

## A COMPILATION OF NUCLEAR WEAPONS TEST DETONATION DATA FOR U.S. PACIFIC OCEAN TESTS

S. L. Simon\* and W. L. Robison<sup>†</sup>

**Abstract**—Prior to December 1993, the explosive yields of 44 of 66 nuclear tests conducted by the United States in the Marshall Islands were still classified. Following a request from the Government of the Republic of the Marshall Islands to the U.S. Department of Energy to release this information, the Secretary of Energy declassified and released to the public the explosive yields of the Pacific nuclear tests. This paper presents a synopsis of information on nuclear test detonations in the Marshall Islands and other locations in the mid-Pacific including dates, explosive yields, locations, weapon placement, and summary statistics.

*Health Phys.* 73(1):258–264; 1997

**Key words:** weapons; fallout; Marshall Islands; atomic bomb

### INTRODUCTION

DURING THE years 1946 through 1962, nuclear weapons testing was conducted by the U.S. over the mid-Pacific ocean and on several islands and atolls in the region. In particular, Bikini and Enewetak, two neighboring coral atolls in the Marshall Islands, were used as sites for nuclear weapons testing during the years 1946 through 1958. In 1962, the U.S. continued atmospheric testing at Christmas Island, Johnston Atoll and several other mid-Pacific locations outside of the Marshall Islands.

During the years of nuclear testing, the Marshall Islands was part of the U.N. constructed Trust Territory of the Pacific (TTP), a group of small island countries entrusted to the U.S. following the end of WWII. The TTP remained in effect until the mid-1980's when the Marshall Islands chose to become an independent republic.

Testing began in the Marshall Islands with shot ABLE (Operations Crossroads) on 30 June (GCT) 1946 and ended with FIG (Operation Hardtack I) on 18 August (GCT) 1958. On 31 October 1958, the U.S. began a unilateral testing moratorium based on the assumption

\* address at the time of writing was Nationwide Radiological Study, P. O. Box 1808, Majuro, Marshall Islands 96960, now Board on Radiation Effects Research, National Academy of Sciences, 2101 Constitution Ave. N. W., Washington, DC 20418; <sup>†</sup> Health and Ecological Assessment Division, Lawrence Livermore National Laboratory, L-286, P. O. Box 808, Livermore, CA. 94551-0808

(Manuscript received 3 April 1996; revised manuscript received 29 November 1996, accepted 13 March 1997)  
0017-9078/97/\$3.00/0

Copyright © 1997 Health Physics Society

that the Soviet Union would also cease atmospheric weapons testing. When the Soviet Union resumed testing in September 1961, the U.S. resumed testing in Nevada and in the Pacific; the first of the Pacific series was in April 1962 in the area by Christmas Island. Thirty-nine nuclear weapon tests were conducted outside of the Marshall Islands by the U.S. near Johnston Atoll and Christmas Island.

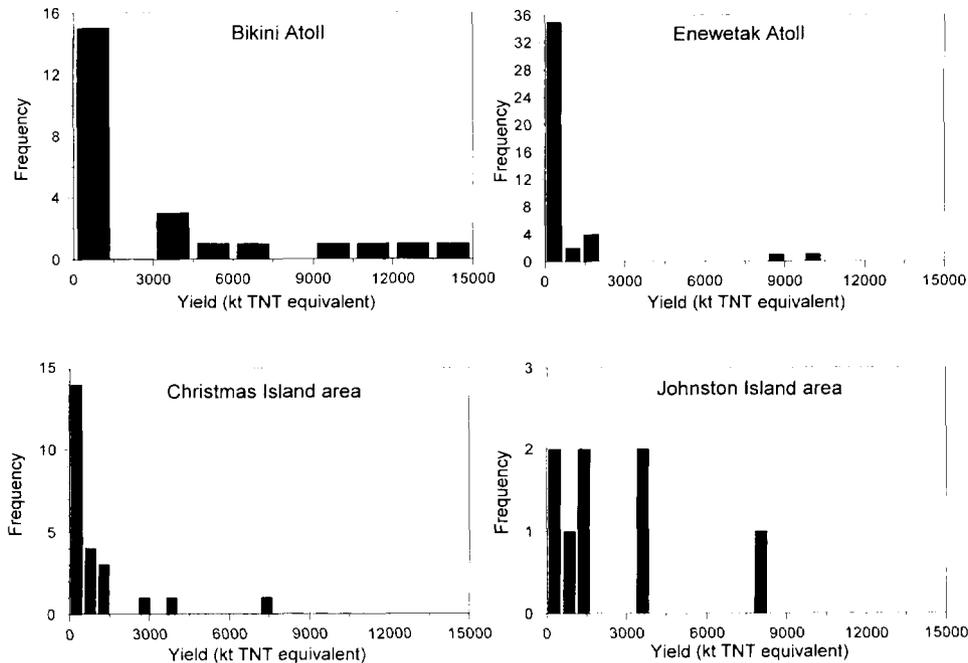
This report presents (1) summary statistics of the explosive yields at each of the four mid-Pacific test site locations; (2) a detailed list of the date, explosive yield, location and weapon placement for each test; and (3) a brief examination of the temporal and yield distributions for each of the four main Pacific test sites. Some of this information has been obtainable over the years in various documents, reports and conference proceedings (see for example, U.S. Congress 1959; Carter and Moghissi 1977; U.S. DOE 1977; DNA 1979; Schell et al. 1980; BARC 1984; Norris et al. 1989; BAS 1992), although the yields for 45 of the 66 tests in the Marshall Islands were not available to the public at the time of those publications.<sup>‡</sup> The availability of data on yields of the tests followed a 1992 request by one author (SLS) through the Ministry of Foreign Affairs of the Republic of the Marshall Islands. Late in 1993, the U.S. Secretary of Energy released the yields of the tests to the Marshall Islands Government and the U.S. public (U.S. DOE 1993). The most recent comprehensive report to date is U.S. DOE (1994).

### DATA SUMMARY

#### Marshall Islands tests

Bikini Atoll, located in the northwest sector of the Republic of the Marshall Islands, was the site of 23 of 66 underwater, ground level and above ground nuclear tests; one additional test was conducted 100 km W of Bikini. Enewetak Atoll, located 350 km west of Bikini, was the site of 42 nuclear tests including two with zero yield. The combined explosive yield (kt TNT equivalent) for both test sites was  $1.08 \times 10^5$  kt TNT (U.S. DOE 1993). The proportions of the total explosive yield at Bikini and

<sup>‡</sup> BAS (1992) gave explosive yields for the test data unreleased at that time though the values were slightly different than the data subsequently declassified and released by the Department of Energy in 1993.



**Fig. 1.** Frequency distributions for explosive yield (kt TNT equivalent) of nuclear tests at Bikini Atoll (Marshall Islands), Enewetak Atoll (Marshall Islands), Christmas Island area (Kiribati), and Johnston Atoll area.

**Table 1.** Summary statistics of numbers of U.S. tests and explosive yields at mid-Pacific locations.

	Bikini Atoll	Christmas Island area	Enewetak Atoll	Johnston Atoll area	Other Pacific locations
Number of tests	24 <sup>a</sup>	24	42	12	3
Missing yield values <sup>b</sup>	0	0	0	4	2
YIELD (kt TNT equivalent)					
Minimum <sup>c</sup>	1.7	2.2	0.0	11.3	30.0
Maximum <sup>c</sup>	15000.0	7650.0	10400.0	8300.0	30.0
Mean <sup>c</sup>	3201.6	968.9	736.1	2472.0	30.0
Median <sup>c</sup>	388.5	310.0	45.5	1495.0	30.0
Total <sup>c</sup>	76838.8	23253.3	31653.4	19776.3+	30+

<sup>a</sup> Includes shot YUCCA, 100 km W of Bikini.

<sup>b</sup> Data not released.

<sup>c</sup> Based on available data only; not strictly correct for Johnston Atoll and Other Pacific locations because of missing values.

Enewetak were 70.8% (76.8 Mt) and 29.2% (31.6 Mt), respectively.

The testing program in the Marshall Islands during the first 6 y of the 12-y program was relatively sparse. The first two nuclear explosions (21 kt each) were at Bikini Atoll in 1946 as part of Operations Crossroads. The next six tests were conducted at Enewetak Atoll, three in 1948 and three in 1951. Less than 1% of the total explosive yield of the Marshall Islands series was released in the tests prior to 1952. Beginning in 1952 with the Ivy series and continuing in 1954 with the Castle series, the testing program escalated in frequency and size of tests. The percentages of the total explosive yield of Marshall Islands tests during 1952, 1954, 1956 and 1958 were 10.2%, 45%, 19.4% and 24.9%, respectively.

On seven different occasions, two nuclear tests were conducted on a single day: once in 1956, five times in

1958, and once in 1962. On five of those occasions, both Enewetak and Bikini Atolls were used as test sites within the same day.

The United States' first experimental thermonuclear test explosion, GEORGE (Operation Greenhouse), was detonated at Enewetak on 8 May (GCT) 1951 and yielded 225 kt (U.S. DOE 1994). The first thermonuclear (hydrogen) bomb tested by the U.S. was MIKE (Operation Ivy), detonated at Enewetak on 31 October (GCT) 1952, yielding 10.4 Mt. On 28 February (GCT) 1954, the U.S. exploded its largest thermonuclear device ever, Castle BRAVO.<sup>§</sup> BRAVO was detonated at Bikini Atoll and yielded approximately 15 Mt equivalent TNT. The

<sup>§</sup> Castle BRAVO is often cited as having been detonated on 1 March 1954. The local time of the detonation was 6:45 a.m., 1 March 1954.

**Table 2.** Summary data listing of U.S. nuclear tests in the Marshall Islands and at other mid-Pacific Ocean locations. Data taken from DNA (1979) and USDOE (1994). Time of test is listed as Greenwich Civil Time (GCT); local time of detonation at Pacific Proving Ground would be 12 h later (dates would also be 1 d later). (Abbreviations: n/a = not available; DOD = Department of Defense; LASL = Los Alamos National Laboratory; LRL = Lawrence Radiation Laboratory; UCRL = University of California Radiation Laboratory; low yield means <20 kt, submegaton means >200 kt but <1 Mt).

Shot name	Operation	Date (GCT)	Time (GCT)	Yield (kt TNT equivalent)	Sponsor	General location	Latitude °N	Longitude °	Height of burst (m)	Weapon placement
ABLE BAKER	Crossroads Crossroads	6/30/46 7/24/46	22:00 21:35	21 21	LASL/DOD LASL/DOD	Bikini Atoll Bikini Atoll	11.62 11.62	165.48 E 165.48 E	158.5 -27.4	airdrop underwater, cable supported
X-RAY	Sandstone	4/14/48	18:17	37	LASL	Enewetak Atoll	11.67	162.23 E	61.0	tower over coral
YOKE	Sandstone	4/30/48	18:09	49	LASL	Enewetak Atoll	11.62	162.32 E	61.0	tower over coral
ZEBRA	Sandstone	5/14/48	18:04	18	LASL	Enewetak Atoll	11.55	162.35 E	61.0	tower over coral
DOG	Greenhouse	4/7/51	18:34	81	LASL	Enewetak Atoll	11.55	162.35 E	91.4	tower over coral
EASY	Greenhouse	4/20/51	18:27	47	LASL	Enewetak Atoll	11.67	162.23 E	91.4	tower over coral
GEORGE	Greenhouse	5/8/51	21:30	225	LASL	Enewetak Atoll	11.62	162.30 E	61.0	tower over coral
ITEM	Greenhouse	5/24/51	18:17	45.5	LASL	Enewetak Atoll	11.67	162.23 E	61.0	tower over coral
MIKE	Ivy	10/31/52	19:15	10400	LASL	Enewetak Atoll	11.23	162.18 E	0.0	surface burst over coral and water
KING	Ivy	11/15/52	23:30	500	LASL	Enewetak Atoll	11.55	162.35 E	451.1	airdrop
BRAVO	Castle	2/28/54	18:45	15000	LASL	Bikini Atoll	11.68	165.27 E	2.1	surface burst from platform over coral
ROMEO	Castle	3/26/54	18:30	11000	LASL	Bikini Atoll	11.68	165.27 E	2.1	barge
KOON	Castle	4/6/54	18:20	110	UCRL	Bikini Atoll	11.48	165.37 E	4.1	surface burst from platform over coral
UNION	Castle	4/25/54	18:05	6900	LASL	Bikini Atoll	11.65	165.38 E	2.1	barge
YANKEE	Castle	5/4/54	18:10	13500	LASL	Bikini Atoll	11.65	165.38 E	2.1	barge
NECTAR	Castle	5/13/54	18:20	1690	LASL	Enewetak Atoll	11.67	162.78 E	2.1	barge
WIGWAM	Wigwam	5/14/55	20:00	30	DOD	Pacific Ocean (250 km SW of San Diego)	28.73	126.27 W	-600.00	subsurface (underwater) burst suspended by cable from barge
LACROSSE	Redwing	5/4/56	18:25	40	LASL	Enewetak Atoll	11.55	162.35 E	5.2	surface burst from platform on coral
CHEROKEE	Redwing	5/20/56	17:51	3800	LASL	Bikini Atoll	11.67	165.38 E	1325.9	airdrop
ZUNI	Redwing	5/27/56	17:56	3500	UCRL	Bikini Atoll	11.48	165.37 E	2.7	surface burst from platform over coral and water
YUMA	Redwing	5/27/56	19:56	0.19	UCRL	Enewetak Atoll	11.50	162.30 E	62.5	tower over coral
ERIE	Redwing	5/30/56	18:15	14.9	LASL	Enewetak Atoll	11.53	162.35 E	91.4	tower over coral
SEMINOLE	Redwing	6/6/56	00:55	13.7	LASL	Enewetak Atoll	11.67	162.22 E	1.4	surface burst in water tank over coral soil
FLATHEAD	Redwing	6/11/56	18:26	365	LASL	Bikini Atoll	11.60	165.45 E	4.6	barge
BLACKFOOT	Redwing	6/11/56	18:26	8	LASL	Enewetak Atoll	11.55	162.35 E	61.0	tower over coral
KICKAPOO	Redwing	6/13/56	23:26	1.49	UCRL	Enewetak Atoll	11.50	162.32 E	91.4	tower over coral
OSAGE	Redwing	6/16/56	01:14	1.7	LASL	Enewetak Atoll	11.53	162.35 E	204.2	airdrop
INCA	Redwing	6/21/56	21:56	15.2	UCRL	Enewetak Atoll	11.62	162.28 E	61.0	tower over coral
DAKOTA	Redwing	6/25/56	18:06	1100	LASL	Bikini Atoll	11.60	165.45 E	0.0	barge
MOHAWK	Redwing	7/2/56	18:06	360	UCRL	Enewetak Atoll	11.50	162.30 E	91.4	tower over coral
APACHE	Redwing	7/8/56	18:06	1850	UCRL	Enewetak Atoll	11.67	162.20 E	0.0	barge over MIKE crater
NAVAJO	Redwing	7/10/56	17:56	4500	LASL	Bikini Atoll	11.65	165.38 E	4.6	barge
TEWA	Redwing	7/20/56	17:46	5000	UCRL	Bikini Atoll	11.67	165.33 E	4.6	barge
HURON	Redwing	7/21/56	18:16	250	LASL	Enewetak Atoll	11.67	162.37 E	0.0	barge
YUCCA	Hardtack I (Operation Newsreel)	4/28/58	02:40	1.7	DOD	97 km W Bikini	12.62	163.02 E	26200.0	air burst from free balloon over water

Table 2. (Continued)

Shot name	Operation	Date (GCT)	Time (GCT)	Yield (kt TNT equivalent)	Sponsor	General location	Latitude °N	Longitude°	Height of burst (m)	Weapon placement
CACTUS	Hardtack I	5/5/58	18:15	18	LASL	Enewetak Atoll	11.55	162.35 E	0.9	surface burst from platform on coral
FIR	Hardtack I	5/11/58	17:50	1360	UCRL	Bikini Atoll	11.68	165.27 E	3.0	barge
BUTTERNUT	Hardtack I	5/11/58	18:15	81	LASL	Enewetak Atoll	11.33	162.35 E	3.1	barge
KOA	Hardtack I	5/12/58	18:30	1370	LASL	Enewetak Atoll	11.67	162.20 E	0.9	surface burst from 3 m deep tank of water on coral
WAHOO	Hardtack I	5/16/58	01:30	9	LASL/DOD	Enewetak Atoll	11.33	162.17 E	-152.4	underwater, suspended by cable
HOLLY	Hardtack I	5/20/58	18:30	5.9	LASL	Enewetak Atoll	11.53	162.35 E	4.0	barge
NUTMEG	Hardtack I	5/21/58	21:20	25.1	UCRL	Bikini Atoll	11.48	165.37 E	3.7	barge
YELLOWWOOD	Hardtack I	5/26/58	02:00	330	LASL	Enewetak Atoll	11.65	162.22 E	3.2	barge
MAGNOLIA	Hardtack I	5/26/58	18:00	57	LASL	Enewetak Atoll	11.53	162.35 E	4.2	barge
TOBACCO	Hardtack I	5/30/58	02:15	11.6	LASL	Enewetak Atoll	11.65	162.22 E	0.0	barge
SYCAMORE	Hardtack I	5/31/58	03:00	92	UCRL	Bikini Atoll	11.68	165.27 E	3.5	barge
ROSE	Hardtack I	6/2/58	18:45	15	LASL	Enewetak Atoll	n/a	n/a	4.7	barge
UMBRELLA	Hardtack I	6/8/58	23:15	8	DOD	Enewetak Atoll	11.37	162.22 E	-45.7	underwater, lagoon bottom
MAPLE	Hardtack I	6/10/58	17:30	213	UCRL	Bikini Atoll	11.68	165.40 E	3.5	barge
ASPEN	Hardtack I	6/14/58	17:30	319	UCRL	Bikini Atoll	11.68	165.27 E	3.3	barge
WALNUT	Hardtack I	6/14/58	18:30	1450	LASL	Enewetak Atoll	11.65	162.22 E	2.2	barge
LINDEN	Hardtack I	6/18/58	03:00	11	LASL	Enewetak Atoll	11.53	162.35 E	2.5	barge
REDWOOD	Hardtack I	6/27/58	17:30	412	UCRL	Bikini Atoll	11.68	165.40 E	3.3	barge
ELDER	Hardtack I	6/27/58	18:30	880	LASL	Enewetak Atoll	11.65	162.22 E	2.8	barge
OAK	Hardtack I	6/28/58	19:30	8900	LASL	Enewetak Atoll	11.60	162.10 E	2.0	barge
HICKORY	Hardtack I	6/29/58	00:00	14	UCRL	Bikini Atoll	11.48	165.37 E	3.7	barge
SEQUOIA	Hardtack I	7/1/58	18:30	5.2	LASL	Enewetak Atoll	11.53	162.35 E	2.0	barge
CEDAR	Hardtack I	7/2/58	17:30	220	UCRL	Bikini Atoll	11.68	165.27 E	3.3	barge
DOGWOOD	Hardtack I	7/5/58	18:30	397	UCRL	Enewetak Atoll	11.65	162.22 E	3.7	barge
POPLAR	Hardtack I	7/12/58	03:30	9300	UCRL	Bikini Atoll	11.68	165.25 E	3.6	barge on water over reef
SCAEVOLA	Hardtack I	7/14/58	04:00	0 (safety experiment)	LASL	Enewetak Atoll	11.55	162.35 E	6.1	barge
PISONIA	Hardtack I	7/17/58	23:00	255	LASL	Enewetak Atoll	11.55	162.32 E	2.0	barge
JUNIPER	Hardtack I	7/22/58	04:20	65	UCRL	Bikini Atoll	11.48	165.37 E	3.7	barge
OLIVE	Hardtack I	7/22/58	20:30	202	UCRL	Enewetak Atoll	11.65	162.22 E	2.4	barge
PINE	Hardtack I	7/26/58	20:30	2000	UCRL	Enewetak Atoll	11.65	162.22 E	2.4	barge
TEAK	Hardtack I	8/1/58	10:50	3800	DOD	Johnston Island area	16.73	169.53 W	77000	high altitude burst from Redstone missile
QUINCE	(Operation Newsreel) Hardtack I	8/6/58	02:15	0	UCRL/DOD	Enewetak Atoll	11.55	162.35 E	0.9	surface burst from platform on coral
ORANGE	Hardtack I (Operation Newsreel)	8/12/58	10:30	3800	DOD	Johnston Island area	16.35	169.53 E	43000	high altitude burst from Redstone missile
FIG	Hardtack I	8/18/58	04:00	0.02	UCRL/DOD	Enewetak Atoll	11.55	162.35 E	0.5	surface burst from platform on coral
ADOBE	Dominic	4/25/62	15:45	190	LASL	Christmas Island area	n/a (~2.0)	n/a (~157 W)	n/a	airdrop (freefall) over Pacific Ocean
AZTEC	Dominic	4/27/62	16:01	410	LASL	Christmas Island area	n/a (~2.0)	n/a (~157 W)	n/a	airdrop (freefall) over Pacific Ocean

Table 2. (Continued)

Shot name	Operation	Date (GCT)	Time (GCT)	Yield (kt TNT equivalent)	Sponsor	General location	Latitude °N	Longitude°	Height of burst (m)	Weapon placement
ARKANSAS	Dominic	5/2/62	18:01	1090	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
QUESTA	Dominic	5/4/62	19:04	670	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
FRIGATE BIRD	Dominic	5/6/62	23:30	n/a	LRL	Pacific Ocean	4.83	149.82 W	n/a	missile launched from Polaris submarine
YUKON	Dominic	5/8/62	18:01	100	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
MESILLA	Dominic	5/9/62	17:01	100	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
MUSKEGON	Dominic	5/11/62	15:37	50	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
SWORDFISH	Dominic	5/11/62	20:02	low	DOD	Pacific Ocean (250 km W of San Diego)	31.24	124.22 W	n/a	underwater burst from antisubmarine rocket
ENCINO	Dominic	5/12/62	17:02	500	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
SWANEE	Dominic	5/14/62	15:21	97	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
CHETCO	Dominic	5/19/62	15:36	73	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
TANANA	Dominic	5/25/62	16:08	2.6	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
NAMBE	Dominic	5/27/62	17:02	43	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
ALMA	Dominic	6/8/62	17:02	782	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
TRUCKEE	Dominic	6/9/62	15:37	210	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
YESO	Dominic	6/10/62	16:01	3000	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
HARLEM	Dominic	6/12/62	15:37	1200	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
RINCONADA	Dominic	6/15/62	16:00	800	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
DULCE	Dominic	6/17/62	16:00	52	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
PETIT	Dominic	6/19/62	15:01	2.2	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
OTOWI	Dominic	6/22/62	16:00	81.5	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
BIGHORN	Dominic	6/27/62	15:19	7650	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
BLUESTONE	Dominic	6/30/62	15:21	1270	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean
STARFISH PRIME	Dominic (Operation Fishbowl)	7/9/62	09:00	1400	DOD	Johnston Island area	16.47	169.62 W	400,000	high altitude from Thor missile
SUNSET	Dominic	7/10/62	16:33	1000	LASL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	airdrop (freefall) over Pacific Ocean
PAMLICO	Dominic	7/11/62	15:37	3880	LRL	Christmas Island area	n/a (~-2.0)	n/a (~-157 W)	n/a	air (parachute drop) over Pacific Ocean

Table 2. (Continued)

Shot name	Operation	Date (GCT)	Time (GCT)	Yield (kt TNT equivalent)	Sponsor	General location	Latitude °N	Longitude°	Height of burst (m)	Weapon placement
ANDROSCOGGIN	Dominic	10/2/62	16:17	75	LRL	Johnston Island area	13.64	172.19 W	n/a	air (parachute drop) over Pacific Ocean
BUMPING	Dominic	10/6/62	16:02	11.3	LRL	Johnston Island area	14.50	168.25 W	n/a	air (parachute drop) over Pacific Ocean
CHAMA	Dominic	10/18/62	16:01	1590	LASL	Johnston Island area	14.53	108.75 W	n/a	airdrop (freefall) over Pacific Ocean
CHECKMATE	Dominic (Operation Fishbowl)	10/20/62	08:30	low	DOD	Johnston Island area	16.06	169.60 W	10s of kms	high altitude from XM-23 Strypi (Sergeant) missile
BLUEGILL 3 PRIME	Dominic (Operation Fishbowl)	10/26/62	09:59	submegaton	DOD	Johnston Island area	16.40	169.60 W	10s of kms	high altitude from Thor missile
CALAMITY	Dominic	10/27/62	15:46	800	LRL	Johnston Island area	14.52	168.26 W	n/a	air (parachute drop) over Pacific Ocean
HOUSATONIC	Dominic	10/30/62	16:01	8300	LRL	Johnston Island area	13.61	172.22 W	n/a	air (parachute drop) over Pacific Ocean
KINGFISH	Dominic (Operation Fishbowl)	11/1/62	12:10	submegaton	DOD	Johnston Island area	16.10	169.67 W	10s of kms	high altitude from Thor missile
TIGHTROPE	Dominic (Operation Fishbowl)	11/4/62	07:30	low	DOD	Johnston Island area	16.10	169.67 W	10s of kms	high altitude from Nike-Hercules missile

first airdrop of a U.S. thermonuclear weapon was CHEROKEE (Operation Redwing, 20 May 1956), also at Bikini Atoll; it yielded 3.8 Mt. For comparison, the largest above-ground test at the Nevada Test Site was 74 kt (Plumbbob HOOD, 5 July 1957). Fifty percent of the tests in the Marshall Islands were larger than any of the tests at Nevada.

### Christmas Island, Johnston Atoll, and other Pacific locations

Thirty-nine nuclear tests were conducted by the U.S. at locations in the mid-Pacific outside of the Marshall Islands. The total explosive yield of those tests equaled 43 Mt. All of the tests at these locations were conducted in 1962 as part of Operation Dominic except for 3 tests in 1958 as part of Operation Hardtack I (Operation Newsreel).

Twelve tests were conducted in the area near Johnston Atoll, an atoll which today remains as a U.S. military installation. The tests near Johnson Atoll were of large yields (see Fig. 1) though all were airbursts. Many of the tests near Johnston were high altitude explosions (greater than  $10^4$  m); the weapon exploded at the highest altitude ( $4 \times 10^5$  m) was STARFISH PRIME (Operation Dominic, 9 July 1962).

Twenty-four tests were conducted in the area near Christmas Island. Christmas Island, a small atoll in the Line Islands of Kiribati (also known as the Gilbert Islands), is about 3,700 km E of Bikini Atoll and 2,500 km S of Hawaii. All of the Christmas Island tests and all but two of the Johnston Island tests were conducted in 1962 as part of Operation Dominic. All the U.S. tests at Christmas Island were air bursts.

Two of the other three tests conducted in the Pacific Ocean were underwater detonations (WIGWAM and SWORDFISH). The third of that group (FRIGATE BIRD) was launched from a Polaris submarine (depth of firing and altitude of detonation unknown).

Summary statistics of the nuclear tests conducted by the U.S. at its four mid-Pacific test sites are presented in Table 1. A complete listing of the date, time, explosive yield, location and weapon placement for these tests is given in Table 2. Fig. 1 provides frequency distributions of the explosive yields at each of the four mid-Pacific test sites.

### CONCLUDING REMARKS

Of the four mid-Pacific test sites, Bikini Atoll had the largest total explosive yield, although the distribution of yields at Bikini was the widest (see Fig. 1). The number of tests that exceeded 1 Mt in yield was 11 at Bikini (45.8%), 7 at Christmas Island (29.2%), 7 at Enewetak Atoll (20.3%) and 5 at Johnston Atoll (41.7%). The 18 tests in the Marshall Islands that were greater than 1 Mt contributed about 95% of the total explosive yield of the Marshall Islands series.

Of interest to physicists and historians is the fission yield of the thermonuclear tests. Those data have not

been made available; however, estimates of 50% fission yield for those tests is an assumption which is often used.

*Acknowledgments*—The U.S. Department of Energy provided information for this report. The Marshall Islands Nationwide Radiological Study and Lawrence Livermore National Laboratory supported this publication.

## REFERENCES

- BARC. Bikini Atoll rehabilitation committee, Report No. 1. Resettlement of Bikini Atoll: feasibility and estimated cost of meeting the federal radiation protection standards. Submitted to the U.S. Congress House and Senate Committees on Interior Appropriations, pursuant to Public Law 97-257; 15 November 1984.
- Carter, M. W.; Moghissi, A. A. Three decades of nuclear testing. *Health Phys.* 33:55–71; 1977.
- Defense Nuclear Agency. Compilation of local fallout data From test detonations 1945–1962 Extracted from DASA 1251. Washington, DC: Defense Nuclear Agency; DNA 1251-2-EX; 1979.
- Norris, R.; Cochran, T. R.; Arkin, W. M. Known U.S. nuclear tests July 1945 to December 1988, Nuclear weapons data-book, working paper No. 86–2 (Rev. 2c). Washington, DC: National Resources Defense Council; January 1989.
- The Bulletin of the Atomic Scientists (BAS). Nuclear notebook: filling in the blanks. 48:48; 1992.
- Schell, W. R.; Lowman, F. G.; Marshall, R. P. Geochemistry of transuranic elements at Bikini Atoll. In: Hanson, W. C., ed. *Transuranic elements in the Environment*. Washington, DC: U.S. Department of Energy; DOE/TIC-22800; 1980.
- U.S. Congress. Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, 86th Congress, 1st Session on “Fallout from nuclear weapons tests”, May 5, 6, 7 and 8, 1959. Appendix I: Announced Nuclear Detonations (K. Telegadas, author). pp. 2517–2534. Washington, DC: United States Government Printing Office; 1959.
- U.S. Department of Energy. Announced United States nuclear test statistics through December 31, 1977. Las Vegas, NV: Nevada Operations Office, U.S. Department of Energy; 1977.
- U.S. Department of Energy. DOE News. Energy Secretary Unveils Openness Initiative. Washington, DC: U.S. Department of Energy; R-93-354; 1993.
- U.S. Department of Energy. United States Nuclear Tests, July 1945 through September 1992. DOE/NV-209 (Rev.14). Las Vegas, NV: U.S. Department of Energy. Available from National Technical Information Service, Springfield, VA; 1994.

