 when measurements were taken at station 7.5 km from Gz.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 32. Operation TEAPOT, AFSWP project participants with bone dose commitment less than 150 millirem (Concluded).

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)														
		D ₇₂	W ^o	Mo ^o	Te ^o	Tu ^o	B ^o	B ^o	E ^o	Al ^o	M ^o	HA ^o	P ^o	ME ^o	A2 ^o	I ^o
8.4f Bolometer Measurements	Took measurements in Bldg. 410 near CP.		IA	IA	IA	IA	IA	IA			IA	IA	IA			
9.1 Technical Photography	Photographed detonation from MC-47 aircraft. (B-50 at HA).		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA		IA
	Photographed damage to equipment in shot area.	3.9			IIC6											
	Manned ground stations at least 10 km from GZ.					IA				IA						
9.4 Atomic Cloud Growth Study	Took theodolite measurements from CP areas. Photographed cloud from aircraft and/or ground stations at least 9 km from GZ.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
9.6 Weather Reconnaissance	Flew pre-shot weather recon mission in F-84.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.
 ** Elements of category matrix are adjusted to shot specific values from table 2.

Table 33. Operation TEAPOT, technical service project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)														
		D ₂₄	W*	Mo*	Te*	Tu*	H*	B*	E*	A1*	W1*	HA*	P*	ME*	A2*	Z*
40.9 Navy Passive Defense Training	Observed Shot Bee from trenches 3200 m SW of GZ. Did not tour display area.											IA				
	Observed Shot Ess from trenches 8200 m SW of GZ and established 0.25 and 2.5 R/hr lines on shot day.	0.49														IIC2
	Conducted simulated rescue exercises in contaminated area on D+1.	0.22														IIB3
	Conducted simulated rescue exercises in contaminated area on D+3.	0.60														IIB5
40.14 Chemical, Biological and Radiological Defense Shelter Tests	Inspected field bunker 430 m from GZ on shot day. Some digging required.	6.0														IIB2
40.15 Engineer Field Fortification and Equipment Tests	Inspected field fortifications 300-420 m from GZ.															IIBb
40.15a Engineer Heavy Equipment Test	Inspected heavy equipment placed in trenches 480-810 m from GZ.															IIBb
40.17 Effects on Steel Transporters or Containers	Inspected various cargo packages placed at stations 1020-2510 m from MET GZ and 500-880 m from Apple II GZ.															IYBb IICb
40.20 Clothing Test	Inspected and recovered clothing from 9 mannequins located 1800-3300 m from GZ.															IIBb
40.21 Ordnance Vehicular Equipment Test	Inspected ordnance equipment as close as 500 m from GZ.		III	IICa**		IICa	IICa	IICa	IICa	IICa	IICa	IICa	IICa	IICa		IICa
Damage Effects Evaluation	Inspected weapons, emplacements, and vehicles as close as 500 m from GZ.															IICa**

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 34. Operation TEAPOT, training project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)																
		DZ	W*	Mo*	Te*	Tu*	H*	B*	P*	HA*	W1*	W2*	HA*	P*	MS*	A2*	Z*	
40.1 Evaluation of IBDA Equipment and Techniques	Checked equipment during simulated bomb drop missions in B-47s over GZ area (34,000-40,000 feet) at shot time.				IA													
40.2 Crew Indoctrination (SAC)	Observed detonation from KC-97 about 10 miles south of GZ.																	IA
40.3 Crew Indoctrination (TAC)	Flew simulated bomb delivery missions in F-84s over GZ area at shot time. Ground support crew manned radar station south of GZ.			IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
40.4 Gust Effects on B-36	Flew simulated bomb delivery mission in B-36 over GZ at shot time.																	IA
40.5 Reconnaissance Crew Indoctrination	Photographed cloud from B-47s at 43,000-47,000 feet over GZ area.																	IA
40.5a Location of EMP	Monitored detonation from off-site remote location.																	IA
40.6 Calibration of Electromagnetic Effects	Manned stations at least 10 km from GZ at shot time. Recovered data from unmanned recording stations 10-20 km from GZ.																	IA
40.8 Calibration of Bomb Debris	Analyzed samples collected by Project 11.2 aircraft.																	IA
40.10 Delivery Crew Indoctrination	Flew simulated weapons delivery maneuvers at 24,000-34,000 feet above GZ. Did not penetrate cloud.																	IA
40.12 Delivery Crew Indoctrination (Dive Bomb)	Simulated dive bomb maneuver over GZ at shot time.																	IA
40.13 Tactical Indoctrination Marine Aircrew	Observed shot from aircraft at least 35 km from GZ.																	IA
40.23 Crew Indoctrination (ADC)	Observed shot from aircraft 25 km SE of GZ.																	IA
40.24 Crew Indoctrination (ARDC)	Flew F-100s at 50,000 feet over GZ at shot time.																	IA

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 35. Operation PLUMBBOB, Desert Rock support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	MONTHS/COMS (See Section 3 text)																									
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
CDR Headquarters	Command functions.																										
293rd MP Co	Provided traffic control to forward areas on shot day. Accompanied monitors to establish 2J mt/hr line on contaminated access roads.	5.0	IA																								
212nd Sig Co	Established and maintained communications network (laid wire, etc) in forward area. Signal pictorial teams took photos in display areas.																										
24th Trans Bn (-) Bq and Hq Co	General support at CDR.																										
38th TC Co (RV)	Transported maneuver troops, observers and technical project personnel to and from forward area.	5.0	IA	IA	IA	VI	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III
511st TC Co (Med)	Transported maneuver troops, observers and technical project personnel to and from forward area.	5.0	IA	IA	IA	VI	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III
2nd TC Ttk Co (Plc)	Transported maneuver troops, observers and technical project personnel to and from forward area.	5.0	IA	IA	IA	VI	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III
8th Field Hosp (-)	Established aid station in forward area and provided ambulance service.	5.0																									
53rd QM Sub Sup Co, Det	General support at CDR.																										
163rd Ldry Co	General support at CDR.																										
QM Petrol Sup Co (-)	General support at CDR.																										
433rd Army Band	General support at CDR.																										

* See Appendix for shot abbreviations.

NOTE: All may have observed one or more shot as CDR Observers (see table 37).

Table 36. Operation PLUMBBOB, Air Force support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/DOSE (See Section 3 text)																									
		D7A	B*	F*	L*	W1*	F*	M*	D1*	J*	E*	G*	SL*	SH*	DO*	F*	SM*	C*	MI*	LP*	PL*	M*	R*	BY*	C*	R*	
4950th Test Gp (M)	General support at ISAFB (except decon).																										
4952nd Sup Sq.	General support.																										
4926th Test Sq (S)	Flew cloud sampling missions in support of Projects 11.2, 21.2 and 33.1 (Aircrews breathed 100% oxygen).	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B
55th Weather Recon Sq	Flew cloud tracking missions. Did not penetrate cloud.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
4900th Air Base Gp	Flew courier missions.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
4935th Air Base Sq	Flew security sweeps prior to shots.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
21st Helicopter Sq (Det 1)	Flew aerial survey and search and rescue missions.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A

* See Appendix for shot abbreviations.

Table 37. Operation PLUMBBOB, observers with bone dose commitment less than 150 millirem (Concluded).

PROJECT/UNIT	ACTIVITY	SOURCES/DOSES (See Section 3 text)																	
		D ₂	B ^o	F ^o	L ^o	W ^o	F ^o	F ^o	D ^o	J ^o	E ^o	O ^o	St ^o	Sh ^o	Do ^o	F ^o	G ^o	Others	
Service (50.2 & 53.3) and CDR Observers (Shot Doppler)	Observed shot from trenches 2900 m SW of GR. Returned to CDR after shot.																		1A
Service** (50.2, 52.2 & 53.3) and CDR Observers (Shot Smoky)	Observed shot from News Mob. Returned to CDR after shot.																		1A

* See Appendix for shot abbreviations.
 ** Navy observers (no project number) were also present.

Table 38. Operation PLUMBBOB, maneuver troops with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	EMPTS/CONS (See Section 3 text)																	
		Dm	B*	F*	L*	M1*	M*	D1*	J*	E*	G*	St*	Sh*	Da*	F.*	M*	G*	Others	
52.1 4th MCFAB	Observed Shot Priscilla from trenches 4000 m SW of G2. Toured Priscilla display area on shot day.						III												
	Observed Shot Priscilla from Mews Mob or Camp Desert Rock					IA													
	Observed Shot Hood from trenches 5000 m SW of G2. Toured display area or marched to 5 B/hr line; air-lifted or trucked to objective areas.					III	III												
50.1 Task Force BIG BANC	Observed Shots Franklin Prime and Smokey from Mews Mob.													IA	IA				
	Observed Shot Galileo and conducted rifle disassembly test in open area 4500 m E of G2.																		IA
	Trucked and marched through Smokey fallout (D+2) on way to infiltration course.	3.0																	IIC4
	Crawled through infiltration course contaminated by Shot Smokey (D+2).	0.03																	IIB4

* See Appendix for shot abbreviations.

Table 39. Operation PLUMBBOB, service project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	MPPG/COGS (See Section 3 text)															
		Dys	B ¹	P ¹	L ¹	M ¹	P ²	P ³	D ¹	D ²	C ¹	C ²	D ³	D ⁴	P ⁴	C ³	C ⁴
50.3 Detection and Cloud Tracking System	Fallout prediction unit operated from van located at Camp Mercury.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Manned meteorology station near Alamo, 50 km S of test site. A second fallout prediction unit also operated from this site.						VI	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
50.4 Evaluation of Water Decon Methods	Operated radar equipment at site located SE of Yucca Lake.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Operated radar equipment (AM/CPS-9) from sites 40-100 miles from test area.												IA	IA	IA	IA	IA
50.5 Protection Afforded by Field Fortifications	Operated radar equipment (AM/MPC-1 and AM/TPS-1D) at minimum safe distance (5-6 km from GZ) on shot day.	5.0											IA	IIC2	IA	IA	
	Operated radar equipment from site at least 13 km from GZ.																
50.6 Protection Afforded by Field Fortifications	Obtained data from USAP radar site at Angel's Peak.	0.54															
	Collected and analyzed soil and water samples taken from GZ area. Tested various water decon methods.																
50.7 Test of Ordnance Material	Inspected foxholes, gun emplacements, etc., 435-900 m SW of GZ.																
	Inspected foxholes, gun emplacements, etc., 435-900 m SW of GZ.																
50.8 Detection of Atomic Bursts & Radioactive Fallout	Evaluated dosimetry data obtained from Project 2.4.	5.0															
	Inspected damage to foxholes 550 m from GZ (915 m at Wood).																
50.9 Test of Ordnance Material	Inspected damage to tanks and armored vehicles placed from 300 to 550 m from GZ (550-730 m at Wood; 375-850 m at Smoky).	5.0															
	Recovered fuses buried at distances of 365-1067 m from GZ.																
50.10 Test of Ordnance Material	Operated AM/TVS-1 Flash Warning Equipment, M65 Scopes, or M2 Aiming Circle at least 15 km S-SW of GZ. (13 km NW of Prialicilla).																
	Operated AM/GAS-1 Flash Detector on Angel's Peak, approximately 60 miles from site.																
50.11 Test of Ordnance Material	Operated AM/MQ-10 Radar from site at least 17 km S of GZ. (12 km NW of Prialicilla; 8 km S of Shasta).																
	Operated AM/MQ-10 Radar from site at least 17 km S of GZ. (12 km NW of Prialicilla; 8 km S of Shasta).																

* See Appendix for shot abbreviations.

Table 39. Operation PLUMBBOB, service project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SMOFS/COSE (see Section 3 text)																											
		7a	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		
	Operated AM/WFO-21 Radar from site at least 37 km S of GZ. (20 km WNW of Pracilla; 15 km S of Shasta).																												
	Operated AM/WFO-4 Rheometer from site at least 14 km from GZ. (8 km from Pracilla and Stokes).																												
	Operated GM-8 Sound Manging Set from site at least 16 km S-W of GZ.																												
	Operated WISE-AJAJ, AM/PPS-ID, and AM/PPS-H33 radars from sites ranging from 5 to 50 km from GZ.																												
	Operated AM/PPS-36 radar from site at least 70 km from GZ.																												
	Manned AM/WFO-1 Operations Center.																												
	Provided weather data from site 200 miles away.																												
	Made fallout predictions from Command Post and compared with survey data.																												
	Conducted aerial radiological survey to 100 N/hr line on shot day.																												
	Conducted ground radiological surveys downwind to 5 N/hr line on shot day.																												
	Flew B-26 aircraft (B-21 helicopter at Smoky) approximately 15 miles from GZ. Did not penetrate cloud.																												
	Observed shot from observer area and conducted radiological survey in areas less than 5 N/hr.																												
	Conducted radiological surveys in residual radiation field less than 5 N/hr.																												
	Observed Shot Stokes from observer area and conducted radiological surveys in residual radiation field less than 5 N/hr.																												
	Participation in Boltmann cancelled due to delays.																												
	Flew simulated bomb run offset from GZ. Were at least 8 km from GZ at detonation time.																												
	Observed detonation from aircraft at least 25 km from GZ.																												
	See Appendix for shot abbreviations.																												

Table 40. Operation PLUMBBOB, AFSWP project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SHOTS/CODE (See Section 3 text)																							
		D7	D6	D5	D4	D3	D2	D1	D0	SH	DO	P1	SM	C	MA	LP	Z1	W	E	BY	C	R			
1.2 Field Test of Airborne Gauges for Measuring Blast Phenomena	Flew and photographed an instrumented balloon over 40 km S of GZ. Fired instrumented rockets from station 4610 m SW of GZ.																								
1.3 Airblast Phenomena in High Pressure Region	Recovered gauges from stations 23-1350 m W of GZ.																								
1.4 Ground Acceleration, Stress & Strain	Recovered data from recording station W (assumed) of GZ on shot day.																								
1.5 Ground Motion Studies	Recovered gauges from instrument array 23-410 m W (assumed) of GZ.																								
1.7 Loading on Simulated Buried Structures	Recovered instrumented drums buried in trenches 230-410 m W of GZ.																								
2.0 Neutron and Gamma Radiation from Shot La Place	Project 2.10 personnel recovered neutron detectors from a cable dragged out of GZ area shortly after the shot. Delivered detectors to lab for analysis.																							III	
2.1 Soil Activation by Neutrons	Project 2.3 personnel took radiation measurements at station 730 m NW of GZ at M+2,3,4,7,8,14 and 15. Recovered neutron detectors, film badges, and other dosimeters (some buried) from a line extending 90-2740 m from GZ. Took radiation measurements in GZ area by lowering instrument from helicopter.																								III
2.2 Neutron-Induced Activities in Soil Elements	Recovered soil samples from stations 180-460 m from GZ. Recovered samples (some buried) from stations 91-910 m SW of GZ. Moved M-48 tank used in Project 57 from 900 to 2400 m from GZ. Took radiation measurements inside and outside of tank.																								III
2.4 Nuclear Radiation Shielding Studies	Recovered instruments from armored vehicles (field fortifications at Priscilla) in GZ area. Recovered soil specimens from array 180-360 m SW of GZ.																								III

* See Appendix for shot abbreviations.

Table 40. Operation PLUMBBOB, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SLOTS/CODES (See Section 3 text)																	
		D ¹	E ¹	F ¹	G ¹	H ¹	I ¹	J ¹	K ¹	L ¹	M ¹	N ¹	O ¹	P ¹	Q ¹	R ¹	S ¹		
2.5 Initial-Gamma Radiation Intensity & Neutron-induced Radiation of RRS Soil	Recovered data/dosimeters from 7 stations 1330-1920 m SE of G2.	IIBb																	
	Recovered data/instruments from stations located 460-3660 m from G2.			IIBb	III	IIBb	III											III	
	Recovered dosimeter from 4 balloon stations along the ground station line mentioned above.			III	IIBb	III													III
2.6 Evaluation of New Radiacs	Recovered dosimeters from R-48 tank in G2 area.																		III
	Recovered dosimeters from Project 2.9 aircraft.																		IA
2.7 Radio-Wave Attenuation Studies	Recovered dosimeters from G2 area on shot day. Evaluation of radiac by Rad-Safe teams at Wood only.	5.0		IIC3	III	III	III	III											III
	Manned receiver station near Bldg. 400 near C7.	IA		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
2.8 Evaluation of Military Radiacs	Recovered transmitter/equipment from Banded Mountain.	IIBb																	
	Recovered data from and maintained equipment in/around bunkers located 800-1460 m W of Balloon shot area in Area 9.	IIBb				III	III	III	III	IA	IA	IA	IA	IA	IA	IA	IA	IA	III
	Recovered transmitter/equipment from Frenchman Flat.																		III
2.9 Nuclear Radiation Received by Aircraft Pinging the W-1 Rocket	Placed instrumented phantoms in 50 R/hr induced activity field shortly after shot; retrieved phantoms 53 hours later.																		III
	Placed instrumented phantoms in 10-20 R/hr induced field shortly after shot; retrieved phantoms 52 hours later.																		III
2.9 Nuclear Radiation Received by Aircraft Pinging the W-1 Rocket	Placed instrumented phantoms and dosimeter rack in 2-7 R/hr induced field shortly after shot; retrieved phantoms and rack 32-56 hours later.																		III
	Placed instrumented phantoms in 50 R/hr field shortly after shot; retrieved phantoms 6.5 and 30 hours later.	5.0																	IIC4
2.9 Nuclear Radiation Received by Aircraft Pinging the W-1 Rocket	Launched W-1 rocket from R-49 aircraft. Flew in formation with launch aircraft.																		IA
	Recovered dosimeters from Project 2.9 aircraft.																		IA

* See Appendix for shot abbreviations.

Table 40. Operation PLUMBBOB, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	SMRTS/DOSE (See Section 3 test)											
		D ₇₀	E ^a	F ^a	G ^a	H ^a	I ^a	J ^a	K ^a	L ^a	M ^a	N ^a	O ^a
2.10 Initial Neutron and Gamma Air-Earth Interface Measurements	Recovered dosimeters from ground stations 1520 and 1830 m NW of G2 and from the Franklin tower 5210 m S of G2 on shot day.	5.0	11C2										
	Recovered dosimeters from ground stations at 460 m intervals from G2. Recovered dosimeter from balloon mooring cables at 4 stations along this line.		III	11Bb	III	III						III	
	Recovered dosimeters from Sheets and Whitney Towers.					JA	IA						
	Recovered dosimeters from surface G2 area.							IA					
	Recovered neutron detectors from cable dragged out of G2 areas.												III
3.1 Underground Concrete-Arch Protective Structures	Recovered instruments/data from and inspected underground structures located 250-400 m W of G2.												III
3.2 Buried Conduits as Personnel Shelters	Recovered instruments/data from and inspected underground structure located 300-410 m NW of G2.												III
3.3 Earth Covered Pre-Fab Ammo Storage Magazines as Personnel Shelter	Recovered instruments/data from and inspected underground structure located 360-420 m NW of G2.												III
3.4 Blast Effects on U-4 and Teqgot Structures	Recovered instruments/data from and inspected structures 270 m W of G2.												III
3.5 Isolation of Structures from Ground Shock	Recovered instruments/data from and inspected buried structures 230-320 m W of G2.												III
3.6 Field Test of Domes and Arch Structures	Recovered instruments/data from and inspected domes and arch structures located 370-310 m SW of G2.												III
3.7 Instrumentation of Structures	Recovered instruments used in Projects 3.1, 3.2, 3.3 and 3.6 and CFTC Projects 33.2 and 33.5.												III
3.8 Soil Survey and Backfill Control	Obtained and analysed soil samples from various other project areas W of G2.												III
4.1 Effects on Large Biological Specimens	Recovered test animals from exposure devices (large metal combats) on shot day. Recovered test animals from exposure devices 790-1070 m (large metal combats) and 6 tank 550 m from G2 (IS) on shot day.	5.0	11B2										III

* See Appendix for shot abbreviations.

Table 40. Operation PLUMBBOB, AFSWP project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	EXPOS/CODE (See Section 3 text)																									
		Dys	B*	F*	L*	Mi*	F*	B*	Di*	J*	S*	O*	St*	Sh*	Do*	F**	Sp*	G*	M*	LI*	SI*	SI*	SI*	SI*	SI*		
4.2 Evaluation of Eye Protection	Recovered test animals from areas 440-2890 m W of GZ on shot day and D-1.																										
5.1 In Flight Structural Response of H53-1 Helicopter	Observed detonation from aircraft or ground station, at least 14 km from GZ.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	
5.2 Structural Response of Airship	Flew helicopter in vicinity (at least 1000 m) of detonation. Main-tained helicopters.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
5.3 In Flight Structural Response of FJ-4 Aircraft	Recovered instruments/blimps from stations at least 5460 m from GZ.																										
5.4 In Flight Structural Response of A4D-1 Aircraft	Flew FJ-4 aircraft in vicinity (at least 3000 m) of detonation. Main-tained aircraft.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
5.5 In Flight Structural Response of F-89 Aircraft	Flew AD-6 aircraft in vicinity (at least 3000 m) of detonation. Main-tained aircraft.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.1 Minefield Clearance	Operated ground support radar for Projects 5.1, 5.3 and 5.4 from site at least 15 km from GZ.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.2 Measurements of Magnetic Component of EM Field	Flew F-89 aircraft in vicinity (at least 2000 m) of detonation. Main-tained aircraft.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.2a Effects on Semi-conductor	Operated ground support radar from site at least 15 km from GZ.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
6.3 Attenuation of EMR by Ionized Medium	Inspected minefield 350 m WE of GZ shortly after detonation, restored fence. Recovered/detonated surviving mines later.																										
6.4 Accuracy and Reliability of MAROL	Recovered instruments from 5 stations .000-3000 m from GZ (400-4400 m W of Triscilla).	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III
	Recovered instruments from station 240 m S of GZ.																										
	Recovered 14 boxes of semi-conductor buried 240-1050 m from GZ.																										
	Flew instrumented aircraft on opposite side of nuclear cloud from ground station. Did not penetrate cloud.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Manned ground receiver station at Frenchman Flat.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Operated remote stations throughout U.S.	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

* See Appendix for shot abbreviations.
 ** Elements of category matrix adjusted for shot specific values listed in table 2.

Table 40. Operation PLUMBBOB, AFSWP project participants with bone dose commitment less than 150 millirem (Concluded).

PROJECT/UNIT	ACTIVITY	SMOFS/CODE (See Section 3 text)																										
		D ₉₃	B°	F°	L°	M1°	F°	H°	Di°	J°	I°	O°	St°	Sh°	Do°	F1°	IA°	Q°	Wh°	Lp°	F1°	H°	E°	Dy°	Co°	W°		
8.1 Thermal Protection of Soldiers	Recovered test animals from 3 stations at slant ranges of 1785 to 3710 m from G2.						III																					
8.2 Prediction of Thermal Protection	Recovered data/instruments from station 1200 m S of G2. (2250-3650 m from Priscilla; 3150 m from Mood).			III	IIBb	III	III																					
8.3a Performance of Spectrograph	Evaluated spectrograph from station at least 12 km from G2.			IA	IA	IA	IA	IA	IA	IA	IA																	
9.1 Support Photography	Photographed detonation from C-47 aircraft. Aircraft did not penetrate cloud.		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Provided photographic support to technical projects up to 1 week after detonation.	5.0	IIC6	IIC6	III	IIC6	III	III	IIC6	IA	IIC6	III	III	IIC6	III	III	IIC6	IIC6	III	III	IIC6	III	III	IIC6	III	III	IIC6	III

* See Appendix for shot abbreviations.

Table 41. Operation HARDTACK II, Air Force support participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SBOTS/CODE (See Section 3 text)																			
		Dy	Ed	M*	T*	Q*	Le*	Ha*	Lo*	DA*	RA*	So*	W*	R*	SA*	DB*	Ev*	Hu*	SP*	B*	
4950th Test Gp (M)	Command and control functions at the Air Operations Centers at Yucca Pass and Angel's Peak.																				
4952d Support Sq.	General support at IS&FB (except decon). Augmented 4950th Test Gp (M) and 4935th AB Sq.																				
4926th Test Sq (S)	Flew cloud sampling missions in support of Projects 11.2 and 21.2. (Aircrews breathed 100% oxygen.)	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B
	Flew high altitude cloud tracking missions in T-33. Did not penetrate cloud.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
4900th Air Base Gp.	Flew courier missions.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
4935th AB Sq.	Flew security sweep prior to shot. General support at IS&FB (except decon).	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
	Flew low altitude cloud tracking missions in C-47, L-20, and B-25 aircraft. Did not penetrate cloud.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
20th Helicopter Sq.	Flew observers around shot area.																				
	Flew aerial radiological survey missions.	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A

* See Appendix for shot abbreviations.

Table 42. Operation HARDTACK II, AFSWP project. participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	SNOTS/CODE (See Section 3 text)																			
		DYS	Ed*	M*	T*	Q*	Le*	Ha*	Lo*	DA*	RA*	So*	W*	R*	SA*	DB*	Ev*	Ro*	SF*	B*	
4.3 Effects on Vision of Combat Personnel	Observed detonation from area 1740 m from G2.						IA														
6.14 Test of Flash Ranging Equipment	Operated equipment at sites at least 7 km from G2. (3 km at Rio Arriba).		IA		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA						
6.15 Electromagnetic Pulse	Manned station at Boulder City, NV, approximately 160 km SE of WTS.		IA		IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA						
8.8 Thermal Radiation	Manned instrumented trailer at least 2 km from G2.				Vis*		IA				IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Manned station in Bldg. 400 at Control Point.										IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
	Recovered data from instrumented trailer 1 km W of G2 shortly after shot.						IA														

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 43. Operation DOMINIC II, Air Force support participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>SHOTS/CODE (See Section 3 text)</u>			
		<u>LF2*</u>	<u>JB*</u>	<u>SB*</u>	<u>LF1*</u>
4900 AB Group	Flew radio-relay missions in C-47 aircraft.	1A			
	Flew courier missions in C-47 aircraft.	1A	1A	1A	1A
	Flew low altitude cloud tracking missions in U3A aircraft. Did not penetrate cloud.	1A	1A	1A	1A
55th Weather Recon Squadron	Flew high altitude cloud tracking mission in WB-50. Did not penetrate cloud.		1A		
1211th Test Squadron (MATS)	Flew cloud sampling missions in B-57 aircraft. Crew breathed 100% oxygen.	1B	1B	1B	1B
	General A/C maintenance at ISAFB (A/C decon not included).	1A	1A	1A	1A
4520th Combat Crew Training Wing	Flew security sweep missions prior to shot.	1A	1A	1A	1A

* See Appendix for shot abbreviations.

Table 44. Operation DOMINIC II, DASA project participants with bone dose commitment less than 150 millirem.

PROJECT/UNIT	ACTIVITY	DFB	SHOTS/CODE (See Section 3 text)			
			LF2*	JB*	SB*	LF1*
1.11 Soils Survey	Collected soil samples from GZ area and dug instrument shafts for other projects prior to shot.			IA		
2.1 Initial Radiation Measurements	Recovered data/instruments from bunkers 190 and 490 m NE of GZ and stations 1220 m NE of GZ.				IICa**	
2.2 Fast-neutron Dose Rate	Photographed and recovered data from instruments located at stations 190, 490, and 1220 m NE of GZ.				IICa**	
2.7 Off-site Meteorology	Collected data from weather stations located 30 to 400 km E of GZ.				IA	
2.10 Physiochemical and Radiochemical Analysis	Analyzed (laboratory) samples collected by Project 2.9 personnel.				IA	
2.14 Shielding Effectiveness Compartmental Structures	Recovered film packets from steel structures approximately 2900 m from GZ.				IICa**	
	Measured radiation intensity near project site on D+2.				IICa**	
	Made measurements with track-mounted spectrometer about 2900 m from GZ on D+3 thru D+12.				IICb**	
2.15 Effectiveness of Enclosure Shields	Monitored radiation data from revetment over 6000 m from GZ on shot day thru H+48.				IICc**	
	Conducted radiological survey of enclosure shield area 4880 m NE of GZ on D+1.				IICb**	
3.2 Dynamic Bearing Capacity of Soils	Recovered data from instrument shelter 1220 m S of GZ on shot day.	3.0			IIC2**	
3.3 Buried Model Arch Structures	Recovered data from recording shelter (bunker) 730 m S of GZ.				IIBb**	
6.9 Correlation of Electric Field Measurements	Obtained data at recording station (trailer) located 12.3 km NW of GZ.				IA	
6.11 Air Conductivity Measurements	Recovered data from instrument bunker 500 m W of GZ and recovered transmitter from station 4.4 km NE of GZ.				IIBb**	
	Manned receiver station 4.5 km SW of GZ.				IA	

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 44. Operation DOMINIC II, DASA project participants with bone dose commitment less than 150 millirem (Continued).

PROJECT/UNIT	ACTIVITY	DFB	SHOTS/CODE (See Section 3 text)			
			LF2*	JB*	SB*	LF1*
6.13 Troposcatter Test Installation	Monitored detonation from off site stations at Alamo, NV, and Death Valley, CA.				V1**	
7.1.1 Pragmatic Instrument Measurements	Recovered data from bunker located 210 m SE of GZ.				IICa**	
7.5 Response of Electrical Power Systems	Recovered data from recording instruments located in a deep (7 ft) concrete pit 670 m SE of GZ. Recovered 45 KW generator.				IIBb**	
7.6 Evaluation of Aerial Radiac Survey System	Flew instrumented helicopters over fallout path at H+2, H+6 and H+22.				IA	
	Launched and recovered instrumented drones from site 6 km NW of GZ.				IA	
	Manned air operations and receiver station 6 km NW of GZ.				IA	
7.6.1 Evaluation of Aerial Radiac Systems - Tripartite	In addition to Project 7.6 flights, flew instrumented helicopters over fallout area at H+5, H+24, and H+47.				IA	
	Plotted and analyzed data from helicopter surveys.				IA	
7.8.1 Magnetic Detection Equipment Test	Operated instruments at station about 8 km N of GZ.				IA	
7.9 Prooftesting Operational Ship-board Material	Inspected damage to ship components/equipment located 290-400 m SW of GZ.				IICb**	
	Recovered data from recording station (bunker) 760 m SW of GZ.				IIBa**	
7.10 Spectral Analysis - Thermal Radiation Pulse	Recovered data from stations 2, 4, and 6 km S of GZ.				IA	
7.13 F-100F/GAM-83B Simulation	Flew F-100F near detonation. (Slant range - 4000 m.)				IA	
7.14 Bomb Alarm Detector Test	Recovered detectors from stations 1-19 km W of GZ.				IIBa**	
	Manned instrument trailer 6 km W of GZ.				IA	
7.15 Effects on B-52/GAM-77	Flew B-52 aircraft over GZ at altitudes of 10,600 and 12,581 ft.				IA	

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

Table 44. Operation DOMINIC II, DASA project participants with bone dose commitment less than 150 millirem (Concluded).

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>DFB</u>	<u>SHOTS/CODE (See Section 3 text)</u>			
			<u>LF2*</u>	<u>JB*</u>	<u>SB*</u>	<u>LF1*</u>
7.16 Airborne E-field Measurements	Flew C-131F at altitude of 9,960 feet directly over detonation.		IA			
	Flew C-131F at an altitude of 13,680 ft, 3230 m E of GZ and an A-3A directly over detonation at an altitude of 18,000 feet.				IA	
8.1 High Time Resolution of First Thermal Pulse	Took measurements from instrument trailers located approximately 3 km S of GZ.					IA
	Took measurements from instrument trailer 30-60 km from GZ.				IA	
8.2 Fallout Hazard Determination	Took measurements with spectrometers connected to 35 mm movie cameras located at forward CP.		IA			IA

* See Appendix for shot abbreviations.

Table 45. Operation DOMINIC II, Project IVY FLATS participants with bone dose commitment less than 150 millirem.

<u>PROJECT/UNIT</u>	<u>ACTIVITY</u>	<u>SHOTS/CODE (See Section 3 text)</u>			
		<u>LP2*</u>	<u>JB*</u>	<u>SB*</u>	<u>LP1*</u>
Observers	Observed shot and troop maneuver from bleachers, approximately 3 km SW of GZ.				IA
Maneuver Troops	Observed Johnnie Boy from remote location.			IA	
	Performed ground assault on objective approximately 1.7 km NE of GZ (tank and APC support) shortly after shot. Maneuver completed by H+1.		0.61		IIB1**

* See Appendix for shot abbreviations.

** Elements of category matrix are adjusted to shot specific values from table 2.

SECTION 4
LIST OF REFERENCES

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APPENDIX
CONUS OPERATION AND SHOT ABBREVIATIONS

<u>Operation</u>	<u>Shots</u>	<u>Operation</u>	<u>Shots</u>
B-BUSTER *	A-Able	T-Teapot	W-Wasp
	B-Baker		Mo-Moth
	C-Charlie		Te-Tesla
	D-Dog		Tu-Turk
	E-Easy		H-Hornet
J-JANGLE *	S-Sugar		b-Bee
	U-Uncle		E-Ess
			A1-Apple 1
TS-TUMBLER-SNAPPER	A-Able		W'-Wasp Prime
	B-Baker		HA-High Altitude
	C-Charlie		P-Post
	D-Dog		ME-MET
	E-Easy		A2-Apple 2
	F-Fox		Z-Zucchini
	G-George	P-Plumbbob	B-Boltzmann
	H-How		F-Franklin
UK-UPSHOT-KNOTHOLE	A-Annie		L-Lassen
	N-Nancy		Wi-Wilson
	Ru-Ruth		P-Priscilla
	D-Dixie		H-Hood
	Ra-Ray		Di-Diablo
	B-Badger		J-John
	S-Simon		K-Kepler
	E-Encore		O-Owens
	H-Harry		St-Stokes
	G-Grable		Sh-Shasta
	C-Climax		Do-Doppler
		F'-Franklin Prime	

*Often combined as BUSTER-JANGLE (BJ)

<u>Operation</u>	<u>Shots</u>	<u>Operation</u>	<u>Shots</u>
PLUMBBOB (Cont'd)	Sm-Smoky	HII-Hardtack II	Ed-Eddy
	G-Galileo		M-Mora
	Wh-Wheeler		T-Tamalpais
	LP-La Place		Q-Quay
	Fi-Fizeau		Le-Lea
	N-Newton		Ha-Hamilton
	R-Rainier		Lo-Logan
	Wy-Whitney		DA-Dona Ana
	C-Charleston		RA-Rio Arriba
	M-Morgan		So-Socorro
			W-Wrangell
DII-DOMINIC II	LF2-Little Feller II		R-Rushmore
	JB-Johnie Boy		Sa-Sanford
	SB-Small Boy		DB-DeBaca
	LF1-Little Feller I		Ev-Evans
			Hu-Humboldt
			SF-Santa Fe
			B-Blanca

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