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UNITED STATES NUCLEAR TESTS
July 1945 to 31 December 1992

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U.S. NUCLEAR TESTS: 16 JULY 1945 to 31 DECEMBER 1992

This working paper summarizes the nuclear tests conducted by the United States.[1] The total number of tests, all conducted between 16 July 1945 through 31 December 1992 are 1051.[2] Table 1 lists the tests chronologically and provides some basic information about each. Tables 2, 3, and 4 summarize the tests by type, location, and purpose. Table 5 summarizes the tests by year and estimated yield. Seven Figures show the test sites in the Central Pacific and in Nevada.

U.S. practice for more than three decades was not to announce all nuclear tests. On 7 December 1993, 204 previously unannounced tests were divulged. Previously 111 of those secret tests had been detected through seismic monitoring, and other means. The monitoring was the result of a close examination of the seismic record by Riley R. Geary of the California Institute of Technology Seismological Laboratory.[3]

Of the 1051 tests,[4] 106 took place in the Pacific, three over the South Atlantic, 925 at the Nevada Test Site, and 17 others in various states and Alaska. Of the 215 atmospheric (including five underwater) tests conducted from 1945 through 1963, approximately 220,000 Department of Defense (DOD) participants, both military and civilian, were present in the Pacific, Atlantic, and continental tests.

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[1] Readers' additions or corrections would be appreciated. The authors would like to acknowledge the assistance of Chuck Hansen, who has been most generous in sharing documents that he has obtained and contributing his knowledge about U.S. testing. His book *U.S. Nuclear Weapons: A Secret History* (Arlington, Texas: Aerofax, Inc., 1988), and his "U.S. Nuclear Weapons Tests, 1945-1962," Revision N, 1 February 1993 have been especially useful. The reader should note that this Working Paper does not discuss several of the traditional issues associated with the history of nuclear testing, such as the health aspects or the arms control efforts to impose full or partial test bans. These issues are covered in an extensive literature that includes: Neal O. Hines, *Proving Ground: An Account of the Radiobiological Studies in the Pacific, 1946-1961* (Seattle: University of Washington Press, 1962); Howard Ball, *Justice Downwind: America's Atomic Testing Program in the 1950's* (New York: Oxford University Press, 1986); Richard L. Miller, *Under the Cloud: The Decades of Nuclear Testing* (New York: The Free Press, 1986); Philip L. Fradkin, *Fallout: An American Nuclear Tragedy* (Tucson: The University of Arizona Press, 1989); A. Costandina Titus, *Bombs in the Backyard: Atomic Testing and American Politics* (Reno: University of Nevada Press, 1986); Robert A. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960* (New York: Oxford University Press, 1978); Carole Gallagher, *American Ground Zero: The Secret Nuclear War* (Cambridge, MA: MIT Press, 1993); Glenn T. Seaborg, *Kennedy, Khrushchev, and the Test Ban* (Berkeley: University of California Press, 1981); Harold Karan Jacobson and Eric Stein, *Diplomats, Scientist, and Politicians: The United States and the Nuclear Test Ban Negotiations* (Ann Arbor: The Univerisity of Michigan Press, 1966).

[2] The term underground test means either a single underground nuclear explosion conducted at a test site, or two or more underground nuclear explosions conducted at a test site within an area delineated by a circle having a diameter of two kilometers and conducted within a total period of time of 0.1 second. The yield of a test is the aggregate yield of all explosions in the test. The term "explosion" means the release of nuclear energy from an explosive canister. Some tests had multiple explosives resulting in multiple nuclear detonations. Department of Energy, Openness Press Conference Facts Sheets, 7 December 1993.

[3] Riley R. Geary, CIT, Seismological Laboratory 252-21, printout.

[4] The total does not include the combat uses of nuclear weapons, at Hiroshima and Nagasaki, which are not considered tests. It does include the 24 joint US/UK tests.

Tests have occurred atop towers, on barges, suspended from balloons, dropped from aircraft, lifted by rockets, on the earth's surface, underwater, and underground. There have been 836 underground tests, 116 of which were before the signing of the Limited Test Ban Treaty. The first test that was purposely designed to be contained was shot *Rainier* on 19 September 1957.[5] The most tests in one year was 98 in 1962. This large number (including an additional 29 through June 1963) was in anticipation of a halt in atmospheric, underwater, and outer space testing, which occurred as a result of the Limited Test Ban Treaty (LTBT), signed on 5 August 1963. The annual average of tests in the 1950s was 19; in the 1960s, 43; in the 1970s, 23; and in the 1980s, 17. On average during the forty-eight year testing period one test was conducted every 16½ days. No tests were conducted in 1993 because of Congressional legislation that imposed a moratorium. President Bill Clinton announced on 3 July 1993 that he was extending the moratorium "at least through September" of 1994.[6] It is quite possible that there will be no more tests conducted at the Nevada Test Site.

The largest nuclear test explosion conducted by the United States was shot *Bravo*, a fifteen megaton (Mt) device tested at Bikini Atoll, Marshall Islands, in the Pacific on 28 February 1954. Very low yield test explosions down to less than a ton and several failures ("fizzles") have also occurred. The U.S. government has had several different policies over the years in announcing tests and in specifying the yields or yield ranges of tests. For all tests the combined yield is estimated to be 180 Mt, the equivalent of almost 12,000 Hiroshima bombs. Approximately 141 Mt of the total was detonated in the atmosphere, almost all between 1952 and 1962. Tests are now limited to a maximum yield of 150 kilotons under terms of the Threshold Test Ban Treaty (TTBT), signed by President Nixon in Moscow on 3 July 1974. The ban did not take effect until 31 March 1976. After ratification by the U.S. Senate on 25 September 1990 the treaty entered into force on 11 December 1990. Through the 1970s and 1980s, the annual average has been 20 tests with a combined yield for the twenty year period of 21 Mt. Beginning on 9 November 1962, eleven months before the LTBT entered into force, every U.S. test has been underground,[7] all but fourteen at the Nevada Test Site (NTS).

Trinity

At a certain point in the development of the atomic bomb at the Los Alamos laboratory in New Mexico a site was needed to test the device. In a six month search

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[5] There were previous underground tests but there were at shallow depths and not contained. The first of these was a weapons effects test on 29 November 1951, buried at only 17 feet. The second was a one kiloton atomic demolition munition emplaced at 67 feet. There were also three underground safety experiments conducted in July and August 1957 that produced very low or zero yields.

[6] For a discussion see Christopher E. Paine, "The U.S. Debate over a CTB," NRDC *Nuclear Weapons Databook Working Paper 93-5*, 28 October 1993.

[7] The last U.S. atmospheric test was shot Tightrope, held on 4 November 1962. The last atmospheric test at NTS was Little Feller I on 17 July 1962.

in the spring and summer of 1944 11 sites in five states were considered.[8] Five sites were considered in New Mexico: Cabezon Peak in Sandoval County, 50 miles northwest of Albuquerque; an abandoned logging camp near Paxton Springs, 15 miles southwest of Grants; the desert south of El Morro National Monument; the Tularosa valley southeast of Socorro, and a section of the Alamogordo Bombing Range, the eventual choice. Other sites considered were: San Nicolas Island, southwest of Los Angeles; Padre Island, off the coast of Texas; Coconino Plateau, south of the Grand Canyon in Arizona; the San Luis Valley region near Great Sand Dunes National Monument, 65 miles southwest of Pueblo, Colorado; the desert in southeastern California, north of Rice; and near Wendover, Utah.[9]

The final choice of a site was made after consultation with General Ent of the Second Air Force on 7 September 1944 who gave permission for a party to approach the Commanding Officier of the Alamogordo Bombing Range to seek an area within the base 18 miles wide by 24 miles long. After a section in the northwest corner was chosen, a base camp was constructed and completed by late December 1944. A successful 100-ton TNT calibration and rehearsal shot was conducted on 7 May 1945. The preparations for the test were greatly increased starting in March when a July 4 date was set. This date was later changed to July 13, and finally on June 30 the earliest date for the Trinity shot was changed to July 16.

The first U.S. test of a nuclear device (nicknamed "Gadget") occurred on Monday 16 July 1945, at 5:29:15 am Mountain War Time, on a 100 foot tower at the White Sands Bombing Range, 55 miles northwest of Alamogordo, New Mexico. Trinity Site is at latitude 33^0 40' 31" North, longitude 106^0 28' 29" West. The explosion was set off at an elevation of 4624 feet. The top of the mushroom cloud reached a height of 35,000 feet and the estimated 20-22 kiloton explosion produced a shallow crater 500 feet in diameter and six feet deep.[10]

Post-War Testing in the Pacific

In the weeks following the dropping of atomic bombs on Hiroshima and Nagasaki, American military and political leaders began planning nuclear weapon experiments to test weapon effects and new designs. On 10 November 1945, a subcommittee of the Joint Chiefs of Staff (JCS) began developing plans for a series of tests of existing and newly developed nuclear weapons. The primary purpose was

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[8] Necah Stewart Furman, *Sandia National Laboratories: The Postwar Decade* (Albuquerque: University of New Mexico Press, 1990), pp. 81-82.

[9] David H. Morrissey, "Almost Ground Zero," *Albuquerque Journal*, 11 February 1990, p. C1.

[10] Lillian Hoddeson, Paul W. Hendersen, Roger A. Meade, and Catherine Westfall, *Critical Assembly: A Technical History of Los Alamos During the Oppenheimer Years, 1943-1945* (New York: Cambridge University Press, 1993), pp. 350-377: K.T. Bainbridge, *Trinity*, Los Alamos Scientific Laboratory, LA-6300-H, issued May 1976; Ferenc Morton Szasz, *The Day the Sun Rose Twice: The Story of the Trinity Site Nuclear Explosion July 16 1945* (Albuquerque: University of New Mexico Press, 1984); Defense Nuclear Agency, *Project Trinity 1945-1946*, DNA 6028F; Vincent C. Jones, *Manhattan: The Army and the Atomic Bomb* (Washington, DC: Center of Military History, 1985), p. 479.

to explore the effects of atomic explosions on naval vessels. The subcommittee's program was accepted by the JCS on 28 December 1945 and approved by President Truman on 10 January 1946. An appropriate site was needed that met basic requirements.

a. It needed to be under control of the United States.
b. The area needed to be uninhabited or subject to evacuation without imposition of unnecessary hardship on a large number of inhabitants.
c. It needed to be within 1000 miles of the nearest B-29 aircraft base, as it was expected that one test nuclear device was to be delivered by air.
d. It needed to be free from storms and extreme cold.
e. It must have a protected harbor at least six miles in diameter thereby being large enough to accommodate both target and support vessels.
f. It needed to be away from cities or other population concentrations.
g. The local winds should be predictably uniform from sea level to 60,000 feet.
h. The water currents should also be predictable and not adjacent to inhabited shorelines, shipping lanes, and fishing areas so as to avoid contaminating populace and their food supplies.

After considering locations in the Atlantic, Caribbean, and Pacific, several atolls in the Marshall Islands, which met the above requirements, were chosen as possible sites. Bikini Atoll was chosen as the site for Operation *Crossroads*. (See Figures 1-4) In early 1946, 161 Bikinians were removed from their island and transported to the uninhabited Rongerik Atoll.[11] Tests *Able* and *Baker* were conducted in June and July 1946 using Fat Man type warheads.[12]

Though the tests were successful, Bikini had deficiencies as a test site, including the lack of land area for a support base and the impossibility of building an airstrip due to island orientation and wind direction. Bikini would not be used again for nuclear testing until Operation *Castle* in 1954.

The Atomic Energy Commission (AEC) studied several possible locations including island sites in the Indian Ocean, Alaska, and Kwajalein Atoll, as well as the continental United States. The AEC selected Enewetak Atoll and, upon approval of the proposal by President Truman, requested that the Military Services prepare the Enewetak Proving Ground and provide logistical support. On 18 October 1947 Joint Task Force-7 was activated to prepare the proving ground and conduct Operation *Sandstone*. Once again the people had to be removed. On 21 December 1947 136 dri-Enewetak were transported to the deserted Ujelang Atoll 124 miles

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[11] In 1948 the Bikinians were moved first to a U.S. naval base on Kwajalein, and eight months later to Kili island where they and their descendants remain. See William S. Ellis, "A Way of Life Lost: Bikini," *National Geographic*, June 1986, pp. 813-834; Jonathan M. Weisgall, "Micronesia and the Nuclear Pacific since Hiroshima," *SAIS Review*, Summer-Fall 1985, pp. 41-55.

[12] Jonathan M. Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll* (Annapolis, MD: Naval Institute Press, 1994): Lloyd J. Graybar and Ruth Flint Graybar, "America Faces the Atomic Age," *Air Force Review*, January-February 1984, pp. 68-77; Lloyd J. Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?" *The Journal of American History*, March 1986, pp. 888-907.

southwest of Enewetak.

On 31 January 1950 President Truman announced that the decision had been made to develop thermonuclear bombs. This decision, coupled with the outbreak of the Korean War in June and an intensifying Cold War lead to decisions to test and build more nuclear weapons. To expedite testing the AEC decided to establish a continental test site and in September 1952 removed Bikini Atoll from the provisional status in which it had been held since Operation *Crossroads* making it part of the Pacific Proving Ground. From 1951 through 1962 the U.S. conducted six additional test series in the Pacific (see Table 1 for details).

Nevada Test Site

The need for a continental test site arose with plans to increase the size of the arsenal in the 1950s, though the search had begun much earlier.[13] Continental-based testing also reduced the expense and logistic problems of testing in the Pacific. Under "Project Nutmeg," a study prepared by the Armed Forces Special Weapons Project, a number of sites were considered on the basis of low population density, geology, favorable year-round weather conditions, safety, and security.[14]

On 18 December 1950 President Truman gave his approval to use a portion of the Air Force's Las Vegas Bombing and Gunnery Range in southeastern Nevada for atomic tests. Construction of the Nevada Test Site facilities began in January 1951. Operation *Ranger* was the first series for which the site was utilized. The first test occurred on 27 January 1951, when a one-kiloton device was dropped from an Air Force B-50 bomber into Frenchman Flat.

Originally 680 square miles were withdrawn. Additional land withdrawals in 1958, 1961, 1964, and 1965 lead to its present size of 1350 square miles. At Mercury (Area 23) in the southeast corner of the NTS are the centralized facilities which support most of the activities at NTS. The Frenchman Flat area was where 14 atmospheric tests were conducted between 1951 and 1962. Ten underground tests were also conducted there between 1965 and 1971, but it is no longer used. The majority of tests took place in the vicinity of Yucca Flat, a valley 10 by 20 miles extending northward from the Control Point. Rainier Mesa (Area 12) was the location for the Defense Nuclear Agency's (DNA) weapons effects tests. Pahute

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[13] Roy B. Snapp, Secretary AEC, "Location of Proving Ground for Atomic Weapons," AEC Paper 141, 15 September 1948.

[14] Among the sites considered were: the Pamlico Sound area off the coast of North Carolina, along the coastal strip between Cape Hatteras and Cape Fear; Utah at the Dugway Proving Ground/Wendover Bombing Range: New Mexico at the Almogordo-White Sands Guided Missile Range, "a state conditioned to nuclear work; and with easy logistics from the center of atomic bomb storage at Sandia"; an area in Nevada from Fallon to Eureka; and the one eventually chosen, the Tonopah-Las Vegas Bombing and Gunnery Range. "If the fallout element over the eastern part of the United States cannot be accepted, sites can be chosen on the coast of Maine or the coasts of Delaware, Maryland or Virginia." Carroll L. Tyler, *Documentation of Establishment of Continental Test Site*, Division of Military Application Memorandum, 14 September 1953. See also Col. George F. Schlatter, USAF, Division of Military Application, AFSWP Briefing on Continental Sites, 17 July 1950.

Mesa, a 166 square mile area, was the location for higher yield tests (Areas 19 and 20) in the northwestern corner. On 1 November 1963 the AEC signed a Memorandum of Understanding (MOU) with the Air Force authorizing use of Pahute Mesa.

The NTS is divided into 27 numbered areas. Each of the two design laboratories tested in designated areas. Los Alamos used Areas 1, 3, 4 (east), 7, 19. Lawrence Livermore used Areas 2, 4 (west), 8, 9, 10 and 20.[15] DNA weapons effects tests took place in Area 12 (See Figures 5, 6 and 7).

Two other Areas are of interest. At Area 6 is Control Point-1 (CP-1), at the crest of Yucca Pass, from which all tests were conducted. In the Operation Control Center, the Test Controller and his panel reviewed weather data prior to each test. Closed circuit TV showed the surface ground zero area at detonation time and remote telemetry equipment monitored the area for radioactivity.

Nuclear test device assembly operations, which require mating special nuclear materials (SNM) and high explosive (HE) materials to the proper configuration for testing, were performed at two locations on the NTS and at one location at Los Alamos. Due to inadequate physical security the Los Alamos National Laboratory (LANL) facility was closed in FY 1984. The LANL assembly building at NTS was in Area 11. As an interim measure towards consolidation, the LANL operation was moved to the Lawrence Livermore National Laboratory assembly area in Area 27 in Jackass Flats and began operations in 1985. The facilities assigned to LANL were formerly the backup facilities for LLNL. The Baker/Able sites within Area 27 were engaged in the assembly, disassembly, and modification of nuclear explosives, non-nuclear explosives, and assemblies containing special nuclear material.[16] Lawrence Livermore performed this work in the Baker compound, and Los Alamos at the Able site. The Baker complex consists of four buildings and six storage magazines. At various times kilogram quantities of plutonium, hundred kilogram quantities of high explosives of many types, and all isotopes of uranium might have been there. Weapon or device components were brought to the test site from the respective laboratories, from other facilities in the complex (Pantex, Rocky Flats, Y-12), or their vendors. The shipments involved air, rail or truck transportation. Assembled nuclear weapons under the custody of the Department of Energy are not transported by air.[17] Ross Aviation Inc., of Albuquerque, NM, under contract to the DOE since 1970, transports components by air.[18]

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[15] U.S. Congress, Office of Technology Assessment, *The Containment of Underground Nuclear Explosions*, OTA-ISC-414 (Washington, DC: U.S. Government Printing Office, October 1989), p. 17.

[16] Energy Research & Development Administration, *Nevada Test Site*, Final Environmental Impact Statement, September 1977, p. 3-44.

[17] DOE, *Pantex Plant Site*, Final Environmental Impact Statement, October 1983, p. 4-43.

[18] HAC, FY 1985 EWDA, Part 6, p. 263.

Nuclear devices were brought to NTS either as components or fully assembled, via safe-secure trucks. On site movements were accompanied by a heavily armed protective force escort in armored vehicles and receive an aerial sweep of the route prior to departure. At the NTS Able site members of the Weapon Engineering (WX-1) and Fabrication & Assembly (WX-3) sections of the Los Alamos Design Engineering Division (WX) prepared the weapon or device for testing. At the Baker compound before the parts for an assembly were received, a detailed assembly procedure was compiled and reviewed by LLNL personnel of the Nuclear Explosives Engineering Division, the Weapons Engineering Division, the Criticality Group, and High Explosives Chemistry. This procedure listed all parts, the steps to be performed in sequence, and all special handling equipment. During an assembly operation, each step was signed off by the Device Engineer.[19]

Beginning on 14 July 1986 ground was broken on a new facility in Area 6, just off the Mercury Highway, which was planned to consolidate both laboratory assembly areas. Known as the combined Device Assembly Facility (DAF)[20] it occupies 109,000 square feet of floor space, and consists of five assembly cell "Gravel Gerties,"[21] two radiography facilities, four high bays (each 1800 square feet, with 25 foot ceilings), three assembly bays (30 by 60 feet each), and one storage bay, four special nuclear material/high explosive storage bunkers, two high explosive magazines and vaults, and various support and maintenance buildings. Security arrangements are extensive within the 22-acre high exclusion area. There are two six-level, 51-foot high guard towers. The 144 square foot guard station has 6-inch thick reinforced walls, with bullet resistant metal doors and glass windows. Eight-foot high parallel fences, 30 feet apart surround the buildings. The entire area has extensive lighting, alarms, movement detection equipment and an aircraft early detection system. The facility is scheduled to be operational in 1995 at a cost of $98.2 million. It was originally built with the idea of supporting a testing rate of some two dozen or more tests per year. The facility will also perform operations on selected significantly damaged nuclear weapons that are deemed inappropriate for processing at Pantex. Other uses may have to be found for the DAF, such as assisting in the dismantlement of U.S. nuclear weapons to supplement the Pantex Plant.

The Nevada Test Site is administered by the Nevada Operations Office (NV) of the Department of Energy (DOE). Approximately 6895 personnel work there with a budget of approximately $450 million (FY 1993). The major operating contractors

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[19] ERDA, *Nevada Test Site*, p. 3-45.

[20] HAC, FY 1985 EWDA, Part 4, pp. 144-147; HAC, FY 1986 EWDA, Part 4, pp. 217-222; DOE, Congressional Budget Request, Atomic Energy Defense Activities, FY 1988, pp. 291-297; DOE, Congressional Budget Request, Atomic Energy Defense Activities, FY 1989, pp. 231-237; Congressional Budget Request, Atomic Energy Defense Activities, FY 1990, p. 68; Congressional Budget Request, Atomic Energy Defense Activities, FY 1992, pp. 77-78.

[21] A Gravel Gertie is where the weapons are assembled. There are many at the Pantex Plant in Texas. The ones at NTS will be 34-feet in diameter, providing 1017 square feet of work space. The circular structure has one-foot thick reinforced concrete walls and a 25 foot thick gravel roof. The entire facility will be earth-bermed and provides total containment in the event of up to a 500 pound explosion.

for DOE at NTS are Reynolds Electrical and Engineering Company (REECo), EG&G/Energy Measurements (formerly Edgerton, Germeshausen, and Grier, Inc.);[22] Raytheon Services Nevada (RSN);[23] and Wackenhut Services, Inc. (WSI).[24] REECo is the principal support contractor. REECo operates the test site and conducted drilling for underground tests and minor construction. In late 1993 approximately 2675 personnel worked at NTS and 725 in Las Vegas. EG&G/EM employs about 1955 people; 1160 in Las Vegas, 97 at NTS, 275 in California, 355 in New Mexico, 18 in Massachusetts, and 50 in Maryland. RSN employs about 1160, 230 at NTS, 345 in Las Vegas and 585 at DOE's Pacific sites. Wackenhut Services provides security and employs about 350 people, 260 at NTS and 90 in Las Vegas.

The Nevada Operations Office was established in Las Vegas, Nevada, on 6 March 1962 to manage the Atomic Energy Commission's (later ERDA's and then DOE's) Nuclear Detonation and Test Readiness Programs at the NTS[25] as well as at other on- and off- continent test locations.[26]

The Manager of the Nevada Operations Office, manages the NTS and is responsible for all operational matters. Each recent program or series of tests was conducted in accordance with the "Planning Directive for Underground Nuclear Tests at the Nevada Test Site," dated 2 April 1982 issued by the Deputy Assistant Secretary of Energy for Military Application.[27] The Manager is supported by three Assistant Managers and a Test Controller. The Assistant Manager for Defense developed and executed policies involving occupational safety and health issues, radiological safety, and environmental assessments. Further responsibilities included approving the weekly NV Master Test Schedule, administering air support, nuclear explosives safety and construction programs for NV programs. The Assistant Manager for Administration is responsible for providing physical security and plant protection,

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[22] Since December 1952 REECo has been a contractor with the test program. A five-year, $2.25 billion contract became effective 1 October 1988. On 25 January 1993 the Nevada Field office announced it will extend the contract for 27 months beginning 1 October 1993, at a cost of about $675 million. DOE News, NV-93-04, 25 January 1993.

[23] The NVO signed a five year contract with RSN on 5 November 1990 for $625 million. The work was formerly performed by Holmes & Narver, Inc., and Fenix & Scisson of Nevada, Inc. (FSN). The work included engineering for drilling and mining operations, technical support, construction, and other services. Holmes & Narver had been a contractor to DOE and its predecessor agencies at the NTS since 13 November 1956 and in the Pacific since 1951. FSN had been a contractor since 18 March 1963.

[24] Wackenhut began as a security contractor on 1 February 1965. Prior to that Federal Services Inc. (from January 1952) and General Plant Protection, Los Angeles, CA were security contractors.

[25] From 1951 until 1962 the Test Division of the Santa Fe Operations Office (SFO) and the Albuquerque Operations Office (ALO) operated the test site. SFO was changed to ALO on 2 April 1956.

[26] One of four Safeguards recommended by the Joint Chiefs of Staff for their support of the Limited Test Ban Treaty was to maintain facilities and resources necessary to institute promptly nuclear tests in the atmosphere should they be deemed essential to U.S. national security or should the Soviet Union abrogate the Treaty. From 1963 until 1975 the United States had Thor rockets on Johnston Island for this purpose.

[27] In DOE/NV, Planning & Operations Directive Underground Nuclear Test Operations, NVO-176 (Rev.1), Appendix 1.

personnel clearance, and technical and communications security programs. The Assistant Manager for Energy & Conservation reviews standard operating procedures and budgetary issues. The Test Controller approved the Operations and Security Plan and conducted a containment review.

It typically took about a year to prepare a vertical shaft test. Approximately 12 months before D-Day, after the design of the device or weapon was known, the diagnostics were researched, the information for the canister (Livermore's term) or rack (Los Alamos's term)[28] design was generated, the geology for the test hole was examined, the test location at NTS selected, and the hole drilled. Huge drill bits were used to bore holes from 400 to 5000 feet in depth[29] and from three to twelve feet in diameter. Normally tests below 20 Kt were detonated in holes 600 to 1000 feet deep. Some of the smallest tests, which are among those that were originally unannounced, were conducted in shafts 400-600 feet deep, with one detonated at only 197 feet. Tests of 20 Kt to 150 Kt normally use holes 1500 to 2200 feet deep. A portable building known as a "bogey tower" was placed over the hole, from which work was done on the canister/rack before it was lowered down the shaft.

Approximately nine months before D-Day, fabrication of the canister began,[30] items were purchased, components assembled and the cables were laid. With three months to go the canister was put in the tower and aligned, the radiation detectors installed, the cables connected, and the diagnostic stations put in place. At five weeks to D-Day tests were conducted on the firing system, and timing signals (systems tests) sent to diagnostic stations to make sure they were operating. At three weeks the nuclear device or warhead was brought to the hole and placed at the lower end of the long (up to 250 feet long by 8 feet in diameter) cylindrical canister/rack. The canister contained the nuclear device or warhead, firing components, radiation detectors, spectroscopes, electronic instrumentation and television cameras. The diagnostic systems normally made up the greater part of the canister's length. Over the years canisters/racks increased in weight to an average of over 100,000 lbs in 1981, (up from an average of 55,000 lbs in 1978).[31] A considerable bundle of electrical cables (coaxial and increasingly fiber optic) connected the firing and diagnostic systems to the surface recording stations. As the complexity of tests increased so too did the number and length of cable used per event. In 1984, 115

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[28] David Creek, "On Trial," *AWE News*, April 1991, p. 4.

[29] Excluding the nine cratering tests, the shallowest shaft test was conducted on 17 October 1963 at a depth of 197 feet. The deepest test at NTS was at 4759 feet on 3 January 1976. A deeper shaft was dug to 5875 feet in Alaska for a 5 Mt blast on 6 November 1971. The deepest explosion ever conducted, at 8443 feet, was a Plowshare experiment on 10 September 1969 in Colorado.

[30] On 26 March 1976 the Augmented Test Logistic Assembly System (ATLAS) complex was completed. This 20-acre facility in north Las Vegas, run by EG&G, fabricates and assemblies canisters. They are delivered intact to NTS, ready for a nuclear device to be attached and emplaced in a shaft.

[31] HASC, FY 1983 DOE, p. 109. In 1981 the cost of a canister was over $400,000 with some costing over $1 million.

cables totalling over 33 miles (on average) were used per event, up from 71 cables totalling 17 miles five years earlier.[32]

The canister containing the nuclear device and the diagnostic equipment was then lowered down the hole.[33] A new system was scheduled to take only two days to lower the device, instead of eight to ten days previously. With two weeks until D-Day, "stemming" or back filling the hole began. The purpose of stemming was to prevent the escape of radioactive materials into the environment. Emplacement holes were stemmed with layers of different materials. The first layer above the rack was magnetite, an iron oxide material which provided shielding for the experiment. This was followed by alternate layers of coarse gravel and fine sand. Two or more epoxy plugs about ten feet thick were placed at intervals to provide gas blocking.

After shot *Baneberry* (18 December 1970) vented an enormous amount of radioactivity into the atmosphere (6,700,000 Ci), new procedures were established in the preparation of each test. The Containment Evaluation Panel (CEP) was created to assist the Manager, NV, in reviewing each upcoming test so that it would be satisfactorily contained. The CEP was composed of representatives from Los Alamos, Lawrence Livermore and Sandia National Laboratories, Defense Nuclear Agency, U.S. Geological Survey, other scientists, and advisors from the EPA, NOAA, DOE headquarters, REECo, Holmes & Narver, Fenix & Scisson. The first CEP meeting was held at Las Vegas on 18-19 March 1971 and approximately 200 have been held since then. At each meeting, normally two or three months before the scheduled shot date, one or more tests were discussed. A representative from the sponsoring laboratory described the event and how the emplacement design and stemming was planned to contain it, based on prior tests in nearby holes and the geology of the area.[34]

On the day before the scheduled detonation several readiness briefings took place normally at Control Point-1 (CP-1) to review the containment system, any unique technical features associated with the test, predicted weather conditions at scheduled shot time, potential fallout exposures if there is an accident, air support missions and other matters. Based upon these reviews a recommendation was made to proceed with or delay the test.

If the decision was made to proceed a final briefing was held at the Control Point on D-Day approximately two hours before the scheduled shot time. At that time an update on the readiness status and weather conditions was made. If the test remained on schedule the Test Controller granted the Test Group Director (TGD)

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[32] HASC, FY 1985 DOE, p. 338.

[33] On 23 October 1975 a test canister fell the last forty feet to the bottom of a 650 foot drilled shaft during emplacement operations. The canister contained a small nuclear device. The total weight of the pipe, canister and equipment that dropped was 175 tons. There were 11 injuries.

[34] The Los Alamos representative was normally from either the Geology/Geochemistry, Geophysics or Geoanalysis group of the Earth & Space Sciences Division. The Lawrence Livermore representative was normally from the Earth Sciences Department.

of the sponsoring agency permission to arm the device.

A small number of scientists accompanied by security guards drove out to a trailer known as the "Red Shack" to electronically arm the device or warhead.[35] Two of the scientists carried a special briefcase and a bag of tiny cubes that had numbers painted on their sides. They alternately picked cubes out of the bag and punched the numbers into an "arm enable" device in the briefcase, generating a random code that was sent to the device/warhead on a special electrical cable. The scientists then went to the Control Point where they opened their briefcase and sent the same random code to the device/warhead, arming it. If security and the weather conditions were satisfactory the Test Controller gave the go-ahead and a secret coded signal was sent to the Red Shack starting a computer that automatically cycled through a 5-to-15-minute program that ended with the detonation. At any point the Test Controller could halt the countdown by pressing a red stop button.

The diagnostic equipment in the canister detected the explosion and information was sent uphole through the cables. Within a fraction of a millisecond following the detonation, the sensors and cables were destroyed, but by that time the data had been transmitted to the recording stations or to the Control Point. This technique of measuring whether the nuclear device performed to design specifications is known as prompt diagnostics.

When the device detonates, it creates a large underground cavity sometimes hundreds of feet in diameter, the bottom of which quickly fills with molten rock, materials and debris. As the heat and pressure subside, material begins to fall into the cavity, creating a void that progressively works its way upward. If the void reaches the surface, the overlying rock collapses under its own weight, producing a large subsidence crater. This may occur minutes, hours or days after the explosion. The size of the underground cavity and the surface crater (if it forms) is dependent on the yield of the explosion, the depth of burial, and the physical properties of the medium in which it is detonated.

A second technique used to measure whether the device/warhead performed to design specifications is nuclear chemistry diagnostics. A few days after the detonation a drill back operation was conducted to remove samples of the radioactive material from the explosion debris. This debris is concentrated in a volume of fused dirt called the puddle. The material samples are either solids or gases left in the cavity. The samples were taken as soon as possible after the detonation and returned to either LANL or LLNL for analysis. From the samples nuclear chemists can learn about fission and fusion yields and burn efficiency (how much nuclear fuel was used). New approaches were being developed which would have retrieved gases from the test hole within minutes after the detonation.

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[35] This paragraph relies on William J. Broad, "Bomb Tests: Technology Advances Against Backdrop of Wide Debate," *New York Times*, 15 April 1986, p. C1.

The NTS is pockmarked with several hundred craters of various sizes from 200 to 2000 feet in diameter and up to 200 feet deep. Astronauts have used the test site for training missions prior to their journeys to the moon.

Types of Tests

There are various ways to categorize the purposes of U.S. tests. One way is to use the categories in the annual NVO publication, *Announced United States Nuclear Tests*: Weapons Related; Weapons Effects; Safety Experiment; Plowshare; Vela Uniform; Storage-Transportation; and Combat. These categories, somewhat modified, are presented in Table 4, and some of them will be discussed below. The most numerous and interesting tests are "Weapons Related," for these constitute the primary purpose for which the test program has been conducted. It is necessary to further break down the Weapons Related tests into Weapon Development, Production Verification, Stockpile Confidence and Physics tests.[36]

Weapon Development: Weapon Development tests comprised approximately 75 to 80 per cent of the nuclear tests conducted each year. These tests contributed to the engineering of a specific new warhead for a specific new weapon system; for example the W87 for the MX, the B83 Strategic Bomb, or the W84 for the Ground Launched Cruise Missile. Recent experience with modern weapons required approximately six nuclear tests to develop a new design and to certify it for introduction into the stockpile. The W87 for the MX Missile required 10 tests.[37] The number depended on many factors: the extent to which the design is innovative; constraints on size, shape, weight, and weight distribution; requirements for certain yields and yield options; the need for certain safety and command and control features. The early tests in the series were to verify and confirm the theoretical concepts that underlie the device's design and operation. Some low yield tests were to test the primary. Later tests in the series after the design was fixed were proof tests to verify the yield. Variable yield warheads, for example the W80-1/0 (ALCM/ACM/SLCM - 5 Kt to 150 Kt), W84 (GLCM - 0.2 Kt to 150 Kt), or W85 (Pershing II - 0.3 Kt to 80 Kt), may have needed several proof tests to verify each of the yields.

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[36] For example, see the statement of Robert B. Barker in, Senate Foreign Relations Committee, Nuclear Testing Issues, S. Hrg. 99-937, May 8, June 19, and 26, 1986, pp. 126-145; also reprinted in SASC, Nuclear Testing Issues, S. Hrg. 99-984, April 29 and 30, 1986, pp. 19-24.

[37] It is likely that the basic nuclear design for the MX warhead (as well as the Trident II warhead and the warhead for the Minuteman III, MK12A) were developed and tested at their full yield prior to the imposition of the 150 Kt TTBT limitation, which the United States began to adhere to after March 1976. By mid-1983 nuclear testing of the W87 was essentially complete. See *Energy and Technology Review*, July 1983, p. 13. The First Production Unit W87 was produced in April 1986. It is possible that one of these first warheads was detonated in shot *Jefferson* on 22 April 1986, as a stockpile confidence test, normally done just prior to or soon after deployment. The test was sponsored by LLNL and used the CORRTEX measuring system. The CORRTEX experiment would probably be conducted with a warhead whose yield is known with some accuracy.

If the new concepts were more exotic more tests might have been needed. During the Reagan Administration there was accelerated funding to examine five Nuclear-Driven Directed Energy Weapon (NDEW) concepts. These were:

* X-ray Laser - a device for converting the output of a nuclear explosive into beams of x-rays which may be capable of producing shock damage to targets thousands of kilometers distant, which were examined for Strategic Defense Initiative application;

* Hypervelocity Pellets - use of specially designed nuclear explosive to propel particles to extremely high velocities which may be capable of producing catastrophic physical damage to targets at great distances, a "nuclear shotgun;"

* Directed Microwaves - a device for converting the output of a nuclear explosive into a beam of high-frequency electromagnetic (microwave) energy which may be capable of causing temporary or permanent internal electronic damage to a target at great distances;

* Particle Beams - use of a specially designed nuclear explosive to accelerate a beam of charged atomic particles. A high-energy particle beam may cause internal electronic damage or may cause missile propellant/high explosives to detonate; and

* Optical Laser - use of a specially designed nuclear explosive to power a laser operating at or near visible light frequencies. Such a laser may be capable of causing shock or thermal damage at great distances.[38]

The head of Theoretical and Computational Physics at LANL estimated that it might require 100 to 200 test explosions per concept to perfect each of these new designs.[39] An extra 500 to 1000 tests at recent testing rates, or even accelerated ones, would have taken decades and tens of billions of dollars to accomplish. In fact, technical failures and budget constraints caused the research programs during the Bush administration to be severely cut back.[40]

Production Verification tests: In recent years about one or two Production Verification or Stockpile Confidence tests had been conducted on average each year. This constituted approximately eight percent of U.S. tests. Production verification tests were underground nuclear tests of war-reserve warheads selected from the production line and were usually the first test in its actual stockpile configuration. Since 1970 20 warhead types (including significant modifications of the B61 and W70) have entered the stockpile and routinely production verification tests have been conducted to certify their yield and military characteristics. Since 1980 the number of warhead types introduced into the stockpile each year has been: 1980, 0; 1981, 3 (W80-1, W70-

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[38] Transcript, Questions for the Record by Senator Kennedy, for DOE SASC hearing held 8 April 1986.

[39] William J. Broad, "U.S. Researchers Foresee Big Rise in Nuclear Tests," *New York Times*, 21 April 1986, p, A1. Not all of the concepts were pursued at the same rate of testing. HAC, FY 1987 EWDA, Part 6, p. 1506.

[40] William J. Broad, "Crown Jewel of 'Star Wars' has Lost its Luster," *New York Times*, 13 February 1990, p. C1; Broad, "Technical Failures Bedevil Star Wars," *New York Times*, 18 September 1990, p. C1.

3 ER, W79 ER); 1982, 0; 1983, 4 (W85, B83, W84, W80-0), 1984, 0; 1985, 0; 1986, 1 (W87); 1987, 0, 1988, 1 (W88); 1989-1993, 0.

Stockpile Confidence tests: A less frequent kind of test is a Stockpile Confidence test of an older warhead type already in the stockpile to see if it still performs as expected. These tests are very rare.[41] Since 1970 only eight tests out of some 300 (.026%) have been conducted to correct defects in stockpiled weapons. The types involved included the B61, W68, W79, W80, and W84. A stockpile confidence test of the W56 for the Minuteman II was conducted recently.[42] There must be a very good reason for a test to be conducted of an older warhead. There is no procedure by which warheads are randomly removed from the stockpile, transported to Nevada and exploded. There are numerous joint Service-DOE programs of non-nuclear testing (see below). In the past, problems have been identified through non-nuclear tests and inspections and explosive nuclear tests have been conducted to see if they were corrected, but even those cases have been quite rare.[43]

Physics tests: Physics tests are conducted to improve the understanding of the fundamental phenomena of a nuclear explosion. Despite the fact that over 1000 tests have been conducted and the National laboratories possess the largest computing facilities in the country the warhead designers claim that there are still things which are not fully understood about a nuclear explosion. Therefore some two or three tests a year, (approximately five percent) were conducted for this purpose.[44] These tests are normally of a very small yield (fractions of a kiloton--down to 100 tons or below) and were normally not announced by the Department of Energy.

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[41] SFRC, Nuclear Testing Issues, p. 131: HFAC, Proposals to Ban Nuclear Testing, 1985, p. 78; Farooq Hussain claims that "only a dozen or so have been conducted over the past thirty-five years." The Impact of Weapons Test Restrictions, *Adelphi Paper* No. 165 (London: IISS, 1981), p. 14.

[42] *Energy & Technology Review*, July 1987, p. 15.

[43] The figure eight comes from SASC, Nuclear Testing Issues, S. Hrg. 99-984, April 29 and 30, 1986, p. 46. For a discussion of some of the warheads for which there have been problems see Thomas B. Cochran, William M. Arkin, Robert S. Norris and Milton M. Hoenig, *Nuclear Weapons Databook*, Volume II, *U.S. Warhead Production*, (Cambridge, Massachusetts, Ballinger Publishing Company, 1987), pp. 46-51; Ray E. Kidder, *Evaluation of the 1983 Rosengren Report from the Standpoint of a Comprehensive Test Ban*, LLNL, Report No. UCID-20804, June 1986; Jack W. Rosengren, *Stockpile Reliability and Nuclear Test Bans: A Reply to a Critic's Comments*, RDA Logicon, 1401 Wilson Blvd., Suite 500, Arlington VA, 22209, November 1986, prepared for DOE, No. RDA-TR-138522-001; Ray E. Kidder, *Stockpile Reliability and Nuclear Test Bans: Response to J.W. Rosengren's Defense of His 1983 Report*, LLNL, Report No. UCID-20990, February 1987; R.E. Kidder, *Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban*, LLNL, Report No. UCRL-53820, October 1987; George H. Miller, et al., *Report to Congress on Stockpile Reliability, Weapon Remanufacture, and the Role of Nuclear Testing*, LLNL, Report No. UCRL-53822, October 1987; Letter from George H. Miller, Associate Director for Defense Systems, LLNL, to Senator Edward M. Kennedy, 27 February 1987.

[44] "Since 1981, one or two LLNL tests per year have been dedicated to weapons physics research;" *Energy & Technology Review*, September 1986, p. 17. Presumably LANL conducted one or two per year as well.

Weapons Effects Tests: The purpose of a weapons effects test is to research the range of nuclear effects, these being airblast, ground and water shock, heat, electromagnetic pulse, neutrons, gamma and x-rays, and apply that knowledge to military systems, plans and policy.[45] More specifically, the weapons effects test program assessed the survivability of U.S. military systems in a nuclear environment and predicted lethality levels for destruction of enemy forces and equipment.[46] The Defense Nuclear Agency is responsible for research in this area and in recent years conducted one or two tests per year at the NTS. Overall ninety-seven weapons effects tests have been conducted accounting for 9 percent of the total.

Most modern weapons effects tests were conducted within a horizontally mined tunnel drilled into Rainier Mesa, at Area 12. These extensive engineering projects took approximately 18 months to prepare. A laboratory supplied device, of a known yield, was located in the Zero Room, which was connected to a long, horizontal line of sight (HLOS) pipe 1000 feet or more long containing several test chambers. The pipe was 800 to 1450 feet below ground and tapered. The end at the Zero Room may be only a few inches in diameter while the other end may be as much as 27 feet in diameter. Within the test chambers were placed hundreds of components and materials, from ballistic missile reentry vehicles to communications equipment. The experiments were mounted at various distances, chosen to expose the equipment to radiation between half and twice their design limits. Sometimes the HLOS pipe was vacuum pumped to less than one micron (one millionth of a meter) of pressure to simulate conditions in space. Various rapid closure mechanisms in the HLOS allowed radiation generated by the nuclear device to reach the test chambers but prevented the escape of debris and radioactive gases. In one test (*Miners Iron*) two huge pressure activated doors weighing three metric tons each closed in less than 30 ms after detonation. In a more recent test (*Mighty Oak*) the doors malfunctioned which caused contamination throughout the tunnel thus ruining much equipment and many experiments. Above-ground instrumentation trailers on the mesa were connected by cables to the hundreds of experiments within the HLOS. Following the test the military hardware was retrieved from the test chambers and the effects of the explosion were evaluated in the laboratory.

An average weapons development vertical shaft test cost approximately $30 to $40 million. Because of the more extensive tunnelling needed for a horizontal effects test, the cost was higher normally ranging between $50 million and $90 million per test.[47]

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[45] "Underground Testing: A Different Kind of Laboratory," *Sandia Technology*, December 1981, pp. 2-15; AEC, Nevada Operations Office, Planning Directive, DOD Nuclear Weapons Effects Test and Other Experiments, Nevada Test Site, NVO-81 (Rev. 4), January 1975;

[46] SAC, FY 1985 DOD, Part 3, p.530. Soviet and East European military equipment is also subjected to U.S. weapons effects tests.

[47] Ronald L. Soble, "Secrecy Cloaks Testing of Awesome Nuclear Arms," *Los Angeles Times*, 27 November 1984, p. 23; Rick Atkinson, "'Underground Events' Test Mettle of U.S. Atomic Arsenal," *Washington Post*, 29 May 1984, p. A6.

Non-explosive testing of nuclear warheads

Unlike the underground nuclear test program at the Nevada Test Site, which mainly dealt with warheads before they entered the stockpile, there are numerous other programs which monitor those warheads in the stockpile on a sustained and regular basis. These programs do not require exploding the warhead.

Each year quantities of weapons are returned from the Department of Defense to the Department of Energy for evaluation testing. The weapons are selected randomly by serial number and are provided with the assistance of Field Command/Defense Nuclear Agency. These weapons are subjected to either Laboratory or Flight test programs. Laboratory testing involves the disassembly of weapons and the testing of selected components to ensure they will survive all conditions specified in the stockpile-to-target sequence, including the effects of transportation, handling, and storage.

Some components are easily removed and tested. Others may entail considerable work to remove and may end up destroying perfectly good components. Tests involve electronic, explosive, strength, and other mechanical tests. Upon completion of the tests, which may take up to six months, the weapons are reassembled using the same components or, if needed, replacement components produced and stored during the original production period. At the time of original production total lifetime quantities of components are determined and produced. If everything is in order the reassembled warhead is returned to the arsenal and redeployed. Detailed figures have been supplied by Pantex showing this activity over the period FY 1980-FY 1992.[48]

Fiscal Year	Evaluation Disassembly (Disposed of)	Evaluation Disassembly (Reassembled)
1980	197	150
1981	161	180
1982	175	189
1983	160	256
1984	134	217
1985	148	251
1986	---	291
1987	121	220
1988	71	234
1989	74	118
1990	95	185
1991	49	112
1992	29	46

[48] Information supplied to NRDC by Tom Walton, Amarillo Area Office, 19 January 1993.

A complementary program is the stockpile surveillance program whereby a certain percentage of war reserve production are not committed to the stockpile but are set aside for special examination. The key focus is on the chemical compatibility of the materials within the warhead assembly. Some of these items are stored at higher temperature to accelerate the aging process.

Computer simulation of nuclear testing

Since the Manhattan Project the designing of new nuclear weapons has been one of the most important driving forces for the development of ever more powerful computers.[49] The three National Laboratories, Los Alamos, Lawrence Livermore and Sandia, are among the first institutions to receive the most advanced computers of the day and have perhaps the most powerful computing capabilities in the world.[50] The computers allow weapon designers to simulate and model a host of problems associated with nuclear weapons. Direct measurement is impossible with temperatures of 10 million degrees, velocities of four million miles per hour, and time scales of millionths of a second. Computer simulation can partially substitute for tests that are banned, such as those in space, atmosphere, water and those above 150 kilotons. In the future under a Comprehensive Test Ban they will be used more widely.

The higher power of the more recent supercomputers[51] has led to more accurate modeling thus reducing the number of tests (and the cost) necessary to design a specific warhead.[52] For example an earlier warhead designed with the Control Data Corporation (CDC) 6600 required 23 field tests, whereas a more recent one designed with the CDC 7600 needed only six. The introduction of the Cray-1 (in 1976), the X-MP (in 1982), and the Cray-2 (in 1985) have no doubt reduced the

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[49] Francis H. Harlow and N. Metropolis, "Computing and Computers: Weapons Simulation Leads to the Computer Era," *Los Alamos Science*, Winter/Spring 1983, pp. 132-141; Benjamin M. Elson. "Los Alamos Boosts Computer Capacity," *Aviation Week & Space Technology*, August 23, 1982, pp. 72-75; Fred W. Dorr, "The Cray-1 at Los Alamos," *Datamation*, October 1978, pp. 113-120: "Preparing for the Cray-2," *Energy and Technology Review*, September 1985, pp. 24-25; D.B. Henderson, "Computation: The Nexus of Nuclear Weapon Development," in N. Metropolis, D.H. Sharp, W.J. Worlton, and K.R. Ames, eds., *Frontiers of Super-Computing* (Berkeley: University of California Press, 1986), pp. 141-51; Department of Energy, *The Need for Supercomputers in Nuclear Weapons Design*, January 1986.

[50] The Los Alamos Director states, "At Los Alamos we house the world's most powerful scientific computing facility with a computing power exceeding 65 of the original Cray I supercomputers." *LANL Institutional Plan, FY 1991- FY 1996*, LALP-90-24, November 1990, p. 1.

[51] It has been estimated that a team of scientists using the calculators of the 1940s would take five years to solve what it takes a Cray computer one second to perform; DOE, *The Need for Supercomputers*, p. 11.

[52] "Computation has become firmly established as a third mode of scientific research complementing the traditional methodologies of theory and experiment. New and more refined mathematical and numerical approaches in areas such as hydrodynamics, turbulence, transport, chemical dynamics, and materials properties can provide insights into phenomena not directly observable through experiment. With the increasing cost of nuclear weapons tests and the possibility that further restrictions will be placed on such experiments, the role of computation is becoming increasingly important." *LANL Institutional Plan FY 1991- FY 1996*, p. 39.

number of tests for certain warhead types still further as well as giving greater amounts of data per test. A Cray-2 is four times as powerful as a Cray-1, which in turn, is four times as powerful as the CDC 7600 and 15-20 times as powerful as the CDC 6600. The newest Cray is the Y-MP, introduced in February 1988, whose performance is two-to three times greater than the most powerful X-MP.[53] With a computing speed 30 times that of a Cray 1 the $20 million Y-MP's eight processors working together are able to perform two to four billion arithmetic operations per second. Los Alamos has two Y-MPs, while Livermore and Sandia have one each.[54] A reasonable estimate of total computer time for a design is 8000 hours.[55]

This trend of reduced numbers of tests per warhead type should be kept in mind as an explanation for the declining number of U.S. tests in recent years, and in refuting arguments that stressed only the number of tests, rather than qualitative factors in debates comparing U.S. and Soviet testing practices.

Secret tests

On 7 December 1993 Secretary of Energy Hazel O'Leary released a list of 204 previously unannounced underground tests. An analysis of this group of tests reveals several interesting features about U.S. testing practices, as well as pointing to several important questions about verifying a comprehensive test ban (CTB) that will need to be discussed during the Conference on Disarmament CTB negotiations that began on 25 January 1994 in Geneva, Switzerland.

All 204 tests were conducted at the Nevada Test Site. The first of these secret tests were a pair detonated on 27 September 1963, the last was conducted on 6 April 1990.[56] Twenty-one percent of the tests in the 1960s were secret, 40 percent of the 1970s were secret, and 8 percent in the 1980s. By presidential administration the Nixon administration was most secretive, with 85 of 181 tests (47 percent) during the period 1969-1974, being unannounced. After more than a four-year period in which all tests were announced (June 1979 to August 1983), the Reagan and Bush administrations reimposed a secret testing policy. From August 1983 to April 1990 there were eighteen secret tests. The reason for such secrecy is not exactly clear. If the purpose was to keep knowledge of such testing from the Soviet Union, or from the American people, it was not a great success. Thirteen of the 18 tests were detected seismically. In two other cases the test was known about through leaks in

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[53] Andrew Pollack, "The Next Generation at Cray," *New York Times*, 10 February 1991, p. D1.

[54] HAC, EWDA FY 1991, Part 6, p. 818. Other types of supercomputers at the three laboratories include Thinking Machines CM-2 at LANL, NCUBE systems at SNL and a Bolt Beranek and Newman TC200 at LLNL; Ibid, p. 819.

[55] DOE, *The Need for Supercomputers*, p. 17.

[56] According to the DOE all tests prior to the signing of the Limited Test Ban Treaty on 5 August 1963 had been publicly announced beforehand, though many were not known to have taken place at the time.

the newspapers.[57] This leaves three tests that were not publicly known: *Navata* on 29 September 1983, and *Kawich A* on 9 December 1988, and *Wexford* on 30 August 1984 that was set off simultaneously with an announced test.

As noted above 111 of the 204 unannounced tests were detected by Riley R. Geary of the California Institute of Technology before their existence was declassified in December.[58] Of the 204 unannounced tests, 19 tests were detonated simultaneously with an announced test, or another unannounced test, as follows: five secret tests that were unknown were each paired with secret tests that were known; seven secret tests that were unknown were each paired with announced tests; and two secret tests were fired simultaneously with one announced test. Of the remaining 185 unpaired secret tests, 43.7 percent (79 out of 185) were undetected and 57.3 percent (106 out of 185) were detected. Using the new information a more exacting examination of the seismic record is underway by Mr. Geary and others. Preliminary results suggest that the number of undetected tests may actually be less than fifty, although they were unidentified at the time.

It should be noted that the number of stations that were well placed to detect and locate an explosion at NTS in the 1960s was a mere handful. The number of stations that can detect and locate explosions has grown over the years to a couple of dozen today. In the 1960s, 48.8 percent (40 out of 82) of the unpaired secret tests were detected; in the 1970s, 59.3 percent (51 out of 86) were detected; in the 1980s, 87.5 percent (14 out of 16) were known; and in the 1990s the single secret test was detected. No doubt, with today's network many of the explosions in the 1960s and 1970s would have been detected. For an eventual CTB one would not only draw upon the current public network but take advantage of other seismometers. The weapon design laboratories have a local seismic network at the NTS, and when it was turned on for a test, it likely recorded even the tiniest explosions. In a CTB regime data from these seismometers should be a part of the verification network.

The Department of Energy continues to classify the precise yields of the previously unannounced tests, except to note that each are less than 20 Kt. The yields of the undetected tests in recent years are probably in the range of 10 tons to several hundred tons. If the precise yields of the small tests were released outside experts would be able to determine the current threshold of verifiability of the existing open seismic network around NTS and work towards its improvement.

Several points need to be made about very low yield tests. First, it would be difficult even for a sophisticated nation like the U.S. to develop confidence in a new nuclear warhead design if it could only (clandestinely) test at this level. Secondly, for

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[57] Michael R. Gordon, "Kremlin Reports U.S. A-Tests, Citing Ease of Detection," *New York Times*, 30 August 1986, p. 1. The article described a Soviet military official in Washington announcing three small U.S. tests to demonstrate that verification is not as difficult as Reagan Administration officials suggested.

[58] Riley R. Geary, "Nevada Test Site's Dirty Little Secrets, " *Bulletin of the Atomic Scientists*, April 1989, pp. 35-38.

a nation that is developing its first bomb, without outside nuclear design assistance or previous test data, an attempted low yield clandestine test of a few hundred tons would pose the risk of an explosion of substantially higher yield and a failure of containment. It should also be noted that the yield-range of interest for the first time proliferator is more likely to be between 5 Kt and 25 Kt.[59]

Would a nation that had signed a CTB engage in clandestine tests? While it is possible that they might, there would penalties for getting caught and the risks of being found out are not insignificant. To prepare a clandestine test would entail activities that might be noticed through satellite observation or other means, while complete test containment would be uncertain for a first time proliferator.

In conclusion, while it is technically possible to conduct very small nuclear explosions that remain undetected by the current public seismological network, modern, state-of-the-art seismometers at appropriate locations can improve chances to detect and locate even smaller explosions, if they should be attempted.

[59] The yields for the first fission tests of the five declared nations were: United States, 23 Kt, Soviet Union, 20 Kt, Great Britain, 25 Kt, France, 60-70 Kt, China, 20 Kt.

U.S. Nuclear Testing Budgets - FY 1962-1971/1977-1994[1]
(BA $ in millions)

Fiscal Year	DOE	DOD/DNA	Total
1962	182.2	108.0	290.2
1963	133.0	111.0	244.0
1964	206.5 (36)	44.0	250.5
1965	214.8 (37)	59.0 (6)	273.8
1966	201.6 (41)	64.0 (4)	265.6
1967	193.2 (31)	61.0 (4)	254.2
1968	242.7 (40)	60.0 (4)	302.7
1969	304.8 (40)	63.0 (5)	367.8
1970	246.5 (44)	61.0 (6)	307.5
1971	212.8 (15)	74.0 (1)	286.8
1977	229.1 (21)	38.2 (0)	267.3
1978	240.0 (20)	27.7 (2)	267.7
1979	221.0 (16)	26.6 (0)	247.6
1980	209.0 (13)	28.6 (1)	237.6
1981	329.9 (13)	30.6 (1)	360.5
1982	320.0 (18)	66.2 (2)	395.2
1983	442.6 (16)	94.2 (2)	536.8
1984	565.0 (15)	94.1 (1)	659.1
1985	613.6 (15)	105.9 (1)	719.5
1986	567.0 (13)	105.3 (3)	672.3
1987	618.7 (12)	85.9 (2)	704.6
1988	609.6 (14)	83.2 (1)	692.8
1989	585.3 (9)	90.2 (2)	675.5
1990	533.3 (8)	109.0 (1)	662.3
1991	499.5 (6)	99.0 (1)	598.5
1992	510.8 (5)	115.5 (2)	626.3
1993	419.4 (0)	104.8 (0)	524.2
1994 est.	461.8 (0)	100.2 (0)	562.0

[1] For FY 1962-1971, Prospects for Comprehensive Nuclear Test Ban Treaty, Hearings before the Subcommittee on Arms Control, International Law and Organization of the Committee on Foreign Relations, US Senate, 92nd Congress, 1st session, (Washington, 22 and 23 July 1971). For FY 1977-1994, transcript, Questions for the Record by Senator Kennedy, SASC, DOE Hearing, 8 April 1986; HASC, FY 1989 DOE, p. 302; HAC, FY 1990 EWDA, Part 6, pp. 470, 498; HAC FY 1991, EWDA, Part 6, p. 816; HAC (Questions for the record, FY 1992), unpublished; HAC, FY 1994 EWDA, Part 6, p. 1282. Figures in parentheses are number of U.S. tests in each Fiscal Year. Does not include 21 UK tests in this time period which are paid for by the British or the 21 Plowshares tests held in these years.

Table 1
U.S. Nuclear Tests 16 July 1945-31 December 1992

Event Name[a]	Time(GMT)[b]	Date	Location	Lab	Type	HOB/ DOB(ft)[c]	Purpose[d]	Yield[e]
Trinity	05:29.45 local	07-16-45	Alamogordo, NM	LA	Tower	100	WR	23 Kt±3
Little Boy	08:15 local	08-06-45	Hiroshima, Japan	LA	B-29 Airdrop	1900±50	Warfare	15 Kt
Fat Man	11:02 local	08-09-45	Nagasaki, Japan	LA	B-29 Airdrop	1650±33	Warfare	21 Kt

The totals throughout the paper do not include the two combat uses of nuclear weapons which are considered tests.

OPERATION *CROSSROADS*

Operation *Crossroads* was at that time the largest peacetime military operation ever conducted with 240 ships, 156 aircraft, and 42,000 personnel. The two tests used Fat Man type bombs (also called Mk 3A, "Christy devices," or Model 1561 devices) similar to the one dropped on Nagasaki. The purpose of the tests was to determine the effects of nuclear detonations on naval ships, planes and on animals. The first test weapon, shot *Able*, was dropped by a B-29 ("Dave's Dream") on a fleet of more than ninety vessels in Bikini Lagoon and exploded 980 feet short and 1870 feet left of the target. The test weapon in *Baker* was encased in a watertight steel caisson suspended beneath a medium landing ship anchored in the midst of the target fleet. An additional deep (1000 ft) underwater detonation, *Charlie*, was planned but was not conducted.

Able	22:00	06-30-46	Bikini (1st)	LA/DOD	B-29 Airdrop	520	WE	23 Kt
Baker	21:35	07-24-46	Bikini	LA/DOD	Underwater	-90	WE	23 Kt

OPERATION *SANDSTONE*

The three tests of Operation *Sandstone* were the first proof tests since Trinity. Second generation warhead design principles were tested, using composite cores and levitation principles in the X-Ray and Yoke tests, and an all U-235 levitated core in the *Zebra* test. The devices were 10,500 lb Mk-3Bs. Proof tested Type B pit. Led to stockpiling Mk 4 bomb. Ten thousand two hundred personnel participated. A fourth shot was cancelled.

X-Ray	18:17	04-14-48	1st Enewetak/Janet	LA	Tower	200	WR	37 Kt
Yoke	18:09	04-30-48	Enewetak/Sally	LA	Tower	200	WR	49 Kt
Zebra	18:04	05-14-48	Enewetak/Yvonne	LA	Tower	200	WR	18 Kt

OPERATION *RANGER*

Operation *Ranger* was the first series of atmospheric tests held at the Nevada Proving Ground (now NTS) and were the first devices tested in the United States since *Trinity*. In November 1950 scientists at Los Alamos decided that a series of small nuclear tests were needed in preparation for the upcoming *Greenhouse* series to establish satisfactory design criteria related to the variation of yield with compression of the fissile material. *Ranger* was a series of experiments involving devices using a fraction of a critical mass ("fractional crit"). The concept of a "fractional crit" originated in 1944 during the Manhattan Project. The White House approved the tests on 11 January 1951 accelerating the establishment of the Nevada Proving Ground. The original name was *Faust* scheduled for the fall of 1951. During the eleven days a total of five devices were dropped from a B-50 bomber. All of the devices detonated approximately 1100 to 1400 feet over Frenchman Flat.

Able	13:45	01-27-51	NTS (FF)	LA	B-50 Airdrop	1060	WR	1 Kt
	Compression vs. critical mass test; MK 4 device weight, 10,800 lbs							
Baker	13:52	01-28-51	NTS (FF)	LA	B-50 Airdrop	1080	WR	8 Kt
	"Fractional crit" test; Mk 4							
Easy	13:47	02-01-51	NTS (FF)	LA	B-50 Airdrop	1080	WR	1 Kt
	Compression vs. critical mass test; Mk 4							
Baker-2	13:49	02-02-51	NTS (FF)	LA	B-50 Airdrop	1100	WR	8 Kt
Fox	13:47	02-06-51	NTS (FF)	LA	B-50 Airdrop	1435	WR	22 Kt
	Proof-test of new type pit (Type D) and the 92-point HE assembly for use on the Mk 5 (Easy) test in Greenhouse. Predicted yield was 34 Kt.							

OPERATION *GREENHOUSE*

Two of the *Greenhouse* tests were thermonuclear experiments. Shot *George* produced the first significant U.S. thermonuclear reaction. *George* was a two-stage device, using a large cylindrical primary and a small D-T secondary. Its objective was to determine experimentally one aspect of the feasibility of a thermonuclear weapon, namely initiation, and not whether a thermonuclear reaction, once initiated, would continue to propagate itself. The deuterium and tritium contributed only a small amount to the yield. Shot *Item* was a major contribution to the development of thermonuclear weapons. It was the first test of a boosted fission device using deuterium and tritium. Shot *Dog* was probably a test of the B6. Fifteen thousand mice, swine, and dogs were used during *Greenhouse* to test the lethality range of blast, heat and radioactivity.

Dog	18:34	04-07-51	Enewetak/Yvonne	LA	Tower	300	WR	81 Kt
	MK 6 proof test; total device weight 10,000 lbs							
Easy	18:27	04-20-51	Enewetak/Janet	LA	Tower	300	WR	47 Kt
	TX-5 proof test; total device weight 2,700 lbs							
George	21:30	05-08-51	Enewetak/Ruby	LA	Tower	200	WR	225 Kt
	First thermonuclear experiment							
Item	18:17	05-24-51	Enewetak/Janet	LA	Tower	200	WR	45.5 Kt
	Tested principle of tritium boosting to enhance fission. Believed to be an oralloy design which did not rely on compression of the D-T.							

OPERATION *BUSTER-JANGLE*

The five Los Alamos weapon development tests constituted the *Buster* phase held in October and November 1951, the second series held at NTS. The objective of these tests was to evaluate new devices for possible inclusion in the stockpile. The two weapons effects tests of the *Jangle* phase were meant to help determine the military utility of surface and underground nuclear detonations. The first three of eight Desert Rock troop exercises were held during *Buster-Jangle*. These exercises were designed to explore the conditions and tactics of the atomic battlefield. A prototype of the B8 was tested during *Buster*.

Able	14:00	10-22-51	NTS (Area 7)	LA	Tower	100	WR	<0.1 Kt
	Fizzle, predicted yield 12-15 Kt							
Baker	15:20	10-28-51	NTS (Area 7)	LA	B-50 Airdrop	1118	WR	3.5 Kt
Charlie	15:00	10-30-51	NTS (Area 7)	LA	B-50 Airdrop	1132	WR	14 Kt
Dog	15:30	11-01-51	NTS (Area 7)	LA	B-50 Airdrop	1417	WR	21 Kt
Easy	16:30	11-05-51	NTS (Area 7)	LA	B-45 Airdrop	1314	WR	31 Kt
	Easy was a proof test of the MK 7, a weapon one-sixth the weight (1,800 lbs), one-half the diameter, and almost one and one-half times the yield of the Fat Man bomb.							
Sugar	17:00	11-19-51	NTS (Area 9)	DOD	Surface	3.5	WE	1.2 Kt
Uncle	19:59.59.7	11-29-51	NTS (Area 10)	LA/DOD	Crater	-17	WE	1.2 Kt

OPERATION *TUMBLER-SNAPPER*

Operation *Tumbler-Snapper* was a series of eight atmospheric tests at NTS. The purpose of the first phase, *Tumbler*, was to collect information on the effect of the height of burst on overpressure. The peak blast overpressure of the devices used during *Greenhouse/Buster-Jangle* were lower than predicted and *Tumbler* was designed to investigate the reasons. The accuracy of the *Greenhouse/Buster-Jangle* data was affirmed, and in general the *Tumbler* shots gave a more comprehensive description of blast phenomena than had been previously known. A further objective was to learn more about the dust "sponge" effect and the relationship of dust to radiation. The purpose of the *Snapper* phase was to test potential warhead designs for inclusion in the stockpile and to study techniques to be used during Operation *Ivy*. *Dog* tested the TX-7 and *Fox* and *George* the Mark 5. In *Easy* and *How* tested the feasibility of a 22-inch implosion system which lead to stockpiling the B12 and efficiency of external initiation. Shot *Easy* was the first test using beryllium as a tamper material. Ten thousand six hundred DOD personnel participated in Desert Rock IV.

Able	17:00	04-01-52	NTS (Area 5)	LA/DOD	B-50 Airdrop	793	WE	1 Kt
Baker	17:30	04-15-52	NTS (Area 7)	LA/DOD	B-50 Airdrop	1109	WE	1 Kt
Charlie	17:30	04-22-52	NTS (Area 7)	LA/DOD	B-50 Airdrop	3447	WR	31 Kt
	Broadcast live on national television							
Dog	16:30	05-01-52	NTS (Area 7)	LA/DOD	B-45 Airdrop	1040	WR	19 Kt
Easy	12:15	05-07-52	NTS (Area 1)	LA	Tower	300	WR	12 Kt
Fox	12:00	05-25-52	NTS (Area 4)	LA	Tower	300	WR	11 Kt
George	11:55	06-01-52	NTS (Area 3)	LA	Tower	300	WR	15 Kt
How	11:55	06-05-52	NTS (Area 2)	LA	Tower	300	WR	14 Kt

OPERATION *IVY*

Event *Mike* was the first test of an experimental thermonuclear device in which a substantial portion of the energy was generated by the fusion of hydrogen isotopes. It used liquid deuterium. Event *King* was the largest fission weapon ever detonated, presumed to be a prototype of the B18 Super Oralloy bomb, weighed 8600 lbs.

Mike	19:14.59.4	10-31-52	Enewetak/Flora	LA	Surface		WR	10.4 Mt
	Experimental thermonuclear device; produced a crater 6240 feet in diameter and 164 feet deep. Total device weight 164,000 lbs. Used TX-5 primary. The total fission yield was 8 Mt or 77 percent of the total yield.							
King	23:30 local	11-15-52	Enewetak	LA	B-36H Airdrop	1480	WR	500 Kt
	Reef near Yvonne							

OPERATION *UPSHOT-KNOTHOLE*

The major purposes of Operation *Upshot-Knothole* were to test devices for possible inclusion in the stockpile; to improve military tactics, equipment, and training for the atomic battlefield; and to enhance civil defense requirements by measuring and assessing blast effects upon dwellings, shelters, automobiles, etcetera. Some objectives were to improve the nuclear weapons used for strategic bomber delivery and those used for tactical battlefield situations, and to establish military doctrine for the tactical use of nuclear weapons. Experimental external neutron generators were tested. It also established that hollow-core nuclear systems can greatly increase the efficiency of implosion weapons and provided tests of radiation implosion mock-ups and primaries as preliminaries to design of the *Castle* devices, and produced information regarding boosting with deuterium gas. The yields ranged from 1 Kt to 61 Kt and included three airdrops, seven tower shots, and an artillery firing using a 280 mm cannon. Approximately 21,000 DOD personnel from the four armed services participated in Desert Rock V. The third and fifth tests of the series were LLNL's first tests since being established as the second design laboratory the year before. These two tests were fizzles.

Annie	13:20	03-17-53	NTS (Area 3)	LA	Tower	300	WR	16 Kt
	More than 600 civil defense and news media observers witnessed the detonation.							
Nancy	13:10	03-24-53	NTS (Area 4)	LA	Tower	300	WR	24 Kt
	Test of primary for TX-14 thermonuclear bomb, similar to Simon device.							
Ruth	13:00	03-31-53	NTS (Area 7)	LL	Tower	304	WR	0.2 Kt
	First LLNL test, fizzle of uranium hydride core							
Dixie	15:30	04-06-53	NTS (Area 7)	LA	B-50 Airdrop	6022	WR	11 Kt
Ray	12:45	04-11-53	NTS (Area 4)	LL	Tower	100	WR	0.2 Kt
	Second LLNL test, fizzle of uranium hydride core							
Badger	12:35	04-18-53	NTS (Area 2)	LA	Tower	300	WR	23 Kt
	Test of primary for TX-16 thermonuclear bomb. Was expected to yield 40 Kt							
Simon	12:30	04-25-53	NTS (Area 1)	LA	Tower	300	WR	43 Kt
	Test of primary for TX17/24 thermonuclear bomb. Predicted yield was 35 Kt							
Encore	15:30	05-08-53	NTS (Area 5)	DOD/LA	B-50 Airdrop	2423	WE	27 Kt
	Used Mark 6							
Harry	12:05	05-19-53	NTS (Area 3)	LA	Tower	300	WR	32 Kt
Grable	15:30	05-25-53	NTS (Area 5)	DOD/LA	Airburst	524	WR	15 Kt
	A 280 mm 85-ton cannon fired an atomic artillery projectile using the Mk-9 warhead that was detonated at a height of 524 feet above Frenchman Flat, NTS. The top of the mushroom cloud reached an altitude of 35,000 feet.							
Climax	11:15	06-04-53	NTS (Area 7)	LA	B-36 Airdrop	1334	WR	61 Kt
	High yield proof test of the B7							

OPERATION *CASTLE*

Operation *Castle* was the culmination in the development of the "super," or hydrogen, bomb that began in 1950. The objectives were threefold: first, to fire six or seven experimental thermonuclear devices, including proof tests of three emergency capability weapons (EC14, EC16 and EC17)--the test firing of one of these, presumably the EC16, was contingent upon the results of the other six tests; second, to obtain diagnostic information on these tests necessary to evaluate their performance; and third, to obtain effects information on devices in the megaton range. The first two shots fired, *Bravo* and *Romeo*, gave yields considerably above those expected just prior to actual detonation and led to the conclusion that a lithium deuteride "dry bomb" was practical for stockpiling purposes. Since this type of device was appreciably simpler to use than a liquid deuterium bomb, the Los Alamos test of the EC16 (called *Jughead*) was cancelled and an alternative device inserted in its place (probably shot *Nectar*). The seventh shot of the *Castle* series, *Echo*, (device named "Ramrod") a LLNL design, was withdrawn following the failure of *Koon*. The design principles for the B15 and the B21 were also established. The total fission yield for the *Ivy* and *Castle* tests was 39 Mt.

Bravo	18:45.00.0	02-28-54	Bikini	LA	Surface	7	WR	15 Mt

Experimental thermonuclear device (named "Shrimp," weight 23,500 lbs, 179.5 in length 53.9 in diameter using lithium deuteride. Produced a crater with a diameter of 6000 feet and a depth of 240 feet. Expected yield 6 Mt (presumed range 4 to 8 Mt). Cloud top 114,000 feet. Used lithium enriched to 40 percent. The fission yield was 10 Mt.

Romeo	18:30.00.4	03-26-54	Bikini	LA	Barge (1st)		WR	11 Mt

Test of EC-17. Expected yield 8 Mt (range 1.5 to 15 Mt). Device named "Runt I," weight 39,600 lbs, 224.9 in length, 61.4 in diameter. Cloud top 110,000 feet. Used natural lithium enriched to 7.5 percent Li-6. The fission yield was 7 Mt.

Koon	18:20.00.4	04-06-54	Bikini/Tare	LL	Surface	13.6	WR	110 Kt

Lawrence Livermore fizzle. Device weight 23,000 lbs, 115.9 in length, 56.4 in diameter. Expected yield 1.5 Mt (range 0.33 to 4 Mt). Device named "Morgenstern." Cloud top 53,000 feet. Koon may have been a test of Ulam's two-stage thermonuclear proposal based on using mechanical shock from the primary to compress the secondary. The fission yield was 100 Kt.

Union	18:10.00.7	04-25-54	Bikini	LA	Barge		WR	6.9 Mt

Test of EC-14. Expected yield 5 to 10 Mt (range 1 to 18 Mt). Device named "Alarm Clock," weight 27,700 lbs, 151 in length, 61.4 in diameter. Cloud top 94,000 feet. Used lithium enriched to 95 percent Li-6. The fission yield was 5 Mt.

Yankee	18:10.00.1	05-04-54	Bikini	LA	Barge		WR	13.5 Mt

Test of EC-24. Expected yield 9.5 Mt (range 7.5 to 15 Mt). Device named "Runt II," weight 39,600 lbs, 225 in length, 61 in diameter. Cloud top 110,000 feet. The fission yield was 7 Mt.

Nectar	18:20.00.4	05-13-54	Enewetak (10th)	LA	Barge		WR	1.69 Mt

Expected yield 2 to 3 Mt (range 1 to 5 Mt). Device named "Zombie," weight 6520 lbs, 110 in length, 34.5 in diameter. Prototype of B-15. Cloud top 71,000 feet. The fission yield was 1.35 Mt.

OPERATION *TEAPOT*

Operation *Teapot*, a series of fourteen tests held at NTS, was authorized by President Eisenhower on 30 August 1954. Some of the tests were for the purpose of expanding the variety of tactical weapons, including those primarily designed for defensive purposes. The series established the feasibility of 16-inch diameter implosion systems and proved the effectiveness of tritium gas boosting of hollow-pit systems, thus establishing the design principles for the XW-25 for the GENIE, the XW-30 for the Talos, the XW-31 and XW-37 for the Nike Hercules missile, the XW-34 for the Lulu, Hotpoint and ASTOR, and the boosted primaries for the TX-15-X4, TX-39-X1, TX-21-X2, TX-27 and TX-28. Approximately 8000 DOD personnel took part in Desert Rock VI. According to a joint AEC-DOD press release, "the mission of Exercise Desert Rock VI . . . [is] to teach its soldiers to view nuclear weapons in their proper perspective. . . . that powerful though these weapons are, they can be controlled and harnessed . . . and that despite the weapons' destructiveness there are defenses against them on the atomic battlefield." The tests confirmed the practicality of small boosted implosion warhead designs. The third shot of the series, *Tesla*, was LLNL's first successful test, two-and-one-half years after the establishment of the laboratory. The LLNL tests had to do with linear (versus spherical) implosion techniques. Devices using external neutron sources were tested during the *Moth*, *Tesla* and *Post* shots. *Turk*, *Apple-1*, *Apple-2*, and *Zucchini* were tests of small high-yield boosted primaries suitable for use in a Class D weapon. LANL test names were flying insects, fruits and vegetables. LLNL test names were early inventors and San Francisco street names.

Wasp	20:00	02-18-55	NTS (Area 7)	LA	B-36 Airdrop	762	WE	1 Kt
Moth	13:45	02-22-55	NTS (Area 3)	LA	Tower	300	WR	2 Kt
Tesla	13:30	03-01-55	NTS (Area 9b)	LL	Tower	300	WR	7 Kt

Predicted yield 2 Kt. First successful Lawrence Livermore test

Turk	13:20	03-07-55	NTS (Area 2)	LL	Tower	500	WR	43 Kt

Test of primary for XW-27.

Hornet	13:20	03-12-55	NTS (Area 3a)	LA	Tower	300	WR	4 Kt

Test of prototype air defense warhead, sealed pit, D-T gas boosted spherical design

Bee	13:05	03-22-55	NTS (Area 7)	LA	Tower	500	WR	8 Kt

Test of air-defense warhead, possibly XW-25

Ess	20:30	03-23-55	NTS (Area 10)	DOD	Crater	-67	WE	1 Kt

Purpose was to prepare a subsurface emplacement site for an atomic demolition munition test, emplace the munition, backfill the shaft, and fire the munition. It made a crater 290 feet in diameter and 96 feet deep. It used the Ranger Able core in a Mark 6 HE assembly, weighing 8000 lbs.

Apple-1	12:55	03-29-55	NTS (Area 4)	LA	Tower	500	WR	14 Kt
Wasp Prime	18:00	03-29-55	NTS (Area 7)	LA	B-36 Airdrop	737	WR	3 Kt
HA (High Altitude)	18:00	04-06-55	NTS (Area 1)	DOD	B-36H Airdrop	36,620	WE	3 Kt
Post	12:30	04-09-55	NTS (Area 9c)	LLNL	Tower	300	WR	2 Kt
MET	19:15	04-15-55	NTS (FF)	LA/DOD	Tower	400	WE	22 Kt
	Military Effects Test)							
Apple-2	12:10	05-05-55	NTS (Area 1)	LA	Tower	500	WR	29 Kt

More than 500 civil defense specialists took part in extensive exercises in mass feeding, communications, police, fire, sanitation, medical, welfare and other public services. A small group of the participants, including women, experienced the detonation in a trench in the forward position.

Zucchini	12:00	05-15-55	NTS (Area 7)	LA	Tower	500	WR	28 Kt

OPERATION *WIGWAM*

Operation *Wigwam* was a single test conducted approximately 400 miles southwest of San Diego, California at 29 degrees North, 126 degrees West. One of only five underwater tests ever conducted, the *Wigwam* device was suspended by cable from a towed unmanned barge to a depth of 2000 feet in water that was approximately 16,000 feet deep. The major purpose of *Wigwam* was to determine the fatal range a deeply detonated nuclear weapon would have on a submarine and on surface ships. The weapon used was the B7, "Betty" nuclear depth charge.

Wigwam	21:00 local	05-14-55	Pacific	DOD	Underwater	-2000	WE	30 Kt

PROJECT 56

Project 56 No. 1	22:10	11-01-55	NTS (Area 11a)	LA	Surface		SE	Zero
Project 56 No. 2	21:15	11-03-55	NTS (Area 11b)	LA	Surface		SE	Zero
One-point safety test of W-25								
Project 56 No. 3	19:55	11-05-55	NTS (Area 11c)	LA	Surface	5	SE	No Yield
Project 56 No. 4	21:30	01-18-56	NTS (Area 11d)	LA	Surface	5	SE	Very Slight

Tests 3 and 4 were one-point safety tests of prototype TX/XW-28 and TX-39 primaries.

OPERATION *REDWING*

The objectives of Redwing were to proof test certain weapons in stockpile or to be stockpiled in the near future, to continue developmental research on promising weapons, to continue long range research on new techniques, ideas and designs. More specifically objectives were to establish the feasibility of 12-inch diameter implosions systems, obtain design information on 8-inch implosion systems, and on two-stage systems of 13-15-inch diameter. The seventeen shots in the *Redwing* series of mid-1956 were primarily to test high-yield thermonuclear devices that could not be tested in Nevada. All *Redwing* shots except CHEROKEE tested new weapon developments. *Cherokee* was less a scientific experiment and more a demonstration to the world of U.S. ability to drop a hydrogen bomb from a bomber. The AEC reported that Operation *Redwing*, "gave important information relating to developing means of reducing fall-out from weapon firing, weapons for defensive purposes, and new design principles." Of the new weapon types, nine tests were sponsored by LANL and seven by LLNL. The test shots fired at Enewetak had smaller yields than those fired at Bikini. High-yield warheads likely tested at *Redwing* were LANL's B/W28 (bomb/Hound Dog), B/W39 3.75 Mt (bomb/Snark, Redstone), and W49 1.4 Mt (Thor, Atlas D, Jupiter) and LLNL's B/W27 (bomb/Regulus II). Lower yield warheads probably included the W40 (Bomarc, Lacrosse), W44 (ASROC), and W45 (MADM, Terrier, Little John). The total yield for the Redwing series was 20.820 Mt with the fission portion approximately nine Megatons. The U.S. Air Force sent manned planes through radiation clouds to measure doses in the clouds and to the crews. The planes, five different B-57s, made 27 passes through clouds from six different nuclear explosions, at times from 20 to 78 minutes after detonation. Maximum radiation doses in the cloud were 800 roentgens per hour. Total radiation doses to crew members were as high as 15 roentgens by film badge. Shot names are North and South American Indian tribes.

Lacrosse	18:25	05-04-56	Enewetak/Yvonne	LA	Surface	17	WR	40 Kt
Test of prototype TX-39 primary, 34.5 in diameter, 100 in length, 8386 lbs device weight								
Cherokee	17:51	05-20-56	Bikini	LA	B-52 Airdrop	4350±150	WR	3.8 Mt
First air drop by U.S. of a thermonuclear weapon--used the B-15 bomb. 34.5 in diameter, 136 in length, 6867 lbs device weight. Cloud top 94,000 feet								
Zuni	17:56.00.3	05-27-56	Bikini	LL	Surface	9	WR	3.5 Mt
Three-stage, "clean," (85 percent fusion), high-yield device (BASSOON) which eventually led to the B-41, 39 in diameter, 135.5 in length, 12,158 lbs device weight								
Yuma	19:56	05-27-56	Enewetak	LL	Tower	205	WR	.19 Kt
Boosted asymmetric Swift device, 5 in diameter, 24.5 in length, did not boost								
Erie	18:15	05-30-56	Enewetak	LA	Tower	300	WR	14.9 Kt
TX-28 primary, low yield boosted device, 20 in diameter, 55 in length, 2106 lbs device weight								
Seminole	00:55	06-06-56	Enewetak	LA	Surface		WR	13.7 Kt
Detonated within in a chamber within a tank of water, 20 in diameter, 55 in length, 1832 lbs device weight								
Flathead	18:26	06-11-56	Bikini (10th)	LA	Barge	15	WR	365 Kt

Test of "dirty" intermediate yield (c. 350 Kt) version of the B-28, 20 in diameter, ~55 in length

Blackfoot	18:26	06-11-56	Enewetak	LA	Tower	200	WR	8 Kt

Low yield air defense prototype boosted device, first use of PBX high explosive, 11.5 in diameter, 23 in length, 130 lbs device weight

Kickapoo	23:26	06-13-56	Enewetak	LL	Tower	300	WR	1.49 Kt

Asymmetric device (Swallow), for air-to-air missile, 8 in diameter, 28 in length

Osage	01:14	06-16-56	Enewetak	LA	B-36 Airdrop	670±35	WR	1.7 Kt

Test of W-25 in instrumented drop case, 17.4 in diameter, 25.7 in length, 3150 lbs device weight

Inca	21:26	06-21-56	Enewetak	LL	Tower	200	WR	15.2 Kt

Low-yield boosted Swan device, progenitor of XW-45, 11.6 in diameter, 22.8 in length

Dakota	18:06	06-25-56	Bikini	LA	Barge		WR	1.1 Mt

TX-28, 20 in diameter, 58 in length

Mohawk	18:06	07-02-56	Enewetak	LL	Tower	300	WR	360 Kt

Boosted Swan primary with Flute secondary, 15 in diameter, 46.2 in length

Apache	18:06.00.2	07-08-56	Enewetak (20th)	LL	Barge		WR	1.85 Mt

Test of XW-27 in Regulus nose cone, 30.2 in diameter, 69.8 in length

Navajo	17:56.00.3	07-10-56	Bikini	LA	Barge		WR	4.5 Mt

Test of "clean" 95 percent fusion TX-21C, 56.2 in diameter, 149.6 in length

Tewa	17:46.00.0	07-20-56	Bikini	LLNL	Barge		WR	5 Mt

Test of "dirty" 87 percent fission Bassoon Prime 3-stage device, 39 in diameter, 135.5 in length, 15,735 lbs weight. Produced a crater of 4000 feet diameter and 129 feet depth

Huron	18:12	07-21-56	Enewetak	LANL	Barge		WR	250 Kt

15.3 in diameter, 43.1 in length

PROJECT 57

Project 57 No. 1	14:27	04-24-57	Bombing Range, NV	AEC	Surface		SE	Zero

Test to determine extent of plutonium contamination of W-25

OPERATION *PLUMBOB*

Operation *Plumbob* (originally called *Pilgrim*), the sixth series held at NTS, included twenty-four detonations and six safety experiments. The series was approved by President Eisenhower on 28 December 1956. The purposes of *Plumbob* were to proof test certain air defense and anti-submarine warheads scheduled for early production; to conduct development tests of components and mockups that provided design information for thermonuclear devices to be fired in Operation *Hardtack I*, including devices having higher yield-to-weight ratios; to conduct exploratory and development tests directed toward achieving more efficient use of nuclear material and warheads of smaller size and weight; and to conduct a deep underground test to explore that mode of testing. Sixteen thousand DOD personnel participated in Desert Rock VII and VIII. The prototype for the W30 warhead for the Talos missile was tested and the W34 warhead for the Lulu, ASTOR, and Hotpoint anti-submarine weapons may have been tested during *Plumbob*. LANL shot names are deceased scientists and engineers. LLNL shot names are North American mountains.

Boltzmann	11:55	05-28-57	NTS (Area 7c)	LA	Tower	500	WR	12 Kt

XW-40 warhead, device weight 295 lbs.

Franklin	11:55	06-02-57	NTS (Area 3)	LA	Tower	300	WR	140 Tons

Possible XW-30, device weight 448 lbs. fizzle, design yield 2 Kt, boosted single stage device.

Lassen	11:45	06-05-57	NTS (Area 9a)	LL	Balloon	500	WR	0.5 Tons

Fizzle, similar to Wheeler device, unboosted all U-235 core.

Wilson	11:45	06-18-57	NTS (Area 9a)	LL	Balloon	500	WR	10 Kt

XW-45-X1 test, gas boosted single stage, follow-up to Redwing Inca.

Priscilla	13:30	06-24-57	NTS (Area 5)	LA/DOD	Balloon	700	WR	37 Kt

Purpose was to study the effects of a nuclear weapon with a known yield. The weapon was drawn from the stockpile, weight 581.4 lbs, probable TX-15/39 primary.

Coulomb-A	17:30	07-01-57	NTS (Area 3h)	LA	Surface		SE	Zero

One-point safety test of XW-31, device weight 782.6 lbs.

Hood	11:40.00.4	07-05-57	NTS (Area 9a)	LL	Balloon	1500	WR	74 Kt

Largest atmospheric test at NTS, device weight 393 lbs, first two-stage test at NTS. Involved 124 aircraft, troop maneuvers by some 2500 Marines.

Diablo	11:30.00.1	07-15-57	NTS (Area 2b)	LL	Tower	500	WR	17 Kt

Similar to Shasta device, weight 1352 lbs.

John	14:00	07-19-57	NTS (Area 10)	DOD	Rocket	18,500	WE	~2 Kt

A F-89J fired a GENIE (AIR-2A) air-to- air rocket with a W25 warhead. The rocket traveled 4240 meters, in 4.5 seconds after release, before detonating.

Kepler	11:50	07-24-57	NTS (Area 4)	LA	Tower	500	WR	10 Kt
Diagnostic shot directed toward ICBM warhead design, device weight 1517 lbs.								
Owens	13:30	07-25-57	NTS (Area 9b)	LL	Balloon	500	WR	9.7 Kt
Possible XW-51 shot, device weight 85 lbs.								
Pascal-A	08:00	07-26-57	NTS (Area 3j)	LA	Shaft	-500	SE	Slight
Stokes	12:25	08-07-57	NTS (Area 7b)	LA	Balloon	1500	WR	19 Kt
XW-30 test, device weight 448 lbs, all oralloy gas boosted.								
Saturn	01:00	08-10-57	NTS (Area 12c)	LL	Tunnel	-100	SE	Zero
One-point safety test of XW-45-X1, oralloy-plutonium composite core, unboosted								
Shasta	12:00	08-18-57	NTS (Area 2a)	LL	Tower	500	WR	17 Kt
Similar to Diablo device, weight 1435 lbs								
Doppler	12:30	08-23-57	NTS (Area 7)	LA	Balloon	1500	WR	11 Kt
Possible test of XW-34, total device weight 275 lbs, gas boosted implosion								
Pascal-B	22:35	08-27-57	NTS (Area 3c)	LA	Shaft	-500	SE	0.3 Kt
Franklin Prime	12:40	08-30-57	NTS (Area 7b)	LA	Balloon	750	WR	4.7 Kt
Possibly XW-30, repeat of Plumbob Franklin shot, all oralloy, implosion.								
Smoky	12:30.00.1	08-31-57	NTS (Area 8)	LL	Tower	700	WR	44 Kt
Test of TX-41 primary, device weight 9408 lbs.								
Galileo	12:40	09-02-57	NTS (Area 1)	LA	Tower	500	WR	11 Kt
Diagnostic shot, device weight 848 lbs, boosted, single-stage.								
Wheeler	12:45	09-06-57	NTS (Area 9a)	LL	Balloon	500	WR	197 Tons
Similar to Lassen device, weight 158 lbs, possibly XW-51, all oralloy, small diameter (12 inch), implosion.								
Coulomb-B	20:50	09-06-57	NTS (Area 3g)	LA	Surface		SE	0.3 Kt
Defined one-point safety limits of XW31, device weight 738 lbs.								
Laplace	13:00	09-08-57	NTS (Area 7b)	LA	Balloon	750	WR	1 Kt
Proof test of gun-type weapon, device weight 503 lbs.								
Fizeau	16:45	09-14-57	NTS (Area 3b)	LA	Tower	500	WR	11 Kt
Possible XW-34 test, device weight 131.3 lbs, boosted, single-stage.								
Newton	12:50	09-16-57	NTS (Area 7b)	LA	Balloon	1500	WR	12 Kt
XW-31 test, device weight 1346 lbs.								
Rainier	16:59.59.5	09-19-57	NTS (Area 12)	LL	Tunnel	-899	WR	1.7 Kt
First detonation contained underground. Seismic waves detected 2300 miles away in Alaska. Probably used W-25.								
Whitney	12:30	09-23-57	NTS (Area 2)	LL	Tower	500	WR	19 Kt
Possible alternate W-27 primary, device weight 7059 lbs.								
Charleston	13:00	09-28-57	NTS (Area 9)	LL	Balloon	1500	WR	12 Kt
Small "clean" thermonuclear device, weight 1225 lbs, secondary failed to fire, expected yield 50-100 Kt.								
Morgan	13:00	10-07-57	NTS (Area 9)	LL	Balloon	500	WR	8 Kt
XW-45-X1 test								

PROJECT 58

Pascal-C	20:15	12-06-57	NTS (Area 3e)	LA	Shaft	-250	SE	Slight
Coulomb-C	20:00	12-09-57	NTS (Area 3i)	LA	Surface	0	SE	0.5 Kt
Pascal-C and Coulomb-C were safety tests of two designs being fired in their final version at HARDTACK.								

PROJECT 58 A

Venus	01:00	02-22-58	NTS (Area 12)	LL	Tunnel	-100	SE	<1 Ton
Uranus	22:00	03-14-58	NTS (Area 12)	LL	Tunnel	-114	SE	<1 Ton

OPERATION *HARDTACK I*

Operation *Hardtack I* included thirty-five tests, all but three of which were at Enewetak and Bikini. Planned at a time when pressures were building for a test moratorium, scientists tried to include tests for as many weapon types as possible. Originally each lab had requested twenty shots and DOD ten shots for a total of fifty. HARDTACK was divided into three parts. The first was development tests of warhead types of which Los Alamos sponsored fifteen and Livermore sponsored fifteen. These tests probably included the W38 (Atlas E/F, Titan I), B41, B43, the W47 (Polaris), the B/W53 (bomb/Titan II), and B/W46 (bomb/Titan II-cancelled), and prototypes for

the W56 and W59 warheads for the Minuteman ballistic missiles. The second part was two shots sponsored by DOD to improve the understanding of the effects of underwater explosions on Navy ships. The third part, also sponsored by DOD, included three high-altitude shots to study ballistic missile defense possibilities. The tests also provided information on the electromagnetic pulse effect from low yield-bursts on electronic components. The total yield is estimated at 35.628 Mt. Shot names are trees, shrubs and plants native to North America and Pacific islands.

Yucca	02:40	04-28-58	Pacific	DOD	Balloon	86,000	WE	1.7 Kt
The test was conducted 85 nm northeast of Enewetak at 12^0 37'North, East 163^0 01' East. The device was attached to an untethered helium balloon and was exploded at high altitude for ABM development, used a W-25 warhead, total payload weight 762 lbs.								
Cactus	18:15	05-05-58	Enewetak	LA	Surface	3	WR	18 Kt
Test of primary for Mark 43, device weight 1432 lbs, similar to Elder device								
Fir	17:50.00.1	05-11-58	Bikini	LL	Barge	10	WR	1.36 Mt
"Smaller clean" two-stage device, became XW-38 prototype								
Butternut	18:15	05-11-58	Enewetak	LA	Barge	10	WR	81 Kt
Probably TX-46, similar to Oak and Yellowwood, total device weight 6185 lbs								
Koa	18:30.00.1	05-12-58	Enewetak	LA	Surface	3	WR	1.37 Mt
Produced a crater 4000 feet in diameter and 171 feet deep, possible XW-35, similar to Plumbob Kepler device								
Wahoo	01:30	05-16-58	Enewetak	DOD/LA	Underwater	-500	WE	9 Kt
Mark 7 in WIGWAM type pressure vessel; fired in 3200 feet of water								
Holly	18:30	05-20-58	Enewetak	LA	Barge	13	WR	5.9 Kt
Proof test of W31Y3, device weight 945 lbs								
Nutmeg	21:20	05-21-58	Bikini	LL	Barge	12	WR	25.1 Kt
Possible XW-47								
Yellowwood	02:00	05-26-58	Enewetak	LANL	Barge	11	WR	330 Kt
TX-46 prototype "fizzle," similar to Butternut and Oak, conducted to develop "clean" version, device weight 5885 lbs								
Magnolia	18:00	05-26-58	Enewetak	LA	Barge	14	WR	57 Kt
Tobacco	02:15	05-30-58	Enewetak	LA	Barge		WR	11.6 Kt
Similar to Pistonia device, weight 346 lbs, XW-50 prototype								
Sycamore	03:00	05-31-58	Bikini	LL	Barge	12	WR	92 Kt
Fizzle, TX-41 prototype, similar to Poplar and Pine devices, weight 9723 lbs, predicted yield 5 Mt								
Rose	18:45	06-02-58	Enewetak (30th)	LA	Barge	15	WR	15 Kt
Possible XW-49 primary, device weight 1476 lbs								
Umbrella	23:15	06-08-58	Enewetak	DOD	Underwater	-150	WE	8 Kt
Maple	17:30	06-10-58	Bikini	LL	Barge	12	WR	213 Kt
Total device weight 380 lbs, two-stage device, possibly XW-55 predecessor								
Aspen	17:30	06-14-58	Bikini	LL	Barge	11	WR	319 Kt
Possible XW-47 prototype, two-stage device, similar to Nutmeg, Redwood and Dogwood devices								
Walnut	18:30	06-14-58	Enewetak	LA	Barge	7	WR	1.45 Kt
XW-49 prototype, total device weight 1683 lbs								
Linden	03:00	06-18-58	Enewetak	LA	Barge	8	WR	11 Kt
Possible XW-50 test, similar to Hardtack II Quay device								
Redwood	17:30	06-27-58	Bikini	LL	Barge	11	WR	412 Kt
Possible XW-47 prototype, similar to Aspen, Nutmeg and Dogwood devices, two-stage device, weight 654 lbs								
Elder	18:30	06-27-58	Enewetak	LA	Barge	9	WR	880 Kt
Possible XW-43 prototype, similar to Cactus device, total device weight 1625 lbs								
Oak	19:30	06-28-58	Enewetak	LA	Barge	7	WR	8.9 Mt
TX-46 prototype, similar to Butternut and Yellowwood devices, total device weight 6113 lbs, produced a crater 4400 feet in diameter and 183 feet deep, predicted yield 7.5 Mt								
Hickory	24:00	06-29-58	Bikini (20th)	LL	Barge	12	WR	14 Kt
Possible XW-47 primary test, similar to Hardtack II Neptune and Titania devices								
Sequoia	18:30	07-01-58	Enewetak	LA	Barge	7	WR	5.2 Kt
Probable test of Pisonia device primary								
Cedar	17:30	07-02-58	Bikini	LL	Barge	11	WR	220 Kt
Total device weight 2470 lbs, two-stage device								
Dogwood	18:30	07-05-58	Enewetak	LL	Barge	12	WR	397 Kt
Possible XW-47 prototype, two-stage device, similar to Redwood, Aspen, Nutmeg devices								
Poplar	03:30	07-12-58	Bikini	LL	Barge	12	WR	9.3 Mt
Possible TX-41, total device weight 9316 lbs, similar to Pine and Sycamore devices, two-stage device								
Scaevola	04:00	07-14-58	Enewetak	LA	Barge	20	SE	0
XW-34 one-point safety test								
Pisonia	23:00	07-17-58	Enewetak	LA	Barge	6.5	WR	255 Kt

Modified Tobacco device, yield higher than expected, probable XW-50 prototype

Juniper	04:20	07-22-58	Bikini	LL	Barge	12	WR	65 Kt

Last of twenty-three tests held at Bikini Atoll, "most radical UCRL shot," test of "entirely new concept," possible XW-47 primary candidate

Olive	20:30	07-22-58	Enewetak	LL	Barge	8	WR	202 Kt

Two-stage device, established capability for high yield with very light weight

Pine	20:30	07-26-58	Enewetak	LL	Barge	8	WR	2 Mt

TX-41 prototype, total device weight 8752 lbs, similar to Sycamore and Poplar devices

Teak	10:50	08-01-58	Over Johnston Island	DOD	Redstone Rocket	252,000	WE	3.8 Mt

DOD ABM effects test, used W-39 warhead, total device weight 6230 lbs, flash of light was visible from Hawaii, 700 miles away.

Quince	02:15	08-06-58	Enewetak	LL/DOD	Surface	3	WR	0

Possible XW-51 test, "fizzle"

Orange	10:30	08-12-58	Johnston Island	DOD	Redstone rocket	141,000	WE	3.8 Mt

Detonated 41.6 km south of Johnston Island. DOD ABM effects test, used W-39 warhead, total device weight 6230 lbs

Fig	04:00	08-18-58	Enewetak	LL/DOD	Surface		WR	0.02

Possible XW-51 test, similar to Quince device, last of forty-three tests held at Enewetak. On August 22 President Eisenhower announced a one-year moratorium to begin October 31.

OPERATION *ARGUS*

Operation *Argus* was a series of three very-high-altitude tests carried out shortly after the conclusion of *Hardtack I* in the South Atlantic about 1100 miles southwest of Capetown, South Africa. It was the only clandestine test series conducted in the seventeen-year period of atmospheric testing. Specially modified Lockheed X-17a three-stage ballistic missiles were fired from the USS *Norton Sound* (AVM 1) carrying low-yield W-25 warheads. The *Argus* operation was not intended as a test of nuclear weapons or their destructive effects. It was an experiment designed to provide information on the trapping of electrically charged particles in the earth's magnetic field with the objective of assessing how very high-altitude nuclear detonations might interfere with communications equipment and ballistic missile performance.

Argus I	02:28	08-27-58	South Atlantic	DOD	Rocket		WE	1.7 Kt

About 300 miles altitude. 38.5^0 South, 11.5^0 West

Argus II	03:18	08-30-58	South Atlantic	DOD	Rocket		WE	1.7 Kt

About 300 miles altitude. 49.5^0 South, 8.2^0 West

Argus III	22:13	09-06-58	South Atlantic	DOD	Rocket		WE	1.7 Kt

About 300 miles altitude. 48.5^0 South, 9.7^0 West

OPERATION *HARDTACK II*

Operation *Hardtack II* was a series of thirty-seven tests, the last the United States conducted before adopting a test moratorium. Nineteen of the tests were conducted to evaluate the yield and efficiency of newly developed nuclear devices. The other eighteen were safety experiments designed to determine the stability of nuclear devices during transportation and storage. A 20th nuclear test (*Adams*) had been planned on October 30 but unfavorable weather conditions caused a delay and it was never fired. After a flurry of thirteen tests in seven days at the end of October, the United States did not test again for more than thirty-four months. The original name of the series was *Millrace*, which encompassed 11 tests (four underground and seven one-point safety). Twenty six were added in a very short period of time. LANL shot names are New Mexico counties. LLNL shot names are North American mountains, Roman gods, goddesses and medieval fairies.

Otero	20:00	09-12-58	NTS (Area 3q)	LA	Shaft	-480	SE	38 Tons

One-point safety test, failed, similar to Hardtack I Sequoia device, XW-44 prototype

Bernalillo	19:30	09-17-58	NTS (Area 3h)	LA	Shaft	-456	SE	15 Tons

Repeat of Otero shot, device still unsafe, XW-44 prototype

Eddy	14:00	09-19-58	NTS (Area 7b)	LA	Balloon	500	WR	83 Tons

Possible W47 warhead

Luna	19:00	09-21-58	NTS (Area 3m)	LANL	Shaft	-484	SE	1.5 Tons

Repeat of Otero/Bernalillo device, still unsafe

Mercury	22:00	09-23-58	NTS (Area 12f)	LL	Tunnel	-183	SE	Slight

Possible XW-47 primary safety test, similar to Hardtack I Juniper device

Valencia	20:00	09-26-58	NTS (Area 3r)	LA	Shaft	-484	SE	2 Tons

Device judged one-point safe in spite of yield, similar to Project 58 Pascal-C device and related to Hardtack II San Juan device

Mars	00:00	09-28-58	NTS (Area 12f)	LL	Tunnel	-140	SE	13 Tons

XW-48 one-point safety test, similar to Tamalpais and Ceres devices

Mora	14:05	09-29-58	NTS (Area 7b)	LA	Balloon	1500	WR	2 Kt

	Test of device used in Otero/Bernalillo/Luna shots							
Hidalgo	14:10	10-05-58	NTS (Area 7b)	LA	Balloon	377	SE	77 Tons
	One-point safety test of Moccasin device, failed, similar to project 58 Coulomb-C device							
Colfax	16:15	10-05-58	NTS (Area 3k)	LA	Shaft	-350	SE	5.5 Tons
	One-point safety test of Otero/Bernalillo/Luna/Mora device, failed							
Tamalpais	22:00.00.1	10-08-58	NTS (Area 12b)	LL	Tunnel	-407	WR	72 Tons
	XW-48 test, similar to Mars and Ceres devices, expected yield 100 tons							
Quay	14:30	10-10-58	NTS (Area 7c)	LA	Tower	100	WR	79 Tons
	Similar to Hardtack I Linden device, possible XW-50 primary							
Lea	13:20	10-13-58	NTS (Area 7b)	LA	Balloon	1500	WR	1.4 Kt
	Similar to Otero/Bernalillo/Luna/Mora devices							
Neptune	18:00	10-14-58	NTS (Area 12c)	LL	Tunnel	-110	SE	115 Tons
	One-point safety test of XW-47 primary, failed, design similar to Hardtack I Hickory and Hardtack II Titania devices							
Hamilton	16:00	10-15-58	NTS (Area 5)	DOD/LL	Tower	50	WR	1.2 Tons
	Predicted yield 20-50 tons							
Logan	06:00.00.1	10-16-58	NTS (Area 12e)	LL	Tunnel	-932	WR	5 Kt
	Similar to Juno device, predicted yield 3-7 Kt							
Dona Ana	14:20	10-16-58	NTS (Area 7b)	LA	Balloon	450	WR	37 Tons
	Similar to Otero/Bernalillo/Mora/Luna/Colfax and Hardtack I Sequoia devices, predicted yield 50-80 tons							
Vesta	23:00	10-17-58	NTS (Area 9e)	LLNL	Surface	0	SE	24 Tons
	One-point safety test of XW-47 primary candidate, similar to Wrangell, Oberon, Sanford devices, failed							
Rio Arriba	14:25	10-18-58	NTS (Area 3s)	LA	Tower	72.5	WR	90 Tons
	Low yield Mk 7							
San Juan	14:30	10-20-58	NTS (Area 3p)	LA	Shaft	-234	SE	Zero
	Successful one-point safety test of device related to Valencia device							
Socorro	13:30	10-22-58	NTS (Area 7b)	LA	Balloon	1450	WR	6 Kt
	Similar to Plumbob Pascal-A and -B and Hardtack II Lea device, possible XW-54 test							
Wrangell	16:50	10-22-58	NTS (Area 5)	LL	Balloon	1500	WR	115 Tons
	Possible XW-47 primary candidate, similar to Vesta, Oberon, Sanford devices, yield below prediction							
Oberon	20:30	10-22-58	NTS (Area 8a)	LL	Tower	25	SE	Zero
	One-point safety test of device similar to Project 58A #1, Hardtack II Vesta, Wrangell, Sanford devices, possible XW-47 primary, successful							
Rushmore	23:40	10-22-58	NTS (Area 9a)	LL	Balloon	500	WR	188 Tons
	Possible XW-47 primary test, similar to Neptune, Titania devices, yield below prediction							
Catron	15:00	10-24-58	NTS (Area 3t)	LA	Tower	72.5	SE	21 Tons
	One-point safety test of device similar to Mora device, failed							
Juno	16:01	10-24-58	NTS (Area 9f)	LL	Surface	0	SE	1.7 Tons
	One-point safety test to determine safety limits of device similar to Logan device							
Ceres	04:00	10-26-58	NTS (Area 8b)	LL	Tower	25	SE	0.7 Tons
	One-point safety test of XW-48, similar to Tamalpais and Mars devices							
Sanford	10:20	10-26-58	NTS (Area 5)	LL	Balloon	1500	WR	4.9 Kt
	Possible XW-47 primary candidate, similar to Oberon, Vesta, Wrangell devices, successful							
De Baca	16:00	10-26-58	NTS (Area 7b)	LA	Balloon	1500	WR	2.2 Kt
	Similar to Catron and Mora devices, yield lower than expected							
Chavez	14:30	10-27-58	NTS (Area 3u)	LA	Tower	52.5	SE	0.6 Tons
	One-point safety test of design similar to De Baca device, failed							
Evans	00:00.00.2	10-29-58	NTS (Area 12b)	LL	Tunnel	-852	WR	55 Tons
	Probable XW-47 primary test, similar to Blanca device, fizzle, predicted yield 2-8 Kt							
Mazama	11:20	10-29-58	NTS (Area 9)	LL	Tower	50	WR	Zero
	Fizzle							
Humboldt	14:45	10-29-58	NTS (Area 3v)	DOD/LL	Tower	25	WR	7.8 Tons
	Repeat of Hamilton shot							
Santa Fe	03:00	10-30-58	NTS (Area 7b)	LA	Balloon	1500	WR	1.3 Kt
Ganymede	11:00	10-30-58	NTS (Area 9g)	LL	Surface	0	SE	Zero
	One-point safety test of W45 variant, successful							
Blanca	15:00.00.0	10-30-58	NTS (Area 12e)	LL	Tunnel	-987	WR	22 Kt
	Test of alternate W47 primary, similar to Evans device, predicted yield was 20 Kt							
Titania	20:34	10-30-58	NTS (Area 8c)	LL	Tower	25	SE	0.2 Tons
	One-point safety test of original W47 primary, similar to Hardtack I Hickory and Hardtack II Neptune devices							

A series called Operation Trumpet had been scheduled at NTS for the spring of 1959 and a series called Operation Willow was scheduled for Enewetak for 1960.

OPERATION *NOUGAT*

Hereafter, with the exceptions of *Dominic I* and *Dominic II*, operations are by Fiscal Year. FY 1962-FY 1976 (1 July 1961-30 September 1976) and FY 1977-FY 1992 (1 October 1976-30 September 1992). LLNL shot names are North American rivers. LANL shot names are small mammals. LLNL shot names are North American rivers.

Antler	17:00.00.12	09-15-61	NTS (Area 12e)	LL	Tunnel	-1318	WR	2.6 Kt
	Possible W45 test							
Shrew	19:45.00.12	09-16-61	NTS (Area 3ac)	LA	Shaft	-322	WR	Low
	Possible XW54 test							
Boomer	22:00	10-01-61	NTS (Area 3aa)	LA	Shaft	-330	WR	Low
	Possible XW54 test							
Chena	18:00.00.12	10-10-61	NTS (Area 12b)	LL	Tunnel	-838	WR	Low
	Possible W44 prototype, similar to Dominic I Swordfish device							
Mink	18:30.00.13	10-29-61	NTS (Area 3ae)	LA	Shaft	-630	WR	Low
	Similar to Hardtack II Quay and Hardtack I Linden devices							
Fisher	23:04.59.63	12-03-61	NTS (Area 3ah)	LA	Shaft	-1191	WR	13.4 Kt
	Repeat of Mink shot, possible XW50 primary test. Crater formed 27 minutes after detonation, 50 deep and 585 feet in diameter							
Gnome	19:00.00.00	12-10-61	Carlsbad, NM	LL	Shaft	-1184	1st PS	3.1 Kt
Mad	18:00.00.16	12-13-61	NTS (Area 9a)	LL	Shaft	-594	WR	0.50 Kt
	Similar to Stillwater device, yield below prediction							
Ringtail	16:35.00.13	12-17-61	NTS (Area 3ak)	LA	Shaft	-1192	WR	Low
	Possible XW-54 test, similar to Shrew and Boomer devices							
Feather	16:30.00.13	12-22-61	NTS (Area 12b)	LL	Tunnel	-812	WR	Low
	Possible test of corroded W47 warhead							

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Stoat	16:30.00.14	01-09-62	NTS (Area 3ap)	LA	Shaft	-992	WR	5.1 Kt
	First in a series of developmental tests of new multipoint detonation system							
Agouti	18:00.00.13	01-18-62	NTS (Area 3ao)	LA	Shaft	-856	WR	6.4 Kt
	One of a group of tests designed to develop a small 10 inch diameter implosion system							
Dormouse	18:00.00.13	01-30-62	NTS (Area 3aq)	LA	Shaft	-1191	WR	Low
	Similar to Mink, Fisher, raccoon, Dormouse Prime, and Packrat devices							
Stillwater	18:00.00.16	02-08-62	NTS (Area 9c)	LL	Shaft	-595	WR	3.07 Kt
	Similar to Mad device							
Armadillo	16:30.00.13	02-09-62	NTS (Area 3ar)	LA	Shaft	-786	WR	7.1 Kt
	Similar to Ermine, Chinchilla I/II devices							
Hard Hat	18:00.00.10	02-15-62	NTS (Area 15a)	DOD	Shaft	-943	WE	5.7 Kt
	Purpose was to test the capability of underground structures to withstand strong motions generated by an underground nuclear detonation in hard rock. The explosion formed a cavity about 126 feet in diameter.							
Chinchilla	16:30.00.13	02-19-62	NTS (Area 3ag)	LA	Shaft	-492	WR	1.9 Kt
	Similar to Ermine, Chinchilla II devices							
Codsaw	17:50.00.16	02-19-62	NTS (Area 9g)	LL	Shaft	-696	WR	Low
	Similar to Hoosic, Hudson, and Arikaree devices, possible W45 test							
Cimarron	18:00.00.16	02-23-62	NTS (Area 9h)	LL	Shaft	-1000	WR	11.90 Kt
Platypus	16:30.00.13	02-24-62	NTS (Area 3ad)	LA	Shaft	-190	WR	Low
	Similar to Shrew, Boomer, and Ringtail devices							
Pampas	19:10.00.09	03-01-62	NTS (Area 3al)	LA/UK	Shaft	-1191	1st UK	Low
Danny Boy	18:15.00.12	03-05-62	NTS (Area 18)	DOD/LL	Crater	-110	WE	0.43 Kt
	Atomic Demolition Munition cratering test, produced crater 265 feet in diameter, 84 feet deep, in basalt							
Ermine	16:30.00.13	03-06-62	NTS (Area 3ab)	LA	Shaft	-240	WR	Low
	Similar to Armadillo and Chinchilla I/II devices							
Brazos	18:00.00.21	03-08-62	NTS (Area 9b)	LL	Shaft	-841	WR	8.4 Kt
	System proof-test, possible XW-55 primary test							
Hognose	16:30.00.13	03-15-62	NTS (Area 3ai)	LA	Shaft	-784	WR	Low
	Similar to Hardtack II Mercury and Oberon devices							
Hoosic	18:00.00.16	03-28-62	NTS (Area 9j)	LL	Shaft	-614	WR	3.40 Kt
	Similar to Hudson and Arikaree devices, possible W45 test							
Chinchilla II	18:00.00.13	03-31-62	NTS (Area 3as)	LA	Shaft	-448	WR	Low
	Similar to Ermine, Armadillo and Chinchilla I devices							
Dormouse II	18:00.00.13	04-05-62	NTS (Area 3az)	LA	Shaft	-856	WR	10.6 Kt
	Similar to Dormouse, Mink, Fisher, Raccoon, Packrat, Hardtack I Linden, and Hardtack II Quay devices							

Passaic	18:00.00.16	04-06-62	NTS (Area 9i)	LL	Shaft	-766	WR	Low
Hudson	18:00.00.16	04-12-62	NTS (Area 9h)	LL	Shaft	-495	WR	Low
Similar to Arikaree, Hoosic, and Codsaw devices, possible W45 test								
Platte	18:00.00.13	04-14-62	NTS (Area 12k)	LL	Tunnel	-628	WR	1.85 Kt
Yield reproducability test, failed, retested in Des Moines shot								
Dead	18:40.00.16	04-21-62	NTS (Area 9k)	LL	Shaft	-634	WR	Low

OPERATION *DOMINIC I*

The 1962 tests in the Christmas and Johnston Island areas and elsewhere in the Pacific constituted Operation *Dominic I*. These tests were also part of either Operation *Nougat* or Operation *Storax* depending on whether they occurred in FY 1962 or FY 1963, respectively. Operation *Dominic I* was a series of thirty-six atmospheric nuclear detonations held at several Pacific Ocean locations from April to November 1962. With the four continental tests of *Dominic II* these were the last atmospheric tests conducted by the United States. No longer able to use the atolls of Enewetak and Bikini, the United States entered into an agreement with the United Kingdom near the end of February 1962 to use Christmas Island for twenty-five of the tests. In return the British were allowed to participate in the nuclear test program at NTS and made diagnostic measurements of the Christmas Island shots. Another ten tests took place in the Johnston Island area. Four types of tests were carried out: (1) About twenty devices were detonated for weapons development purposes. In these tests, progress was made in nuclear technology that resulted in significant increases in the yield-to-weight ratios, more efficient use of nuclear materials, reduction of the fission component of total yield, and increased safety and reliability of stockpiled weapons. Among the *Dominic* development tests were some failures occurring in cases where designs involved a substantial extension of known technology; (2) Several stockpiled bombs and warheads were proof tested. These weapons had been designed after *Hardtack* and manufactured during the moratorium. The designs had extrapolated to the maximum extent practicable the nuclear weapons technology developed during *Hardtack* and previous tests. Each of the nuclear weapons proof tested functioned satisfactorily; (3) A third group were five high altitude effects tests from the kiloton to megaton range. The *Fishbowl* portion of the *Dominic* tests (sponsored by DOD) investigated the ability of the intercontinental missiles systems, the early warning systems, and the command and control systems to operate in a nuclear environment. Some failures occurred. Three Thor rockets malfunctioned in flight (*Bluegill*, 2 June; *Starfish*, 19 June; *Bluegill Double Prime*, 15 October) and had to be destroyed, with their warheads. On 25 July (*Bluefish Prime*) a Thor missile blew up on the launch pad on Johnston Island, causing extensive damage. The nuclear warhead was destroyed by radio command causing extensive alpha contamination of the launch pad; (4) Proof tests of two complete nuclear weapons systems were carried out. The entire Polaris and ASROC system including the delivery vehicles, missiles, and nuclear warheads were tested under realistic conditions. An Atlas ICBM was planned to be fired from Vandenberg AFB, California to a target north of Johnston Island. The test was canceled in late May. On March 2 President Kennedy publicly announced his decision to resume atmospheric testing, giving the date as 23 April. Los Alamos shot names are New Mexico towns and pueblos. Livermore shot names are North American rivers.

Adobe	15:45	04-25-62	Christmas Is	LA	B-52 Airdrop	2900	WR	Intermediate
W50 development and verification test, similar to Aztec, Kingfish Triple Prime devices								
Aztec	16:01	04-27-62	Christmas Is	LA	B-52 Airdrop	2610	WR	Intermediate
W50 test similar to Adobe, Kingfish and Bluegill Triple Prime device								
Black	18:00.00.16	04-27-62	NTS (Area 9p)	LL	Shaft	-714	WR	Low
Possible XW-55 test in mockup								
Arkansas	18:01	05-02-62	Christmas Is	LL	B-52 Airdrop	5030	WR	Low Mt
Mk 56 test								
Questa	19:04	05-04-62	Christmas Is	LA	B-52 Airdrop	5230	WR	Intermediate
Mk 59 test, similar to Alma, Rinconada, and Sunset devices								
Frigate Bird	23:30	05-06-62	Pacific	LL	Polaris A2	10-15,000	WR	600 Kt
The submarine *USS Ethan Allen* (SSBN-608), launched a Polaris missile while submerged about 155 nautical miles east northeast of Christmas Island in the Pacific Ocean (North 4 degrees 50 minutes, West 149 degrees 25 minutes). The re-entry vehicle/warhead traveled about 1020 nm toward the island, detonating as an airburst at an altitude of about 8300 feet, 125 miles from the nominal aim point. The yield of the W47Y1 warhead on the Polaris A2 SLBM was not announced but is estimated to be 600 Kt. Shot *Frigate Bird* was the first and only operational test of a U.S. SSBN/SLBM weapon system.								
Paca	19:33.00.0	05-07-62	NTS (Area 3ax)	LA	Shaft	-848	WR	Low
Test of "100 lb/100 Kt" class device								
Yukon	18:01	05-08-62	Christmas Is	LL	B-52 Airdrop	2880	WR	Intermediate
Similar to *Nougat* Arikaree, Hudson, Codsaw and Hoosic devices and *Dominic I* Muskegon and Chetco devices, test to increase yield-to-weight ratios of ICBM warheads								
Mesilla	17:01	05-09-62	Christmas Is	LA	B-52 Airdrop	2450	WR	Intermediate
Similar to Dulce device								
Arikaree	15:00	05-10-62	NTS	?	Shaft	?	WR	Low
Similar to Hudson, Hoosic, and Codsaw devices, possile W45								

Muskegon	15:37	05-11-62	Christmas Is	LL	B-52 Airdrop	2995	WR	Intermediate
Similar to Chetco and Yukon devices								
Swordfish	20:02	05-11-62	Pacific	DOD	Underwater	-650	WE	Low
The *USS Agerholm* (DD-826) steaming in an area about 370 nm west-southwest of San Diego, California, North 31 degrees 14 minutes, west 124 degrees 13 minutes, fired an anti-submarine rocket (ASROC) at a target raft about 4000 yards away. The W44 warhead detonated underwater, about 350 yards beyond the nominal aim point, producing a low yield. Among other things the test was meant to determine the effect of the nuclear explosion on the sonar gear of destroyers and submarines. Shot *Swordfish* is the last of only five underwater tests.								
Encino	17:02	05-12-62	Christmas Is	LA	B-52 Airdrop	5510	WR	Intermediate
Test of MK 43 bomb inside MK 15 Mod 0 Type 3 bomb case								
Aardvark	19:00.00.10	05-12-62	NTS (Area 3)	?	Shaft	-1424	WR	40 Kt
Test of improved TX-33Y2 AFAP								
Swanee	15:21	05-14-62	Christmas Is	LL	B-52 Airdrop	2940	WR	Intermediate
Test of "clean" ABM warhead, similar to Bluestone device, possible W65 progenitor								
Eel	15:00.00.16	05-19-62	NTS (Area 9m)	?	Shaft	-714	WR	Low
Chetco	15:36	05-19-62	Christmas Is	LL	B-52 Airdrop	6905	WR	Intermediate
Similar to Muskegon and Yukon devices								
White	15:00.00.15	O5-25-62	NTS (Area 9b)	LL	Shaft	-632	WR	Low
Probable XW-58 primary test; similar to Sacromento device								
Tanana	16:08	05-25-62	Christmas Is	LL	B-52 Airdrop	9030	WR	Low
"Fizzle"								
Nambe	17:02	05-27-62	Christmas Is	LA	B-52 Airdrop	7140	WR	Intermediate
Raccoon	17:00.00.14	06-01-62	NTS (Area 3a)	?	Shaft	-539	WR	Low
Similar to Dormouse, Dormouse Prime, Mink, Fisher, Packrat; *Hardtack I* Linden and *Hardtack II* Quay devices								
Packrat	17:00.00.12	06-06-62	NTS (Area 3aw)	?	Shaft	-860	WR	Low
Alma	17:02	06-08-62	Christmas Is	LA	B-52 Airdrop	8865	WR	Intermediate
Mk 59, similar to Questa, Rinonada, and Sunset devices								
Truckee	15:37	06-09-62	Christmas Is	LL	B-52 Airdrop	6970	WR	Intermediate
XW-58 development and verification test								
Yeso	16:01	06-10-62	Christmas Is	LA	B-52 Airdrop	8325	WR	Low Mt
Fourth largest *Dominic I* yield, similar to *Hardtack I* Koa device								
Harlem	15:37	06-12-62	Christmas Is	LL	B-52 Airdrop	13,645	WR	Intermediate
W47Y2 test								
Des Moines	21:00.00.12	06-13-62	NTS (Area 12j)	?	Tunnel	-660	WR	Low
Similar to Platte device								
Rinconada	16:00	06-15-62	Christmas Is	LA	B-52 Airdrop	9105	WR	Intermediate
Possible W59 test, similar to Questa, Alma, and Sunset devices								
Dulce	16:00	06-17-62	Christmas Is	LA	B-52 Airdrop	9090	WR	Intermediate
Similar to Mesilla device								
Petit	15:01	06 19-62	Christmas Is	LL	B-52 Airdrop	14,995	WR	Low
Second Lawrence Livermore "fizzle" in *Dominic I*								
Daman I	17:00.00.13	06-21-62	NTS (Area 3be)	?	Shaft	?	WR	Low
Otowi	16:00	06-22-62	Christmas Is	LA	B-52 Airdrop	9010	WR	Intermediate
Possible W50 primary in mockup								
Bighorn	15:19	06-27-62	Christmas Is	LL	B-52 Airdrop	11,810	WR	Mt Range
Haymaker	18:00.00.12	06-27-62	NTS (Area 3aus)	?	Shaft	-1340	WR	67 Kt
Marshmallow	17:00	06-28-62	NTS (Area 16a)	DOD-LL	Tunnel	-1000	WE	Low
First named Jericho. Purpose was to study effects on equipment and materials at a simulated high altitude								
Bluestone	15:21	06-30-62	Christmas Is	LL	B-52 Airdrop	4980	WR	Low Mt
XW-56X2 device								
Sacramento	21:30.00.16	06-30-62	NTS (Area 9v)	?	Shaft	-489	WR	Low
Similar to White device								

OPERATION *STORAX*

Sedan	17:00	07-06-62	NTS (Area 10h)	LL	Crater	-635	2nd PS	104 Kt
An excavation experiment to study the effects and phenomenology of cratering detonation in alluvium. Some 12 million tons of rock and earth were lifted by the explosion with over eight million falling outside the crater. The crater produced was 1280 feet in diameter and 320 feet deep. The thermonuclear device was similar to the *Dominic I* Swanee and Bluestone devices.								

OPERATION DOMINIC II

The four weapons effects tests at NTS in July of 1962 constituted Operation DOMINIC II and were also part of Operation STORAX.

Little Feller II	19:09	07-07-62	NTS (Area 18)	DOD	Surface	3	WE	22 tond
	Used a Davy Crockett W54 stockpiled warhead.							
Starfish Prime	09:00	07-09-62	Johnston Is	DOD	Thor Rocket	248 mi	WE	1.45 Mt
	High altitude, 400 km, used a W49 warhead with a Mk4 reentry vehicle							
Sunset	16:33	07-10-62	Christmas Is	LA	B-52 Airdrop	5000	WR	Intermediate
	Possible W59 test, similar to Questa, Alma, and Rinconada devices							
Pamlico	15:37	07-11-62	Christmas Is	LL	B-52 Airdrop	14,330	WR	Low Mt
	Advanced principles test for high-efficiency thermonuclear burn, last Christmas Island airdrop							
Johnnie Boy	16:45	07-11-62	NTS (Area 18)	DOD	Crater	-2	WE	500 tons
	W30 TADM test, similar to *Plumbob* Stokes device							
Merrimac	16:00.00.15	07-13-62	NTS (Area 3bd)	LL	Shaft	-1356	WR	Intermediate
Small Boy	18:30	07-14-62	NTS (Area 5)	DOD	Tower	10	WE	1.65
	Similar to *Nougat* Ermine, Chinchilla I/II and Armadillo devices, test of missile silo hardening principles.							
Little Feller I	17:00	07-17-62	NTS (Area 18)	DOD	Surface	40	WE	18 tons
	Warhead was a stockpiled W54 (Davy Crockett). Robert F. Kennedy and General Maxwell D. Taylor observed the detonation. This was the last atmospheric test at NTS.							
Wichita	21:00.00.16	07-27-62	NTS (Area 9y)	LL	Shaft	-493	WR	Low
York	15:00.00.15	08-24-62	NTS (Area 9z)	LL	Shaft	-744	WR	Low
Bobac	17:00.00.13	08-24-62	NTS (Area 3bl)	LA	Shaft	-676	WR	Low
Raritan	?	09-06-62	NTS (Area 9u)	LL	Shaft	-525	WR	Low
Hyrax	17:10.00.12	09-14-62	NTS (Area 3bh)	LA	Shaft	-711	WR	Low
Peba	17:00.00.12	09-20-62	NTS (Area 3bb)	LA	Shaft	-792	WR	Low
Allegheny	17:00.00.15	09-29-62	NTS (Area 9x)	LL	Shaft	-692	WR	Low
Androscoggin	16:17	10-02-62	Johnston Is	LL	B-52 Airdrop	10,260	WR	Intermediate
	Third Lawrence Livermore "fizzle," retested in Housatonic shot							
Mississippi	17:00.00.16	10-05-62	NTS (Area 9ad)	LL	Shaft	-1622	WR	115 Kt
Bumping	16:02	10-06-62	Johnston Is	LL	B-52 Airdrop	10,000	WR	Low
	Test to improve yield-to-weight ratio							
Roanoke	15:00.00.16	10-12-62	NTS (Area 9q)	LL	Shaft	-510	WR	Low
Wolverine	?	10-12-62	NTS (Area 3av)	LA	Shaft	-250	WR	Low
Chama	16:01	10-18-62	Johnston Is	LL	B-52 Airdrop	11,970	WR	Low Mt
	"Thumbelina" device, lightweight, small diameter							
Tioga	?	10-18-62	NTS (Area 9f)	LL	Shaft	-200	WR	Low
Bandicoot	18:00.00.08	10-19-62	NTS (Area 3bj)	LA	Shaft	-792	WR	Low
Checkmate	08:30	10-20-62	Johnston Island area	DOD	STRYPI Rocket (XM-33)	91.5 mi	WE	Low
	High altitude effects test using XW-50X1 warhead							
Bluegill Triple Prime	09:59	10-26-62	Johnston Is	DOD	Thor Rocket	30 mi	WE	Submegaton
	High altitude, 30 miles, used W50 warhead in MK 4 reentry vehicle							
Santee	15:00.00.14	10-27-62	NTS (Area 10)	LL	Shaft	-1048	WR	Low
Calamity	15:46	10-27-62	Johnston Island area	LL	B-52 Airdrop	11,780	WR	Intermediate
Housatonic	16:01	10-30-62	Johnston Is	LL	B-52 Airdrop	12,130	WR	Mt Range
	Repeart of Androscoggin							
Kingfish	12:10	11-01-62	Johnston	DOD	Thor Rocket	60 mi	WE	Submegaton
	High altitude, 60 miles, W50 warhead with MK 4 reentry vehicle, similar to Adobe, Aztec and Bluegill Triple Prime devices							
Tightrope	07:30	11-04-62	Johnston	DOD	Nike Hercules	13 mi	WE	Low
	High altitude, 13 miles, used W31 warhead, last U.S. atmospheric test							
St. Lawrence	?	11-09-62	NTS (Area 2b)	LL	Shaft	-550	WR	Low
Gundi	16:30	11-15-62	NTS (Area 3bm)	LA	Shaft	-800	WR	Low
	Test for guntype 175 mm projectile							
Anacostia	18:00.00.14	11-27-62	NTS (Area 9i)	LL	Shaft	-747	3rd PS	Low
Taunton	?	12-04-62	NTS (Area 9aa)	LL	Shaft	-750	WR	Low
Tendrac	19:00.00.10	12-07-62	NTS (Area 3ba)	LA/UK	Shaft	-993	2nd UK	Low
Madison	17:25.00.12	12-12-62	NTS (Area 12g)	LL	Tunnel	-1320	WR	Low
Numbat	18:45.00.12	12-12-62	NTS (Area 3bu)	LA	Shaft	-761	WR	Low
Manatee	13:10	12-14-62	NTS (Area 9af)	LL	Shaft	-200	WR	Low
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Casselman	16:00.00.16	02-08-63	NTS (Area 10g)	LL	Shaft	-994	WR	Low

Acushi	18:30.00.14	02-08-63	NTS (Area 3bg)	LA	Shaft	-856	WR	Low
Ferret	?	02-08-63	NTS (Area 3bf)	LA	Shaft	?	WR	Low
Hatchie	?	02-08-63	NTS (Area 9e)	LA	Shaft	?	WR	Low
Chipmunk	?	02-15-63	NTS (Area 3ay)	LA	Shaft	?	WR	Low
Kaweah	19:47.00.14	02-21-63	NTS (Area 9ab)	LL	Shaft	-745	4th PS	Low
Carmel	19:47.08.63	02-21-63	NTS (Area 2h)	LL	Shaft	-536	WR	Low
Jerboa	19:00	03-01-63	NTS (Area 3at)	LA	Shaft	?	WR	Low
Toyah	16:22.07	03-15-63	NTS (Area 9ac)	LL	Shaft	?	WR	Low
Gerbil	15:49.00.12	03-29-63	NTS (Area 3bp)	LA	Shaft	-917	WR	Low
Ferret Prime	17:52.00.13	04-05-63	NTS (Area 3by)	LA	Shaft	-793	WR	Low
Coypu	?	04-10-63	NTS (Area 3af)	LA	Shaft	?	WR	Low
Cumberland	16:03	04-11-63	NTS (Area 2e)	LL	Shaft	?	WR	Low
Kootanai	16:09.30	04-24-63	NTS (Area 9w)	LL	Shaft	?	WR	Low
Paisano	?	04-24-63	NTS (Area 9wi)	LL	Shaft	?	WR	Low
Gundi Prime	18:19.30	05-09-63	NTS (Area 3db)	LA	Shaft	?	WR	Low
Double Tracks (Pu dispersal)		05-15-63	Bombing Rnge, NV	?	Surface	0	ST	Zero
Harkee	14:55	05-17-63	NTS (Area 3bv)	LA	Shaft	?	WR	Low
Tejon	?	05-17-63	NTS (Area 3cg)	LA	Shaft	?	WR	Low
Stones	15:40.00.14	05-22-63	NTS (Area 9ae)	LL	Shaft	-1289	WR	Intermediate
Clean Slate I (Pu dispersal)		05-25-63	Bombing Rnge, NV	?	Surface	0	ST	Zero
Pleasant	15:03.30	05-29-63	NTS (Area 9ah)	LL	Shaft	?	WR	Low
Clean Slate II (Pu dispersal)		05-31-63	Bombing Range, NV	?	Surface	0	ST	Zero
Yuba	17:00.00.12	06-05-63	NTS (Area 12b)	LL	Tunnel	-796	WR	Low
Hutia	14:00.00.13	06-06-63	NTS (Area 3bc)	LA	Shaft	-442	WR	Low
Apshapa	14:12	06-06-63	NTS (Area 9ai)	LL	Shaft	?	WR	Low
Clean Slate III (Pu dispersal)		06-09-63	Bombing Range, NV	?	Surface	0	ST	Zero
Mataco	14:10.00.13	06-14-63	NTS (Area 3bk)	LA	Shaft	-642	WR	Low
Kennebec	23:00.00.15	06-25-63	NTS (Area 2af)	LL	Shaft	-740	WR	Low

Limited Test Ban Treaty signed 5 August 1963

OPERATION *NIBLICK* (Fiscal Year 1964, 41 total: 27 announced, 14 secret)

Pekan	23:45.00.13	08-12-63	NTS (Area 3bw)	?	Shaft	-992	WR	Low
Satsop	13:00.00.15	08-15-63	NTS	?	Shaft	-738	WR	Low
Kohocton	13:20.00.14	08-23-63	NTS	?	Shaft	-835	WR	Low
Ahtanum	13:53.00.15	09-13-63	NTS	?	Shaft	-740	WR	Low
Bilby	17:00.00.13	09-13-63	NTS	?	Shaft	-2344	WR	249 Kt

First underground test reported felt in Las Vegas

# Carp (No.1)	14:20	09-27-63	NTS (Area 3)	LA	Shaft	-1079	WR	Low, Mb 3.0
* Narraguagus	17:30	09-27-63	NTS (Area 2)	LL	Shaft	-492	WR	Low, Mb 3.0
Grunion	14:00.00.11	10-11-63	NTS	?	Shaft	-857	WR	Low
Tornillo	14:00.00.15	10-11-63	NTS	?	Shaft	-489	5th PS	Low
Clearwater	17:00.00.14	10-16-63	NTS	?	Shaft	-1785	WR	Intermediate
* Mullet	16:00	10-17-63	NTS (Area 2)	LL	Shaft	-197	WR	<20 Kt
Shoal	17:00.00.1	10-26-63	Fallon, NV	?	Shaft	-1205	1st VU	12 Kt
Anchovy	16:00.00.12	11-14-63	NTS (Area 3bq)	LA	Shaft	-854	WR	Low
Mustang	15:00.00.15	11-15-63	NTS (Area 9at)	LL	Shaft	-544	WR	Low
Greys	17:30.00.14	11-22-63	NTS (Area 9ax)	LL	Shaft	-987	WR	Intermediate
Sardine	16:38.30.12	12-04-63	NTS (Area 3ch)	LA	Shaft	-860	WR	Low
Eagle	16:02.00.15	12-12-63	NTS (Area 9av)	LL	Shaft	-540	WR	Low
* Tuna	15:24	12-20-63	NTS (Area 3)	LA	Shaft	-1358	WR	<20 Kt

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Fore	16:00.00.15	01-16-64	NTS (Area 9ao)	LL	Shaft	-1610	WR	20-200 Kt(19)
Oconto	16:00.00.15	01-23-64	NTS (Area 9ay)	LL	Shaft	-868	WR	<20 Kt
# Club	16:00	01-30-64	NTS (Area 2)	LL	Shaft	-590	WR	<20 Kt, Mb 4.1
* Solendon	15:38	02-12-64	NTS (Area 3)	LA	Shaft	-492	WR	<20 Kt
# Bunker	15:30	02-13-64	NTS (Area 9)	LL	Shaft	-745	WR	<20 Kt, Mb 4.0
# Bonefish	15:37.20	02-18-64	NTS (Area 9)	LA	Shaft	-984	WR	<20 Kt, Mb 4.4
* Mackerel	15:37	02-18-64	NTS (Area 4)	LA	Shaft	-1092	WR	<20 Kt
Klickitat	15:30.00.14	02-20-64	NTS (Area 10)	?	Shaft	-1616	6th PS	20-200 Kt (24)

Objective was to develop "clean" nuclear explosive for excavation applications.

# Handicap	15:00	03-12-64	NTS (Area 9)	LL	Shaft	-469	WR	<20 Kt Mb 3.3
Pike	16:02.00.12	03-13-64	NTS	?	Shaft	-376	WR	<20 Kt
Hook	14:40.00.12	04-14-64	NTS	?	Shaft	-663	WR	<20 Kt
Sturgeon	14:30.00.12	04-15-64	NTS (Area 3bo)	LA	Shaft	-491	WR	<20 Kt
* Bogey	14:29	04-17-64	NTS (Area 9)	LL	Shaft	-390	WR	<20 Kt
Turf	20:10.00.16	04-24-64	NTS (Area 10c)	?	Shaft	-1663	WR	20-200 Kt (100)
Pipefish	20:47.00.12	04-29-64	NTS	?	Shaft	-859	WR	<20 Kt (15)
* Driver	13:00	05-07-64	NTS (Area 9)	LL	Shaft	-492	WR	<20 Kt
Backswing	14:40.00.15	05-14-64	NTS	?	Shaft	-536	WR	<20 Kt
Minnow	16:15.00.12	05-15-64	NTS	?	Shaft	-792	WR	<20 Kt
Ace	16:45.00.15	06-11-64	NTS (Area 2n)	LL	Shaft	-862	7th PS	<20 Kt

Objective was to develop "clean" nuclear explosive for excavation applications.

# Bitterling	14:01	06-12-64	NTS (Area 3)	LA	Shaft	-630	WR	<20 kt Mb 3.6
# Duffer	13:30	06-18-64	NTS (Area 10)	LL	Shaft	-1463	WR	<20 Kt Mb 3.2
Fade	13:30.00.14	06-25-64	NTS (Area 9be)	LL	Shaft	-673	WR	<20 Kt
Dub	13:33.00.14	06-30-64	NTS (Area 10a)	LL	Shaft	-847	8th PS	<20 Kt (9)

First hole drilled in Area 10, no diagnostic canister, purpose to see if the major fraction of the fission product will actually be pushed away from the explosion source, hole depth 1295 feet.

OPERATION *WHETSTONE* (Fiscal Year 1965, 48 tests: 35 announced, 13 secret)

Bye	13:15.00.15	07-16-64	NTS (Area 10i)	LL	Shaft	-1277	WR	20-200 Kt
Cormorant	17:18.30.03	07-17-64	NTS (Area 3df)	LA	Shaft	-891	3rd UK	<20 Kt
* Links	13:30	07-23-64	NTS (Area 9)	LL	Shaft	-394	WR	<20 Kt
* Trogon	17:30	07-24-64	NTS (Area 3)	LA	Shaft	-633	WR	<20 Kt
Alva	16:00.00.14	08-19-64	NTS (Area 3df)	LL	Shaft	-545	WR	<20 Kt
Canvasback	22:17.00.06	08-22-64	NTS (Area 3cp)	LA	Shaft	-1469	WR	<20 Kt (18)
* Player	14:30	08-27-64	NTS (Area 9)	LL	Shaft	-295	WR	<20 Kt
Haddock	17:06.00.04	08-28-64	NTS (Area 3dl)	LL	Shaft	-1193	WR	<20 Kt
Guanay	18:15.00.08	09-04-64	NTS (Area 3di)	LA	Shaft	-856	WR	<20 Kt (12)
# Spoon	14:00	09-11-64	NTS (Area 9)	LL	Shaft	-587	WR	<20 Kt Mb 3.3
* Courser	17:02	09-25-64	NTS (Area 3)	LA	Shaft	-1178	4th UK	<20 Kt
Auk	20:03.00.04	10-02-64	NTS (Area 3do)	LA	Shaft	-1484	WR	<20 Kt (12)
Par	14:00.00.12	10-09-64	NTS (Area 2p)	LL	Shaft	-1325	9th PS	38 Kt
Barbel	15:59.30.04	10-16-64	NTS (Area 3bx)	LA	Shaft	-849	WR	<20 Kt
Salmon	16:00.00.00	10-22-64	Hattiesburg, MS	?	Shaft	-2717	2nd VU	5.3 Kt
* Garden (No. 20)	15:00	10-23-64	NTS (Area 9)	LL	Shaft	-489	WR	<20 Kt
Forest	17:04.58.61	10-31-64	NTS (Area 9al)	LL	Shaft	-1249	WR	<20 Kt
Handcar	15:00.00.11	11-05-64	NTS (Area 10b)	LL	Shaft	-1319	10th PS	12 Kt

Objective to study effects of nuclear explosives in carbonate rock so as to assist in determining if nuclear explosions are potentially useful for recovery of deeply buried minerals. Caronate rock is the medium in which mineral deposits frequently are found.

Crepe	21:15.00.10	12-05-64	NTS (Area 9bg)	LL	Shaft	-1323	WR	20-200 (18 Kt)
Drill	21:15 (?)	12-05-64	NTS (Area 2a1)	LL	Shaft	?	WR	3.4 Kt
Parrot	20:00.00.04	12-16-64	NTS (Area 3dk)	?	Shaft	-592	WR	1.3 Kt
* Cassowary	20:00	12-16-64	NTS (Area 3)	LA	Shaft	-492	WR	<20 Kt
Mudpack	20:10.00.10	12-16-64	NTS (Area 10n)	DOD/LL	Shaft	-498	WE	2.7 Kt

Purpose was to obtain information concerning ground shock

Sulky	19:35.00.09	12-18-64	NTS (Area 18d)	LL	Shaft	-90	11th PS	0.092 Kt

Objective to explore cratering mechanics in hard, dry rock and study dispersion pattern of airborne radionuclides released under these conditions.

----------1965 [10] ----------

Wool	16:00.00.14	01-14-65	NTS (Area 9bh)	LL	Shaft	-706	WR	<20 Kt
# Tern	18:22	01-29-65	NTS (Area 3)	LA	Shaft	-689	WR	<20 Kt Mb 3.6
Cashmere	15:30.00.11	02-04-65	NTS (Area 2ad)	LL	Shaft	-762	WR	<20 Kt
Alpaca	15:10.29.49	02-12-65	NTS (Area 2a)	LL	Shaft	-737	WR	<20 Kt
Merlin	17:30.00.04	02-16-65	NTS (Area 3ct)	LA	Shaft	-972	WR	10.1 Kt
Wishbone	16:18.47.15	02-18-65	NTS (Area 5a)	DOD/LL	Shaft	-588	WE	<20 Kt

Purpose was to study effects on equipment and materials, first underground experiment in Area 5.

* Seersucker	15:28	02-19-65	NTS (Area 9)	LL	Shaft	-472	WR	<20 Kt
Wagtail	19:13.00.03	03-03-65	NTS (Area 3an)	LA	Shaft	-2459	WR	20-200 Kt (65)

# Suede	15:23.50	03-20-65	NTS (South Yucca)	LL	Shaft	-469	WR	<20 Kt Mb 3.3
Cup	15:34.08.16	03-26-65	NTS (Area 9cb)	LL	Shaft	-1761	WR	20-200 Kt (35)
Kestrel	21:00.00.04	04-05-65	NTS (Area 3dd)	LA	Shaft	-1466	WR	<20 Kt
Palanquin	13:14.00.11	04-14-65	NTS (Area 20k)	LL	Crater	-280	12th PS	4.3 Kt

The objective was to explore cratering mechanics in hard, dry rock and study dispersion pattern of airborne radionuclides released under these conditions, produced crater 240 feet diameter and 70 feet deep.

Gum Drop	22:00.00.03	04-21-65	NTS (Area 16a)	LL/DOD	Tunnel	-834	WE	<20 Kt (21)

Purpose was to study effects on equipment and materials. Confirmed prediction of damage to reentry vehicle composites.

# Chenille	13:39	04-22-65	NTS (Area 9)	LL	Shaft	-459	WR	<20 Kt Mb 3.9
# Muscovy	21:44	04-23-65	NTS (Area 3)	LA	Shaft	-590	WR	<20 Kt Mb 3.7
Tee	15:47.11.15	05-07-65	NTS (Area 2ab)	LL	Shaft	-624	WE	<20 Kt
Buteo	18:15.00.10	05-12-65	NTS (Area 20a)	LA	Shaft	-2282	WR	<20 Kt
Scaup	17:32.36.23	05-14-65	NTS (Area 3da)	LA	Shaft	-1401	WR	<20 Kt
Cambric	14:57.52	05-14-65	NTS (Area 9al)	LL	Shaft	?	WR	0.75 Kt
Tweed	13:08.52.11	05-21-65	NTS (Area 9bg)	LL	Shaft	-922	WR	<20 Kt
Petrel	19:45.00.04	06-11-65	NTS (Area 3dy)	LA	Shaft	-593	WR	1.3 Kt
# Organdy	20:27:38	06-11-65	NTS (Area 9)	LL	Shaft	-551	WR	<20 Kt Mb 3.6
Diluted Waters	16:30.00.15	06-16-65	NTS (Area 5e)	DOD/LL	Shaft	-640	WE	<20 Kt

Purpose was to study effects on equipment and materials

Tiny Tot	17:00.00.09	06-17-65	NTS (Area 15e)	DOD/LL	Tunnel	-364	WE	<20 Kt

Purpose was to obtain information on ground shock. First known nuclear detonation conducted on a rock surface within an underground cavity

OPERATION *FLINTLOCK* (Fiscal Year 1966, 48 tests: 41 announced, 7 secret)

* Izzer	13:04	07-16-65	NTS (Area 9)	LL	Shaft	-535	WR	<20 Kt
* Pongee	13:21	07-22-65	NTS (Area 2)	LL	Shaft	-440	WR	<20 Kt
Bronze	17:00.00.04	07-23-65	NTS (Area 7f)	LA	Shaft	-1741	WR	20-200 Kt (60)
Mauve	17:23.30.04	08-06-65	NTS (Area 3dp)	LA	Shaft	-1053	WR	<20 Kt (18)
# Ticking	13:43.09	08-21-65	NTS (Area 9)	LL	Shaft	-682	WR	<20 Kt Mb 3.4
Centaur	13:51.13.11	08-27-65	NTS (Area 2ak)	LL	Shaft	-564	WR	<20 Kt
Screamer	20:08.00.04	09-01-65	NTS (Area 3dg)	LA	Shaft	-990	WR	<20 Kt (12)
Charcoal	17:12.00.03	09-10-65	NTS (Area 7g)	LA	Shaft	-1494	5th UK	20-200 Kt
Elkhart	15:08.23.10	09-17-65	NTS (Area 9bs)	LL	Shaft	-720	WR	<20 Kt
Long Shot	21:00.00.08	10-29-65	Amchitka, AK	DOD	Shaft	-2300	3rd VU	~80 Kt
Sepia	18:00.00.05	11-12-65	NTS (Area 3en)	LA	Shaft	-791	WR	<20 Kt
# Kermet	18:17.33	11-23-65	NTS (Area 2)	LL	Shaft	-643	WR	<20 Kt Mb 3.6
Corduroy	15:13.02.10	12-03-65	NTS (Area 10k)	LL	Shaft	-2236	WR	20-200 Kt (100)
Emerson	15:39.18.15	12-16-65	NTS (Area 2al)	LL	Shaft	-853	WR	<20 Kt
Buff	19:15.00.04	12-16-65	NTS (Area 3dh)	LA	Shaft	-1642	WR	20-200 Kt (36)

----------1966 [7]----------

Maxwell	15:37.43.10	01-13-66	NTS (Area 9br)	LL	Shaft	-601	WR	<20 Kt
Lampblack	18:35.00.04	01-18-66	NTS (Area 7i)	LA	Shaft	-1842	WR	20-200 Kt (32)
* Sienna	18:35	01-18-66	NTS (Area 3)	LA	Shaft	-902	WR	<20 Kt
Dovekie	18:28.00.04	01-21-66	NTS (Area 3cd)	LA	Shaft	-1093	WR	<20 Kt
# Reo	15:17.20	01-22-66	NTS (Area 10)	LL	Shaft	-682	WR	<20 Kt Mb 3.2
Plaid II	18:17.37.10	02-03-66	NTS (Area 2r)	LL	Shaft	-886	WR	<20 Kt
Rex	15:55.07.04	02-24-66	NTS (Area 20h)	LL	Shaft	-2204	WR	19 Kt
Red Hot	18:15.00.10	03-05-66	NTS (Area 12g)	DOD	Shaft	-1330	WR	<20 Kt

Purpose was to study ground shock

Finfoot	18:41.00.07	03-07-66	NTS (Area 3du)	LA	Shaft	-642	WR	<20 Kt
Clymer	18:04.13.11	03-12-66	NTS (Area 9bu)	LL	Shaft	-1303	WR	<20 Kt
Purple	19:00.00.04	03-18-66	NTS (Area 3ds)	LA	Shaft	-1092	WR	<20 Kt
Templar	14:55.28.14	03-24-66	NTS (Area 9bt)	LL	Shaft	-495	13th PS	<20 Kt

Device similar to Cabriolet. Objective was to develop "clean" nuclear explosive for excavation applications.

Lime	18:40.00.04	04-01-66	NTS (Area 7j)	LA	Shaft	-1842	WR	<20 Kt
Stutz	13:57.17.10	04-06-66	NTS (Area 2ca)	LL	Shaft	-739	WR	<20 Kt (5)
Tomato	22:27.30.04	04-07-66	NTS (Area 3ek)	LA	Shaft	-742	WR	<20 Kt
Duryea	14:13.43.10	04-14-66	NTS (Area 20a)	LL	Shaft	-1786	WR	70 Kt
Fenton	14:55.28	04-23-66	NTS (Yucca ?)	?	Shaft	?	WR	<20 Kt/Mb 3.3

Formerlly an unannounced test

Pin Stripe	18:38.00.14	04-25-66	NTS (Area 11b)	DOD/LL	Shaft	-970	WE	<20 Kt (14 Kt)
Purpose was to study effects on equipment and material								
• Ochre	13:33	04-29-66	NTS (Area 3)	LA	Shaft	-413	WR	<20 Kt
Traveler	13:32.17.09	05-04-66	NTS (Area 2cd)	LL	Shaft	-646	WR	<20 Kt
Cyclamen	14:00.00.04	05-05-66	NTS (Area 3dn)	LA	Shaft	-1001	WR	12 Kt
Chartreuse	15:00.00.08	05-06-66	NTS (Area 19d)	LA	Shaft	-2183	WR	73 Kt
Tapestry	19:37.26.20	05-12-66	NTS (Area 2an)	LL	Shaft	-810	WR	<20 Kt (10)
Piranha	13:30.00.04	05-13-66	NTS (Area 7e)	LA	Shaft	-1800	WR	20-200 Kt (100)
Dumont	13:56.28.14	05-19-66	NTS (Area 2t)	LL	Shaft	-2200	WR	20-200 Kt (190)
Discus Thrower	20:00.00.04	05-27-66	NTS (Area 8a)	DOD/LA	Shaft	-1105	WE	22 Kt
Purpose was to study ground shock transmissions on underground structures.								
Pile Driver	15:30.00.09	06-02-66	NTS (Area 15)	DOD/LA	Tunnel	-1518	WE	62 Kt
Purpose was to study nuclear detonation effects on underground structures.								
Tan	14:00.00.04	06-03-66	NTS (Area 7k)	LA	Shaft	-1839	WR	20-200 Kt (140)
Puce	14:30.00.04	06-10-66	NTS (Area 3bs)	LA	Shaft	-1592	WR	<20 Kt
Double Play	17:00.00.04	06-15-66	NTS (Area 16a)	DOD/LL	Tunnel	-1075	WE	<20 Kt
Purpose was to study effects on equipment and materials								
Kankakee	18:02.47.13	06-15-66	NTS (Area 10p)	LL	Shaft	-1494	WR	20-200 Kt
Vulcan	17:13.00.07	06-25-66	NTS (Area 2bd)	LL	Shaft	-1057	14th PS	25 Kt
Halfbeak	22:15.00.07	06-30-66	NTS (Area 19b)	LA	Shaft	-2688	WR	365 Kt

OPERATION *LATCHKEY* (Fiscal Year 1967, 38 tests: 27 announced, 11 secret)

Saxon	15:33.30.13	07-28-66	NTS (Area 2cc)	LL	Shaft	-500	15th PS	<20 Kt
Objective was to develop "clean" nuclear explosive for excavation applications.								
Rovena	13:16.00.07	08-10-66	NTS (Area 10s)	LL	Shaft	-635	WR	<20 Kt
• Tangerine	15:36	08-12-66	NTS (Area 3)	LA	Shaft	-285	WR	<20 Kt
Derringer	15:30.00.54	09-12-66	NTS (Area 5i)	?	Shaft	-835	WE	<20 Kt (12)
Daiquiri	18:00.00.04	09-23-66	NTS (Area 7n)	LA	Shaft	-1841	WR	<20 Kt
Newark	14:45.30.09	09-29-66	NTS (Area 10u)	LL	Shaft	-750	WR	<20 Kt (4)
• Khaki	19:00	10-15-66	NTS (Area 3)	LA	Shaft	-761	WR	<20 Kt
Simms	14:45.00.00	11-05-66	NTS (Area 10w)	LL	Shaft	-650	16th PS	<20 Kt
Objective was to develop "clean" nuclear explosive for excavation applications.								
Ajax	12:00.00.14	11-11-66	NTS (Area 9al)	LL	Shaft	-782	WR	<20 Kt
Cerise	15:02.00.04	11-18-66	NTS (Area 3eu)	LA	Shaft	-693	WR	<20 Kt
• Vigil	15:00	11-22-66	NTS (Area 10)	LL	Shaft	-298	WR	<20 Kt
Sterling	12:15.00.05	12-03-66	Hattiesburg, MS	LL	Shaft	-2717	4th VU	380 Tons
# Sidecar	17:50	12-13-66	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 3.9
New Point	21:00.00.08	12-13-66	NTS (Area 11c)	DOD/LL	Shaft	-825	WE	<20 Kt (12)
Purpose was to study effects on equipment and materials								
Greeley	15:30.00.08	12-20-66	NTS (Area 20g)	LL	Shaft	-3985	WR	870 Kt

1967 [14]

# Rivet I	14:55	01-18-67	NTS (Area 10)	LL	Shaft	-495	WR	<20 Kt Mb 3.2
Nash	16:45.00.14	01-19-67	NTS (Area 2ce)	LL	Shaft	-1194	WR	20-200 Kt (28)
Bourbon	17:40.03.41	01-20-67	NTS (Area 7n)	LA	Shaft	-1836	WR	20-200 Kt (29)
# Rivet II (No.40)	16:30	01-26-67	NTS (Area 10)	LL	Shaft	-646	WR	<20 Kt Mb 3.8
Ward	15:15.00.13	02-08-67	NTS (Area 10x)	LL	Shaft	-844	WR	<20 Kt (11)
Persimmon	18:34.00.04	02-23-67	NTS (Area 3dn)	LA	Shaft	-981	WR	<20 Kt (4)
Agile	18:50.00.0	02-23-67	NTS (Area 2)	?	Shaft	-2400	WR	20-200 Kt (90)
Rivet III	15:00.00.0	03-02-67	NTS (Area 10v)	LL	Shaft	-890	WR	<20 Kt
# Mushroom	15:19	03-03-67	NTS (Area 3)	LA	Shaft	-587	WR	<20 Kt Mb 3.7
• Fizz	17:00	03-10-67	NTS (Area 3)	LA	Shaft	-384	WR	<20 Kt
• Oakland	14:20	04-04-67	NTS (Area 2)	LL	Shaft	-541	WR	<20 Kt
• Heilman	15:00	04-06-67	NTS (Area 2)	LL	Shaft	-499	WR	<20 Kt
Fawn	15:00.00.04	04-07-67	NTS (Area 3eo)	LA	Shaft	-889	WR	<20 Kt
Chocolate	15:09.00.04	04-21-67	NTS (Area 3es)	LA	Shaft	-789	WR	<20 Kt (7)
Effendi	14:45.00.0	04-27-67	NTS (Area 2ap)	LL	Shaft	-719	WR	<20 Kt
Mickey	13:40.00.04	05-10-67	NTS (Area 7m)	LA	Shaft	-1639	WR	20-200 Kt (24)
Commodore	15:00.00.0	05-20-67	NTS (Area 2am)	LL	Shaft	-2449	WR	250 Kt
Scotch	14:00.00.04	05-23-67	NTS (Area 19as)	LA	Shaft	-3207	WR	155 Kt

* Absinthe	12:30	05-26-67	NTS (Area 3)	LA	Shaft	-387	WR	<20 Kt
Knickerbocker	15:00.01.50	05-26-67	NTS (Area 20d)	LL	Shaft	-2069	WR	76 Kt
Switch	13:10.00.00	06-22-67	NTS (Area 9bv)	LL	Shaft	-990	17th PS	<20 Kt
	Objective was to develop "clean" nuclear explosive for excavation applications.							
Midi Mist	16:00.00.00	06-26-67	NTS (Area 12n)	DOD/LL	Tunnel	-1230	WE	<20 Kt (30)
	Purpose was to study effects on equipment and materials							
Umber	11:25.00.04	06-29-67	NTS (Area 3em)	LA	Shaft	-1018	WE	<20 Kt (11)

OPERATION *CROSSTIE* (Fiscal Year 1968, 48 tests: 30 announced, 18 secret)

* Vito	13:30	07-14-67	NTS (Area 10)	LL	Shaft	-315	WR	<20 Kt
Stanley	13:00.00.00	07-27-67	NTS (Area 10q)	LL	Shaft	-1587	WR	20-200 Kt (23)
# Gibson	14:00	08-04-67	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 4.0
Washer	14:10.00.00	08-10-67	NTS (Area 9az)	LL	Shaft	-1525	WR	<20 Kt
Bordeaux	20:12.30.04	08-18-67	NTS (Area 3dr)	LA	Shaft	-1089	WR	<20 Kt (18)
# Lexington	13:30	08-24-67	NTS (Area 2)	LL	Shaft	-741	WR	<20 Kt Mb 3.8
Door Mist	16:30.00.04	08-31-67	NTS (Area 12g)	DOD	Tunnel	-1463	WE	<20 Kt (21)
Yard	13:45.00.00	09-07-67	NTS (Area 10af)	?	Shaft	-1700	WR	20-200 Kt
* Gilroy	17:30	09-15-67	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
Marvel	20:45.00.00	09-21-67	NTS (Area 10ds)	LL	Shaft	-572	18th PS	2.2 Kt
	Objective was to develop special emplacement techniques to reduce amount of radioactivity released to atmosphere.							
Zaza	17:00.00.04	09-27-67	NTS (Area 4c)	LA	Shaft	-2188	WR	20-200 Kt (120)
Lanpher	14:30.00.00	10-18-67	NTS (Area 2x)	LL	Shaft	-2343	WR	20-200 Kt (140)
Sazerac	14:30.00.06	10-25-67	NTS (Area 3fa)	LA	Shaft	-992	WR	<20 Kt
* Cognac	14:30	10-25-67	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
* Worth	14:45	10-25-67	NTS (Area 10)	LL	Shaft	-613	WR	<20 Kt
Cobbler	15:00.00.04	11-08-67	NTS (Area 7u)	LA	Shaft	-2200	WR	<20 Kt (25)
# Polka	13:00	12-06-67	NTS (Area 10)	LL	Shaft	-623	WR	<20 Kt Mb 3.3
Gasbuggy	19:30.00.14	12-10-67	Farmington, NM	LL	Shaft	-4240	19th PS	29 Kt
	Objective to investigate the feasibility of using nuclear explosives to stimulate a low producing gas field. First Plowshare joint government-industry nuclear experiment to test out an industrial application, El Paso Natural Gas Company and Department of Interior participated.							
Stilt	15:00.00.04	12-15-67	NTS (Area 3fh)	LA	Shaft	-1092	WR	<20 Kt (2)

1968 [22]

Hupmobile	16:30.00.00	01-18-68	NTS (Area 2y)	LL	Shaft	-810	WE	7.4 Kt
	Established many of the criteria for underground diagnostics still used today							
Staccato	5:00.00.00	01-19-68	NTS (Area 10t)	LL	Shaft	-1455	WR	20-200 Kt
Faultless	18:15.00.08	01-19-68	Hot Creek Valley, NV	?	Shaft	-3200	WR	200-1000 Kt (1200)
	Purpose was to examine the suitability of the this part of Nevada for testing high yield nuclear devices.							
* Brush	15:00	01-24-68	NTS (Area 3)	LA	Shaft	-387	WR	<20 Kt
Cabriolet	16:00.00.11	01-26-68	NTS (Area 20l)	LL	Crater	-170	20th PS	2.3 Kt
	Objective to study effects and phenomenology of cratering detonations in hard rock (rhyolite), produced crater 360 feet in diameter and 120 feet deep.							
# Mallet	15:30	01-31-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
* Torch	15:00	02-21-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
Knox	15:30.00.00	02-21-68	NTS (Area 2da)	?	Shaft	-2116	WR	20-200 Kt (130)
Dorsal Fin	17:08.30.04	02-29-68	NTS (Area 12e)	DOD	Tunnel	-1345	WE	<20 Kt (20)
* Russet	15:30	03-05-68	NTS (Area 6)	LA	Shaft	-390	WR	<20 Kt
Buggy I	17:04.00.11	03-12-68	NTS (Area 30)	LL	Crater	-135	21st PS	5.4 Kt
	Five 1.1 Kt charges spaced 150 feet apart, simultaneously detonated to study the effects and phenomenology of nuclear row-charge cratering, produced crater 850 feet long, 250 wide and 65 feet deep, counts as one test.							
Pommard	15:19.00.06	03-14-68	NTS (Area 3ee)	LA	Shaft	-686	WR	1.5 Kt
Stinger	15:00.00.04	03-22-68	NTS (Area 19l)	LA	Shaft	-2191	WR	20-200 Kt (120)
Milk Shake	18:44.27.04	03-25-68	NTS (Area 5k)	DOD	Shaft	-868	WE	<20 Kt (10)
* Bevel	15:02	04-04-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
Noor	14:00.00.0	04-10-68	NTS (Area 2be)	LL	Shaft	-1250	WR	20-200 Kt (20)
Shuffle	14:05.00.0	04-18-68	NTS (Area 10t)	LL	Shaft	-1615	WR	20-200 Kt (25)
Scroll	17:01.30.00	04-23-68	NTS (Area 19n)	LL	Shaft	-735	5th VU	<20 Kt (6)
Boxcar	15:00.00.00	04-26-68	NTS (Area 20i)	LL	Shaft	-3832	WR	1.3 Mt
	Largest nuclear test conducted in the continental U.S.							

# Hatchet	16:00	05-03-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 4.1
# Crock	14:10	05-08-68	NTS (Area 10)	LL	Shaft	-594	WR	<20 Kt Mb 3.9
Clarksmobile	13:00.00.00	05-17-68	NTS (Area 2)	LL	Shaft	-1550	WR	20-200 Kt (15)
* Adze (No.60)	14:45	05-28-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
# Wembley	14:21.30	06-05-68	NTS (Area 3)	LA	Shaft	-781	WR	<20 Kt Mb 4.0
Tub	21:30.00.00	06-06-68	NTS (Area 10a)	LL	Shaft	-620	WR	<20 Kt
Rickey	13:59.59.97	06-15-68	NTS (Area 19c)	LA	Shaft	-2242	WR	20-200 Kt (300)
* Funnel	15:30	06-25-68	NTS (Area 3)	LA	Shaft	-387	WR	<20 Kt
* Sevilla	15:30	06-25-68	NTS (Area 3)	LA	Shaft	-1174	WR	<20 Kt
Chateaugay	12:22.00.00	06-28-68	NTS (Area 20t)	LL	Shaft	-1992	WR	20-200 Kt (58)

OPERATION *BOWLINE* (Fiscal Year 1969, 47 tests: 26 announced, 21 secret)

# Spud	14:00	07-17-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 4.0
Tanya	13:00.00.00	07-30-68	NTS (Area 2dt)	LL	Shaft	-1250	WR	20-200 Kt (10)
# Imp	13:00	08-09-68	NTS (Area 2)	LL	Shaft	-597	WR	<20 Kt Mb 3.5
# Rack	17:00	08-15-68	NTS (Area 9)	LL	Shaft	-653	WR	<20 Kt Mb 3.9
Diana Moon	16:30.00.04	08-27-68	NTS (Area 11e)	DOD	Shaft	-794	WE	<20 Kt
Sled	22:45.00.04	08-29-68	NTS	?	Shaft	-2393	WR	20-200 Kt (200)
Noggin	14:00.00.13	09-06-68	NTS (Area 9bx)	LL	Shaft	-1909	WR	20-200 Kt (110)
Knife A	14:00.00.04	09-12-68	NTS (Area 3fb)	LA	Shaft	-1089	WR	<20 Kt
Stoddard	14:00.00.04	09-17-68	NTS (Area 2cm)	LL	Shaft	-1535	22nd PS	20-200 Kt (28)

Objective to develop "clean" nuclear explosive for excavation applications.

Hudson Seal	17:05.00.09	09-24-68	NTS (Area 12n)	DOD	Tunnel	-1092	WE	<20 Kt (21)
* Welder	14:00	10-03-68	NTS (Area 3)	LA	Shaft	-384	WR	<20 Kt
Knife C	14:29.00.04	10-03-68	NTS (Area 3er)	LA	Shaft	-989	WR	<20 Kt (3)
# Vat	14:30	10-10-68	NTS (Area 9)	LL	Shaft	-630	WR	<20 Kt Mb 3.9
# Hula	16:36	10-29-68	NTS (Area 9)	LL	Shaft	-656	WR	<20 Kt Mb 3.4
# Bit	18:30	10-31-68	NTS (Area 3)	LA	Shaft	-485	WR	<20 Kt Mb 3.9
* File	18:30	10-31-68	NTS (Area 3)	LA	Shaft	-751	WR	<20 Kt
Crew	15:15.00.09	11-04-68	NTS (Area 2db)	LL	Shaft	-1980	WR	20-200 Kt (22)
# Auger	15:30	11-15-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 3.9
Knife B	15:45.00.04	11-15-68	NTS (Area 3dz)	LA	Shaft	-1191	WR	<20 Kt (8)
Ming Vase	18:00.00.03	11-20-68	NTS (Area 16a)	DOD	Tunnel	-1010	WE	<20 Kt (16)
Tinderbox	16:19.00.04	11-22-68	NTS (Area 9az)	LL	Shaft	-1442	WR	<20 Kt (3)
Schooner	16:00.00.14	12-08-68	NTS (Area 20u)	LL	Crater	-350	23rd PS	30 Kt

Objective to study the effects and phenomenology of cratering detonations in hard rock (tuff), produced crater 800 feet diameter, 270 feet deep.

* Bay Leaf	15:00	12-12-68	NTS (Area 3)	LA	Shaft	-426	WR	<20 Kt
Tyg	15:10.00.08	12-12-68	NTS (Area 2dc)	LL	Shaft	-870	WR	<20 Kt (20)
# Sciasors	15:20	12-12-68	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 3.9
Benham	16:30.00.04	12-19-68	NTS (Area 20c)	LL	Shaft	-4600	WR	1.15 Mt

Less than full yield test of the XW71 warhead for the Spartan ABM

1969 [17]

Packard	19:00.00.07	01-15-69	NTS (Area 2u)	LL	Shaft	-810	WE	10.0 Kt
Wineskin	19:30.00.04	01-15-69	NTS (Area 12r)	LL	Shaft	-1700	WR	20-200 Kt (40)
# Shave	15:00	01-22-69	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 4.1
Vise	15:00.00.04	01-30-69	NTS (Area 3ei)	?	Shaft	-1490	WR	20-200 Kt (28)
* Biggin	15:17	01-30-69	NTS (Area 9)	LL	Shaft	-797	WR	<20 Kt
# Nipper	15:00	02-04-69	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 3.7
* Winch	15:00	02-04-69	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt
Cypress	16:18.20.88	02-12-69	NTS (Area 12g)	?	Tunnel	-1350	WE	<20 Kt (15)
* Valise	14:30	03-18-69	NTS (Area 9)	LL	Shaft	-298	WR	<20 Kt
# Chatty (No. 80)	14:40	03-18-69	NTS (Area 2)	LL	Shaft	-640	WR	<20 Kt Mb 3.8
Barsac	18:12.00.04	03-20-69	NTS (Area 3gc)	?	Shaft	-998	WR	<20 Kt (10)
Coffer	14:30.00.00	03-21-69	NTS (Area 2dc)	LL	Shaft	-1525	WR	<100 Kt (26)
# Gourd	13:04	04-24-69	NTS (Area 2)	LL	Shaft	-594	WR	<20 Kt Mb 3.8
Thistle	17:00.00.04	04-30-69	NTS (Area 7t)	LA	Shaft	-1838	WR	20-200 Kt
Blenton	17:00.00.04	04-30-69	NTS (Area 7p)	LA	Shaft	-1829	WR	20-200 Kt
Purse	13:45.00.04	05-07-69	NTS (Area 20v)	LL	Shaft	-1964	WR	20-200 Kt (90)

# Aliment	18:00	05-15-69	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 4.1
Torrido	14:15.00.04	05-27-69	NTS (Area 7w)	LA	Shaft	-1689	WR	20-200 Kt (35)
* Ipecac	17:00	05-27-69	NTS (Area 3)	LA	Shaft	-407	WR	<20 Kt
Tapper	14:00.00.04	06-12-69	NTS (Area 3go)	LA	Shaft	-994	WR	<20 Kt (10)
# Bowl	16:00	06-26-69	NTS (Area 2)	LL	Shaft	-649	WR	<20 Kt Mb 4.1

OPERATION *MANDREL* (Fiscal Year 1970, 52 tests: 42 announced, 10 secret)

Ildrim	13:02.30.04	07-16-69	NTS (Area 2au)	LL	Shaft	-1346	WR	20-200 Kt (18)
Hutch	14:55.00.04	07-16-69	NTS (Area 20f)	LL	Shaft	-1800	WR	20-200 Kt (300)
Spider	14:30.00.04	08-14-69	NTS (Area 2bp)	LL	Shaft	-784	WR	<20 Kt
Pliers	13:45.00.04	08-27-69	NTS (Area 3gn)	LA	Shaft	-784	WR	<20 Kt
* Horehound	16:45	08-27-69	NTS (Area 3)	LA	Shaft	-1086	WR	<20 Kt
Rulison	21:00.00.01	09-10-69	Grand Valley, CO	LA	Shaft	-8443	24th PS	47 Kt

Objective to investigate the feasibility of using nuclear explosives to stimulate a low producing gas field. Austral Oil Company, CER Geonuclear Corporation, Department of Interior participated. Deepest nuclear explosion ever conducted in U.S.

Minute Steak	18:02.20.42	09-12-69	NTS (Area 11f)	DOD	Shaft	-867	WE	<20 Kt (10)
Jorum	14:30.00.04	09-16-69	NTS (Area 20e)	LL	Shaft	-3800	WR	<1 Mt (800 Kt)
# Kyack	14:30	09-20-69	NTS (Area 2)	LL	Shaft	-607	WR	<20 Kt Mb 3.8
* Seaweed	14:30	10-01-69	NTS (Area 3)	LA	Shaft	-407	WR	<20 Kt
Milrow	22:06.00.04	10-02-69	Amchitka, AK	LA	Shaft	-3992	WR	~1 Mt
Pipkin	14:30.00.14	10-08-69	NTS (Area 20b)	LL	Shaft	-2025	WR	200-1000 Kt (120)
* Seaweed B	14:00	10-16-69	NTS (Area 3)	LA	Shaft	-387	WR	<20 Kt
Cruet	19:30.00.04	10-29-69	NTS (Area 2cn)	LL	Shaft	-855	WR	11 Kt
Pod	20:00.00.04	10-29-69	NTS (Area 2ch)	LL	Shaft	-1025	WR	20-200 Kt
Calabash	22:01.51.43	10-29-69	NTS (Area 2av)	LL	Shaft	-2050	WR	110 Kt
Scuttle	15:15	11-13-69	NTS (Area 2bh)	LL	Shaft	?	WR	<20 Kt
* Planer	13:52	11-21-69	NTS (Area 3)	LA	Shaft	-1237	WR	<20 Kt
Piccalilli	14:52.00.04	11-21-69	NTS (Area 3fc)	LA	Shaft	-1292	WR	20-200 Kt (20)
Diesel Train	17:00.00.04	12-05-69	NTS (Area 12e)	DOD	Tunnel	-1375	WE	<20 Kt (20)
* Culantro	15:00	12-10-69	NTS (Area 3)	LA	Shaft	-440	WR	<20 Kt
# Tun	15:30	12-10-69	NTS (Area 10)	LL	Shaft	-653	WR	<20 Kt Mb 4.2
Grape A	15:00.00.04	12-17-69	NTS (Area 7s)	LA	Shaft	-1806	WR	20-200 Kt (60)
Lovage	15:15.00.04	12-17-69	NTS (Area 3fe)	LA	Shaft	-1240	WR	<20 Kt (15)
Terrine	19:00.00.04	12-18-69	NTS (Area 9bi)	LL	Shaft	-1500	WR	20-200 Kt (50)

1970 [8]

Fob	16:30.00.21	01-23-70	NTS	LL	Shaft	-875	WR	<20 Kt
Ajo	17:00.00.04	01-30-70	NTS (Area 3gd)	LA	Shaft	-998	WR	<20 Kt (20)
* Belen	17:00	02-04-70	NTS (Area 3)	LA	Shaft	-1378	WR	20-200 Kt
Grape B	17:00.00.04	02-04-70	NTS (Area 7v)	LA	Shaft	-1819	WR	20-200 Kt (110)
Labis	15:00.00.04	02-05-70	NTS (Area 10an)	LL	Shaft	-1450	WR	25 Kt
Diana Mist	19:15.00.04	02-11-70	NTS (Area 12n)	DOD/LA	Tunnel	-1310	WE	<20 Kt (12)
Cumarin	14:28.38.04	02-25-70	NTS (Area 3gz)	LA	Shaft	-1340	WR	20-200 Kt (30)
Yannigan	15:30.00.04	02-26-70	NTS (Area 2ay)	LL	Shaft	-1287	WR	20-200 Kt (70)
Cyathus	14:24.00.94	03-06-70	NTS (Area 8b)	LL	Shaft	-950	WR	8.7 Kt
Arabis	15:00.00.21	03-06-70	NTS (Area 9)	LL	Shaft	-820	WR	<20 Kt
Jal	14:03.30.04	03-19-70	NTS (Area 3hh)	LA	Shaft	-988	WR	<20 Kt (6)
Shaper	23:05.00.04	03-23-70	NTS (Area 7r)	LA	Shaft	-1839	WR	20-200 Kt (70)
Handley	19:00.00.20	03-26-70	NTS (Area 20m)	LL	Shaft	-3957	WR	>1 Mt (1900 Kt)

Less than full yield test of the XW71 warhead for the Spartan ABM

Snubber	14:30.00.04	04-21-70	NTS (Area 3ev)	LA	Shaft	-1125	WE	<20 Kt (9)
Can	15:00.00.04	04-21-70	NTS (Area 2dd)	LL	Shaft	-1310	WR	20-200 Kt (15)
Beebalm	14:13.00.04	05-01-70	NTS (Area 3fn)	LA	Shaft	-1280	WR	<20 Kt (1)
Hod	14:40.00.17	05-01-70	NTS (Area 9)	LL	Shaft	-870	WR	<20 Kt (9)
Mint Leaf	15:30.00.17	05-05-70	NTS (Area 12t)	DOD/LL	Tunnel	-1330	WE	<20 Kt (21)

Tenth DOD sponsored event in the Minute Gun series.

Diamond Dust	14:00.00.04	05-12-70	NTS (Area 16a)	DOD	Tunnel	-830	6th VU	<20 Kt
Cornice	13:30.00.02	05-15-70	NTS (Area 10ap)	LL	Shaft	-1455	WR	20-200 Kt (45)
Manzanas	14:00.00.04	05-21-70	NTS (Area 3gr)	LA	Shaft	-789	WR	<20 Kt (1)
Morrones	14:15.00.04	05-21-70	NTS (Area 3ei)	LA	Shaft	-1580	WR	20-200 Kt (30)

Hudson Moon	14:16.00.17	05-26-70	NTS (Area 12e)	DOD	Tunnel	-1386	WE	<20 Kt (9)
Flask	15:00.00.05	05-26-70	NTS (Area 2az)	LL	Shaft	-1743	25th PS	105 Kt
* Piton A	11:45	05-28-70	NTS (Area 9)	LL	Shaft	-328	WR	<20 Kt
# Piton	12:00	05-28-70	NTS (Area 9)	LL	Shaft	-774	WR	<20 Kt Mb 3.8
Arnica	13:00.00.04	06-26-70	NTS	?	Shaft	-1015	WR	20-200 Kt

OPERATION *EMERY* (Fiscal Year 1971, 16 tests: 10 announced, 6 secret)

# Scree	15:05	10-13-70	NTS (Area 9)	LL	Shaft	-817	WR	<20 Kt Mb 3.9
Tijeras	14:30.00.04	10-14-70	NTS (Area 7y)	LA	Shaft	-1839	WR	20-200 Kt (94)
# Truchas	14:30	10-28-70	NTS (Area 3)	LA	Shaft	-872	WR	<20 Kt Mb 3.9
Abeytas	15:00.00.04	11-05-70	NTS (Area 3gx)	LA	Shaft	-1291	WR	20-200 Kt (24)
# Penasco	15:00	11-19-70	NTS (Area 3)	LA	Shaft	-886	WR	<20 Kt Mb 4.1
# Corazon	15:07	12-03-70	NTS (Area 3)	LA	Shaft	-790	WR	<20 Kt Mb 3.1
Artesia	16:00.00.09	12-16-70	NTS	?	Shaft	-1592	WR	20-200 Kt
Cream	16:00.00.17	12-16-70	NTS	?	Shaft	-965	WR	<20 Kt
* Canjilon	16:00	12-16-70	NTS (Area 3)	LA	Shaft	-991	WR	<20 Kt
Carpetbag	16:05.00.16	12-17-70	NTS (Area 2dg)	LL	Shaft	-2171	WR	220 Kt
Baneberry	15:30.00.20	12-18-70	NTS (Area 8d)	LL	Shaft	-910	WR	10 Kt (28)

1971 [12]

Embudo	14:50.00.04	06-16-71	NTS (Area 3hd)	LA	Shaft	-994	WR	<20 Kt (18)
* Dexter (No. 100)	14:00	06-23-71	NTS (Area 3)	LA	Shaft	-390	WR	<20 Kt
Laguna	15:30.00.04	06-23-71	NTS	LA	Shaft	-1493	WR	20-200 Kt (10)
Harebell	14:00.00.16	06-24-71	NTS (Area 2br)	LL	Shaft	-1702	WR	20-200 Kt (32)
Camphor	?	06-29-71	NTS (Area 12g)	DOD	Tunnel	?	WE	<20 Kt

OPERATION *GROMMET* (Fiscal Year 1972, 34 tests: 12 announced, 22 secret)

Diamond Mine	14:00.00.14	07-01-71	NTS (Area 16a)	DOD	Tunnel	-873	7th VU	<20 Kt

The objective is to give a direct measure of the decoupling effect of the carbon heatsink used in the Diamond Dust test. Device detonated in a spherical cavity 4.9 meter in radius.

Miniata	14:00.00.08	07-08-71	NTS (Area 2)	LL	Shaft	-1735	26th PS	83 Kt
# Bracken	14:00	07-09-71	NTS (Area 10)	LL	Shaft	-997	WR	<20 Kt Mb 3.4
# Apodaca	13:33	07-21-71	NTS (Area 3)	LA	Shaft	-790	WR	<20 Kt Mb 3.4
* Barranca	13:30	08-04-71	NTS (Area 3)	LA	Shaft	-886	WR	<20 Kt
* Nama	18:07	08-05-71	NTS (Area 9)	LL	Shaft	-892	WR	<20 Kt
* Baltic	14:31	08-06-71	NTS (Area 9)	LL	Shaft	-1348	WR	<20 Kt
Algodones	14:00.00.03	08-18-71	NTS	LA	Shaft	-1731	WR	20-200 Kt (66)
# Frijoles	14:00	09-22-71	NTS (Area 3)	LA	Shaft	-843	WR	<20 Kt Mb 3.6
Pedernal	14:00.00.04	09-29-71	NTS	LA	Shaft	-1242	WR	<20 Kt
* Chantilly	14:30	09-29-71	NTS (Area 2)	LL	Shaft	-1082	WR	<20 Kt
Cathay	14:30.00.04	10-08-71	NTS	LL	Shaft	-1240	WR	<20 Kt (7)
# Lagoon	14:30	10-14-71	NTS (Area 10)	LL	Shaft	-997	WR	<20 Kt Mb 3.9
Cannikin	22:00.00.06	11-06-71	Amchitka, AK	LL	Shaft	-5875	WR	<5 Mt

Proof test of W71 warhead for Spartan ABM missile

Diagonal Line	20:15.00.17	11-24-71	NTS (Area 11g)	DOD/LL	Shaft	-867	WE	<20 Kt
# Parnassia	15:45.03.4	11-30-71	NTS (Area 2)	LL	Shaft	-1082	WR	<20 Kt Mb 4.4
Chaenactis	21:09.59.16	12-14-71	NTS	LL	Shaft	-1085	WR	20-200 Kt (24)
* Yerba	21:10	12-14-71	NTS (Area 1)	LA	Shaft	-1089	WR	<20 Kt
* Hospah	21:10	12-14-71	NTS (Area 3)	LA	Shaft	-991	WR	<20 Kt

Event Name	Time	Date	Location	Lab	Type	DOB	Purpose	Yield
1972 [18]								
* Mescalero	15:10	01-05-72	NTS (Area 3)	LA	Shaft	-394	WR	<20 Kt
# Cowles	21:45	02-03-72	NTS (Area 3)	LA	Shaft	-987	WR	<20 Kt Mb 4.1
# Dianthus	19:02	02-17-72	NTS (Area 10)	LL	Shaft	-997	WR	<20 Kt Mb 4.3
* Sappho	18:50	03-23-72	NTS (Area 2)	LL	Shaft	-646	WR	<20 Kt
# Onaja	21:00.01	03-30-72	NTS (Area 3)	LA	Shaft	-915	WR	<20 Kt Mb 4.3
* Jicarilla	15:42	04-19-72	NTS (Area 3)	LA	Shaft	-485	WR	<20 Kt
Longchamps	16:32.00.16	04-19-72	NTS	?	Shaft	-1071	WR	<20 Kt
Misty North	19:15.00.04	05-02-72	NTS	DOD	Tunnel	-1238	WE	<20 Kt (19)
# Kara	14:00	05-11-72	NTS (Area 2)	LL	Shaft	-850	WR	<20 Kt Mb 3.6
Zinnia	14:10.00.16	05-17-72	NTS	LL	Shaft	-1059	WR	<20 Kt (8)
Monero	17:00.00.05	05-19-72	NTS	LA	Shaft	-1763	WR	<20 Kt (7)
# Merida	15:20	06-07-72	NTS (Area 2)	LL	Shaft	-669	WR	<20 Kt Mb 3.8
* Capitan (No.120)	14:41	06-28-72	NTS (Area 3)	LA	Shaft	-440	WR	<20 Kt Mb 3.7
* Haplopeppus	16:30	06-28-72	NTS (Area 9)	LL	Shaft	-604	WR	<20 Kt
# Tajique	16:30	06-28-72	NTS (Area 7)	LA	Shaft	-1089	WR	<20 Kt
OPERATION *TOGGLE* (Fiscal Year 1973, 27 tests: 11 announced, 16 secret)								
Diamond Sculls	17:16.00.16	07-20-72	NTS	DOD	Tunnel	-1391	WE	<20 Kt (21)
Used full scale missile								
# Atarque	13:30.03	07-25-72	NTS (Area 3)	LA	Shaft	-964	WR	<20 Kt Mb 3.8
* Cuchillo	13:31	08-09-72	NTS (Area 3)	LA	Shaft	-436	WR	<20 Kt
Oscuro	15:30.00.19	09-21-72	NTS	LA	Shaft	-1838	WR	20-200 Kt (100)
Delphinium	14:30.00.16	09-26-72	NTS	LL	Shaft	-970	WR	15 Kt
# Akbar	15:15	11-09-72	NTS (Area 10)	LL	Shaft	-872	WR	<20 Kt Mb 3.7
# Arsenate	18:15	11-09-72	NTS (Area 9)	LL	Shaft	-820	WR	<20 Kt Mb 3.7
* Canna	18:00	11-17-72	NTS (Area 9)	LL	Shaft	-699	WR	<20 Kt
# Tuloso	16:30	12-12-72	NTS (Area 3)	LA	Shaft	-889	WR	<20 Kt Mb 3.3
* Solanum	15:30	12-14-72	NTS (Area 9)	LL	Shaft	-659	WR	<20 Kt
Flax	20:15.00.24	12-21-72	NTS	LL	Shaft	-2258	WR	20-200 Kt (27)
1973 [15]								
* Alumroot	15:30	02-14-73	NTS (Area 9)	LL	Shaft	-597	WR	<20 Kt
Miera	16:10.00.19	03-08-73	NTS	LA	Shaft	-1866	WR	20-200 Kt (70)
# Gazook	20:15	03-23-73	NTS (Area 2)	LL	Shaft	-1069	WR	<20 Kt Mb 3.3
* Natoma	14:50	04-05-73	NTS (Area 10)	LL	Shaft	-797	Wr	<20 Kt
Angus	22:25:00.03	04-25-73	NTS	LA	Shaft	-1475	WR	20-200 Kt (23)
# Colmor	15:15	04-26-73	NTS (Area 3)	LA	Shaft	-787	WR	<20 Kt Mb 3.6
Starwort	17:15.00.16	04-26-73	NTS	?	Shaft	-1850	WR	90 Kt
* Mesita	13:30	05-09-73	NTS (Area 3)	LA	Shaft	-489	WR	<20 Kt
Rio Blanco	16:00.00.12	05-17-73	Rifle, CO	LL	Shaft	?	27th PS	Three 33 Kt
Three devices fired at -5840, -6230, -6690 feet								
# Kashan	13:30.00.7	05-24-73	NTS (Area 10)	LL	Shaft	-869	WR	<20 Kt Mb 4.1
* Cabresto	13:30	05-24-73	NTS (Area 7)	LA	Shaft	-646	WR	<20 Kt
Dido Queen	17:00.00.17	06-05-73	NTS	DOD	Tunnel	-1280	WE	<20 Kt (18)
Almendro	13:00.00.08	06-06-73	NTS	LA	Shaft	-3475	WR	200-1000 Kt (250)
# Potrillo	14:44.59.6	06-21-73	NTS (Area 7)	LA	Shaft	-1863	WR	20-200 Kt Mb 5.1
Portulaca	19:15.12.40	06-28-73	NTS	LL	Shaft	-1540	WR	20-200 Kt (24)
# Silene	19:45	06-28-73	NTS (Area 9)	LL	Shaft	-649	WR	<20 Kt Mb <2?
OPERATION *ARBOR* (Fiscal Year 1974, 19 tests: 5 announced, 14 secret)								
* Polygonum	14:30	10-02-73	NTS (Area 2)	LL	Shaft	-699	WR	<20 Kt
# Waller (No. 140)	15:15	10-02-73	NTS (Area 2)	LL	Shaft	-1017	WR	<20 Kt Mb 3.9
Husky Ace	17:00.00.08	10-12-73	NTS	DOD	Tunnel	-1345	WE	<20 Kt (8)
Bernal	?	11-28-73	NTS	LA	Shaft	?	WR	<20 Kt
# Pajara	19:00.00.5	12-12-73	NTS (Area 3)	LA	Shaft	-912	WR	<20 Kt Mb 4.5

* Seafoam	15:17	12-13-73	NTS (Area 2)	LL	Shaft	-649	WR	<20 Kt
* Spar	17:30	12-19-73	NTS (Area 3)	LA	Shaft	-489	WR	<20 Kt
* Elida	19:16	12-19-73	NTS (Area 3)	LA	Shaft	-1250	WR	<20 Kt

1974 [15]

* Pinedrops	16:38	01-10-74	NTS (Area 10)	LL	Shaft	-1122	WR	<20 Kt
Latir	17:00	02-27-74	NTS	LA	Shaft	?	WR	20-200 Kt (150)
* Hulsea	18:00	03-14-74	NTS (Area 2)	LL	Shaft	-640	WR	<20 Kt
* Sapello	16:15	04-12-74	NTS (Area 3)	LA	Shaft	-590	WR	<20 Kt
# Portrero	15:13	04-23-74	NTS (Area 2)	LL	Shaft	-689	WR	<20 Kt Mb 3.6
* Plomo	14:02	05-01-74	NTS (Area 3)	LA	Shaft	-489	WR	<20 Kt
* Jib	16:55	05-08-74	NTS (Area 3)	LA	Shaft	-587	WR	<20 Kt
# Grove	14:15.00.5	05-22-74	NTS (Area 2)	LL	Shaft	-1027	WR	<20 Kt Mb 4.4
Fallon	13:38.30.2	05-23-74	NTS	LL	Shaft	?	6th UK	20-200 Kt
# Jara	14:40.00.0	06-06-74	NTS (Area 3)	LA	Shaft	-1240	WR	<20 Kt Mb 4.3
Ming Blade	15:59.59.9	06-19-74	NTS	DOD	Tunnel	?	WE	<20 Kt (20)

OPERATION *BEDROCK* (Fiscal Year 1975, 27 tests: 15 announced, 12 secret)

Threshold Test Ban Treaty signed 3 July 1974; submitted to United States Senate for ratification on 29 July 1976

Escabosa	16:00.00.0	07-10-74	NTS	LA	Shaft	?	WR	20-200 Kt (170)
# Crestlake	14:00.01.3	07-18-74	NTS (Area 2)	LL	Shaft	-1223	WR	<20 Kt Mb 3.9
Puye	14:00.00.0	08-14-74	NTS	LA	Shaft	?	WR	<20 Kt (40)
Portmanteau	15:00.00.0	08-30-74	NTS	LL	Shaft	?	WR	20-200 Kt (200)
# Pratt	14:00.00.3	09-25-74	NTS (Area 3)	LA	Shaft	-1027	WR	<20 Kt Mb 4.3
# Trumbull	14:30	09-26-74	NTS (Area 4)	LL	Shaft	-859	WR	<20 Kt Mb 3.3
Stanyan	15:05.00.0	09-26-74	NTS	LL	Shaft	?	WR	20-200 Kt (100)
* Estaca	17:13	10-17-74	NTS (ARea 3)	LA	Shaft	-1050	WR	<20 Kt
Hybla Fair	?	10-28-74	NTS	DOD/LL	Tunnel	?	WE	<20 Kt
Test the feasibility of using a very low yield nuclear device as a X-ray source								
* Temescal	15:30	11-02-74	NTS (Area 4)	LL	Shaft	-859	WR	<20 Kt
* Puddle	15:00	11-26-74	NTS (Area 3)	LA	Shaft	-600	WR	<20 Kt
# Keel	17:30.00.5	12-16-74	NTS (Area 3)	LA	Shaft	-1148	WR	<20 Kt Mb 4.2 (4)

1975 [6]

# Portola (No.160)	15:30	02-06-75	NTS (Area 10)	LL	Shaft	-649	WR	<20 Kt Mb 3.5
# Teleme	16:13	02-06-75	NTS (Area 9)	LL	Shaft	-997	WR	<20 Kt Mb 4.5
* Bilge	20:10	02-19-75	NTS (Area 3)	LA	Shaft	-1046	WR	<20 Kt
Topgallant	20:15	02-28-75	NTS	?	Shaft	?	WR	20-200 Kt (125)
Cabrillo	15:00	03-07-75	NTS	?	Shaft	?	WR	20-200 Kt (120)
Dining Car	19:45	04-05-75	NTS	DOD	Tunnel	?	WE	<20 Kt (20)
Cost $20,2 million								
Edam	14:10	04-24-75	NTS	?	Shaft	?	WR	20-200 Kt (9)
Obar	15:00	04-30-75	NTS	?	Shaft	?	WR	20-200 Kt (41)
Tybo	14:00	05-14-75	NTS	LL	Shaft	?	WR	200-1000 Kt (380)
Stilton	14:20.00.2	06-03-75	NTS	LL	Shaft	-2398	WR	20-200 Kt (275)
Mizzen	14:40	06-03-75	NTS	?	Shaft	-1516	WR	20-200 Kt (160)
* Alviso	13:00	06-11-75	NTS (Area 2)	LL	Shaft	-600	WR	<20 Kt
* Futtock	11:49	06-18-75	NTS (Area 3)	LA	Shaft	-607	WR	<20 Kt
Mast	13:00	06-19-75	NTS	LA	Shaft	-2992	WR	200-1000 Kt (520)
Camembert	12:30	06-26-75	NTS	LL	Shaft	-4300	WR	200-1000 Kt (750)

OPERATION *ANVIL* (Fiscal Year 1976 and quarter, 21 tests: 18 announced, 3 secret)

Marsh	17:00	09-06-75	NTS	LA	Shaft	-1400	WR	<20 Kt (15)
Husky Pup	17:11.26	10-24-75	NTS	DOD	Tunnel	?	WE	<20 Kt (15)
Cost $2.5 million								
Kasseri	14:30	10-28-75	NTS	LL	Shaft	?	WR	200-1000 Kt (1200)
# Deck	15:30.00.3	11-18-75	NTS (Area 3)	LA	Shaft	-1069	WR	<20 Kt Mb 4.3

Inlet	15:00	11-20-75	NTS	LA	Shaft	-2680	WR	200-1000 Kt (500)
Leyden	15:30	11-26-75	NTS	LL	Shaft	-1050	WR	<20 Kt (5)
Chiberta	20:00	12-20-75	NTS	LL	Shaft	-2348	WR	20-200 Kt (160)
			1976 [5]					
Muenster	19:15.00.2	01-03-76	NTS	LL	Shaft	-4759	WR	200-1000 Kt (800)
Keelson	14:20.00.1	02-04-76	NTS	LA	Shaft	-2099	WR	20-200 Kt (200)
Esrom	14:40	02-04-76	NTS	LL	Shaft	-2148	WR	20-200 Kt (150)
Fontina	14:45.00.2	02-12-76	NTS	LL	Shaft	-3998	WR	200-1000 Kt (900)
Cheshire	11:30.00.2	02-14-76	NTS	LL	Shaft	-3828	WR	200-500 Kt (350)
# Shallows	14:50	02-26-76	NTS (Area 3)	LA	Shaft	-797	WR	<20 Kt Mb 4.1
Estuary	14:00.00.0	03-09-76	NTS	LA	Shaft	-2850	WR	200-500 Kt (350)
Colby	12:30.00.2	03-14-76	NTS	LL	Shaft	-4175	WR	500-1000Kt (800)
Pool	14:15.00.1	03-17-76	NTS	LA	Shaft	-2883	WR	200-500 Kt (500)
Strait	14:45.00.1	03-17-76	NTS	?	Shaft	-2558	WR	200-500 Kt (200)
Last high-yield test								
Mighty Epic	19:50.00.2	05-12-76	NTS	DOD	Tunnel	?	WE	<20 Kt
Cost $26.4 million								
# Rivoli	17:30	05-20-76	NTS (Area 2)	LL	Shaft	-656	WR	<20 Kt Mb 3.7
Billet	20:30.00.079	07-27-76	NTS	?	Shaft	?	WR	20-150 Kt
Banon	14:30.00.168	08-26-76	NTS	?	Shaft	?	7th UK	20-150 Kt
OPERATION *FULCRUM* (Fiscal Year 1977, 21 tests: 11 announced, 10 secret)								
# Gouda	14:30	10-06-76	NTS (Area 2)	LL	Shaft	-656	WR	<20 Kt Mb 3.7
* Sprit	14:58	11-10-76	NTS (Area 3)	LA	Shaft	-597	WR	<20 Kt
Chevre	15:15	11-23-76	NTS	LL	Shaft	?	WR	<20 Kt
Redmud	14:49.30.083	12-08-76	NTS	LA	Shaft	-1401	WR	<20 Kt
Asiago	15:09.00.166	12-21-76	NTS	?	Shaft	-1086	WR	<20 Kt
* Sutter	15:58	12-21-76	NTS (Area 2)	LL	Shaft	-656	WR	<20 Kt
Rudder	18:00.00.076	12-28-76	NTS	LA	Shaft	-4205	WR	20-150 Kt
			1977 [8]					
# Oarlock	17:53	02-16-77	NTS (Area 3)	LA	Shaft	-1050	WR	<20 Kt Mb 4.3
# Dofino	14:24	03-08-77	NTS (Area 10)	LL	Shaft	-925	WR	<20 Kt Mb 3.8
Marsilly	15:00.00.167	04-05-77	NTS	LL	Shaft	-2263	WR	20-150 Kt
Bulkhead	15:00.00.084	04-27-77	NTS	LA	Shaft	-1948	WR	20-150 Kt
Crewline	17:00.00.076	05-25-77	NTS	LA	Shaft	-1850	WR	20-150 Kt
* Forefoot	17:15	06-22-77	NTS (Area 3)	LA	Shaft	-633	WR	<20 Kt
# Carvelline	14:07	07-28-77	NTS (Area 4)	LL	Shaft	-682	WR	<20 Kt Mb 3.7
Strake	16:40.00.074	08-04-77	NTS	LA	Shaft	-1699	WR	20-150 Kt
# Gruyere	14:41	08-16-77	NTS (Area 9)	LL	Shaft	-679	WR	<20 Kt Mb 3.7
# Flotost	15:49	08-16-77	NTS (Area 2)	LL	Shaft	-902	WR	<20 Kt Mb 4.0
# Scupper	17:32	08-19-77	NTS (Area 3)	LA	Shaft	-1473	WR	<20 Kt Mb 3.3
Scantling	17:55.00.075	08-19-77	NTS	LA	Shaft	-2299	WR	20-150 Kt
Ebbtide	14:36.30.077	09-15-77	NTS	LA	Shaft	-1250	WR	<20 Kt
Coulommiers	14:00.00.161	09-27-77	NTS	LL	Shaft	-1738	WR	20-150 Kt
OPERATION *CRESSET* (Fiscal Year 1978, 23 tests: 16 announced, 7 secret)								
Bobstay	14:15.00.076	10-26-77	NTS	LA	Shaft	-1250	WR	<20 Kt
Hybla Gold	18:06.00.074	11-01-77	NTS	DOD	Tunnel	-1263	WE	<20 Kt
Cost $8.6 million								
Sandreef	22:00.00.075	11-09-77	NTS	LA	Shaft	-2299	WR	20-150 Kt
Seamount	19:30.00.077	11-17-77	NTS	LA	Shaft	-1220	WR	<20 Kt
# Rib	15:00	12-14-77	NTS (Area 3)	LA	Shaft	-699	WR	<20 Kt Mb 3.8
Farallones	15:30.00.169	12-14-77	NTS	LL	Shaft	-2191	WR	20-150 Kt

1978 [7]

Campos	21:52.59.6	02-13-78	NTS	LL	Shaft	?	WR	<20 Kt
Reblochon	17:00.00.164	02-23-78	NTS	LL	Shaft	-2158	WR	20-150 Kt
On 21 February a worker fell down the shaft and died.								
# Karab	14:59.59.6	03-16-78	NTS (Area 4)	LL	Shaft	-1086	WR	<20 Kt Mb 4.1
Iceberg	16:30.00.20	03-23-78	NTS	LA	Shaft	-2099	WR	20-150 Kt
* Topmast(No.180)	16:30	03-23-78	NTS (Area 7)	LA	Shaft	-1499	WR	<20 Kt
Fondutta	15:30.00.161	04-11-78	NTS	LL	Shaft	-2076	8th UK	20-150 Kt
Backbeach	17:45.00.073	04-11-78	NTS	LA	Shaft	-2004	WR	20-150 Kt
* Asco	14:35	04-25-78	NTS (Area 10)	LL	Shaft	-600	WR	<20 Kt
Transom	?	05-10-78	NTS	LA	Shaft	?	WR	Zero
No nuclear yield; device was destroyed by Hearts detonation on 09-06-79								
# Jackpots	17:00.00.0	06-01-78	NTS (Area 3)	LA	Shaft	-997	WR	<20 Kt Mb 3.7
# Satz	13:59.59.3	07-07-78	NTS (Area 2)	LL	Shaft	-1033	WR	<20 Kt Mb 4.3
Lowball	17:00.00.075	07-12-78	NTS	LA	Shaft	-1850	WR	20-150 Kt
Panir	14:00.00.164	08-31-78	NTS	LL	Shaft	-2234	WR	20-150 Kt
Diablo Hawk	15:15.00.161	09-13-78	NTS	DOD	Tunnel	-1373	WE	<20 Kt
First known X-ray laser test, apparatus fails, cost $35.9 million								
# Cremino	16:30	09-27-78	NTS (Area 8)	LL	Shaft	-689	WR	<20 Kt Mb 3.4
Draughts	17:00.00.071	09-27-78	NTS	LA	Shaft	-1450	WR	20-150 Kt
Rummy	17:20.00.076	09-27-78	NTS	LA	Shaft	-2099	WR	20-150 Kt

OPERATION *QUICKSILVER* (Fiscal Year 1979, 18 tests: 16 announced 2 secret)

Emmenthal	15:25.00.169	11-02-78	NTS	LL	Shaft	-1889	WR	<20 Kt
Quargel	19:00.00.166	11-18-78	NTS	LL	Shaft	-1778	9th UK	20-150 Kt
# Concentration	17:07.29.8	12-01-78	NTS (Area 3)	LA	Shaft	-797	WR	<20 Kt Mb 3.7
Farm	15:30.00.158	12-16-78	NTS	LL	Shaft	-2260	WR	20-150 Kt

1979 [1]

Baccarat	18:00.00.099	01-24-79	NTS	LA	Shaft	-1069	WR	<20 Kt
Quinella	20:00.00.089	02-08-79	NTS	?	Shaft	-1899	WR	20-150 Kt
Kloster	18:05,00.164	02-15-79	NTS	LL	Shaft	-1758	WR	20-150 Kt
Memory	18:30.00.095	03-14-79	NTS	?	Shaft	-1200	WR	<20 Kt
# Freezeout	15:59.59.7	05-11-79	NTS (Area 3)	LA	Shaft	-1099	WR	<20 Kt Mb 4.4
Pepato	14:00.00.170	06-11-79	NTS	LL	Shaft	-2234	WR	20-150 Kt
Chess	15:00.13.542	06-20-79	NTS	LA	Shaft	-1099	WR	<20 Kt
Fajy	14:44.00.168	06-28-79	NTS	LL	Shaft	-1761	WR	20-150 Kt
Burzet	15:07.30.163	08-03-79	NTS	LL	Shaft	-1476	WR	20-150 Kt
Offshore	15:00.00.112	08-08-79	NTS	LA	Shaft	-1292	WR	20-150 Kt
Nessel	15:08.00.171	08-29-79	NTS	LL	Shaft	-1522	10th UK	20-150 Kt
Hearts	15:00.00.089	09-06-79	NTS	LA	Shaft	-2099	WR	20-150 Kt
Detonation destroyed Transom device that did not detonate on 05-10-78. Exact yield given to Soviets as part of Joint Verification Experient								
Pera	17:02.00.090	09-08-79	NTS	LL	Shaft	-656	WR	<20 Kt
Sheepshead	15:00.00.091	09-26-79	NTS	LL	Shaft	-2099	WR	20-150 Kt

OPERATION *TINDERBOX* (Fiscal Year 1980, 15 tests, all announced)

Backgammon	15:00.00.096	11-29-79	NTS	LA	Shaft	-751	WR	<20 Kt
Azul	18:00.00.091	12-14-79	NTS	LL	Shaft	-672	WR	<20 Kt
Detonation destroyed Peninsula device that was damaged during emplacement on 10-23-75. The Peninsula device was not tested.								

1980 [0]

Tarko	15:00.00.093	02-28-80	NTS	LL	Shaft	-1210	WR	<20 Kt
Norbo	15:35.00.090	03-08-80	NTS	LL	Shaft	-889	WR	<20 Kt
Liptauer	14:00.00.090	04-03-80	NTS	LL	Shaft	-1368	WR	20-150 Kt
Pyramid	20:00.00.089	04-16-80	NTS	LA	Shaft	-1899	WR	20-150 Kt
Colwick	17:00.00.083	04-26-80	NTS	LL	Shaft	-2076	11th UK	20-150 Kt
Canfield	18:46.30.092	05-02-80	NTS	LA	Shaft	-1151	WR	<20 Kt

Flora	13:00.00.089	05-22-80	NTS	LA	Shaft	-1099	WR	<20 Kt
Kash	17:15.00.086	06-12-80	NTS	LL	Shaft	-2116	WR	20-150 Kt

Possibly either Kash or Tafi was a test of a W68 warhead randomly selected from the production line after having its high explosive changed.

Huron King	15:10.00.074	06-24-80	NTS	DOD	Shaft	-1050	WE	<20 Kt

Part of an Air Force and National Security Agency program to improve the database on nuclear hardening design techniques for satellites. A vertical line of sight test using a small DSCS III prototype. Cost $10.3 million

Tafi	19:05.00.082	07-25-80	NTS	LL	Shaft	-2230	WR	20-150 Kt
Verdello	18:19.00.092	07-31-80	NTS	LA	Shaft	-1200	WR	<20 Kt
Bonarda	14:45.00.094	09-25-80	NTS	LA	Shaft	-1250	WR	20-150 Kt
Riola	15:26.30.084	09-25-80	NTS	LL	Shaft	-1391	WR	<20 Kt

OPERATION *GUARDIAN* (Fiscal Year 1981, 16 tests, all announced)

Dutchess	19:15.00.116	10-24-80	NTS	LA	Shaft	-1401	12th UK	<20 Kt
Miners Iron	18:00.00.090	10-31-80	NTS	DOD	Tunnel	-1279	WE	<20 Kt

A test to evaluate the nuclear hardness of candidate materials for MX components such as motor cases, ablative nozzle, propellant and external booster parts. The test used 2000 channels of data. Cost $26.2 million.

Dauphin	16:50.00.084	11-14-80	NTS	LL	Shaft	-1050	WR	<20 Kt

Second known X-ray laser test

Serpa	15:10.00.086	12-17-80	NTS	LL	Shaft	-1879	13th UK	20-150 Kt

---1981 [0]---

Baseball	20:25.00.90	01-15-81	NTS	LA	Shaft	-1850	WR	20-150 Kt
Clairette	18:00.00.117	02-05-81	NTS	LA	Shaft	-1161	WR	<20 Kt
Seco	15:00.00.8	02-25-81	NTS	LL	Shaft	-751	WR	<20 Kt
Vide	14:35.00.0	04-30-81	NTS	LL	Shaft	-1059	WR	<20 Kt
Aligote	16:00.00.0	05-29-81	NTS	LA	Shaft	-1050	WR	<20 Kt
Harzer	18:00.00.0	06-06-81	NTS	LL	Shaft	-2089	WR	20-150 Kt
Niza	14:00.00.096	07-10-81	NTS	LL	Shaft	-1118	WR	<20 Kt
Pineau	15:00.00.096	07-16-81	NTS	LA	Shaft	-669	WR	<20 Kt
Havarti	13:41.00.086	08-05-81	NTS	LL	Shaft	-656	WR	<20 Kt
Islay	14:31.00.088	08-27-81	NTS	LL	Shaft	-964	WR	<20 Kt
Trebbiano	15:00.00.103	09-04-81	NTS	LA	Shaft	-1000	WR	<20 Kt
Cernada	15:00.00.089	09-24-81	NTS	LA	Shaft	-699	WR	<20 Kt

OPERATION *PRAETORIAN* (Fiscal Year 1982, 22 tests, all announced)

Paliza	19:00.00.103	10-01-81	NTS	?	Shaft	-1548	WR	20-150 Kt
Tilci	20:00.00.036	11-11-81	NTS	?	Shaft	-1460	WR	20-150 Kt
Rousanne	15:00.00.0	11-12-81	NTS	?	Shaft	-1699	14th UK	20-150 Kt
Akwi	15:00.00.098	12-03-81	NTS	?	Shaft	-1620	WR	20-150 Kt
Caboc	21:05.00.093	12-16-81	NTS	?	Shaft	-1099	WR	<20 Kt

---1982 [0]---

Jornada	16:00.00.104	01-28-82	NTS	?	Shaft	-2099	WR	20-150 Kt

Exact yield given to Soviets as part of Joint Verification Experiment. May have used W80 warhead.

Molbo	14:55.00.083	02-12-82	NTS	?	Shaft	-2135	WR	20-150 Kt
Hosta	15:25.00.089	02-12-82	NTS	?	Shaft	-2099	WR	20-150 Kt
Tenaja	18:00.00.088	04-17-82	NTS	?	Shaft	-1171	WR	<20 Kt
Gibne	18:05.00.084	04-25-82	NTS	?	Shaft	-1870	15th UK	20-150 Kt
Kryddost	20:00.00.083	05-06-82	NTS	?	Shaft	-1099	WR	<20 Kt
Bouschet	18:17.00.110	05-07-82	NTS	?	Shaft	-1850	WR	20-150 Kt
Kesti	14:00.00.849	06-16-82	NTS	?	Shaft	-948	WR	<20 Kt
Nebbiolo	14:15.00.090	06-24-82	NTS	?	Shaft	-2099	WR	20-150 Kt
Monterey	20:05.00.083	07-29-82	NTS	?	Shaft	-1312	WR	20-150 Kt
Atrisco	14:00.00.090	08-05-82	NTS	?	Shaft	-2099	WR	20-150 Kt

Exact yield given to Soviets as part of Joint Verification Experiment.

Queso	15:00.00.000	08-11-82	NTS	?	Shaft	-708	WR	<20 Kt
Cerro	14:00.00.090	09-02-82	NTS	?	Shaft	-751	WR	<20 Kt

Huron Landing	16:00.00.091	09-23-82	NTS	DOD	Tunnel	?	WE	<20 Kt

Simultaneous with Diamond Ace. A horizontal line of sight test on MX components. It was one of the largest, most complex tests DNA ever conducted, using 3000 channels of data to assess 400 separate experiments. Cost $48.1 million

Diamond Ace	16:00.00.091	09-23-82	NTS	DOD	Tunnel	?	WE	<20 Kt

Simultaneous with Huron Landing. The first event in the DISTANT ARBOR series. A joint DNA/DOE test to provide detailed diagnostic data of the radiation output of a low-yield nuclear device. Cost $2.5 million.

Frisco	17:00.00.082	09-23-82	NTS	?	Shaft	-1479	WR	20-150 Kt
Borrego	13:30.00.096	09-29-82	NTS	?	Shaft	-1850	WR	<150 Kt

OPERATION *PHALANX* (Fiscal Year 1983, 19 tests, 16 announced, 3 secret)

Seyval	19:17.00.103	11-12-82	NTS	?	Shaft	-1200	WR	<20 Kt
Manteca	15:20.00.090	12-10-82	NTS	?	Shaft	-1355	WR	20-150 Kt

---1983 [4]---

Coalora	16:00.00.096	02-11-83	NTS	?	Shaft	-997	WR	<20 Kt
Cheedam	17:00.00.087	02-17-83	NTS	?	Shaft	-1125	WR	<20 Kt

Possibly either Cheedam or Crowdie was a successful test of the W79.

Cabra	20:20.00.088	03-26-83	NTS	?	Shaft	-1778	WR	20-150 Kt

Third known X-ray laser test, sensors fail

Turquoise	19:05.00.0	04-14-83	NTS	?	Shaft	-1748	WR	<150 Kt
Armada	13:53.00.0	04-22-83	NTS	?	Shaft	-869	16th UK	<20 Kt
Crowdie	15:20.00.085	05-05-83	NTS	?	Shaft	-1279	WR	<20 Kt
Mini Jade	14:30.00.0	05-26-83	NTS	DOD	Tunnel	-1245	WE	<20 Kt

A test to obtain data to predict ground motion and cratering prediction. The test was conducted in a hemispherical cavity having an eleven meter radius. Cost $10.5 million.

Fahada	15:00.00.090	05-26-83	NTS	?	Shaft	-1260	WR	<20 Kt
Danabiu	17:10.00.088	06-09-83	NTS	?	Shaft	-1050	WR	<20 Kt
Laban	13:33.00.0	08-03-83	NTS	?	Shaft	-1069	WR	<20 Kt

First test to use laser optical line of sight (LOLOS) system, designed for precisely measuring downhole alignment of a diagnostics canister.

Sabado	14:00.00.0	08-11-83	NTS	?	Shaft	-1050	WR	<20 Kt
# Jarlsberg	13:59.59.9	08-27-83	NTS (Area 10)	LL	Shaft	-656	WR	<20 Kt Mb 4.1
Chancellor	14:00.00.0	09-01-83	NTS	?	Shaft	-1691	WR	20-150 Kt

Exact yield given to Soviets as part of Joint Verification Experiment.

Tomme/Midnight Zephyr	15:00.00.0	09-21-83	NTS	DOD	Tunnel	?	WE	<20 Kt

The second event in the Distant Arbor series. A joint DNA/DOE test to provide data for a low yield test bed. Cost $3.3 million

# Branco	16:24.59.7	09-21-83	NTS (Area 2)	LL	Shaft	-961	WR	<20 Kt Mb 3.7
Techado	15:00.00.0	09-22-83	NTS	?	Shaft	-1748	WR	<150 Kt
* Navata	16:00	09-29-83	NTS (Area 3)	LA	Shaft	-600	WR	<20 Kt

OPERATION *FUSILEER* (Fiscal Year 1984, 17 tests: 12 announced, 5 secret)

# Muggins	15:59.59.2	12-09-83	NTS (Area 3)	LA	Shaft	-800	WR	<20 Kt Mb 4.0
Romano	18:30.00.0	12-16-83	NTS	?	Shaft	-4310	WR	20-150 Kt

Fourth known X-ray laser test, first hard X-ray laser evidence

---1984 [6]---

Gorbea	15:30.00.0	01-31-84	NTS	?	Shaft	?	WR	20-150 Kt
Midas Myth/Milagro	17:00.00.105	02-15-84	NTS	DOD	Tunnel	?	WE	<20 Kt

The first test in a series of three to validate hardness specifications for major elements of the triad. This 800 foot line of sight test provided data on the nuclear hardness of strategic reentry systems, specifically the MX's Mark 21. First use of glass strand fiber optics cables, which provide clearer reception of data and are secure from "tapping," thus improving the level of security. Cost $46.1 million.

Tortugas	17:45.00.094	03-01-84	NTS	LA	Shaft	-2096	WR	20-150 Kt
Agrini	14:30.00.084	03-31-84	NTS	LL	Shaft	-1050	WR	<20 Kt
Mundo	19:05.00.093	05-01-84	NTS	LA	Shaft	-1860	17th UK	20-150 Kt
# Orkney	13:49.59.6	05-02-84	NTS (Area 10)	LL	Shaft	-689	WR	<20 Kt Mb 3.4
# Bellow	15:59.59.3	05-16-84	NTS (Area 4)	LL	Shaft	-679	WR	<20 Kt Mb 3.8
Caprock	13:04.00.102	05-31-84	NTS	LA	Shaft	-1968	WR	20-150 Kt
Duoro	15:15.00.089	06-20-84	NTS	LA	Shaft	-1250	WR	20-150 Kt

# Normanna	13:59.59.9	07-12-84	NTS (Area 10)	LL	Shaft	-656	WR	<20 Kt Mb 3.9
Kappeli	15:30	07-25-84	NTS	LL	Shaft	-2099	WR	20-150 Kt
Correo	15:00.00.094	08-02-84	NTS	LL	Shaft	-1099	WR	<20 Kt
Fifth known test of X-ray laser, laser fails								
Dolcetto	14:45.00.102	08-30-84	NTS	LA	Shaft	-1200	WR	<20 Kt
• Wexford	14:45	08-30-84	NTS (Area 2)	LL	Shaft	-1030	WR	<20 Kt
Breton	14:00.00.0	09-13-84	NTS	LL	Shaft	-1584	WR	20-150 Kt

OPERATION *GRENADIER* (Fiscal Year 1985, 17 tests: 14 announced, 3 secret)

# Vermejo	18:13.59.3	10-02-84	NTS (Area 4)	LA	Shaft	-1148	WR	<20 Kt Mb 4.1
Villita	16:40.00.0	11-10-84	NTS	LA	Shaft	?	WR	<20 Kt
Egmont	19:40.00.089	12-09-84	NTS	LL	Shaft	-1807	18th UK	20-150 Kt
Tierra	14:45.00.0	12-15-84	NTS	LL	Shaft	-2099	SC	20-150 Kt
Test of B83 bomb								
# Minero	16:19:59.7	12-20-84	NTS (Area 3)	LA	Shaft	-797	WR	<20 Kt Mb 4.0

---1985 [2]---

Vaughn	16:31.00.096	03-15-85	NTS	LA	Shaft	-1400	WR	20-150 Kt
Cottage	18:30.00.082	03-23-85	NTS	LL	Shaft	-1689	WR	20-150 Kt
Sixth known X-ray laser test, first focusing attempt								
Hermosa	20:00.00.090	04-02-85	NTS	LA	Shaft	-2099	WR	20-150 Kt
Used CORRTEX								
Misty Rain	23:15.00.092	04-06-85	NTS	LL/DOD	Tunnel	?	WE	<20 Kt

The second in a series to validate hardness specifications. A 900 foot line of sight test in support of the MX system, specifically the Mk 21 reentry vehicle. Also included was a satellite vulnerability experiment to test its electronics in a radiation environment. Some X-ray laser lethality testing was also conducted. Cost 54.4 million.

Towanda	15:20.00.083	05-02-85	NTS	LA	Shaft	-2168	WR	20-150 Kt
Salut	15:15.00.082	06-12-85	NTS	LL	Shaft	?	WR	20-150 Kt
Ville	17:30.00.088	06-12-85	NTS	LL	Shaft	-961	WR	<20 Kt
Maribo	18:03.00.084	06-26-85	NTS	LL	Shaft	-1250	WR	<20 Kt
Serena	14:00.00.088	07-25-85	NTS	LL	Shaft	-1958	WR	20-150 Kt

Possibly either Serena or Rocquefort was a test of a prototype Earth Penetrating Weapon (EPW). More EPW tests are planned.

# Cebrero	13:00	08-14-85	NTS (Area 9)	LL	Shaft	-600	WR	<20 Kt

Identified by Soviet official at embassy in Washington to show ease of detection, see *New York Times*, 30 August 1986, p. 1. Described as "very small."

Chamita	16:25.00.087	08-17-85	NTS	LA	Shaft	-1089	WR	<20 Kt

Test associated with hypervelocity pellet (NDEW) experiment. A 1 kg tungsten/molybdenum plate was accelerated to 70 km/sec.

Ponil	14:15.00.081	09-27-85	NTS	LA	Shaft	-1200	WR	<20 Kt

OPERATION *CHARIOTEER* (Fiscal Year 1986, 18 tests: 15 announced, 3 secret)

Mill Yard	21:40	10-09-85	NTS	LA/DOD	Tunnel	?	WE	<20 Kt

A second cavity experiment, similar to Mini Jade, to obtain data on cratering phenomenology and airburst phenomena. Also addressed issues on superhardening silos and the basing of the small ICBM. The shot used a very low yield device detonated at ground level in a 22 meter diameter hemispherical cavity. Yield range probably 50 to 100 tons. Cost $15.4 million.

Diamond Beech	23:20.00.086	10-09-85	NTS	LL/DOD	Tunnel	?	WE	<20 Kt

Third and final proof test for low yield test bed. Cost $15.5 million.

# Abo	16:00	10-30-85	NTS (Area 3)	LA	Shaft	-649	WR	<20 Kt

Identified by Soviet official at embassy in Washington to show ease of detection. American official described yield as "tiny," "one-hundreth of a kiloton," see, *New York Times*, 30 August 1986, p. 1.

Rocquefort	21:35.00.086	10-16-85	NTS	LL	Shaft	-1361	WR	20-150 Kt
Kinibito	15:00.00.067	12-05-85	NTS	LA	Shaft	-1968	19th UK	20-150 Kt
Goldstone	19:01.00.089	12-28-85	NTS	LL	Shaft	-1640	WR	20-150 Kt

Seventh X-ray test, first good measure of brightness shows basic laser is dimmer than previously believed.

---1986 [2]---

Glencoe	16:15.00.076	03-22-86	NTS	LA	Shaft	-1969	WR	20-150 Kt

Test associated with candidate warhead for SICBM.

Mighty Oak	14:08.30.095	04-10-86	NTS (Area 12)	DOD/LL	Tunnel	-1300	WE	1.3 Kt

The final test to validate hardness specifications for the Mark-21 reentry vehicle for the MX missile and the first validation test for the Trident II (D-5) reentry system. X-ray laser lethality experiments were also conducted. Test malfunctioned. Cost $74.4 million

# Mogollon	23:12.29.9	04-20-86	NTS (Area 3)	LA	Shaft	-850	WR	<20 Kt Mb 3.8

Identified by Soviet official at embassy in Washington to show ease of detection, see *New York Times*, 30 August 1986, p. 1. Described as "larger" [than Cebrero or Abo]

Jefferson	14:30.00.086	04-22-86	NTS (Area 20)	LL	Shaft	-1969	WR	20-150 Kt

Used CORRTEX. Possibly confidence test of a first production unit of the W87.

Panamint	13:59.00.083	05-21-86	NTS (Area 4)	LL	Shaft	-1640	WR	<20 Kt
Tajo	15:04.00.064	06-05-86	NTS (Area 7)	LL	Shaft	-1640	WR	20-150 Kt
Darwin	20:27.45.1	06-25-86	NTS (Area 20)	LL	Shaft	-1640	20th UK	20-150 Kt

Device emplaced 05-07. Trident related.

Cybar	21.00.00.055	07-17-86	NTS (Area 19)	LA	Shaft	-2100	WR	20-150 Kt

Exact yield given to Soviets as part of Joint Verification Experiment.

Cornucopia	15:05.00.086	07-24-86	NTS (Area 2)	LL	Shaft	-1300	WR	<20 Kt
# Galveston (No.200)	16:09.00.1	09-04-86	NTS (Area 19)	LA	Shaft	-1597	WR	<20 Kt Mb 3.5
Aleman	14:57.00.107	09-11-86	NTS (Area 7)	LA	Shaft	-1640	WR	<20 Kt
Labquark	22:30.00.102	09-30-86	NTS (Area 20)	LL	Shaft	-1969	WR	20-150 Kt

Eighth X-ray laser test, focusing tests

OPERATION *MUSKETEER* (Fiscal Year 1987, 15 tests, all announced)

Belmont	19:25.00.089	10-16-86	NTS (Area 20)	LL	Shaft	-1969	WR	20-150 Kt
Gascon	16:00.00.066	11-14-86	NTS	LL	Shaft	-1969	WR	20-150 Kt
Bodie	17:50.05.093	12-13-86	NTS (Area 20)	LL	Shaft	?	WR	20-150 Kt

1987 [0]

Hazebrook	15:00.00.082	02-03-87	NTS	LL	Shaft	-984	WR	<20 Kt

Yield on order of 10 to 30 tons

Tornero	16:45.00.065	02-11-87	NTS	LL	Shaft	-984	WR	<20 Kt
Middle Note	18:28.00.085	03-18-87	NTS (Area 12)	DNA	Tunnel	-1312	WE	<20 Kt

The test was the second in a series of four in support of the Trident II and included testing of W88 components of the Mk-5 reentry body system. It also included testing of W87 components of MX Mk-21 reentry body system. Lethality and survivability experiments were also conducted in support of the Strategic Defense Initiative Organization. Cost $55.2 million.

Delamar	13:40.00.600	04-18-87	NTS	LL	Shaft	-1640	WR	20-150 Kt

Ninth known X-ray laser test

Presidio	22:00.00.088	04-22-87	NTS	LA	Shaft	-984	WR	<20 Kt
Hardin	13:30.00.089	04-30-87	NTS	LL	Shaft	-1969	WR	20-150 Kt
Brie	15:20.00.002	06-18-87	NTS	LL	Shaft	-650	WR	<20 Kt
Mission Ghost	16:00.00.1	06-20-87	NTS (Area 12)	DNA	Tunnel	-1000	WE	<20 Kt

The test was a hemispherical cavity event to develop the containment and instrumentation technology and provide data needed to plan the Misty Echo test scheduled for August 1988. These include the type and extent of grouting and the instrumentation shielding/design against electromagnetic pulse effects. The test used a device with output characteristics similar to a modern weapon. Cost $11.7 million.

Panchuela	16:05.00.096	06-30-87	NTS	LA	Shaft	-985	WR	<20 Kt
Midland	19:00.00.077	07-16-87	NTS	LA	Shaft	-1604	21th UK	20-150 Kt
Tahoka	14:00.00.088	08-13-87	NTS	LA	Shaft	-1920	WR	20-150 Kt
Lockney	15:00.00.055	09-24-87	NTS	LA	Shaft	-1920	WR	20-150 Kt

OPERATION *TOUCHSTONE* (Fiscal Year 1988, 14 tests: 13 announced, 1 secret)

Borate	16:00.00.087	10-23-87	NTS	LL	Shaft	-1600	WR	20-150 Kt
Waco	16:30.00.090	12-01-87	NTS	LA	Shaft	-640	WR	<20 Kt
Mission Cyber	16:30.00.084	12-02-87	NTS (Area 12)	DNA	Tunnel	-960	WE	<20 Kt

The test was the third in a series of four in support of the Trident II program. It included tests for the final hardness verification and survivability assessment for the Mk-5 reentry system. Experiments were also conducted to assess the vulnerabilities of the D-5 missile body electronic packages and the Mk-6 guidance electronics. SDIO advanced development experiments associated with the Army's ERIS and HEDI ballistic missile defense programs, and SDIO lethality and survivability experiments were also conducted. Cost $64.5 million.

1988 [3]

Kernville	18:10.00.089	02-15-88	NTS (Area 20)	LL	Shaft	-1800	WR	20-150 Kt

Tenth known X-ray laser test, first high-quality data on basic laser

Abilene	17:15	04-07-88	NTS (Area 3)	LA	Shaft	-800	WR	<20 Kt
Shellbourne	15:35:05	05-13-88	NTS (Area 4)	LL	Shaft	-1500	WR	<150 Kt
Laredo	22:30	05-21-88	NTS	LA	Shaft	-1200	WR	20-150 Kt
Comstock	13:00:02	06-02-88	NTS (Area 20)	LL	Shaft	-2000	WR	20-150 Kt
Rhyolite	14:00	06-22-88	NTS	LL	Shaft	-640	WR	<20 Kt
Nightingale	14:00	06-22-88	NTS	LL	Shaft	-640	WR	<20 Kt
Alamo	15:05:30	07-07-88	NTS (Area 19)	LA	Shaft	-1920	WR	?
Kearsarge	17:00	08-17-88	NTS (Area 19)	LA	Shaft	-2020	WR/JVE	<150 Kt
# Harlingen	18:30	08-23-88	NTS (Area 6)	LA	Shaft	-948	WR	<20 Kt
Bullfrog	18:30	08-30-88	NTS	?	Shaft	-1600	WR	<150 Kt

OPERATION *CORNERSTONE* (Fiscal Year 1989, 12 tests: 10 announced, 2 secret)

Dalhart	14:00	10-13-88	NTS	LA	Shaft	-2100	WR	<150 Kt
# Monahans	20:15	11-09-88	NTS (Area 3)	LA	Shaft	-948	WR	<20 Kt
* Kawich A	15:15	12-09-88	NTS (Area 8)	LL	Shaft	-1260	WR	<20 Kt
Misty Echo	20:30:01	12-10-88	NTS	DOD/LA	Tunnel	-1200	WE	<20 Kt

A cratering and ground shock event to develop energy coupling and cratering prediction codes useful for assessing the vulnerability of strategic structures to nuclear attack, and to ensure the most effective allocation of strategic warheads for targeting purposes, including future weapon systems such as the earth penetrator warhead. Cost $43.8 million.

1989 [0]

Texarkana	20:06:04	02-10-89	NTS (Area 6)	?	Shaft	-1650	WR	20-150 Kt (5.4 Mb)
Kawich	16:15	02-24-89	NTS	?	Shaft	?	WR	<20 Kt (4.4 Mb)
Ingot	14:00	03-09-89	NTS	LL	Shaft	-1600	WR	20-150 Kt (5.1 Mb)
Palisade	13:10	05-15-89	NTS	?	Shaft	?	WR	<20 Kt (4.6)
Tulia	18:07	05-26-89	NTS	LA	Shaft	?	WR	<20 Kt
Contact	21:15	06-22-89	NTS (Area 20)	LL	Shaft	-1800	WR	20-150 Kt (5.4 Mb)
Amarillo	15:31	06-27-89	NTS (Area 19)	LA	Shaft	-2100	WR	20-150 Kt (5.3 Mb)
Disko Elm	15:00	09-14-89	NTS	DOD/LL	Tunnel	?	WE	<20 Kt

The fourth and final test in support of the Trident II. Sought to demonstrate systems survivability while operating in a simulated boost phase flight profile. Cost $60.2 million.

OPERATION *AQUEDUCT* (Fiscal Year 1990, 11 tests, 10 announced, 1 secret)

Hornitos	15:30	10-31-89	NTS (Area 20)	LL	Shaft	-1850	WR	20-150 Kt (5.6 Mb)
Muleshoe	20:20	11-15-89	NTS	?	Shaft	?	WR	<20 Kt
Barnwell	15:00	12-08-89	NTS (Area 20)	LL	Shaft	-2000	22st UK	20-150 Kt (5.7 Mb)
Whitefawn	22:00	12-20-89	NTS	LL	Shaft	-550	WR	<20 Kt

1990 [1]

Metropolis	16:00	03-10-90	NTS	?	Shaft	-1500	WR	20-150 Kt (5.1 Mb)
# Bowie [No. 204]	17:00	04-06-90	NTS	LA	Shaft	-699	WR	<20 Kt (3.1 Mb)
Bullion	16:00	06-13-90	NTS (Area 20)	LL	Shaft	-2000	WR	20-150 Kt (5.8 Mb)
Austin	18:15	06-21-90	NTS	LA	Shaft	?	WR	<20 Kt (4.5 Mb)
Mineral Quarry	15:00	07-25-90	NTS	DOD/LA	Tunnel	?	WE	<20 Kt (4.8 Mb)

In support of the Small ICBM program. Other experiments include seeker components for materials from the Army Ballistic Missile office, decoys and advanced re-entry body components from the Air Force Ballistic Missile Office and tunnel hardening experiments from DNA. Cost $74.6 million.

Sundown	17:15	09-20-90	NTS	LA	Shaft	?	WR	<20 Kt
Ledoux	18:02	09-27-90	NTS	?	Shaft	?	WR	<20 Kt

OPERATION *SCULPIN* (Fiscal Year 1991, 8 tests, all announced)

Tenabo	17:30	10-12-90	NTS (Area 20)	LL	Shaft	?	WR	20-150 Kt (5.6 Mb)
Houston	19:17:7	11-14-90	NTS	LA	Shaft	?	23d UK	20-150 Kt (5.7 Mb)

1991 [0]

Coso	21:02:45	03-08-91	NTS	LL	Shaft	-1100	WR	<20 Kt (4.4 Mb)
Bexar	19:00	04-04-91	NTS (Area 19)	LA	Shaft	-2000	WR	20-150 Kt (5.6 Mb)
Montello	15:30	04-16-91	NTS (Area 20)	LL	Shaft	?	WR	20-150 Kt (5.4 Mb)
Floydada	16:00	08-15-91	NTS	LA	Shaft	-1600	WR	<20 Kt (4.2 Mb)
Hoya	19:00	09-14-91	NTS	?	Shaft	-2200	WR	20-150 Kt (5.5 Mb)
Treaty verification test								
Distant Zenith	16:30	09-19-91	NTS	DOD/LA	Tunnel	?	WE	<20 Kt (4.0 Mb)
Cost $70.6 million.								

OPERATION *JULIN* (Fiscal Year 1992, 8 tests, all announced)

Lubbock	19:12	10-18-91	NTS	LA	Shaft	-1500	WR	20-150 Kt (5.2 Mb)
Bristol	18:35:04	11-26-91	NTS	?	Shaft	?	24d UK	<20 Kt (4.7 Mb)

1992 [0]

Junction	16:30	03-26-92	NTS	LA	Shaft	-2100	WR	20-150 Kt (5.6 Mb)
Diamond Fortune	17:30	04-30-92	NTS	DOD/LA	Tunnel	?	WE	<20 Kt
A test conducted in a cavity to assess the energy coupling and cratering effects of a shallow earth penetrating weapon. Helps develop prediction codes to assess the vulnerability of strategic structures to nuclear attack. Cost $27 million.								
Victoria	16:45	06-19-92	NTS	LA	Shaft	-880	WR	<20 Kt (3.0 Mb)
Yield less than 0.1 Kt								
Galena	14:59:59.6	06-23-92	NTS (Area 7)	LL	Shaft	-950	WR	<20 Kt
Hunters Trophy	17:00:00.0	09-18-92	NTS	DNA/LL	Tunnel	-1264	WE	<20 Kt (4.4 Mb)
A horizontal line of sight test in support of SDIO advanced development experiments associated with the Army's ERIS and HEDI ballistic missile defense programs, SDIO survivability experiments (space components), and decoys and advanced re-entry body components from the Air Force Ballistic Missile Office. Cost $85.9 million.								
Divider	15:04:00.0	09-23-92	NTS (Area 3)	LA	Shaft	-1150	WR	<20 Kt (4.4 Mb)

Sources for Table 1:

DOE, *Announced United States Nuclear Tests, July 1945 through December 1992*, NVO-209 (Rev. 13), Nevada Operations Office, January 1993; DOE, Openness Press Conference Fact Sheets, 7 December 1993; U.S. Department of Energy Nevada Operations Office, "Data on 204 Underground Tests at DOE's Nevada Test Site" (declassified in December 1993); "Nuclear Explosions 1945-November 29, 1985;" Swedish National Defense Research Institute, computer printout; U.S. Department of Interior/Geological Survey, "Preliminary Determination of Epicenters," monthly; Riley Geary, Seismological Laboratory 252-21, California Institute of Technology, printout; Ola Dahlman and Hans Israelson, *Monitoring Underground Nuclear Explosions* (Amsterdam: Elsevier Scientific Publishing Company, 1977), pp. 383-399; Stockholm International Peace Research Institute, Yearbooks 1968-69 through 1993; Bruce A. Bolt, *Nuclear Explosions and Earthquakes* (San Francisco: W.H. Freeman and Company, 1976); Defense Nuclear Agency volumes supporting Nuclear Test Personnel Review program: Project Trinity 1945-1946 (DNA 6028F); Operation Crossroads 1946 (DNA 6032F); Operation Sandstone 1948 (DNA 6033F); Operation Ranger 1951 (DNA 6022F); Operation Greenhouse 1951 (DNA 6034F); Operation Buster-Jangle 1951 (DNA 6023F); Shots Able to Easy (DNA 6024F); Shots Sugar and Uncle (DNA 6025F); Operation Tumbler-Snapper 1952 (DNA 6019F); Shots Able, Baker, Charlie, and Dog (DNA 6020); Shots Easy, Fox, George, and How (DNA 6021F); Operation Ivy 1952 (DNA 6036F); Operation Upshot-Knothole 1953 (DNA 6041F); Shots Annie to Ray (DNA 6017F); Shot Badger (DNA 6015F); Shot Simon (DNA 6016F); Shots Encore to Climax (DNA 6018F); Operation Castle 1954 (DNA 6035F); Operation Teapot 1955 (DNA 6009F); Shots Wasp to Hornet (DNA 6010F); Shot Bee (DNA 6011F); Shots Ess through Met and Shot Zucchini (DNA 6013F); Shot Apple 2 (DNA 6012F); Operation Wigwam (DNA 6000F); Operation Redwing 1956 (DNA 6037F); Plumbob Series 1957 (DNA 6005F); Shots Boltzmann to Wilson (DNA 6008F); Shot Priscilla (DNA 6003F); Shot Hood (DNA 6002F); Shots Diablo to Franklin Prime (DNA 6006F); Shot Smoky (DNA 6004F); Shot Galileo (DNA 6001F); Shots Wheeler to Morgan (DNA 6007F); Operation Hardtack I 1958 (DNA 6038F); Operation Hardtack II 1958 (DNA 6026F); Operation Dominic I 1962 (DNA 6040F); Operation Dominic II (DNA 6027F); Safety Experiments November 1955-March 1958 (DNA 6030F); Projects Gnome and Sedan (DNA 6029F); Operations Nougat and Whetstone (DNA 6320F); Operations Flintlock and Latchkey (DNA 6321F); Operation Castle, Report of the Manager, Santa Fe Operations, Pacific Proving Ground Spring of 1954, Contract No. DNA 001-79-C-0455; DNA, *Compilation of Local Fallout Data from Test Detonations 1945-1962 Extracted from DASA 1251*, Volume I - Continental U.S. Tests, Volume II - Oceanic U.S. Tests, Contract No. DNA 001-79-C-0081, 1 May 1979; Defense Atomic Support Agency, *Nuclear Test Summary Trinity-Hardtack*, DASA 1220, 15 August 1962; Defense Atomic Support Agency, *Nuclear Test Summary Nougart-Dominic*, DASA-1211, 15 August 1963; DOD-DOE, *The Effects of Nuclear Weapons*, compiled and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, 1977; *History of the Air Force Atomic Energy Program, 1943-1953* (Washington, DC: U.S. Air Force Historical Division) Volumes I-V; Chuck Hansen, *U.S. Nuclear Weapons: The Secret History* (Arlington, Texas: Aerofax, Inc., 1988); Chuck Hansen, "U.S. Nuclear Weapons Tests, 1945-1962," Appendix 1, Revision N, 1 February 1993.

Notes for Table 1:

a. The symbol "#" before the name of a event denotes an unannounced test. 111 of these secret tests were known to have occurred through detection of a seismic signature, or by other means. The original research was conducted by Riley R. Geary (see Sources). The symbol "*" before the name of ninety three events denotes an unannounced test that remained secret until DOE's release on 7 December 1993.

b. Greenwich Mean Time unless otherwise noted.

c. Height of Burst/Depth of Burial

d. Purpose abbreviated:
- WR = Weapons Related
- WE = Weapons Effects
- SE = Safety Experiment
- ST = Storage-Transport
- VU = Vela Uniform
- SC = Stockpile Confidence
- UK = Joint US/UK Test
- PS = Plowshare

e. The nomenclature for test yields varied according to information policy governing specific years. In some cases, no yield information has been released; in a few cases, the terms "very slight" and "slight" were used without amplification. Except for tests where specific yields or relative specific yields such as "about 2 Kt," "several Mt," "less than 0.1 Kt," etcetera, were announced, test yields are given in these terms:

1945 through 1963:
- Low (less than 20 Kt)
- Intermediate (20 to 200 Kt) – all tests except Operation *Dominic I*
- Intermediate (20 to 1000 Kt) – Operation *Dominic I*
- Submegaton (less than one Mt, but more than 200 Kt)
- Megaton Range (range of yield unknown)
- Low Megaton (from one to several Mt)

1964 through February 1976:
- Less than 20 Kt
- 20 to 200 Kt
- 200 to 1000 Kt

March 1976: During a series of high-yield tests conducted during this month, two ranges were added to the above, and the 200 to 1000 Kt range was dropped.
- 200 to 500 Kt
- 500 to 1000 Kt

Since March 1976: On 31 March 1976 the Soviet Union and the United States agreed to limit the maximum yield of underground tests to 150 Kt. The yield ranges now reported are:
- Less than 20 Kt
- Less than 150 Kt
- 20 to 150 Kt

Most of the figures in parentheses are from Dahlman and Israelson, *Monitoring Underground Nuclear Explosions* and may carry a high degree of uncertainty.

Table 2
U.S. NUCLEAR TESTS BY TYPE
(to 31 December 1992)

TESTS		
Underground	Shaft[a]	760[b]
	Tunnel[c]	67
	Crater[d]	9
	Subtotal	836
Atmospheric	Tower[e]	56
	Airdrop[f]	52
	Barge[g]	36
	Surface[h]	28
	Balloon[i]	25
	Rocket[j]	12
	Artillery[k]	1
	Subtotal	210
Underwater[l]		5
	TOTAL	1051

Notes for Table 2:

a. A nuclear device exploded at the bottom of a drilled or mined vertical hole.

b. Includes twenty-four joint US/UK tests.

c. A nuclear device exploded at the end of a long horizontal drift mined into a mountain or mesa.

d. A nuclear device placed shallow enough underground to produce a throw-out of earth when exploded. NVO categorizes four weapons effects tests (11-29-51, 3-23-55, 3-5-62, 7-11-62) and five Plowshares tests (7-6-62, 4-14-65, 1-26-68, 3-12-68, 12-8-68) as crater tests which are included as underground tests.

e. A nuclear device mounted at the top of a steel or wooden tower and exploded in the atmosphere. Towers ranged in height from 100 feet to 700 feet.

f. A nuclear device dropped from an aircraft. Five types of aircraft have been used: B-29 (1), B-50 (13), B-45 (2), B-36 (6) and B-52 (30).

g. A nuclear device exploded from a barge moored in the lagoon at Enewetak or Bikini. This technique, first used in 1954, was to compensate for the lack of land at the Pacific Proving Ground.

h. A nuclear device placed on or close to the Earth's surface.

i. A nuclear device suspended from a balloon and exploded in the atmosphere. Only conducted in 1957 and 1958. The height of burst for fixed balloon shots was between about 400 feet and 1500 feet. In one test a device carried by an unthethered balloon detonated at 86,000 feet.

j. A nuclear device launched by rocket and exploded in the atmosphere. Seven types were used: Thor (3), X-17a (3), Redstone (1), Polaris (1), Strypi (1), Nike Hercules (1), Genie (1).

k. This category is identified by DOE as "airburst," referring to an explosion of a nuclear weapon at such a height that the expanding fireball does not touch the Earth's surface prior to the time the fireball reaches its maximum luminosity. The only airburst event reported by DOE, however, is Event Grable (25 May 1953), an atomic artillery shell fired from a 280mm cannon.

l. The five underwater tests (and depths) were: 24 July 1946 (-90 feet), 14 May 1955 (-2000 feet), 16 May 1958 (-500 feet), 8 June 1958 (-150 feet), 11 May 1962 (-550 feet).

Table 3

U.S. NUCLEAR TESTS BY LOCATION
(to 31 December 1992)

Pacific[a]	4	
Johnston Island Area[b]	12	
Enewetak[c]	43	
Bikini[d]	23	
Christmas Island Area[e]	24	
	106	Total Pacific
Nevada Test Site (underground)	825	
Nevada Test Site (atmospheric)[f]	100	
	925	Total Nevada Test Site
Alamagordo, New Mexico	1	(16 July 1945) Trinity
Carlsbad, New Mexico	1	(10 December 1961) 1st Plowshare
Hattiesburg, Mississippi	2	(22 October 1964, 3 December 1966) 2nd, 4th VU
Grand Valley, Colorado	1	(10 September 1969) 24th Plowshare
Rifle, Colorado	1	(17 May 1973) 27th Plowshare
Farmington, New Mexico	1	(10 December 1967) 19th Plowshare
Central Nevada (Hot Creek Valley)	1	(19 January 1968)
Fallon, Nevada	1	(26 October 1963) 1st VU
Bombing Range, Nevada	5	(24 April 1957, 15, 25, 31 May 1963, 9 June 1963)
Amchitka, Alaska	3	(29 October 1965, 2 October 1969, 6 November 1971)
	17	Total Other
South Atlantic	3	(27 August 1958, 30 August 1958, 6 September 1958)
	1051	GRAND TOTAL

Notes for Table 3:

a. The four tests were: Wigwam (14 May 1955), Yucca (28 April 1958), Frigate Bird (6 May 1962), and Swordfish (11 May 1962).

b. Johnston Island, a possession of the United States since the acquisition of Hawaii in the nineteenth century, is about 780 nautical miles west-southwest of Hawaii. Two tests were held in 1958 and 10 in 1962.

c. Enewetak Atoll, part of the Marshall Islands, is approximately 2380 nautical miles southwest of Honolulu. The major part of the atoll is a small ring of 40 named islands at 11.35 North 162.35 East. The atoll is approximately 23 miles by 17 miles enclosing a lagoon of 388 square miles. Its depth averages 160 feet with a maximum of approximately 200 feet. The total land area of the atoll is 2.75 square miles (1761 acres) with three islands, Enewetak, Enjebi and Medren, comprising almost half the area. Of the 43 tests held at Enewetak Atoll, 25 were held on eight of the islands (10 at Runit) with the other 18 held in the waters or reef nearby. The 43 tests were held between 14 April 1948 and 18 August 1958.

d. Bikini is 189 nautical miles east of Enewetak. Its islands consist of about 2.7 square miles of surface area and encircles a lagoon that is 25 miles long and 15 miles wide, with a maximum depth of about 200 feet. The twenty-three tests were held in four years, 1946, 1954, 1956 and 1958. Bikini was selected as the site of Operation *Crossroads* on 21 December 1945. Bikini was discovered in 1825 by Lieutenant Otto von Kotzebue of the Russian Navy.

e. Christmas Island is an atoll lying 2 degrees north of the equator, approximately 1200 nautical miles south and slightly east of Hawaii. While a British possession, it was used to test UK nuclear devices during Operation *Grapple* X, Y, and Z from May 1957 to September 1958. Twenty four U.S. tests were held there from 25 April 1962 to 11 July 1962. In 1979, Christmas Island ceased to be part of the British Crown Colony of the Gilbert and Ellice Islands and became part of the Republic of Kiribati, whose capital is Tarawa and which comprises the Gilbert Islands, the Phoenix Islands (round Canton) and the Line islands (Christmas, Fanning, Palmyra, Jarvis, Washington, Starbuck and Malden). The former Christmas Island is now called Kiritimati and has a permanent population of 1200, mainly of Gilbertese origin.

f. One hundred atmospheric tests were held at the Nevada Test Site from 27 January 1951 to 17 July 1962.

Table 4

U.S. NUCLEAR TESTS BY PURPOSE
(to 31 December 1992)

Weapons Related[a]	857	
Weapons Effects	98	
Safety Experiment[b]	34	
Plowshare[c]	27	
Vela Uniform[d]	7	
Storage-Transportation[e]	4	
Joint US/UK	24	
	1051	TOTAL

a. The twenty-four joint US/UK tests between 1 March 1962 and 31 December 1992 are also weapon related.

b. An experiment designed to confirm a nuclear explosion will not occur in case of an accidental detonation of the explosive associated with the device.

c. Application of nuclear explosives to develop peaceful uses for atomic energy between 10 December 1961 and 17 May 1973.

d. Vela tests are nuclear explosions designed to provide information so as to improve the capability of detecting, identifying, and locating underground nuclear explosions. The seven were conducted on 10/26/63, 10/22/64, 10/29/65, 12/3/66, 4/23/68, 5/12/70, 7/1/71.

e. Detonation of combinations of high explosives and nuclear materials designed to study distribution of nuclear materials during accidents in several transportation and storage configurations. The four were conducted on 5/15/63, 5/25/63, 5/31/63, 6/9/63 at the Bombing Range, Nevada.

Table 5
U.S. NUCLEAR TESTS BY YEAR WITH ESTIMATED YIELDS

Year	Number	Cumulative Total Yield (Kt)[a]		Cumulative Yield (Kt)	UK[b]	Unannounced[c]
1945	1	1	23	23	0	0
1946	2	3	42	65	0	0
1947	0	3	0	65	0	0
1948	3	6	104	169	0	0
1949	0	6	0	169	0	0
1950	0	6	0	169	0	0
1951	16	22	510	679	0	0
1952	10	32	11,004	11,683	0	0
1953	11	43	252	11,935	0	0
1954	6	49	48,200	60,135	0	0
1955	18	67	197	60,332	0	0
1956	18	85	20,820	81,152	0	0
1957	32	117	346	81,498	0	0
1958	77	194	35,628	117,126	0	0
1959	0	194	0	117,126	0	0
1960	0	194	0	117,126	0	0
1961	10	204	56	117,182	0	0
1962	98	302	24,102	141,284	2	0
1963[d]	47	349	639	141,923	0	4
1964	47	396	1113	143,036	2	17
1965	39	435	636	143,672	1	10
1966	48	483	2,231	145,903	0	7
1967	42	525	1,323	147,226	0	14
1968	55	580	4,832	152,058	0	22
1969	46	626	2,944	155,002	0	17
1970	38	664	3,100	158,102	0	8
1971	24	688	4,854	162,956	0	12
1972	26	714	352	163,308	0	18
1973	24	738	1082	164,390	0	15
1974	23	761	804	165,194	1	15
1975	22	783	4,048	169,242	0	6
1976	21	804	4,514	173,756	1	5
1977	20	824	472	174,228	0	8
1978	21	845	560	174,788	2	7
1979	16	861	492	175,280	1	1
1980	17	878	410	175,690	3	0
1981	17	895	366	176,056	1	0
1982	19	914	568	176,624	1	0
1983	19	933	286	176,910	1	4
1984	20	953	534	177,444	2	6
1985	18	971	492	177,936	1	2
1986	15	986	375	178,311	1	2
1987	15	1001	354	178,665	1	0
1988	15	1016	322	178,987	0	3
1989	12	1028	336	179,323	1	0
1990	9	1037	230	179,553	1	1
1991	8	1045	224	179,777	1	0
1992	6	1051	80	179,857	0	0

Notes to Table 5:

a. The nomenclature for test yields varied according to information policy governing specific years. In some cases the exact yield or a yield range was given. In the latter case three formats have been used (see below). The yields following the equal (=) signs are the authors estimates of the average yield in each range, which were used to compute the total annual and cumulative yields.

1945 through 1963:
- Low (less than 20 Kt) = 6 Kt
- Intermediate (20 to 200 Kt) - all tests = 50 Kt except Operation Dominic I
- Intermediate (20 to 1000 Kt) = 200 Kt, used for Operation Dominic I only
- Submegaton (less than one Mt, but more than 200 Kt) = 300 Kt
- Megaton Range = 5.0 Mt
- Low Megaton (from one to several Mt) = 1.4 Mt

1964 through February 1976:
- Less than 20 Kt = 6 Kt
- 20 to 200 Kt = 50 Kt
- 200 to 1000 Kt = 300 Kt

During a series of high-yield tests conducted during March 1976, two ranges were added, and the 200 to 1000 Kt range was dropped.
- 200 to 500 Kt = 300 Kt
- 500 to 1000 Kt = 750 Kt

Since March 1976:

On 31 March 1976, the Soviet Union and the United States agreed to limit the maximum yield of underground tests to 150 Kt. The yield ranges now reported are:
- Less than 20 Kt = 6 Kt
- 20 to 150 Kt = 50 Kt
- Less than 150 Kt = 20 Kt

b. Includes twenty-four joint U.S./UK tests.

c. The 204 unannounced tests are included in the number column.

d. Number pre-treaty 333; post-treaty 718.

By decade:

1940s	6
1950s	188
1960s	432
1970s	235
1980s	167
1990s	23
TOTAL	1051

Figure 1
The Central Pacific showing Bikini, Enewetak and Christmas Island

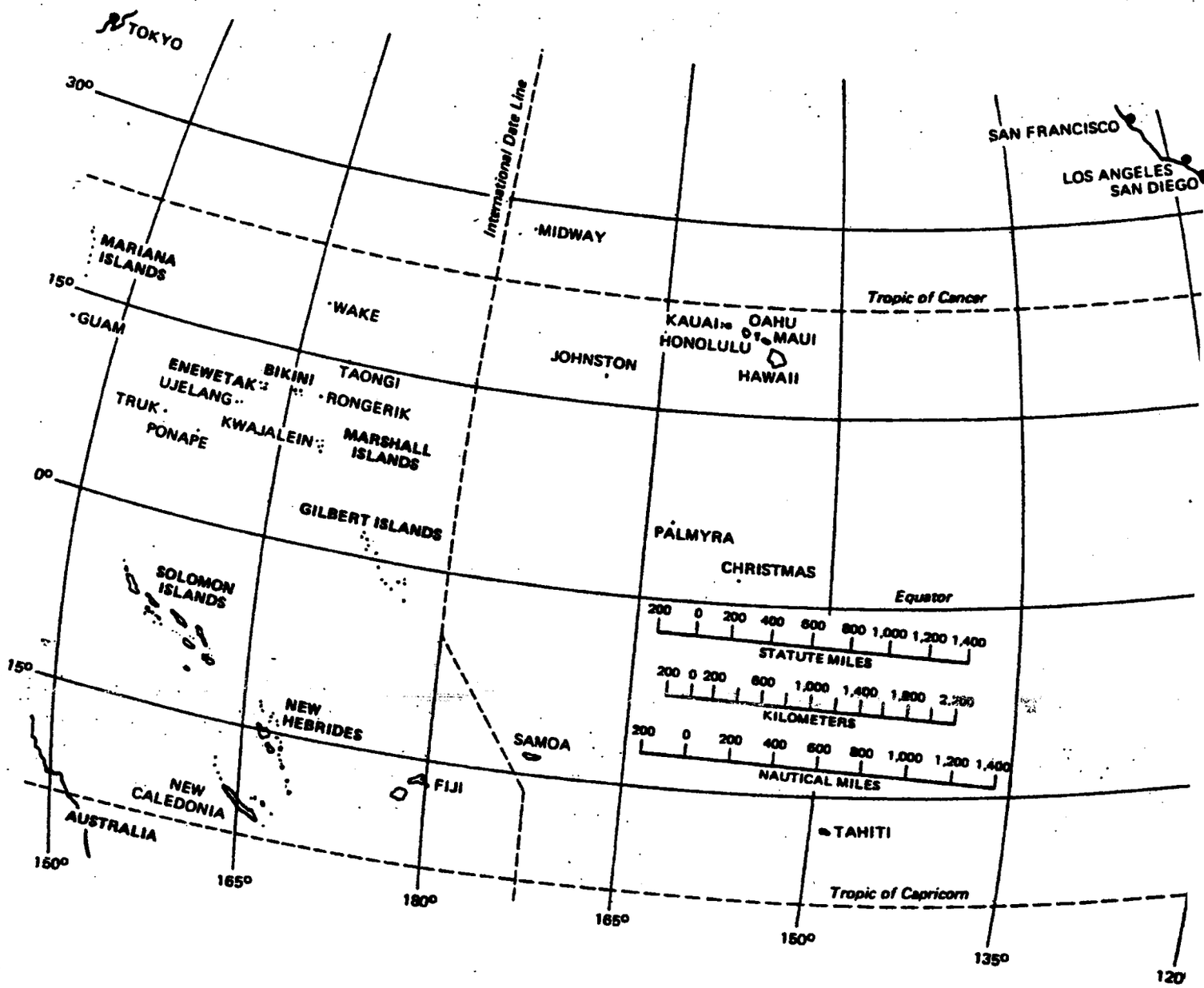


Figure 2
Bikini Atoll, 1958, showing pre-Hardtack Detonation Sites

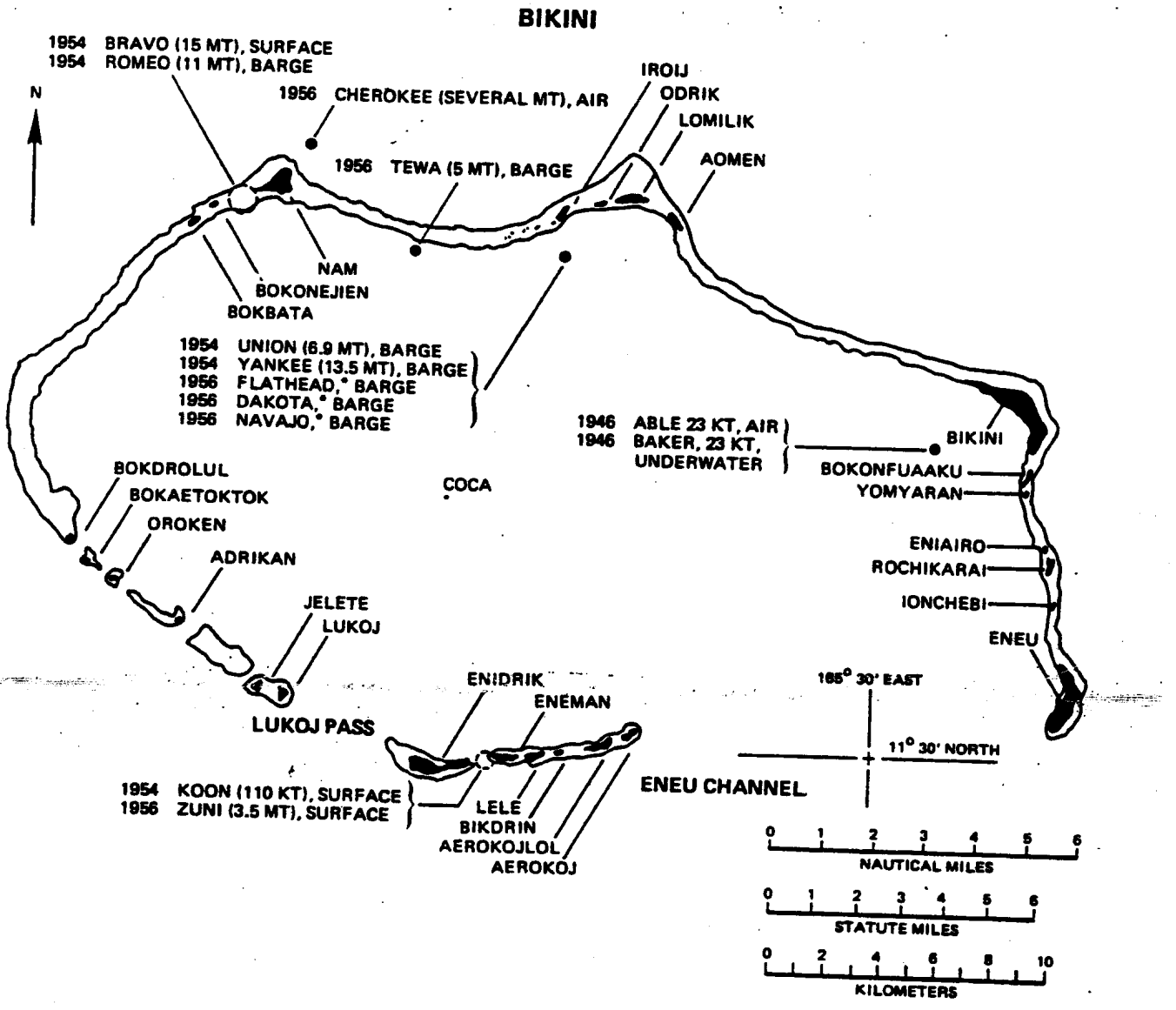
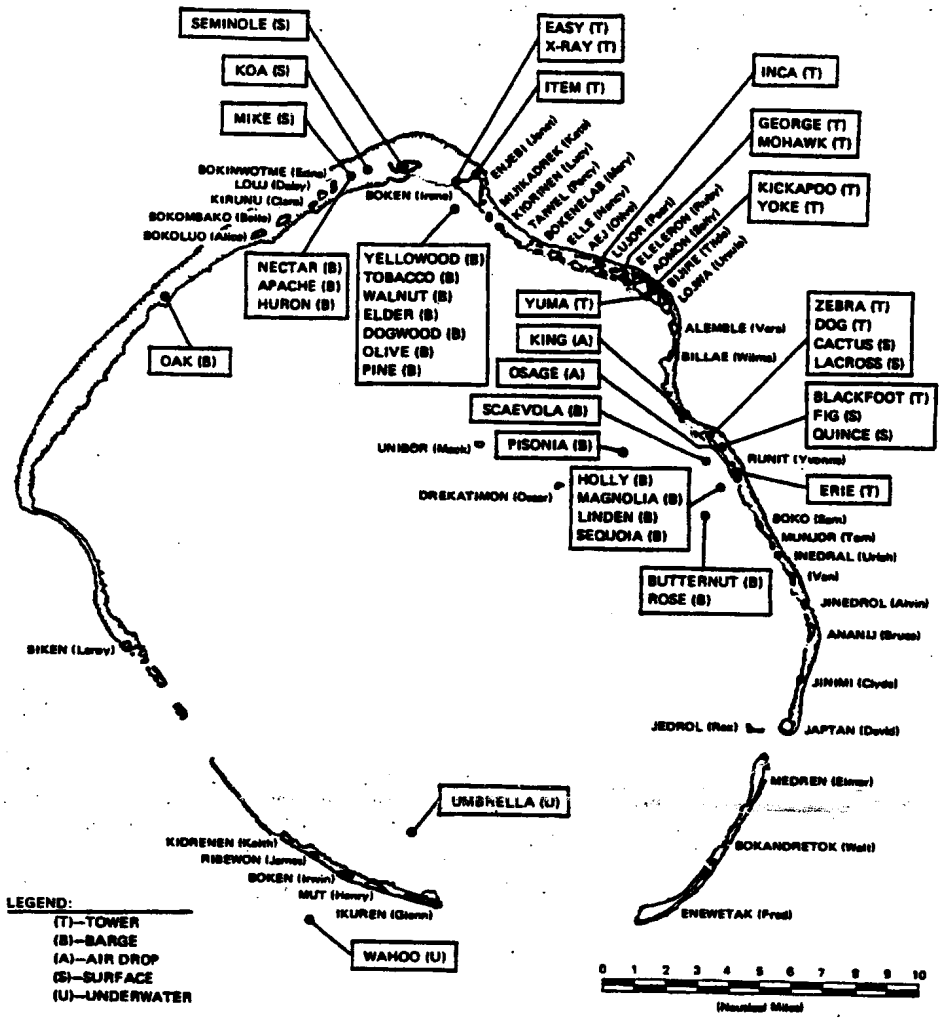
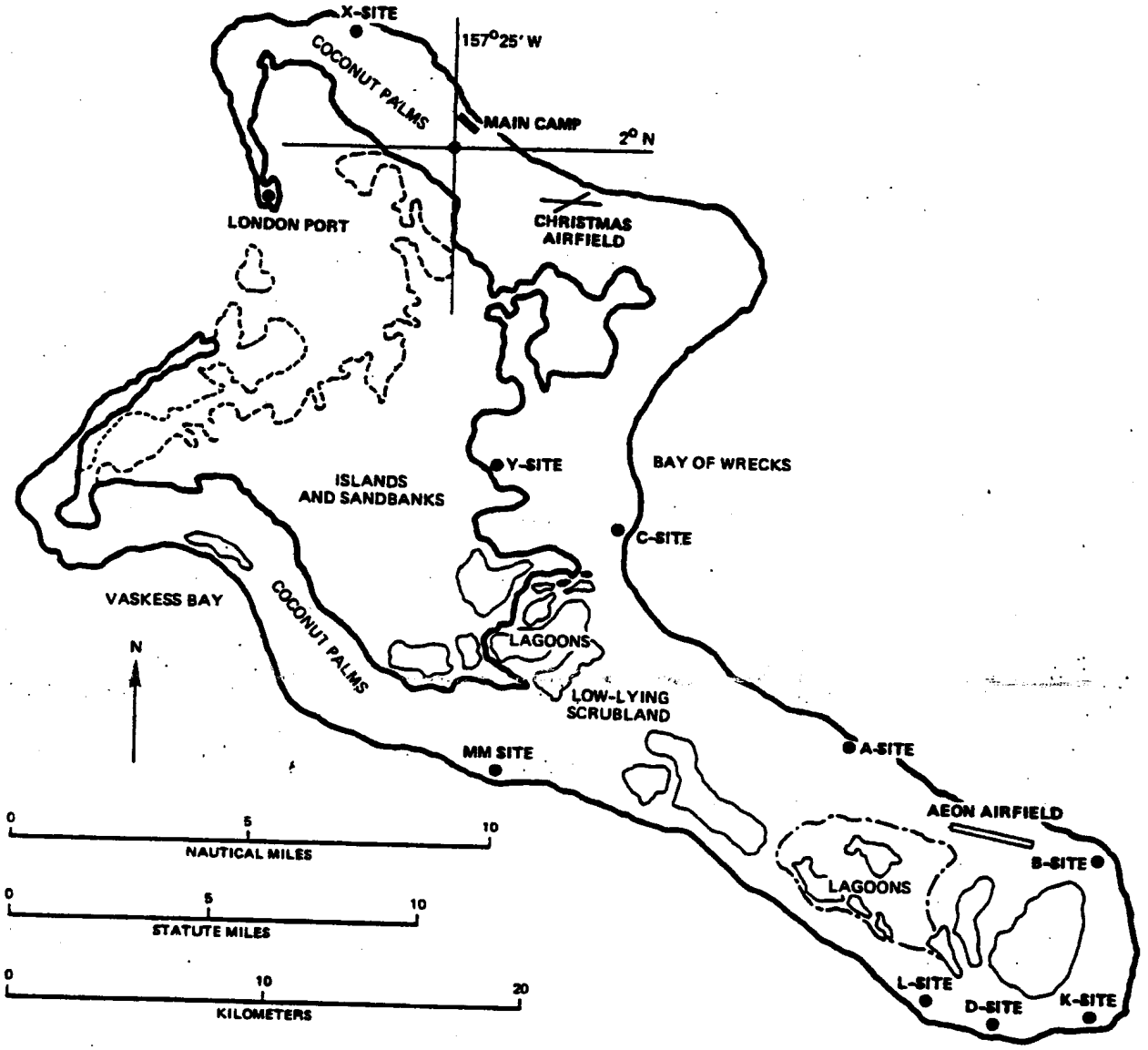


Figure 3
Nuclear Detonation Sites on Enewetak Atoll



NUCLEAR DETONATION SITES ON ENEWETAK ATOLL.

Figure 4
Christmas Island



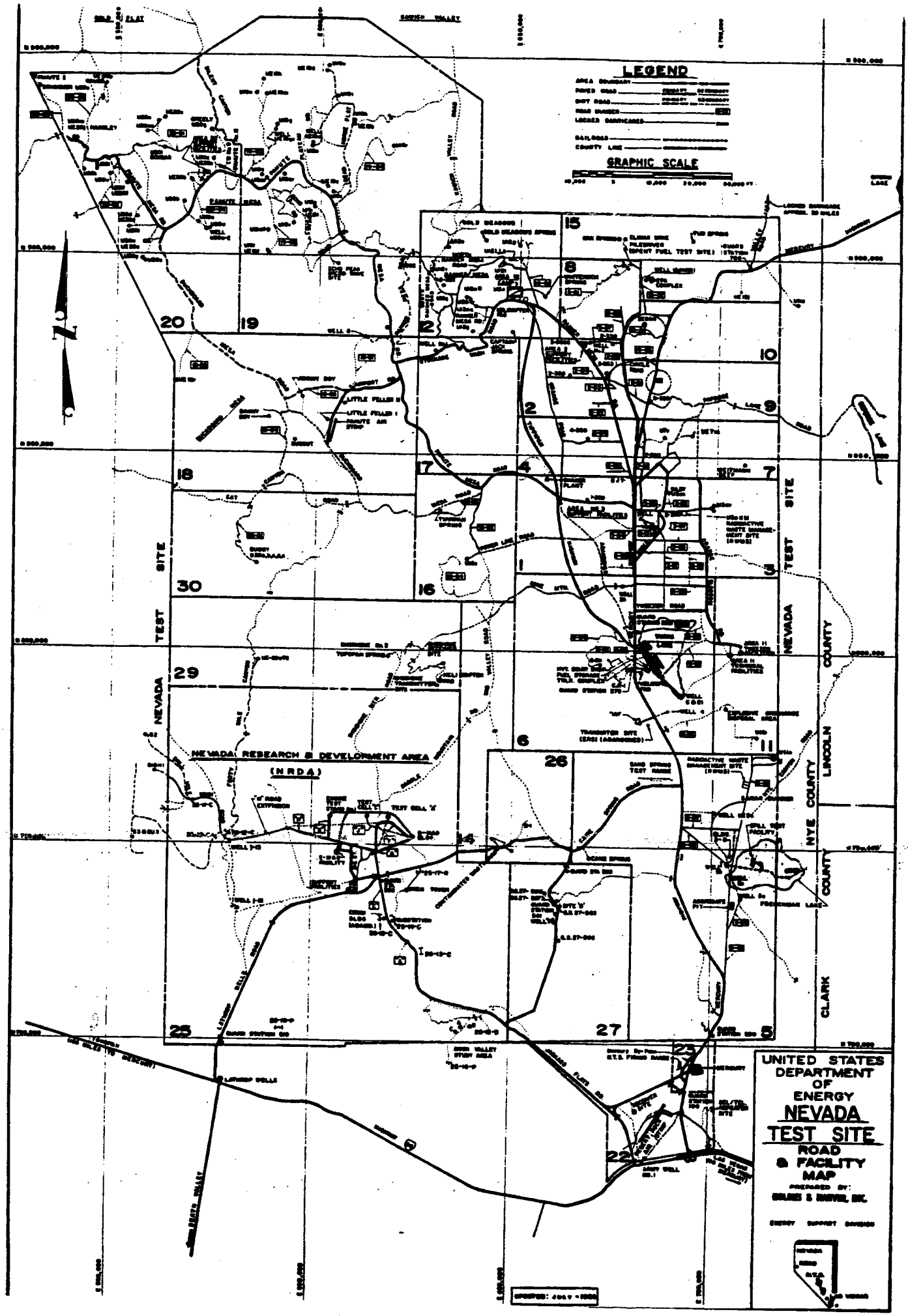


Figure 5 Nevada Test Site

Figure 6
Nevada Test Site with Shaded Areas Indicating Principal Areas Used for Underground Testing

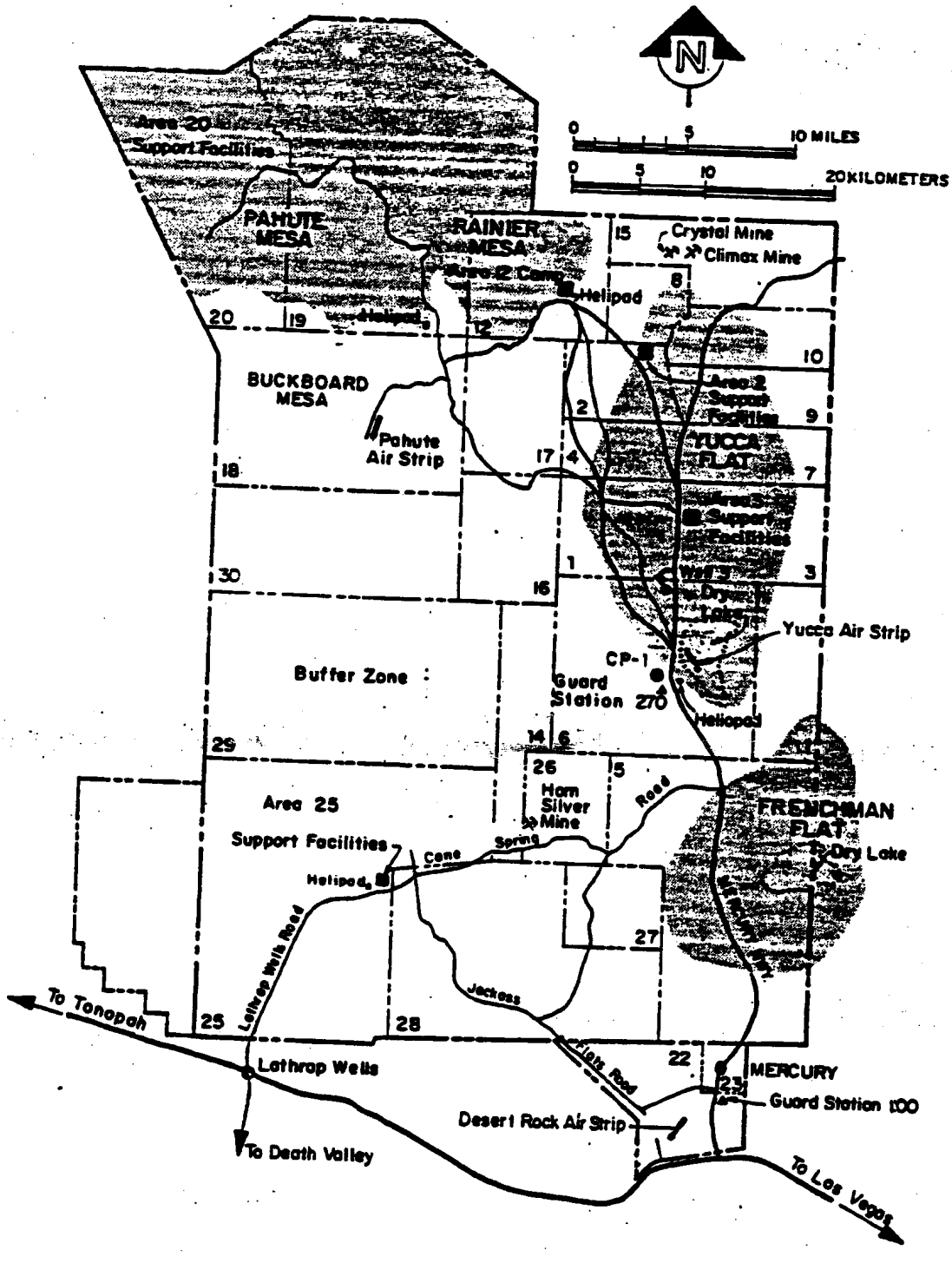
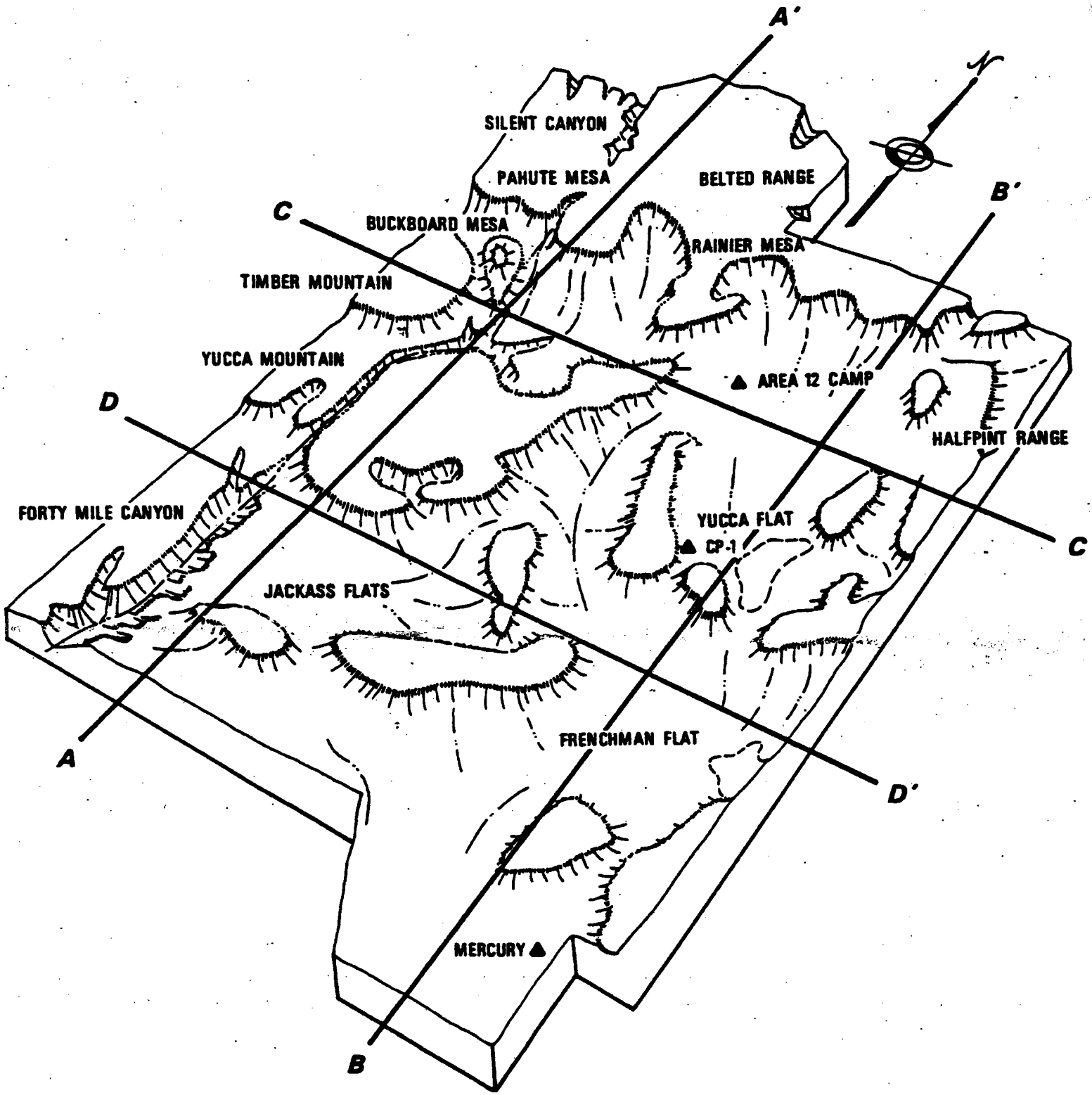


Figure 7
Nevada Test Site Topography



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The NRDC Nuclear Weapons Data Center

Since 1980 the Natural Resources Defense Council has sponsored the **Nuclear Weapons Data Center.** The purpose of the Center is to compile and disseminate accurate information on the world's nuclear forces in order to promote a more informed debate on nuclear weapons and arms control issues. The Center has published five volumes of its *Databook* series describing the U.S. and Soviet nuclear arsenals, and the U.S. nuclear weapons production complex. Currently in press is Volume V, entitled, *British, French and Chinese Nuclear Weapons* (Westview). Since May 1987, the Center staff has contributed a monthly column to *The Bulletin of the Atomic Scientists,* entitled Nuclear Notebook.

The Center also publishes other occasional materials, including Working Papers. The Working Paper series is intended to present preliminary research findings for comment and review for eventual publication in forthcoming *Databook* volumes.

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