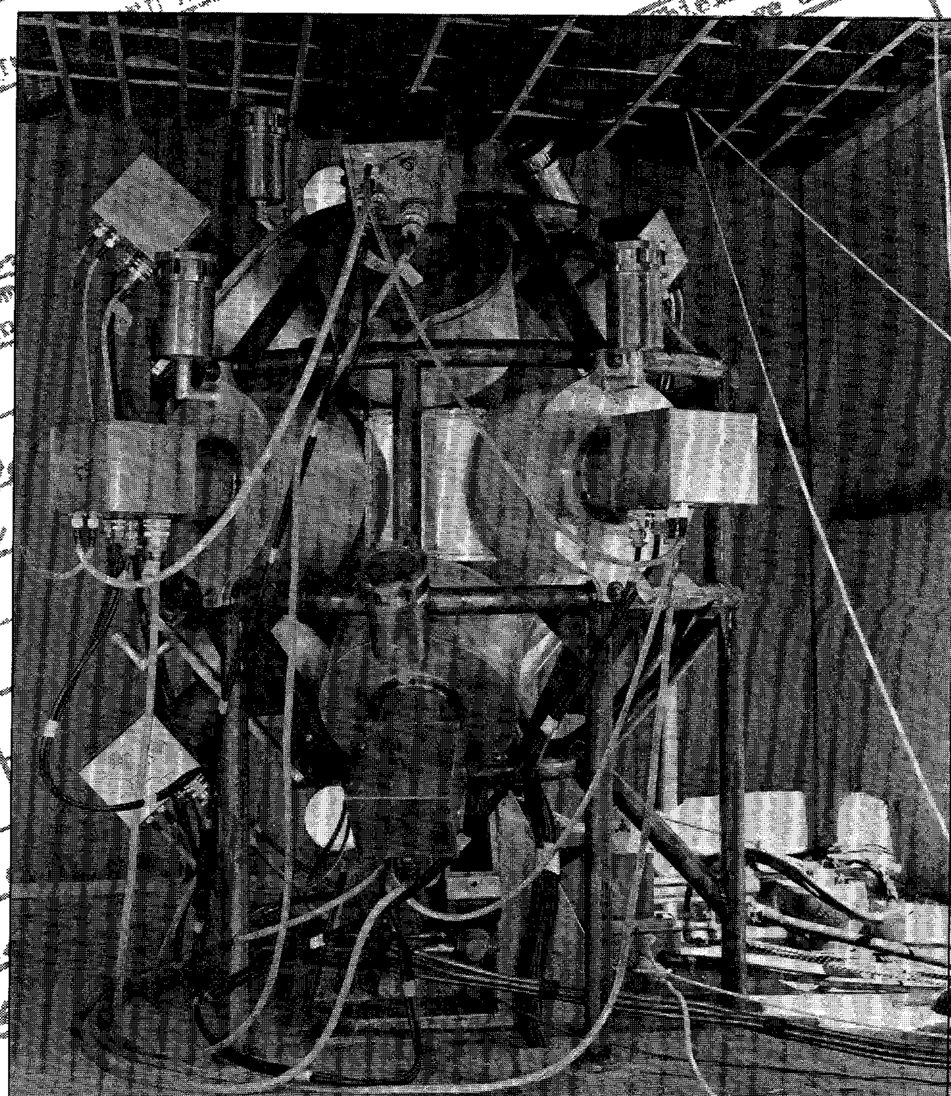
LA-13044-H
History

The Bayo Canyon/Radioactive Lanthanum (RaLa) Program

Los Alamos National Laboratory



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Los Alamos National Laboratory

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Supported by the Human Studies Project Team

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Los Alamos, New Mexico 87545

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ABSTRACT

The Bayo Canyon/Radioactive Lanthanum (RaLa) Program
by
J. E. Dummer, J. C. Taschner, and C. C. Courtright

Los Alamos National Laboratory (formerly Los Alamos Laboratory and Los Alamos Scientific Laboratory) conducted 254 radioactive lanthanum (RaLa) implosion experiments from September 1944 through March 1962. The purpose of these experiments was to test implosion designs for nuclear weapons. Conventional high explosives surrounding common metals (used as surrogates for plutonium) and a radioactive source, as small as one-eighth inch in diameter and containing up to several thousand curies of radioactive lanthanum, were involved in each experiment detonated. The resulting cloud containing radioactive lanthanum and other vaporized materials moved with the prevailing winds and was deposited on the ground (fallout), often to distances of several miles.

This report was prepared by members of the Los Alamos National Laboratory Human Studies Project Team to summarize the existing records as an aid in evaluating the off-site impact, if any, of the entire 18-year program. The report provides a historical setting for the program, which was conducted in its entirety in Technical Area 10 (TA-10), Bayo Canyon, about three miles east of Los Alamos. A description of the site is followed by a discussion of a series of collateral experiments conducted in 1950 by the US Air Force and aimed at developing an airborne detector for tracking atmospheric nuclear weapons tests. All known off-site measurements from the RaLa program are discussed, and the relevant data found are summarized in tabular and narrative form. Besides the radiolanthanum, other potential trace radioactive material that may have been present in the fallout is discussed, and the amounts are estimated. Off-site safety considerations are discussed at length, beginning with the earliest test in 1944. A preliminary off-site dose assessment is made using current methods. Brief biographical data on 33 persons important to the program are presented as footnotes.

Overview

Introduction

Los Alamos National Laboratory (formerly Los Alamos Laboratory and Los Alamos Scientific Laboratory) conducted 254 radioactive lanthanum (RaLa) implosion experiments from September 1944 through March 1962 in Technical Area 10 (TA-10) in Bayo Canyon. The purpose of these experiments was to test implosion designs for nuclear weapons. Conventional high explosives surrounding common metals (used as surrogates for plutonium) and a radioactive source, as small as one-eighth inch in diameter and containing up to several thousand curies of radioactive lanthanum, were involved in each experiment detonated. The resulting cloud containing radioactive lanthanum and other vaporized materials moved with the prevailing winds and was deposited on the ground (fallout), often to distances of several miles.

The purpose of this report is to document the results of an extensive search of records, primarily at Los Alamos, and to provide data suitable for evaluating the impact of these experiments, if any, on populations in the vicinity of Los Alamos. A preliminary assessment is included.

Description of the Site

Technical Area 10 in Bayo Canyon, which covers approximately 100 acres, is located about 3 miles east of the center of the Los Alamos town site in north-central New Mexico, about 11 miles southwest of Española, and 25 miles northwest of Santa Fe by air (see Fig. 1, a map of the area around the Bayo Canyon firing site). Bayo Canyon, one of many canyons cut into the Pajarito Plateau, is situated in the second canyon north of Los Alamos Mesa. The canyon trends generally in an east-west direction and is bound on the south by Kwage Mesa and on the north by Otowi Mesa (see Fig. 2, TA-10 in Bayo Canyon, and Fig. 3, an aerial photograph of Bayo Canyon looking west-northwest). The mean elevation for both mesas is about 7,100 feet. The floor of Bayo Canyon is about 6,700 feet. Access to the site is from New Mexico State Road 502 (formerly State Road 4) onto a dirt road that leads west into Pueblo Canyon and then into Bayo Canyon.

When Bayo Canyon was selected for the implosion experiments in May 1944 (Ref. 1), it was considered a good location, far from any residential areas yet relatively near the rest of the Laboratory. In addition to the Los Alamos town site and White Rock, the nearest continuously populated area was San Ildefonso Pueblo, located about 8 miles east by air.

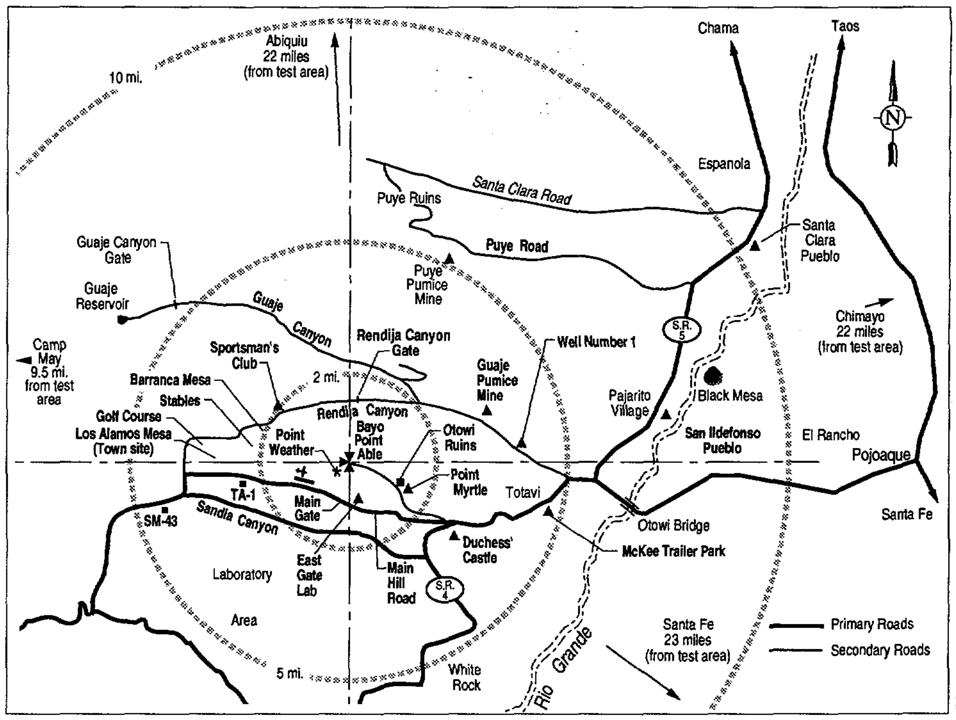

Fig. 1. Map of region of interest centered on Bayo Canyon firing site. (An enlarged map also appears in Appendix A-2 on page A-2.12.)

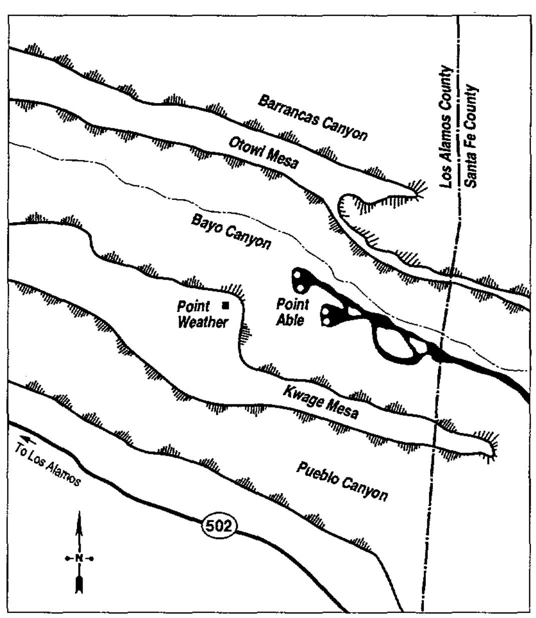

Fig. 2. TA-10, Bayo Canyon site.

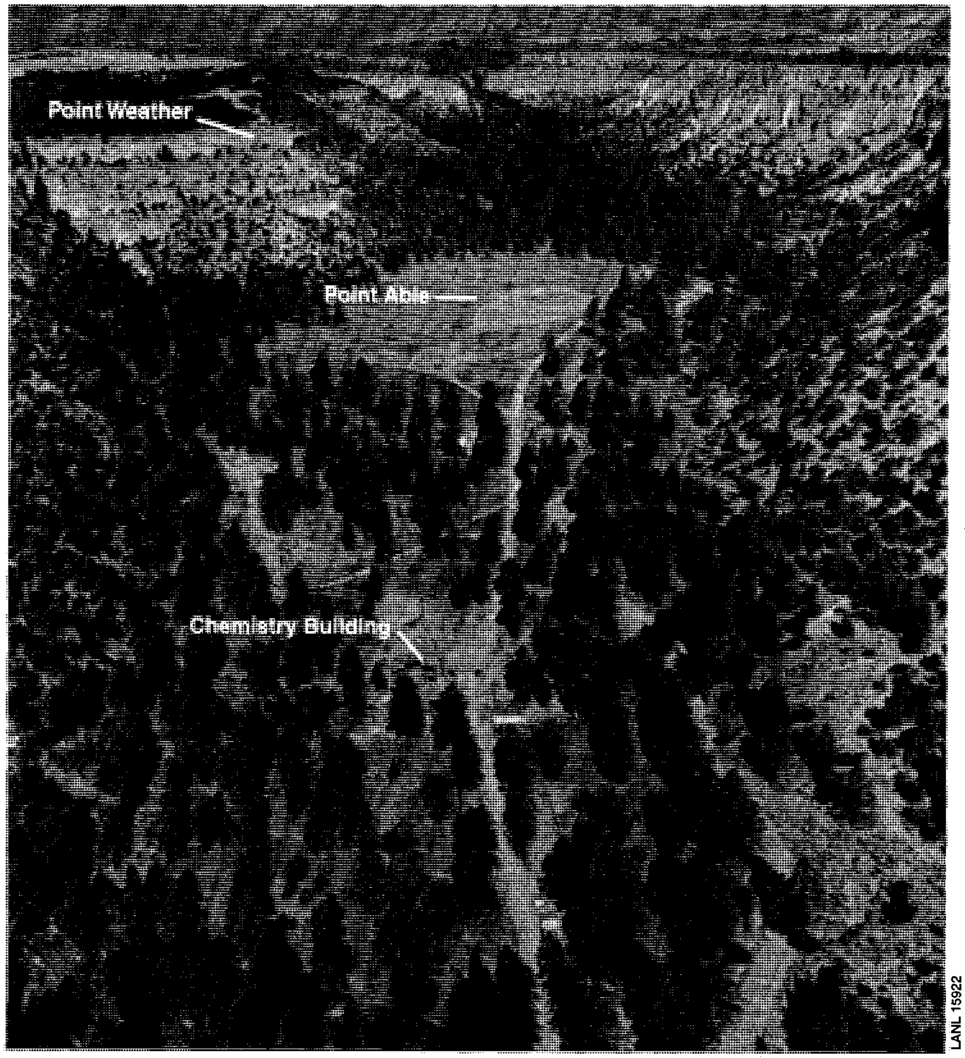

Fig. 3. Aerial view of Bayo Canyon looking west-northwest.

Historical Perspective

Until the summer of 1944, designers of both the uranium and plutonium bombs focused on developing a gun-like device in which a subcritical mass of fissile material, backed by a propellant explosive, was fired down the gun barrel into a second subcritical mass. Together, the two subcritical masses became supercritical, producing a nuclear explosion.

The gun-type assembly was relatively straightforward compared to the implosion technique that eventually would have to be used for the plutonium bomb. Initially, both the uranium bomb ("Little Boy") and the plutonium bomb ("Thin Man") were of the gun-type design. However, the plutonium gun-type bomb presented a number of difficulties that, in the end, could not be overcome. These difficulties forced the development of the more complicated implosion device ("Fat Man").

Until the instant of full assembly, the number of neutrons in the gun-type assembly had to be kept to an absolute minimum. "Because the gun assembly is a slow process in comparison with the speed of a nuclear explosion, extra neutrons threatened to set off the explosion too early and cause a 'fizzle' " (Ref. 2). The problem with plutonium was the possibility of spontaneous fission, the natural tendency of some heavy atomic nuclei to split (fission) and thus emit neutrons; this could occur in reactor-made plutonium but not in uranium-235.

When Segré[1] and his group measured the spontaneous fission rate in microgram amounts of ". . . cyclotron-made plutonium, they found it to be comfortably small" (Ref. 3). When the first samples of reactor-made plutonium arrived from the Clinton Laboratory reactor in Oak Ridge, Tennessee, in mid-April 1944, Segré's group was alarmed because they found the "spontaneous fission rate to be *five times* that of the cyclotron-produced samples—a rate far too high for a [plutonium] gun assembly" (Ref. 3). The high spontaneous fission rate was caused by the presence of plutonium-240 in the reactor-produced plutonium.

"A crisis ensued. Groves[2], wanting to preserve the investment that had been made in plutonium production (hundreds of millions of dollars), ordered a plutonium bomb assembled by other means. The only possible alternative was implosion, an assembly explored thus far at Los Alamos only as a contingency. In such an assembly, a subcritical sphere of fissionable material is collapsed inward by the blast from a symmetrical array of high explosives. This process had the advantage of being so rapid that spontaneous fission neutrons would not have time to interfere with the explosion. But those working on implosion in June 1944 thought it would be virtually impossible to achieve a practical implosion for use in the present war. As a result, Los Alamos was forced to turn its relatively small implosion program into a model 'big science' effort involving hundreds of workers" (Ref. 3).

On July 17, 1944, Oppenheimer[3], director of the Laboratory, stopped work on the plutonium gun assembly and gave top priority to implosion. "Los Alamos was able to complete the 'Fat Man' as the

[1]Emilio G. Segré, atomic physicist, leader of Radioactivity Group at Los Alamos Laboratory, April 1943 to October 1945.

[2]General Leslie R. Groves, military leader of the Manhattan Engineering District, September 1942 to December 1946.

[3]J. Robert Oppenheimer, theoretical physicist, Director of Manhattan Project Y at Los Alamos Laboratory, November 1942 to October 1945.

plutonium implosion bomb came to be called, as well as the uranium gun, in time for combat use because Project Y was reorganized radically, and confronted its problems by a powerful methodology fostered by the wartime context" (Ref. 4).

"On 1 November 1943, Serber[4] conceived of a novel procedure for diagnosing implosion based on placing a gamma ray source at the center of a spherical implosion assembly. The emitted gamma rays would travel outward radially, through both the collapsing shell and the high explosives. Because increasing compression of the metal caused the gamma rays to be increasingly absorbed, the emerging gamma rays, monitored by detectors set around the high explosives, would provide information on density changes in the collapsing sphere of metal. The data would indicate the time of collapse, the degree of compression, and the symmetry, by comparing the gamma ray intensity in different directions" (Ref. 5).

"Radiolanthanum-140, an isotope having a 40-hour half-life and a strong gamma emission at about 2 MeV, was soon found to be a suitable source. . . . In principle, large amounts of lanthanum could be obtained from the Clinton reactor in Oak Ridge, because it was made by the beta decay of radiobarium-140, a 12.5-day half-life element which formed plentifully . . . " (Ref. 6). The original plan was to use the barium-lanthanum pair as the gamma source. Parrat[5] warned, "A site for each shot must be selected which is far removed . . . so . . . that winds cannot carry the material in dangerous amounts. . . . half-life of Ra-Ba-La sources places severe requirements on the proper functioning of the equipment and personnel (and winds)" (Ref. 7). However, when the decision was made later to remove the radiobarium and use only the radiolanthanum, as proposed by Alvarez[6] in May 1944 (Ref. 8), the potential hazard was dramatically reduced.

In the fall of 1944, scientists at the Clinton Laboratory began chemically processing irradiated reactor fuel to produce the radioactive lanthanum for Los Alamos. After being irradiated for about 40 days, aluminum-canned natural uranium fuel slugs were pushed from the Clinton reactor and allowed to "cool" for 1 to 5 days. The processing of slugs began with nitric acid dissolution followed by a series of extraction and purification steps. The first significant amounts of radiolanthanum arrived at Los Alamos by truck in mid-September 1944 as a mixture of barium-140 and lanthanum-140. Chemists at Bayo Canyon prepared the sources by separating the lanthanum-140 from a solution containing the radioactive parent barium-140 and other impurities, including strontium-89 and -90 (see Impurities in RaLa Sources section below).

The separated lanthanum-140 and an unavoidable but small amount of barium and strontium were encapsulated by the chemists as specified by the experimenters, often in a metal sphere no larger than a matchhead. The small size was possible because a pure 1,000-curie lanthanum-140 source weighs only about 1.8 milligrams. The lanthanum-140 source was placed in a shielded container and trucked to the firing site, where it was loaded remotely into the explosives test assembly. The implosion assembly was surrounded by a number of ionization chambers (see Fig. 4, a RaLa experimental setup for shot 78) and later scintillation detectors (see Fig. 5, a RaLa experimental setup from the mid-1950s) to measure the decrease in gamma-ray transmission during implosion. Once the source was inserted, the experiment was detonated from one of the control buildings, where signals from the detectors also were recorded.

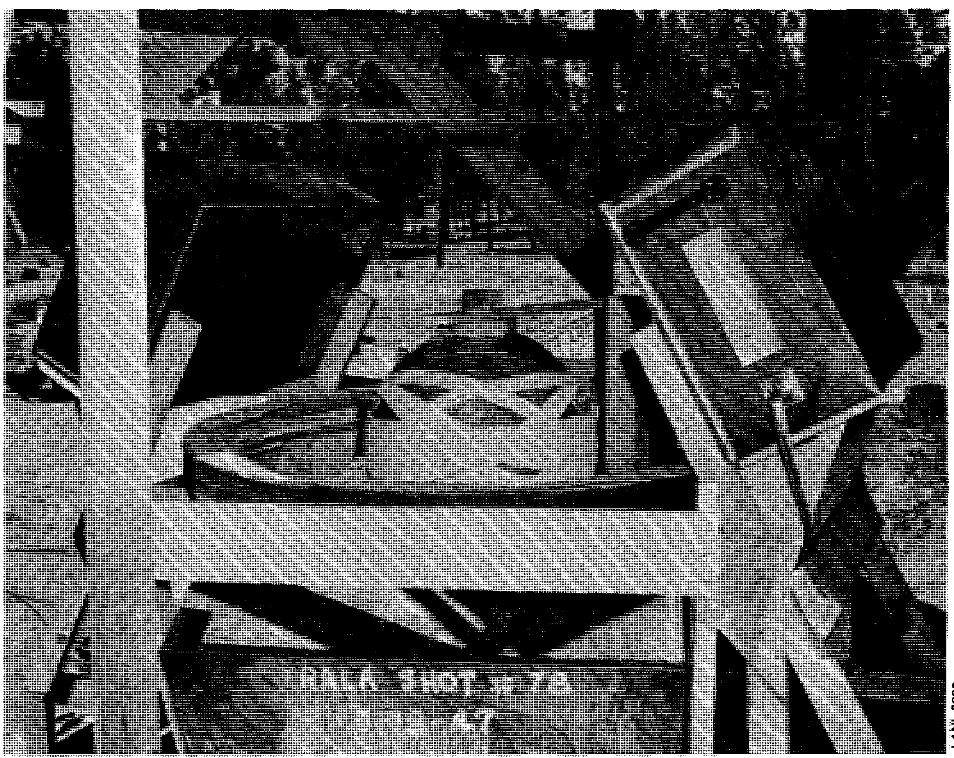

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Fig. 4. A RaLa experimental setup for shot 78, May 13, 1947.

[4]Robert Serber, University of California theoretical physicist, Theoretical Division, leader of T-2 Group, September 1943 to November 1945.

[5]Lyman G. Parratt, Cornell University physicist, Ordnance Engineering Division, leader of Instrumentation Group (E-2), March 1944 to August 1944; leader of X-Ray Method Group (G-2), August 1944 to October 1945.

[6]Luis W. Alvarez, Ordnance Engineering Division, E-11 RaLa; later, leader of Electric Detonators Group (G-7).

The explosives test assemblies used material with "mechanical properties similar to plutonium. Uranium [although used] had the disadvantage of being a strong gamma-ray absorber. Metals . . . such as iron, copper, or cadmium" were used. "Most of the [early] shots employed cadmium" (Ref. 9). Over the years, the experiments used from 60 to about 7,000 curies of lanthanum-140 (see Appendix A-1). A small amount of strontium-90 and other radionuclides also were present in the sources as an impurity (see Impurities in RaLa Sources section below). The amount of high explosives ranged from about 40 to 700 pounds, depending on the type of experiment (see Appendix A-1).

The explosives detonation resulted in the dispersion of all materials inside the high explosives in the form of aerosols and solid debris. Depending on wind conditions and the amount of explosives, aerosols were dispersed to varying degrees within Bayo Canyon, on the adjacent mesas, and beyond. After 1949, standard procedures required that detonations not be conducted unless winds were blowing toward unpopulated areas to the north or northeast; however, last minute wind shifts or unsuspected shear layers occurred occasionally.

The RaLa experiments were terminated in March 1962. While these experiments were essential to the development of the implosion-type nuclear weapon, newer and better techniques were developed for gathering the information needed to confirm computer models and designs. At that time, the site was abandoned; later it was decontaminated, and buildings were removed (Ref. 10).

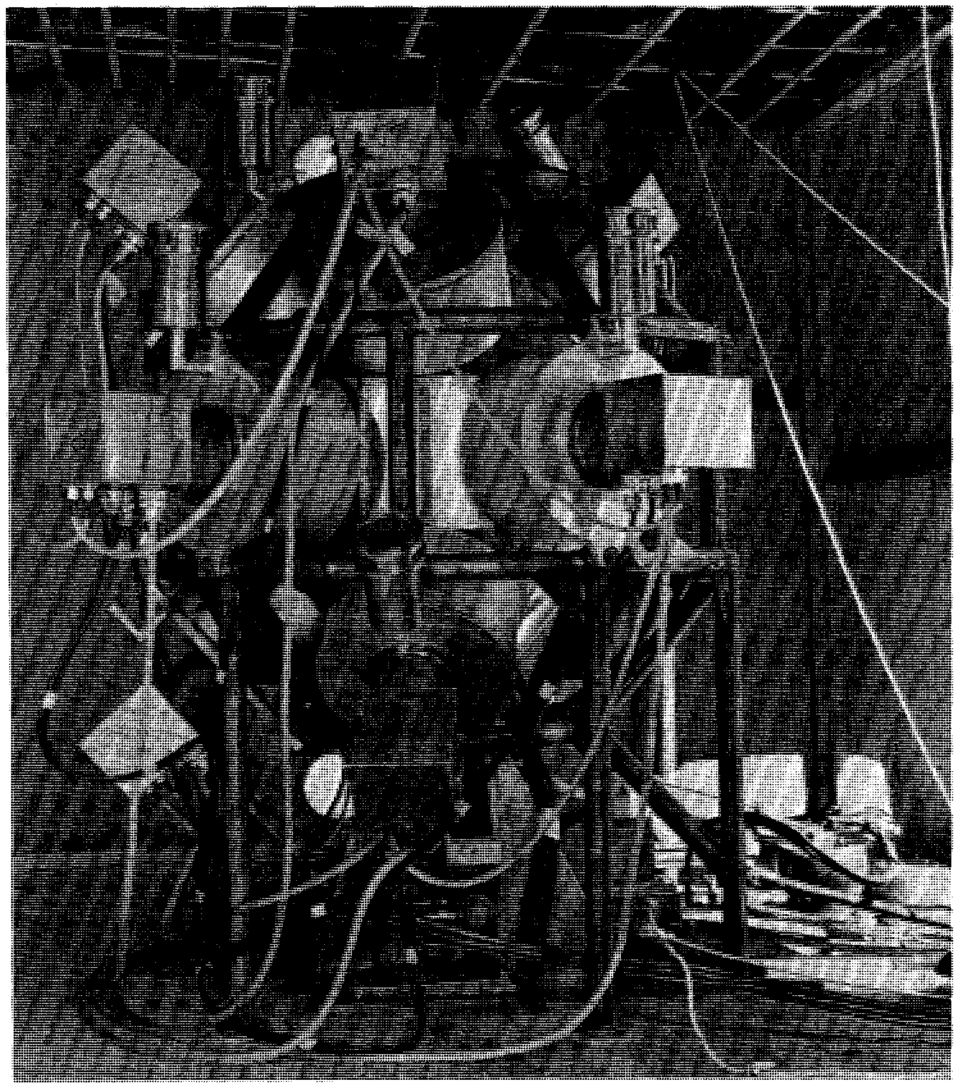
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Fig. 5. A RaLa experimental setup from the mid-1950s.

General Accounting Office (GAO) Report: Tracking Radioactive Releases

A GAO fact sheet prepared for US Senator John Glenn titled *Examples of Post World War II Radiation Releases at US Nuclear Sites*, was published on November 23, 1993 (Ref. 11). The final item in this report mentions releases during atmospheric radiation-tracking tests at Los Alamos, New Mexico, in March and April 1950, during which a B-17 aircraft was used to measure radioactivity. The GAO fact sheet states that four atmospheric tracking tests were conducted at Los Alamos in March and April 1950. The report states that ". . . the Air Force Cambridge Laboratory, Cambridge, Massachusetts, and the Los Alamos Laboratory exploded three simulated nuclear devices at Los Alamos resulting in atmospheric fallout. . . . " It also states, "Resulting radioactive clouds were tracked downwind by a B-17 aircraft carrying an experimental ionization-measuring apparatus." The GAO report continues, "On July 19, 1950, another radiation detection test was conducted near Los Alamos using an unidentified 400-curie radioactive source." The GAO fact sheet implies that this test was similar to the other three, but in reality it was only a fly-over of a stationary source that remained intact.

The GAO fact sheet implies a joint operation between Air Force Cambridge Research Laboratory and Los Alamos for the express purpose of making and tracking fallout. There was, of course, cooperation, but the cited RaLa experiments were simply three shots, numbers 147, 148, and 149, executed in March and early April 1950, in a long series of 254 sequentially numbered implosion test experiments that were conducted between September 1944 and March 1962. The measurements made by the Air Force, although of interest to the Laboratory, were for their purposes only and were add-ons to the Laboratory's ongoing implosion experiments.

The following section gives information on the events leading up to and details of the Air Force flights over and near Bayo Canyon.

Air Force B-17 Flights

The Air Force Cambridge Research Laboratory (AFCRL) had been studying atmospheric electrical conductivity (also referred to as air conductivity and ion conductivity) for a number of years, using instruments mounted in aircraft. The technique had reportedly (Ref. 12) been used in the 1948 nuclear device test series, Operation Sandstone, at Eniwetok to detect radioactive fallout, but a report of this activity has not been found. In anticipation of upcoming atmospheric nuclear device tests in the Pacific, the AFCRL wanted to continue evaluating the technique as a way to track a radioactive cloud and measure the radioactive fallout from the cloud on the ground. The B-17 flights near Los Alamos in early 1950 were conducted as part of these evaluations.

In October 1949, Los Alamos' Burriss[7] informed the Pentagon (Ref. 13) that "Certain experiments at Los Alamos form dust clouds containing active particulate material. Observation of the formation of such clouds, the particulate fall-out and their ultimate disposition might be of some significance [to] your proposals for tests at Eniwetok . . . ." (the upcoming Greenhouse atmospheric test series). Holzman[8] and Crowson[9] were invited to visit and observe two specific RaLa tests. Los Alamos visitor records do not record their visit; however, later that year Davis[10] from Oak Ridge did visit "to discuss dispersion and fallout of airborne material" (Ref. 14). Shlaer[11] sent Davis information about upcoming Bayo shots, source strengths, wind conditions, and a map "indicating locations of interest in connection with fallout measurements" (Ref. 15). This was apparently done in preparation for the B-17 flyovers at Los Alamos.

The Oak Ridge connection to these AFCRL activities has not been positively established, but a letter from White[12] to Davis after the first two flights said, "Your B-17 made two flights in this neighborhood and obtained some interesting results, the details of which we expect to see tomorrow" (Ref. 16). We do know that Davis used aircraft-mounted air-conductivity apparatus and other instruments to detect airborne radioactivity at Oak Ridge and Hanford in 1949 (Ref. 17).

The Laboratory arranged for these flights to take place, with the approval of the Atomic Energy Commission's (AEC's) Santa Fe Operations Office (SFOO) and with the caveat that a public announcement be made "so there will not be a furor when an 'enemy plane' comes flying over" (Ref. 18). The *Los Alamos News* published this information (Ref. 19). Specific details of coordination were made through the Laboratory's Radiologic Safety Group (H-1) and the Air Force weather contingent at Los Alamos (particularly a Major Eddy[13]) for the AFCRL to fly before and after RaLa tests (Ref. 20). No special shots were fired to accommodate the Air Force flights nor was the wind condition favorable for one of the shots the Air Force was prepared to track.

Limited discussions of the flyovers were found in Los Alamos records, particularly H- and J-Division monthly reports. Shlaer reports that his biophysics section ". . . cooperated with Mr. Coroniti[14] of AFCRL on Operation Hypo-sail [apparently a local code name for the AFCRL operation]. This operation attempted to measure the path of the cloud . . . and fall-out pattern . . . [using] ion conductivity measurements obtained with instruments in a B-17" (Ref. 21). The report describes the administrative and technical assistance provided to the Air Force and closes with ". . . a total of five B-17 flights in which the cloud path and the fall-out pattern for two shots were determined . . . The preliminary calculations indicated that the results were good but a final report will be submitted to this group at a later date" (Ref. 21). The "preliminary calculations" have not been found; the "final report" is undoubtedly the AFCRL report (Ref. 22). Later, a Los Alamos Air Force assignee reported the experiments to Kirtland Air Force Base (Ref. 23).

In July 1950, the AFCRL returned to fly over a static 400-curie lanthanum-140 source provided by Los Alamos. Los Alamos personnel transported the source in a heavily shielded container to an isolated spot 22 air miles north of Los Alamos near Abiquiu (the local code name was Operation Ghost) and "set up . . . to clarify in our minds the value of the air conductivity method" (Ref. 24). According to an AFCRL report (Ref. 25), the operation was done at the request of White to help him understand the mechanism involved in the measurements, particularly whether the ions generated at ground level were transported to various altitudes by turbulence (apparently the mechanism favored by the AFCRL) or whether ions were generated at a given altitude by gamma-ray interactions at that altitude (our current opinion is that the latter mechanism is more nearly correct). The AFCRL agreed ". . . to install in the B-17 an ionization chamber [provided by Los Alamos] so that its results could be correlated with the conductivity values" (Ref. 25).

The H-Division monthly report for June-July 1950 (Ref. 16) confirmed this: "In addition to the air conductivity apparatus carried on the B-17, we put on board equipment designed to measure gamma rays by means of a sealed

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[7] Stanley W. Burriss, military liaison officer, M-4 Group.

[8] Colonel B. J. Holzman, Air Force meteorologist; later, participated in atmospheric tests in the Pacific Ocean.

[9] Major Delmar Crowson, Air Force officer; later, director of military applications for the AEC.

[10] Francis J. Davis, Oak Ridge National Laboratory scientist; involved in measurements of radioactivity from aircraft.

[11] Simon Shlaer, Los Alamos biophysicist, leader of Biophysics Section, Radiologic Safety Group (H-1), March 1947 to September 1967.

[12] Thomas N. White, Los Alamos physicist, leader of Radiologic Safety Group (H-1), August 1948 to December 1951; leader of Special Dosimetry Group (H-6), July 1951 to September 1955.

[13] Major Eddy, Air Force meteorologist assigned to the Los Alamos Radiologic Safety Group.

[14] Samuel C. Coroniti, Atmospheric Physics Laboratory, Air Force Cambridge Research Laboratories; author of the three AFCRL reports on air conductivity measurements.

ionization chamber." The equipment was reported not to have operated exactly as desired, but it was "possible to say that for the evaluation of [a] gamma ray source the sealed ion chamber is superior by virtue of the lower background reading." This is opposite to the conclusion drawn by the AFCRL. Unfortunately, a report of data collected by the Los Alamos ion chamber has not been found in either Los Alamos or AFCRL records. An attempt to derive what the instrument should have shown was calculated knowing the strength of the source and using barium-lanthanum-140 air-absorption measurements made by ORNL (Ref. 26). These results were compared with the air-conductivity instrument readings (converted to roentgen per second) in the AFCRL report. The AFCRL values were higher than our calculated values by about a factor of 20. For a number of reasons, including operation below saturation voltage (see below), we would expect the converted air-conductivity measurements to be lower than the calculated values. No satisfactory explanation of this discrepancy has been found.

The conductivity apparatus used by the AFCRL was "based on an instrument first used by Gerdien" and reported in 1905 (Ref. 27). It consisted of two concentric cylinders through which air flowed. A potential difference was applied between the cylinders. The charge collected on the central cylinder was measured with a sensitive [vibrating reed] electrometer. "The value of the potential applied between the cylinders is arbitrary with the restriction that it must be less than the initial saturation voltage for a given air flow" (Ref. 27). The fact that the air-conductivity instrument operated at less than saturation voltage confounds conversion of the data to accepted units of radiation measurement, e.g., the roentgen, which by definition requires electronic equilibrium. In fact, the author goes on to say, "At saturation all ions in a given volume of air are being collected and the instrument operates as an ion counter." Therefore, the chosen method of operating this device, at least in terms of its propensity to "measure" radioactivity as an ion chamber, can be described as operating "off the plateau." Ion chambers so operated would be expected to read "low" and are very sensitive to voltage variations.

Air conductivity was described by the AFCRL as varying at the Earth's surface from 0.4×10^{-4} to 5×10^{-4} electrostatic units (ESU) per second (Ref. 28). Conductivity reportedly increases with distance from cities or other sources of air pollution and shows a maximum in summer and a minimum in winter. Diurnal variations exist as well, and the amplitudes of both annual and diurnal variation differ widely at different locations. Plane and balloon measurements show an increase of conductivity with altitude, doubling with each 10,000 feet. The AFCRL report states, "The increase in conductivity is associated with the increase in the rate of ion formation due to the variation in cosmic ray intensity with height" (Ref. 29).

With all these uncertainties, it is very difficult to know how to properly relate any of the AFCRL measurements with ionizing radiation. It is clear that the apparatus responds to ionizing radiation and there is some evidence of a direct proportionality. Measurements made during flights over the fixed source at varying altitudes showed an approximate inverse square relationship at three altitudes. Measurements recorded on flights over the firing pad at Bayo Canyon shortly after two different shots correlated with the dose rate remaining on the pad, in the sense that the pad having the higher measured surface activity gave the higher conductivity response in about the correct ratio.

The cloud-tracking measurements are all expressed as unitless ratios of air conductivity to some background air conductivity. The AFCRL choice of background level is not always clear. Presumably, they used a value appropriate to the altitude just before or after an increase was noted. During the background-measuring flights, air conductivity at a fixed altitude over a large area of northern New Mexico varied by about a factor of 2. If the excess air conductivity over background conductivity is all attributed to ionizing radiation and the radiation background is assumed to be less than that measured at ground level (0.03 mR/h), then all the measurements made during the cloud tracking, except those made over fixed sources (like Point Able after a test and the source at Abiquiu), would be in the range of about 0.03 to less than 0.2 mR/h.

The following discussion attempts to describe in some detail the various flights in the AFCRL reports in the light of known operations in Bayo Canyon during the period of the AFCRL visits. This information was not totally available to the Air Force when its reports were prepared, and some difficulty was encountered in matching the AFCRL data to the appropriate Bayo Canyon shot.

Our analysis of the AFCRL reports shows that the AFCRL made a total of six flights (plus one later near Abiquiu), with each including several passes over or near Bayo Canyon and extending to some distance beyond. Only two of these flights recorded information immediately following a shot. Table 1 summarizes information in the referenced AFCRL reports and adds some details for clarity.

The major flights following Bayo Canyon RaLa shots are discussed below, using a combination of information from the AFCRL reports and shot information found in Los Alamos records.

Shot 147, containing 1,665 curies of lanthanum-140, was fired at 1323 hours on March 24, 1950. The cloud went in an easterly direction and was tracked by flight 2. The cloud was visible from the plane for 5 to 15 minutes. The plane made 17 passes around or through the suspected cloud location at altitudes from 9,000 to 13,500 feet MSL (mean sea level) for 1 hour and 34 minutes following the shot. Initially, the cloud was circled, then a pass was made directly over Point Able at 7 minutes elapsed time. The pilot then attempted to track the cloud using an air-conductivity readout in the cockpit to penetrate the moving cloud center. The tortuous path required by the aircraft moving at 180 mph to track an invisible cloud moving at perhaps 20 to 30 mph is illustrated in Figs. 6 and 7, prepared by an experienced

Table 1. Summary of Information in AFCRL Reports

Flight Number Shot Number*	Date	Purpose	Time	Reference Figures from AFCRL Reports
1	3/23/50	To conduct background measurements and practice	1128-1246 1128-1246	4A, 4B (Ref. 22)
2 147	3/24/50	To track eastward-moving cloud for 94 minutes	1323-1516	Table II, Figures 5-A, B, C, 11, 12, 13, 14, 15, 16, 17, 29, 30, 31 (Ref. 22)
3	3/25/50	To detect and locate possible fallout one day after shot 147	1018-1146	26, 27, 28, 29, 30, 31, 33, 34, Table IV (Ref. 22)
4	3/31/50	To collect fallout readings two days after shot 148	1159-1450	Table I (Ref. 22)
5	4/04/50	To obtain background measurements	unknown	Graphs 18-19, Figs. 6, 7, 8, 9-10 (Ref. 22)
6 149	4/06/50	To track cloud that went NNW and NNE	1330-1450	18, 19, 22, 24, Graph 25, Table III (Ref. 22)
7	7/19/50	Seven passes over stationary lanthanum-140 source 22 air miles north of Los Alamos	Midday	2, 3, 4, 5, 6, 7 (Ref.25)

*Flight number assigned and Bayo shot number added for clarity.

pilot using available data from the AFCRL report and known characteristics of a B-17 aircraft. Noted in the figures are the pass number, time in minutes after the shot, altitude in feet x 10^{-2} MSL, and the maximum air-conductivity ratio measured in the cloud.

The cloud was penetrated every few minutes for the first 33 minutes. The cloud width at this time, as determined by the extent of the measurements, had grown to about 5 miles across and the aircraft had climbed to 12,000 feet MSL. Contact with the cloud was maintained every few minutes for the next 30 minutes with the conductivity ratio remaining nearly constant until the 62-minute reading, which dropped sharply from around 1.8 to 1.07. No further contacts were reported until another 30 minutes had elapsed, when a ratio of 1.03 was recorded at an elapsed time of 93-94 minutes over Watrous NM, about 40 miles from the previous contact and 70 miles east of the firing point. The cloud still appeared to be about 6 miles across. The cloud-transport calculation done by Los Alamos (see Dose Assessment below) showed that material from shot 147 could not have reached this distance in the time period stated.

Shot 148, which contained 1,743 curies, was fired at 1416 hours on March 29, 1950. The cloud rose to an elevation of 3,200 feet above the mesas, moved to the west-northwest, and then split with a portion going south and the balance moving to the north and east. The portion that went south was detected on the ground in the Los Alamos town site and in TA-1. No aircraft readings were reported for this shot.

Flight 4 made background measurements on March 31, 1950, two days after shot 148 but not in the probable area of fallout from that shot. Part of the cloud went over Los Alamos and thus into the restricted air space. Flight 4 covered only an area east of the Rio Grande. The measurements along the Rio Grande basin on this day gave the same background readings as those found earlier on March 23, March 25, and later on April 4, 1950. On flight 4, the mountainous region east of Santa Fe again had readings of 1.28 to 1.54 ESU/s. The Air Force interpreted these readings as indicating the possible presence of (natural) radioactive material on or below the ground.

Shot 149 containing 1,306 curies was fired on April 6, 1950, at 1330 hours. The cloud rose above the canyon and dispersed in 1.5 minutes in strong turbulent winds, according to ground observations (Ref. 30). The AFCRL report said the cloud immediately dispersed in all directions. The initial direction was to the north-northwest and then north-northeast. During flight 6 the airplane had a problem in locating the invisible "cloud." Passes were made over Point Able, where the readings were twice as large as those obtained on shot 147. The radiation readings taken by the Laboratory at the firing pad after 149 were also twice as large as on 147.

The cloud from shot 149 apparently started north and split into two sections. One drifted north and northeast, and the other drifted north-northwest from Los Alamos. Later, the eastern cloud developed a small third peak resulting in more dispersion. The reading recorded 20 minutes after the shot was 5.7 x background. A section of the cloud was detected over Truchas 1 hour after the shot, with a reading of 1.35 times background. The other portion of the cloud was detected 2 hours postshot, 10 miles north-northwest of Los Alamos. Tracking was terminated after 2 hours, even though AFCRL investigators reported that they could have tracked it longer.

Flight 7 was made on July 19, 1950, over the fixed source positioned on the ground near Abiquiu, New Mexico (36° 15' 30" N, 106° 20' W), for reasons discussed earlier. The plane made seven passes directly over the source at heights between 950 and 4,000 feet above the terrain. The radioactive source was described by the Air Force as a point source residing in the center of the lead container having a cavity radius of 1 inch and a depth of 6 inches. The results of these measurement are discussed above. The AFCRL report (Ref. 31) mentioned that "Before an accurate evaluation of this instrument . . . can be determined, many more controlled tests are necessary."

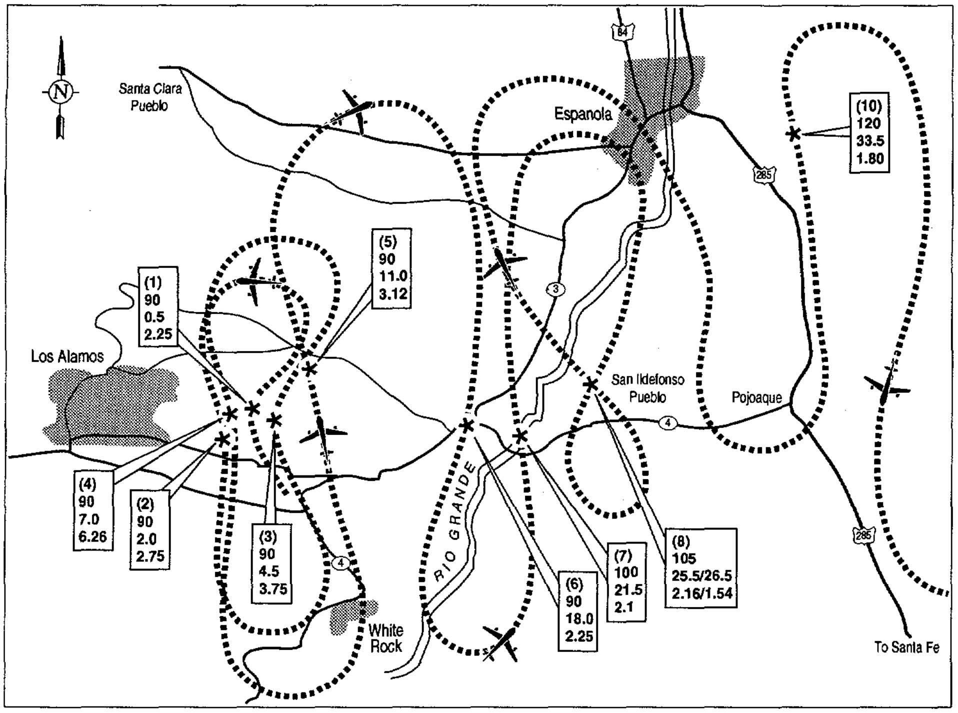

Fig. 6. Reconstructed 3/24/50 flight path of AFCRL B-17 tracking RaLa shot 147—early portion of flight. (Noted in the figures are the pass number, time in minutes after the shot, altitude in feet x 10^{-2} MSL, and the maximum air-conductivity ratio measured in the cloud.)

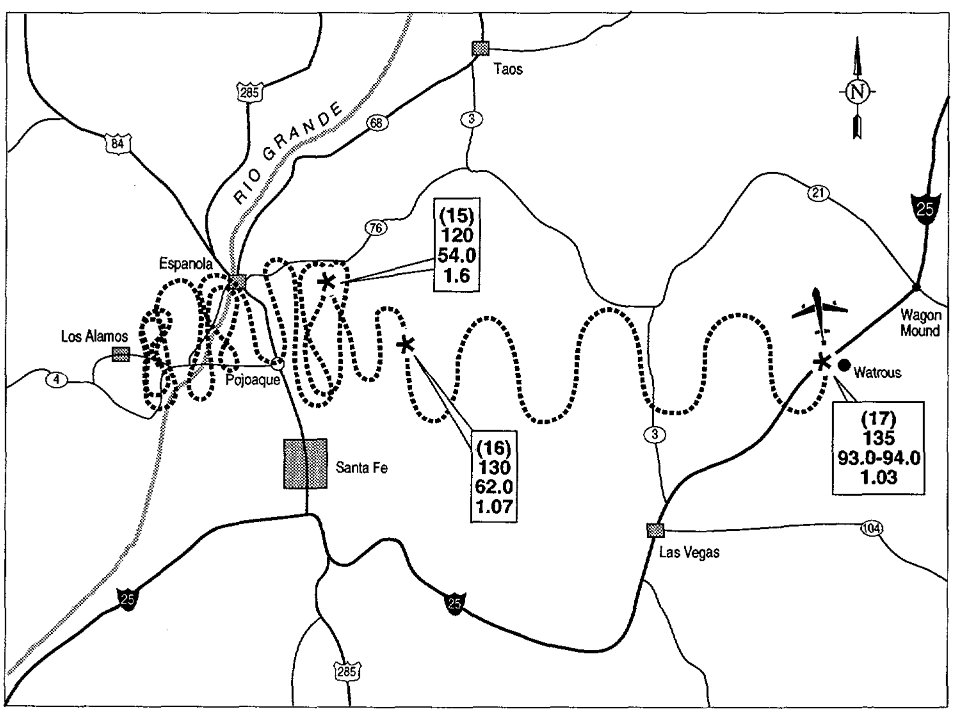

Fig. 7. Reconstructed 3/24/50 flight path of AFCRL B-17 tracking RaLa shot 147—complete reconstructed flight.

No record was found indicating that additional controlled tests were conducted; however, in September 1950, Wykoff[15] wrote White that he had been informed that "... simulated cloud tests will be held at Los Alamos during the early part of October [1950]. The exact date is not known" (Ref. 32). Wykoff proposed to use the B-17 to fly a scintillation detector against these tests and mentioned that Coroniti also wished to return at the same time for further tests with a fixed source using two scintillation detectors, a single Geiger counter, and large and small ion-conductivity gear to address a list of objectives. As far as we have been able to determine in our search of records at Los Alamos and the AFCRL, these tests were never done.

[15] P. H. Wykoff, director of the 4.0 Program (for Operation Greenhouse), AFCRL.

Off-Site Radiation Measurements and Weather

Attempts to measure radioactivity off site from Bayo Canyon varied widely over the nearly 18 years of testing. For some of the earliest shots (5 through 16), air samples were taken in the northeastern-most part of the Los Alamos residential area, nearest Bayo Canyon (Ref. 33). The results of the air samples were all reported as "negative," meaning "no Beta and Gamma active material was ever found" and "no amounts of any consequence, of the Ra La [sic] source, are carried by air to the mesa." Air sampling results in Los Alamos for several additional early shots are also recorded (See A-2, shots 17, 18, 27 and 50). No details on these measurements, such as the detector used, counting times, etc. have been found. For most of the first 126 shots, records of the wind direction at the time of the shot probably were not maintained—none were found in our search.

In 1949, at least by shot 127 (May 20), personnel from Kirtland Air Force Base in Albuquerque were providing weather prediction and observational services for the Bayo Canyon experiments. The first *Report of Distribution* (code for RaLa shot at Bayo Canyon), dated November 9, 1949 (shot 139), reported weather forecasts and verification, triangulation data on the cloud height and direction of movement, and a brief narrative (Ref. 34). Clouds usually dissipated in a few minutes, so only the earliest part of the cloud track was recorded. This type of report (15 examples exist), often with the initial cloud movement plotted on a rough map, was prepared regularly through July 13, 1950 (shot 154), when a 20-month cessation of activities began at Bayo Canyon. A similar type of report (20 examples exist), without the triangulation detail but usually including a map, was prepared later in the mid-1950s. The first of these that we found was dated October 5, 1956 (shot 212) (Ref. 35). The last report found was dated June 3, 1958 (shot 232). These reports are the source of most of the cloud behavior information given in Appendix A-1. An example of each type of report is reproduced in Appendix B as B.9 and B.10; see also A-3, Refs. A.23, A.25, and A.26.

For the first 125 shots or so, dose-rate measurements of ionizing radiation outside the confines of Bayo Canyon appear to have been made (on the evidence of the data retained) only when the cloud was expected to move towards the Los Alamos town site, to cross the main Los Alamos access road (formerly State Road 4, now 502) or during several special attempts to gather specific fallout data to the north (see Appendix A-2). There are references to radiation surveys on North Mesa in H-1 Monitoring Section report, January-February, 1950 (Ref. 36). When Bayo Canyon operations resumed after the 20-month hiatus in the spring of 1952, postshot measurements of radioactive fallout at distances some miles beyond Bayo Canyon were begun on a regular basis per a new directive, *H-1 Program for Bayo Canyon Shots* (Refs. 37, 38). Initially these radiation surveys were made from Point Weather past the stables, picnic grounds, golf course, and North Community and from Bayo Canyon up the main hill road. Only positive readings, defined as "anything above background," (0.02-0.05 mR/hr) were recorded or reported. This could explain why a number of shots in this time frame have no data to report in Appendix A. By August of 1954, the evidence is that a revised H-1 Program (Ref. 39) was in place and the monitoring was to be "through the fallout pattern" on existing passable roads around Bayo Canyon and at other locations reachable by automobile when required (see Fig. 1). Again, only positive readings were to be recorded. These measurements often were made by H-5 (Industrial Hygiene) personnel, who were responsible for similar measurements on atmospheric tests at the Nevada Test Site, and were perhaps done with the dual purpose of training and collecting data. Their results were reported to the Health Physics Group (H-1). The practice of not only crossing the predicted path of the fallout but completing the perimeter of passable roads around Bayo Canyon seems to have begun when H-1 assumed the exclusive role of monitoring in September of 1955.

The Bayo Canyon perimeter survey was made in either a clockwise (beginning to the north into Rendija and Guaje canyons) or counterclockwise (starting down State Road 4, the main Los Alamos access road), depending on the observed wind direction at shot time. Additional monitoring was done on more distant roads (e.g., Puye Road, State Road 5, now designated as State Road 30) as dictated by the radiation levels found nearer the firing point. These measurements continued regularly to the end of the Bayo Canyon operations in 1962. Records of surveys are the source of most of the radiation dose information in Appendix A and are "missing" (probably not prepared because there were no positive findings) for only a few of the last 100 or so shots. Examples of several types of survey reports are included in Appendix B as B.6 through B.8.

The radiation data were usually collected by a two-person team in a pickup truck equipped with hand-held, battery-operated dose-rate-measuring equipment and a two-way radio. Locations of measurements were identified by recording the vehicle odometer reading along with a radiation reading in milliroentgens per hour (mR/h) and the time. Readings were made from the passenger side window about 3 feet above the ground.

The beta window on the Geiger-Mueller (GM) detector was routinely in the open position, making it sensitive to both beta and gamma radiation, although the instrument was calibrated to gamma rays with the shield closed. Readings, therefore, are always somewhat high in terms of mR/h. Contemporary measurements made in both the open-shield and closed-shield positions show the error to be small, perhaps 15% (Ref. 40). Further, the data recorded in Appendix A are taken from the original survey sheets, and the background radiation, usually between 0.02 and 0.05 mR/h, although known and recorded in Appendix A-2, has not been subtracted, for ease in record review. This subtraction is important only in the lower readings, where background may be as much as 50% of the total. Several Bayo Canyon shots (for example, shots 180 and 181) were executed during periods of high fallout from atmospheric nuclear weapons tests at the Nevada Test Site; data have been corrected for this phenomenon.

A few measurements of airborne activity, concentration, particle size, and radiation deposition at locations close to the Bayo Canyon firing point were attempted beginning in the summer of 1949. Additional measurements of this type were recorded from time to time at further distances and are noted in Appendix A-2.

Impurities in RaLa Sources

From the earliest experiments, impurities in the RaLa sources were a concern to all parties involved—the physicists wanted a single, high-energy gamma ray in a "mass-less" form; the chemists needed purity, or at least knowledge of the impurities to ensure reproducible chemical reactions. Health physicists were concerned about dose considerations. Early in the experiments, they were concerned about the dose to the experimenters; later, they were concerned about off-site doses from potential long-lived impurities such as strontium-90. The strontium-90 impurity is addressed in this section. Although strontium-90 determinations on the product were not done until much later in the program, total strontium in milligrams per curies of barium-140 shipped was determined at Oak Ridge for many of the early shipments. Enough other information exists, particularly the amount of barium "carried over" in the separations done at Los Alamos, to make reasonable upper-limit estimates of the amount of strontium-90 (and other shorter lived impurities) in each shot for later use in dose reconstructions.

Clinton Laboratory in Tennessee asked Los Alamos in March 1944 how much beta activity other than that in barium-lanthanum could be tolerated in the source (Ref. 41). In April 1944, Oppenheimer wired "... confirm our request for Radio Barium Radio Lanthanum ... no high requirements on freedom from other beta and gamma activity" (Ref. 42). However, an early chemical flow sheet from Clinton Laboratory describes the final process step for treating the nitrate with 12N hydrochloric acid (Ref. 43). Although this added a step to the chemical separation process, the chloride step reduced the strontium contaminant considerably, enough in fact that Oak Ridge could recover strontium from the process.

The reduction (cleanup of strontium) from the strontium theoretically available from the known fuel irradiation time of approximately 40 days was at least 85%. With only two exceptions, all material received from Clinton Laboratory (and later Idaho National Engineering Laboratory) was so treated. Friedlander[16] reported that "a final purification stage installed in new plant ... known to reduce Fe, Cr, Ni, Pb, and Sr in final product considerably. Such a step has been used in old plant" (Ref. 44).

Appreciable (not specified) amounts of barium-140 were carried over in the initial lanthanum-140 separation (Ref. 45), and any strontium present would have carried over as well. Early measurements of this carry-over were not found. Soil samples after shots 24 to 27 (June 1945) were taken to determine the amount of barium carried into the sources—the physicists had established requirements on the purity. These are the earliest measurements found of this important value and ranged widely from 0.03 to 0.4% (Ref. 46); the worst case, 0.4%, was used in our estimations of impurities for all the previous shots. The amount of strontium present was calculated assuming that the strontium and barium remained together.

It also should be noted that the Clinton Laboratory shipments 10 and 13, from which sources for shots 28 to 32 and 41 to 44 were prepared, did not get the chloride treatment (Ref. 47) and should represent the worst case as far as strontium-90 is concerned. In preparing the source for shot 33, considerable barium, 0.9%, carried over (Ref. 48), but it was prepared from shipment 11, which had the chloride step.

By June 1947, the Clinton shipping papers from which the "mg of Sr per curie of Ba" data arise, state "no analysis, clean as any shipped before" (Ref. 49), and the chloride cleanup at Oak Ridge (and later Idaho) is assumed not to have changed. In 1949, the order of the purification step was changed to reduce organic impurities, but this is assumed not to have changed the cleanup. Several barium carry-over measurements were reported in CMR-10 monthly reports in the late 1940s and "in general meet the 0.1% spec set by GMX-5 [the Bayo Canyon experimenters]" (Ref. 50). In general, the values found are much smaller. Measured or conservative barium-140 carry-over values are used in the calculation of impurities.

In October 1949, an independent measurement of impurities was made at Oak Ridge (Ref. 51). A source made in July 1948, using material similar to that received as shipment 34, was allowed to decay completely (the 12-day barium-140, at least). Strontium-89 and strontium-90 were essentially all that remained after almost a year. Strontium-90 constituted 0.01% of the original activity, which agrees well with determinations made at Los Alamos on similar material.

Barium carry-over measurements continued to be made periodically at Los Alamos. For example, after shot 173, debris collected at the firing site showed the barium carry-over to be less than 0.07% (Ref. 52). In mid-1956, two old sources that had decayed were analyzed after decay, showing strontium-90 values such as 0.001% of the lanthanum-140, or essentially "clean" (Ref. 53); but it was recognized that even more could be removed. The final step at removing the strontium-90 was taken soon after these results were known. Schulte[17] began cleaning up the barium shipments as they were received from Idaho by using hydrochloric acid, which, as seen earlier, does a very effective job of separating strontium from barium. Cleanup approaching 0.0000001% was achieved and can be considered "complete" removal of the strontium-90.

[16]Gerhart F. Friedlander, leader of the RaLa Chemistry Group (CM-14), Los Alamos Chemistry and Metallurgy Division, April 1945 to October 1945; leader of Radiochemistry Group (C-4), October 1945 to January 1946.

[17]John W. Schulte, chemist, leader of Los Alamos CMB-DO-GS, the group responsible for preparing the RaLa sources near the end of the program.

Knowing the initial strontium cleanup and the barium carry-over in the barium-140 separation process (called "milking") *is not quite* the whole story. Since strontium-90 has a very long half-life relative to lanthanum-140, the time since removal of the fuel elements from the reactor core must be known for each lanthanum-140 source milked. Milking times are always within a day of shot time, which is well-known. Barium carry-over was measured periodically (see paragraph above), but the time between the cessation of fuel irradiation and the first milking is less well known. It must include cooling time, dissolving time (at Oak Ridge or Idaho), and transport time. Since these were seldom known exactly, some conventions were adopted for the calculations. A synopsis of the data used for estimating the strontium-90 and other impurities for this report is included in the memo report from the Policy and Program Analysis Group (ESH-12) (Ref. 54).

During the entire 18 years of the RaLa/Bayo Canyon series of 254 experiments, about 226 *milli*curies of strontium-90 was released. Schulte in 1973 (Ref. 55) estimated "less than 790 millicuries" of strontium-90 using very conservative single values of impurity content, which supports the current calculation. Over 80% of the 226 millicuries was released in the seven shots in 1945, all made from the barium-lanthanum that had received no chloride during initial separation. No single shot contained over 30 millicuries, and the last 60 or so contained 0.001 millicuries or less. These values and those calculated for other short-lived impurities (strontium-89 and barium-140) were considered in the dose assessment (see the Dose Assessment section below).

Off-Site Safety Considerations

During the early years of the RaLa operations, the overriding concern was the potential radiation exposure to the chemists and experimenters in Bayo Canyon. After all, the quantities of radioactive material to be handled in these tests far exceeded amounts handled previously anywhere in the world. Nevertheless, beginning with the planning of the very first RaLa shot, concern was shown for people outside the immediate experimental areas. The following chronological excerpts found during the document search describe this concern and some of the steps taken to address that concern. Minimal editorial comments are included only to aid the reader. Several of the more important documents are included in their entirety as Appendix B. Other relevant documents that can be released have been made available.

In a June 26, 1944, memo (Ref. 56), Hempelmann[18] (we believe as an effort of the Safety Committee) reported to Dow[19] that he, Lipkin[20], and Commander Birch[21] reviewed the plans for the first RaLa shot at Bayo Canyon. They found that "the experiment seems to present little, if any, danger from fragmentation and radioactive materials to people at Los Alamos. In the opinion of the explosive experts, it is extremely improbable, if not impossible for any fragment from 200 lb charge to travel the two-mile distance from the site of the experiment to the main camp. Calculations also show that, assuming the worst possible conditions, even with a direct wind blowing toward Los Alamos, the amount of radiation delivered to any one point in Los Alamos would not be excessive."

Hempelmann goes on to say that the Safety Committee wants certain meteorological studies and "some system of monitoring the main camp [Los Alamos] for radioactive materials be set up during the experiment . . . In our opinion, the only danger to people other than the personnel concerned with the experiment might come from (1) fragments landing on the main road which comes within a mile and (2) radioactive materials washed into the drinking water of people in the construction camp at the junction of Los Alamos and Frijoles Roads. Arrangements will be made to close the main road during an explosion, and the water at the camp will be checked after the experiment."

Hempelmann reported to the Safety Committee five days after the first RaLa shot (Ref. 57) that ". . . there was not as much danger as anticipated in this experiment . . . The air around was sampled but no trace of activity [was detected]."

The January 31, 1945, Safety Committee meeting (Ref. 58) had as its main topic the closing of the main road leading from Bayo Canyon. Commander Bradbury[22] stated that the quantities of high explosives were increasing. Committee members were worried that debris might fall on the road (the Main Hill Road) and that the period of time from 5:30 PM to 6:30 PM was not a good time to fire since traffic leaving Los Alamos was still at its peak (four of the first five shots were fired in approximately this time frame; see Appendix A-1). One committee member suggested a 24-hour notice before closing the road; another member suggested that the time period from 5:30 PM to traffic's end be avoided as a firing time. This was suggested to Rossi[23], who was called in to discuss the problem: "he stated it was impossible to do the experiment at any given hour" but "he would try to have the experiment completed before 5:30." It was suggested that if it was impossible to complete the test before 5:30 PM they could postpone it until evening, but Rossi "objected to this because it would be too dangerous and complicated to work on the experiment at night." Rossi went on to explain that they had tried firing after dark once and did not want to do so again unless absolutely necessary. Rossi thought they could almost tell the day before the appointed time of the shot if they could fire it (i.e., the winds would be proper, trusting in the well known "persistence" behavior of the weather) and would inform the committee if this was the case. No records were found to show that this happened.

The Safety Committee recommended in a February 1945 memorandum (Ref. 59) that ". . . main road be closed to all traffic during time of each large shot in order to insure a cleared area of 2500 yards from Bayo Canyon Site. (This memo is included in Appendix B as B.1.) This will involve closing the main road from the point where the Bayo Canyon road branches off [the main road] to a point approximately opposite the incinerator west of Gate #1 [the Main Gate]. It will also necessitate the evacuation of personnel from the East Gate Laboratory. In order to insure the least inconvenience to everyone, the following procedure will be adopted." An eight-item procedure followed. A copy of this memo is included in Appendix B as B.1.

The March 7, 1945, Safety Committee (Ref. 60) discussed the general question of access to outlying areas on Sundays

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[18]Dr. Louis H. Hempelmann, physician from Barnes Hospital, St. Louis, Missouri; leader of the Los Alamos Health Group (A-6), July 1944 to December 1945; leader of A-10 Group, August 1946 to May 1947; during the Manhattan Project, responsible to the Laboratory Director.

[19]David Dow, leader of A-1 Group, January 1944 to February 1946; leader of H Division, May 1947 to May 1948; assistant to the Los Alamos Director for nontechnical administrative functions.

[20]David Lipkin, organic chemist, leader of the Corrosion Protection Group (CMR-7), October 1945 to July 1946; Safety Committee member.

[21]Lt. Commander A. F. Birch, Ordnance Engineering Division, leader of Proving Ground Group (E-1), March 1944 to August 1944; leader of Gun Group (O-1), August 1944 to August 1945; Safety Committee member.

[22]Lt. Commander N. E. Bradbury, physicist in Los Alamos Explosives Division, leader of the Implosion Research Group (X-1), August 1944 to March 1945; leader of X-6, March 1995 to October 1945; Safety Committee member; Director of the Los Alamos Scientific Laboratory, 1945 to 1970.

[23]Bruno Rossi, Los Alamos Weapons Physics or G Division (G for gadget, code for weapon), leader of the RaLa Method Group (G-6), August 1944 to August 1945.

(Saturdays were work days) and after 5:30 PM. The committee felt that Los Alamos residents thought that access to all areas was permitted during these hours. An example given involved a Bayo shot conducted on a Sunday with people within the danger (from shrapnel or missiles) area. Arrangements (safety) for an especially large high-explosives Bayo shot were mentioned without details. Safety Committee meeting minutes later in March (Ref. 61) stated, "A memorandum for general distribution was written by Mr. Dow on the subject of restricted areas and a copy was presented to each member of the Safety Committee ... Mr. Dow remarked that all canyons, trails, etc. would be properly marked; it was also suggested that a map should be drawn up ... to show which of these areas are restricted." Neither the memorandum nor the map have been found. In May of the same year, a Safety Committee member suggested that "... announcement be made over the PA System Saturday mornings and perhaps Saturday afternoons warning the people to look at the bulletin boards before hiking trips." Since this "would not contact the wives and children who do most of the hiking," another member suggested "an announcement be made over the radio during the noon program ...." (Ref. 62).

Steinhardt[24] wrote Hoffman[25] a Summary Report on Health Conditions dated June 19, 1945 (Ref. 63). The bulk of the report concerned the Bayo Canyon workers. In the final section, Contamination of Inhabited Areas, he reported, "Air counts taken in Los Alamos have never given results other than negative." He adds parenthetically, "(The Los Alamos Weather Station has been requested to submit data on wind direction and velocity on day when shots have been fired. As yet this info has not been received.)"

Further discussion continued in late January 1946, by the Tech Area Safety Committee (Ref. 64): "regarding fragments from half scale shots fired at Bayou [sic] Canyon ... It was the opinion of the Committee that there would be a chance of fragments reaching the main road from these shots, but it was suggested a radio controlled patrol close this road and that the patrol cars be notified approximately ten minutes before the shot is to be fired ... and have radioactive tests made on this road, findings to be reported to the Committee and final conclusions to be drawn ... based on these findings."

One can only speculate why the record of Bayo Canyon-related documents of the type described thus far becomes essentially nonexistent for nearly four years. The activity in Bayo Canyon was anything but dormant; over 60 shots were executed with hardly a pause between Trinity, July 1945, and the spring of 1949. The massive change in Laboratory personnel after the end of World War II, the concomitant reorganization under Bradbury, and the aggressive leadership of Shipman[26], the new Health Division Leader who arrived in late 1948, certainly are factors.

White and Shipman observed an early December 1948 Bayo cloud that drifted southward from the firing site (see notes on shot 114, Appendix A-2), and memos were exchanged with Mueller[27]. Mueller suggests, "... further surveys on the contamination pattern for Bayo shots, as a function of meteorological conditions ... " but is quick to call attention to the "hazards [night work, presumably] and costs [delays?] which would be introduced by conditioning GMX-5's firing upon the meteorological situation."

In the spring of 1949, Shipman wrote to Mueller through Bradbury and MacDougall[28] (Ref. 65) with recommended precautions for Bayo Canyon shots: "1. No shot shall be made at any time without a previous test of the wind direction from the mesa above the canyon floor. This test may be made with a smoke pot or balloon, but should be made as close to the time of shot (not over one half hour). 2. If the test indicates that the wind is blowing in the direction of Los Alamos itself (Tech area and housing area), the shot should be postponed until the wind is favorable. 3. If the test indicates that the wind is blowing in the direction of the road, in other words any northerly wind, the shot shall not be made during the traffic rush from 4 PM to 5:30 PM, and then only with the specific approval of group H-1 (Dr. T. N. White). Under these circumstances permission for these shots may be delayed until the road has been closed and cleared of all traffic by the establishment of suitably placed road blocks." Shipman closes by saying, "These precautions are necessitated by the use of larger and larger sources. ..." It was this same concern, we believe, that earlier prompted Burriss (Ref. 66) to encourage local weather studies, leading to the Air Force assistance, pointing out "that our concern over wind conditions in Bayo is based on plans to use something like ten times the source size now employed. ..." In reality the source sizes never approached the size that Shipman and Burriss were concerned with—greater than 10,000 curies.

In the introduction to the April-May monthly progress report of the newly reorganized H (Health) Division (Ref. 67), Shipman remarked, "It was formerly felt that little or no significant radioactivity was being deposited in the surrounding country as result of these operations. More recent observations have shown that this is not the case. Very significant levels of activity can be deposited on the ground, at least within a radius of three miles. Intensive studies are in progress and will be discussed further in future reports."

Later in the Radiologic Safety section of the April-May 1949 progress report

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[24]Ralph G. Steinhardt, Jr., health technician for early Bayo Canon operations, February 1944 to March 1946.

[25]Joseph G. Hoffman, physicist in Explosives (X) Division; later, H-Division, Health Physics Section, June 1944 to November 1946, terminated April 1947.

[26]Thomas L. Shipman, physician, leader of the Los Alamos Laboratory Health Division, 1948 to 1969.

[27]Donald Mueller, physicist, post-war group leader of the RaLa Bayo Canyon experimenters (GMX-5), August 1948 to June 1963.

[28]Duncan MacDougall, leader of GMX Division, responsible for the Bayo Canyon shots, August 1948 to September 1970; assistant director for weapons, September 1970 to July 1972; associate director for weapons, July 1972 to September 1976.

(Ref. 68), White described Bayo Canyon fallout measurement efforts as being of greater urgency since the discovery of a new pumice mining operation in Guaje Canyon. He added "The gathering of data on radioactive fall-out is made very difficult by the rugged terrain to the north and east of Bayo Canyon, in which direction the cloud is usually blown."

In mid-May, Shipman announced a meeting (Ref. 69) "... to consider some of the recent findings relative to the fall-out from ... Bayo Canyon shots, and the effect which these findings will have on selection of the new firing site." In a postscript on the AEC copy of the memo, Shipman encouraged AEC to send a representative to the meeting and also states, "... that the proposed new site (Monterrey) [Mesa] will be unacceptable." A new firing site was never developed.

In the May-June 1949 progress report (Ref. 70), General Remarks section (repeated in the Abstract), Shipman said "... certain decisions connected with the operations in Bayo Canyon were reached. These decisions resulted from the fact that on two occasions during the month it became necessary to close the main access road to the Hill for periods of approximately two hours. On one other occasion, with help from meteorologists from Kirtland Field, plus a large measure of luck, operations went off very smoothly. General agreement has been reached, however, that in the future no shots will be fired in Bayo Canyon if wind is in such a direction as to necessitate a road block." The relevant section of this progress report is included as Appendix B.2.

It also was decided that no GMX-5 work be performed after dark. A fully revised set of regulations was to be ready when operations were resumed. Also reported was that "[t]he most important lesson learned [from the road block operations] was that the proper location for the senior representative of the Health Division was in the Communications Center ... [where] almost perfect communications can be maintained with widely separated personnel, and the entire state of affairs can be clearly visualized" (Ref. 71).

The H-1 Radiologic Safety section of the May-June 1949 progress report (Ref. 72) gives a discussion of Bayo Canyon operations. "From the viewpoint of radiological safety, an outstanding feature of recent Bayo operations has been the excellent quality of the work done by personnel from the Meteorological Detachment from Kirtland Air Force Base. In addition to their regular duties at Kirtland, these men have performed all-night weather observations at Los Alamos prior to shot days. They have provided predictions of phenomenal accuracy, particularly for 10 June, when there was a period of less than one hour that was suitable for a shot." The report continues with interesting information and is included as Appendix B.2.

In a report to Bradbury (Ref. 73), Shipman described the June 6, 1949, shot, which was delayed until after 10 PM; the road from the airport to Totavi was blocked for 2 hours from about 10 PM to midnight. Cars that drove through a contaminated area with activity as high as 15 mR/h (contact) were asked to return to Los Alamos for monitoring and decontamination the next day. He emphasized poor communications and the need for briefings for security and urged CMR-10 chemists to get to Bayo Canyon early. He also worried about "Totavi Camp ... nearly 5 miles from the site [Bayo] where detectable activity was found and with proper [worst] conditions could be serious." The danger of GMX-5 personnel working in the dark also was emphasized.

Shipman followed up on the same day with a memo to Mueller (Ref. 74) recording a conversation with him. Mueller, the GMX-5 operational leader, agreed with the Shipman memo (Ref. 75) that a 0600 weather report is "absolutely necessary." Shipman replied (Ref. 76) with an offer of reconsideration of the various health and safety regulations but continued to recommend no shot requiring a road block and no GMX-5 operations in the dark.

In June, AEC Security expressed its inability to provide adequate patrol (ground) coverage of North and Tank (Barranca) mesas since they had been advised not to cross the fence that bisects these two mesas. Shipman told Hoyt[29] (Ref. 77), who was responding to the security issue, "... ground contamination resulting from Bayo Operations is essentially of no significance. We do feel people should be kept out while the material is actually settling down ... perhaps as much as two or three hours, depending on distance and wind velocity. For this reason we do not feel that it is necessary to maintain motor patrols on the mesas or in the canyons north of Bayo Site." Shipman went on to propose, "The one thing that might be done with advantage is to have the patrol plane take a couple of turns over the area north of Bayo Canyon an hour or so prior to the anticipated time of the operations." Aircraft surveillance of this area before and after shots was soon established (Ref. 78). Examples that this procedure functioned were found in a listing of L-13 (light aircraft) Patrol Flights (Ref. 79) made in the last half of 1949. "Mission" entries on two Bayo Canyon shot mornings recorded the following: "Cleared area Bayou [sic] for shot" and "Requested to patrol Bayou [sic] Canyon - sighted surveyors near site."

The June-July 1949 progress report (Ref. 80) states, "Regulations which will govern the carrying out of operations at [Bayo] Site have been agreed upon. It is unanimously agreed that no shots should be fired with the wind in either of the northerly quadrants. There is some difference of opinion whether operations should proceed with essentially calm conditions. It is the opinion of H-Division that under these conditions there is almost certain to be a slight but unpredictable drift, particularly in the upper air. With the cloud moving quite slowly the fall-out would be over a small area and consequently productive of contamination of high intensity. Under these conditions it would be perfectly possible to drop serious contamination around Pass Gate [Main Gate], on the

[29]Henry Hoyt, assistant director for administration, Los Alamos Scientific Laboratory, November 1946 to October 1970.

road, and what would probably be most serious of all, over the new asphalt plant East of the Pass Gate. The serious effects of evacuating or shutting down this asphalt cannot be over estimated."

In the H-1 Radiologic Safety section of the same report (Ref. 81), the results of a July 18 meeting are described in which the above restrictions were agreed upon and discussions held about what weather predictions can do to meet the experimenters' requirements. An example of the cancellation of a shot based on an unfavorable prediction is described.

Shipman responded to AEC Security in August 1949 (Ref. 82), "In response to your request . . . I can give you the following information: It has been agreed that no operations in this canyon [Bayo] will be carried out unless the wind is blowing from a direction to the south of an axis running due east and west. This rule is primarily to avoid the necessity of establishing a road block or dropping contaminated material on the town site, the Tech Area [TA-1], the pass gate, the asphalt plant, etc. . . . We have practically no concern about anyone tramping through the region where fallout has taken place except . . ." The three "excepts" are paraphrased here:

- Do not be in the fallout itself 2 to 4 hours postshot.
- Picnics are not permitted for 48 hours after the shot, but there are no restrictions on walking.
- The area affected varies with the wind velocity.

The remainder of the memorandum also is informative; the entire memo is included in Appendix B as B.3.

In the August-September 1949 progress report (Ref. 83), Shipman reported, "Group H-1 [has] finally had some success in trapping material falling from Bayo cloud, but the difficulties of this work are enormous and interpretation of the results is not yet entirely clear."

The September-October 1949 progress report, H-1 Radiologic Safety section (Ref. 84), describes preparations to attempt aerial photography of Bayo Canyon clouds to better record territory covered. (These were not successful and were abandoned after only one try.) The Biophysics Section (Ref. 85) reported "The last three Bayo shots [135, 136, 137] yielded good flypaper fallout data." The first two shots took place on unpaved surfaces, while the last one was fired on asphalted apron. More details were given on these experiments, clearly to evaluate the concept that paving could reduce fallout (see Appendix A-2).

Shipman sent a memo (Ref. 86) to Bradbury expressing his worry about plans for a new road to Santa Fe and a landing strip southeast of Buckman Mesa, about 10 miles east of Los Alamos. The site had been considered as a possible site for Bayo shots, should the continued use of the present site be regarded as inadvisable. "H-Division is still wrestling with the problem of determining the actual hazard to people who may be actually in the fallout or who may be more or less permanent residents of areas contaminated . . . This seems like a simple problem, but actually it has proven itself to be both complicated and baffling. Progress is being made. . . ."

The November-December 1949 H-1 monthly report, Biophysics section (Ref. 87), discusses the two Bayo shots on December 8 and 16 (140, 141), one paved and one unpaved and the results. (See Appendix A-2.) The report also gives an analysis of the RaLa fallout hazard to an adult at two miles working under normal physical activity for the entire duration of the fallout. This short exposure would result in only one-tenth the exposure permissible for continuous breathing. This analysis is summarized: "On the whole, considering the frequency of Bayo experiments, the magnitude of the dosage accumulated under the worst (and very unlikely) circumstances, I [Shlaer] believe the fall-out is of negligible hazard to adults at a distance of two miles."

The Health Division progress report for December 20, 1949, to January 20, 1950, Abstract (Ref. 88), reports, "The Biophysics Section of Group H-1 has succeeded in providing some definitive answers relative to operations in Bayo Canyon." Details of shot 142 were recorded in the handwritten notes attributed to Shlaer (see Ref. A.14, Appendix A-3). "It was predicted that lower winds would be light from the S.E. with the upper winds strong from the N.W. In view of the conclusions from the successful collection of data from the previous two shots, it was agreed to conduct the shot even though the access road [to Bayo] would likely be in the fallout. The shot was delayed by [operational] difficulties in the canyon till 4:30 PM when the winds were generally quite low. The result was that the cloud went straight up about 2,000 ft producing a beautiful ring halo which was visible for a very long time—over 10 minutes. The cloud moved very slowly in a westerly and southwesterly direction. It was expected that all the residential areas as well as the Tech Area might receive the fallout. Division leaders were notified. In spite of the fallout pattern expected from watching the cloud, no appreciable surface activity was found in the residential or tech areas. The highest activity outside of North Mesa [was found] east of the gate, where surface activity [i.e., in contact with the ground] reached 20 mR/h. The hottest areas found on Los Alamos Mesa were about 200 yards east of the tower (air strip) where the activity was about 1 mR/h."

Shipman suggested that MacDougall (Ref. 89) consider ". . . slowing down the GMX-5 operational schedule somewhat, and . . . scheduling shipments [of radiobarium] at intervals of six weeks instead of four weeks." Shipman's concern here was overexposure of the chemists, not off-site considerations.

The 1949 H-Division annual report, H-1 Radiologic Safety Biophysics section (Ref. 90), characterized their major research as "the investigation of the seriousness of fall-out of particles of radioactive materials from clouds," which began after the road near Main Gate to Los Alamos became contaminated. The meager results "justify a fairly confident conclusion that there is no serious hazard at . . . two miles . . . under representative wind conditions. Biological data on the results of inhaling the material involved are quite meager and it is believed that the effort to protect populated areas from the cloud should be continued."

The research in late 1949 on the Bayo Canyon fallout prompted the following in the Abstract of the January-February 1950 progress report (Ref. 91): "For the time being the problem of estimating the fall-out from the cloud in Bayo seems to be under control. The extent to which further studies be resumed in the spring or summer will in part depend on the desires of other divisions or agencies to study the meteorological aspects of this subject." The Biophysics section in the H-1 Radiologic Safety, January-February 1950 progress report (Ref. 92) gives some details on two shots (145, 146), which are summarized in Appendix A.2. "Both of these shots indicate that turbulent surface winds together with the possibility of an inversion of temperature in the canyon will tend to concentrate 'fall-out' in the canyon. Movement of the cloud after it rises above the mesa tops, under these conditions, is rapid, dissipation occurs quickly, and 'fall-out' is scattered over a larger area and is less concentrated. Conversely, light winds allow the cloud to rise quickly above the mesa tops, but the slow movement gives a heavier 'fall-out' along its track."

Cole[30] wrote Shipman in April, 1950 (Ref. 93), asking about "danger from irradiation [sic] as far north of Bayo Site as Pine Springs." The Tuffa [sic] mine in Guaje Canyon was noted as being much closer. Cole asked for an investigation of the situation.

Shipman replied on the same day with one of the most complete examples of his contemporary thinking on this subject (Ref. 94). "It is our present feeling that any area which is two miles or more from the firing point [Bayo] may be regarded as a non-hazardous area." He gives three qualifications: (1) Small children in residential areas should not be repeatedly exposed. (2) Nonhazardous amounts in Tech Areas could upset counting. (3) A steady, low-velocity wind could deposit greater activity in a 2- to 5-mile area than could strong, gusty winds. Pines Springs, 4.5 miles from the firing point, is "definitely outside area . . . hazardous" area. The pumice mine, 3 miles from the firing point, had a " . . . small remote chance of repeated deposition . . . . In last nine months . . . quarry has [n]ever received more than a thoroughly insignificant amount of contamination." The above was further qualified as dependent on not increasing the source size materially. The remainder of the memorandum is of enough general interest to include in its entirety in Appendix B as B.4.

The experiments that permitted Shipman to make the above statements were summarized by Shlaer at a meeting of the Medical and Laboratory Directors of the US AEC, held in Los Alamos, September 28-29, 1950 (Ref. 95). Shlaer mentioned " . . . a number of spot surveys made more than two years ago failed to detect any significant radiation at distances over half a mile from the site. However in the spring of 1949 there were several occasions when easily measured radioactive deposits were found on the main access road at distances of one to three miles from the point of dispersal. Road-blocks were tried but proved unpopular especially in absence of any quantitative evaluation of the hazard."

Shlaer goes on to describe six months of concerted effort, often unsuccessful, to evaluate the fallout hazard in very difficult terrain and variable meteorological conditions. To aid in coping with these difficulties, "a number of conditions" for firing the Bayo tests "were formulated by the Health Division in co-operation with the physicists conducting the tests": wind from 135° to 270° and above 5 mph, no dispersal after dark or during rain or rush hour. "These studies showed 1) that the fall-out of radioactive material is reduced by at least a factor of two when dispersal is from an asphalt surface, as compared to that from an unpaved one; and 2) that a man directly in the path of the maximum fallout, at a distance of about two miles with the maximum proposed amount dispersed, and with a wind of 5 mph would inhale about 1.5 times the daily permissible amount for continuous exposure." Although the details of Shlaer's calculation have not been found, we believe the "maximum proposed amount" referred to plans to utilize 10-kilocurie amounts of RaLa in each shot, a level that was never approached (see Appendix A-1).

No Bayo shots were fired between July 13, 1950 and March 26, 1952.

In the division leader's summary to the January-February 1952 progress report (Ref. 96), Group H-1 is described as "giving consideration to the planned activities in Bayo Canyon [there had been no Bayo Canyon shots for nearly 2 years] and a detailed Monitoring Operations Plan is being worked out to meet the new conditions which will exist at that Site." The earliest version that has been found, entitled "H-1 Program for Bayo Canyon Shots *Responsibilities*" is dated March 8, 1952 (Ref. 37). It is marked in pen "Superseded [sic] by March 11, 1952 Plan," and is thought to be the first actually followed beginning with shot 155 (March 26, 1952). This version of the plan has not been found. The Program outlines responsibilities in four sections: Weather, Communications, Bayo Canyon and Road Monitoring. (See Off-Site Radiation Monitoring) A second version exists with the same title dated July 23, 1952, (Ref. 38) with only minor differences. The third and only other version found is dated in pen "4-1-58" (Ref. 39). Based on other evidence found in the monitoring reports, we believe this version to have been in effect from summer of 1954 on. This plan has a number of differences from the earlier versions found. Of importance to this section is the specification of acceptable weather conditions, namely that "Favorable winds for *forecasting a shot day* [emphasis added] shall be from 180° to 270°" (that is, one can *plan* to shoot if the wind is predicted to blow towards the south back around to the toward the west) but "Favorable winds for a *shot* [emphasis added] shall be from 150° to 330° " (that is, one can actually fire only if the wind is blowing toward almost south-southeast around to about north-northeast). This version of the H-1 Program is reproduced in its entirety in Appendix B as B.5.

Also in the January-February 1952 (Ref. 96) progress report, Group H-5 was

[30] R. E. Cole, AEC, Santa Fe Operations Office, Engineering and Construction.

reported as having completed preparations ". . . for air sampling in connection with forthcoming activities in Bayo Canyon."

Meyer[31], H-1 Group Leader, reported to Shipman (Ref. 97) a meeting on the weather conditions under which Bayo Canyon operations would be allowed to proceed. The conditions were mean air flow between 315° and 45° (note that this is much more restrictive than cited above, allowing only winds blowing toward the northwest through the northeast), with high probability that air flow would continue within these limits for an hour; no thunderstorm or precipitation expected for an hour; and operations not to proceed after 7:00 PM. Mueller took exception to the after-dark restriction and Shipman clarified his feelings on the subject to Mueller (Ref. 98).

In the August-September 1952 H-Division progress report (Ref. 99), H-5 reports, "Good coverage was obtained on the last Bayo Shot [either shot 156 or 157] and evaluation has been completed, showing no hazard in any inhabited area. Data from the fall-out trays proved to be particularly valuable in tracing the path of the fall-out from the cloud."

The weather controls in effect at shot time are described (Ref. 100) in a 1954 procedure for the Bayo Canyon site. Since the procedure was reapproved in 1960, it apparently describes the practice in effect for at least these 6 years: "Close contact is maintained with Group H-1 on shot day through the Bayo Senior H-1 Monitor. Group H-1 obtains information on wind direction and velocity from the H-6 weather section. Group H-1 is responsible for the decision that the wind is satisfactory for the shot. The statement from H-1, that satisfactory conditions for firing prevail, implies that no person outside the fenced and posted area of Bayo Canyon Site will be endangered by the shot. Group H-1 is responsible for any necessary clearance of personnel required from areas outside of the site."

The 1954 annual report, Group H-1 section (Ref. 101), states as an example of the year's activities that "Fifteen [we believe it was only 13, see Appendix A-1] RaLa Shots were detonated by GMX-5. In each case, weather control was provided . . . Post shot surveys were made and no instances of off-site personnel or inhabited area contamination were found."

The AEC Santa Fe Operations Office assured the AEC Director of Military Applications in 1956 (Ref. 102) that "No chance that the use of a 1000 Curie RaLa source in the . . . 150 pound HE confinement test [at Pantex] will create health . . . problem . . . in the area. The average Los Alamos unconfined Bayo tests with equivalent HE involves a RaLa source about three times the strength to be used in the confinement . . . test. None of the Bayo tests of this size has created a health . . . problem."

Shipman, under pressures related to the proposed housing areas on Barranca Mesa and, we believe, concerns of increasing RaLa source amounts, now began a series of memos (Ref. 103) suggesting alternatives to N. Bradbury. Two possibilities other than building a new Los Alamos firing site are as follows: "(1) Fire the Bayo shots with complete containment . . . and (2) fire them in Nevada." Shipman ends his case with the following, "Entire Bayo Canyon program has always been somewhat like a delinquent child, and yet I suppose we would be rather lonesome if it ever left permanently." Shipman's first suggestion was prophetic, as the RaLa program was moving towards completely contained shots in the early 1960s when the RaLa technique was discontinued.

Later in March 1959, Shipman addressed Bayo Canyon issues again to Bradbury (Ref. 104) in more detail, especially his concerns about moving the site. Shipman continued his argument in yet another memo to Bradbury (Ref. 105), which provides a map showing the newly surveyed area on Barranca Mesa in relation to Bayo Canyon. He warns, "Should this region become a residential area, it is very obvious I think that wandering children could easily come within missile range."

In the March-April 1959 H-Division progress report (Ref. 106), the Nuclear Field Test Section reports, "A survey of the last two years of shots at Bayo Canyon gives an average radius of intensity of 1 mR/h at two miles . . . [and] on occasion . . . at 5 miles . . ." This is not understood today in the light of the existing record. (See Appendix A-1.) For the 17 shots in this time range, 16 have recorded survey data and only 3 of these show readings in the 1 mR/h range at 1.5 miles from the firing point. It is difficult to get an average intensity of 1 mR/h at 2 miles, as reported, from these data. Except for a single particle that reached the Rio Grande on shot 192, there are no recorded readings of the order 1 mR/h at 5 miles or beyond at *any* time in the program. (See Appendix A-1.)

In August of 1960 Shipman was still lobbying for something to be done about Bayo Canyon; he suggested that it be a topic for the Laboratory Planning Council (Ref. 107). One point he makes is, "One such [Bayo] particle was found and proved capable of producing a very definite radiation burn on the skin of a rabbit." It is interesting to note that shot 244 that produced the "hot" particle was the last to produce any detectable radiation outside Bayo Canyon.

Bradbury reported to Burke[32] (Ref. 108), that " . . . there will be no problems with respect to construction activities in Subdivision #2 and we shall simply restrict our firings to conditions which cannot harm construction personnel in the area. We agree that by the time there are actual occupied houses in the eastern zone of Barranca Mesa Subdivision #2, we shall probably have to cease firing activities which could spread radioactivity. . . "

On the same day, perhaps in response to the previous letter to which he was an addressee, MacDougall reported to Bradbury (Ref. 109) that "Most (or all) of the shots fired recently in Bayo have been of the type . . . the ball [containing the RaLa] is supposed to stay intact . . . so that no radioactive material is released. This has, indeed, been true for all shots to date"

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[31]D. D. Meyer, leader of the Health Physics Group (H-1), 1950 to 1972.

[32]John Burke, area manager of the AEC, Los Alamos Office.

(from November 1960 to June 1961, and for the remainder of the RaLa program).

In February 1963, Hall[33] told Laboratory management (Ref. 110), "As of Dec 31, 1962 RALA [sic] may no longer be released to the Bayo Canyon atmosphere." Although there had not been a RaLa shot for almost a year nor one that released RaLa to the atmosphere for almost 2 years, this may be considered the official end of the RaLa Bayo Canyon story.

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[33]Jane Hall, technical associate director of the Los Alamos Scientific Laboratory, April 1950 to June 1970.

Document Research

The major portion of the radioactive fallout information related to Bayo Canyon was in a single box of Group H-1 records stored at the Los Alamos Records Center (Ref. 111). Most of the documents are one-of-a kind originals, including unanalyzed rough notes, often not dated or signed, occasionally dated incorrectly. A large fraction of the information in this record box concerns site operational health physics aspects (exposure of workers, decontamination) and, although not relevant to the task at hand, required review. Information related to the individual experiments (times, dates, source size) often was found or confirmed using these data. Also in this box was an incomplete selection of documents related to Bayo Canyon, mostly administrative in nature, all of which were found in other more complete collections. The collection of the monthly reports of the several Health Division groups, principally H-1 (Radiologic Physics) and H-6 (Biophysics), produced very little "new" information not recorded in the original data but did provide some summary information and insight into contemporary thinking, not always obvious in the raw data.

The relevant records of the weapons program were searched, primarily those of GMX-5 (for shot number, date and time, high explosives content, source size), CMR-10 (for source size and impurity data, dates), J-Division (for elusive information about the Air Force instrumentation), and the several predecessors and offspring of each of these organizations. Not an insignificant challenge in the record search was tracking the many organizational changes over the 18 years of the Bayo Canyon experiments. This task was made immeasurably easier by the Los Alamos archivist's "green books" (which became "blue books" during our tenure), where the organizational history of the Laboratory is tracked. Other collections searched included the Director's files, the Los Alamos archives, and the Los Alamos Legal Support Center (using related keywords).

One author of this report made a brief visit to Hanscom Air Force Base in Massachusetts, site of the Philips Laboratory, formerly the AFCRL, to search for additional information on the B-17 flights and instrumentation. Finally, a number of gaps in information concerning primarily early barium shipments from Clinton Laboratory were filled by documents obtained directly from Oak Ridge National Laboratory.

Dose Assessment

This section was prepared by the authors listed in Ref. 112.

Two dose reconstructions were performed: the first was to determine in detail the dispersion and radiological effect of the shots tracked by the Air Force B-17 and the second was to evaluate the "overall" radiological impact of the RaLa series to local inhabitants.

In the detailed evaluation, computer modeling and dose assessment were conducted for RaLa shots 146 through 149, in which a total of 5.6 kCi of lanthanum-140 and lesser amounts of barium-140, strontium-89, and strontium-90 were dispersed. These releases were concurrent with cloud-tracking missions flown by the Air Force in 1950 (see above). The objectives of the modeling and dose assessment for these four shots were to model the explosives release, determine the initial dispersion and deposition of materials from the detonation cloud, evaluate the potential for long-range atmospheric transport, and estimate radiation exposures and subsequent health risk to nearby residents. The Explosive Release Atmospheric Deposition (ERAD) model, developed at Sandia National Laboratories, was used to simulate the high-explosive release and the immediate dispersal and deposition of radioactive particles. The potential for long-range transport was examined using the Regional Atmospheric Modeling System (RAMS), originally developed at Colorado State University. Output from ERAD was used for the RAMS source term.

Results showed that radioactive particles generated by the detonations were lofted to heights above the atmospheric-mixing layer, thus were subject to long-range dispersion. Although long-range atmospheric transport out to 100 km and farther was demonstrated by the RAMS model, predicted air concentrations were at or below the detection limit of today's radiation-monitoring equipment. These results would appear to call into question the Air Force cloud-tracking mission measurements. Results also showed that external exposure to ground-deposited lanthanum-140 dominated the total dose. The doses received by members of the public in the northern New Mexico communities of Los Alamos, Española, Pojoaque Pueblo, San Ildefonso Pueblo, and Santa Clara Pueblo for any one of these four experiments were 1 mrem or less.

For the overall dose assessment for the entire RaLa series, the information available in Appendix A.1 was used. Detailed meteorological data were available for only some 40 shots, so statistically representative meteorological data had to be developed for the modeling. A wind rose was developed specific to the afternoon-evening time of the majority of the shots, and the wind frequency in each sector was used to determine the fraction of activity dispersed towards each hypothetical receptor. A methodology was followed to calculate the realistic maximum doses to permanent inhabitants and others who might have been in public access areas. HOTSPOT 7, a Gaussian plume-based dispersion model, was used to determine the average dose per sector per curie of shot radioactivity.

The dose from penetrating radiation from ground-deposited lanthanum-140 was greater than from inhalation and immersion in the cloud by several orders of magnitude. The representative meteorological data predicted that the highest expected doses to an average permanent resident would have occurred in Los Alamos. The highest annual dose was calculated to have occurred in 1955 and was approximately 17 mrem. Assuming an individual had been at the Los Alamos site continuously throughout the experiments, the total calculated dose to the hypothetical individual from the 18-year RaLa series would have been approximately 110 mrem. The average dose in Los Alamos was calculated to be 6 mrem/yr. Doses at nearby Totavi trailer camp, San Ildefonso Pueblo, and Santa Clara Pueblo were approximately 70%, 30%, and 20%, respectively, of those doses at Los Alamos, again assuming continuous occupancy. Visitors to nearby public areas received negligible doses.

A detailed presentation of the dose reconstructions is in preparation (Ref. 112).

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Biographical Footnotes in Alphabetical Order

Luis W. Alvarez, Ordnance Engineering Division, E-11 RaLa; later, leader of Electric Detonators Group (G-7).

Lt. Commander A. F. Birch, Ordnance Engineering Division, leader of Proving Ground Group (E-1), March 1944 to August 1944; leader of Gun Group (O-1), August 1944 to August 1945; Safety Committee member.

Lt. Commander N. E. Bradbury, physicist in Los Alamos Explosives Division, leader of the Implosion Research Group (X-1), August 1944 to March 1945; leader of X-6, March 1995 to October 1945; Safety Committee member; Director of the Los Alamos Scientific Laboratory, 1945 to 1970.

John Burke, area manager of the AEC, Los Alamos Office.

Stanley W. Burriss, military liaison officer, M-4 Group.

R. E. Cole, AEC, Santa Fe Operations Office, Engineering and Construction.

Samuel C. Coroniti, Atmospheric Physics Laboratory, Air Force Cambridge Research Laboratories; author of the three AFCRL reports on air conductivity measurements.

Major Delmar Crowson, Air Force officer; later, director of military applications for the AEC.

Francis J. Davis, Oak Ridge National Laboratory scientist; involved in measurements of radioactivity from aircraft.

David Dow, leader of A-1 Group, January 1944 to February 1946; leader of H Division, May 1947 to May 1948; assistant to the Los Alamos Director for nontechnical administrative functions.

Major Eddy, Air Force meteorologist assigned to the Los Alamos Radiologic Safety Group.

Gerhart F. Friedlander, leader of the RaLa Chemistry Group (CM-14), Los Alamos Chemistry and Metallurgy Division, April 1945 to October 1945; leader of Radiochemistry Group (C-4), October 1945 to January 1946.

General Leslie R. Groves, military leader of the Manhattan Engineering District, September 1942 to December 1946.

Jane Hall, technical associate director of the Los Alamos Scientific Laboratory, April 1950 to June 1970.

Dr. Louis H. Hempelmann, physician from Barnes Hospital, St. Louis, Missouri; leader of the Los Alamos Health Group (A-6), July 1944 to December 1945; leader of A-10 Group, August 1946 to May 1947; during the Manhattan Project, responsible to the Laboratory Director.

Joseph G. Hoffman, physicist in Explosives (X) Division; later, H-Division, Health Physics Section, June 1944 to November 1946, terminated April 1947.

Colonel B. J. Holzman, Air Force meteorologist; later, participated in atmospheric tests in the Pacific Ocean.

Henry Hoyt, assistant director for administration, Los Alamos Scientific Laboratory, November 1946 to October 1970.

David Lipkin, organic chemist, leader of the Corrosion Protection Group (CMR-7), October 1945 to July 1946; Safety Committee member.

Duncan MacDougall, leader of GMX Division, responsible for the Bayo Canyon shots, August 1948 to September 1970; assistant director for weapons, September 1970 to July 1972; associate director for weapons, July 1972 to September 1976.

D. D. Meyer, leader of the Health Physics Group (H-1), 1950 to 1972.

Donald Mueller, physicist, post-war group leader of the RaLa Bayo Canyon experimenters (GMX-5), August 1948 to June 1963.

J. Robert Oppenheimer, theoretical physicist, Director of Manhattan Project Y at Los Alamos Laboratory, November 1942 to October 1945.

Lyman G. Parratt, Cornell University physicist, Ordnance Engineering Division, leader of Instrumentation Group (E-2), March 1944 to August 1944; leader of X-Ray Method Group (G-2), August 1944 to October 1945.

Bruno Rossi, Los Alamos Weapons Physics or G Division (G for gadget, code for weapon), leader of the RaLa Method Group (G-6), August 1944 to August 1945.

John W. Schulte, chemist, leader of Los Alamos CMB-DO-GS, the group responsible for preparing the RaLa sources near the end of the program.

Emilio G. Segrè atomic physicist, leader of Radioactivity Group at Los Alamos Laboratory, April 1943 to October 1945.

Robert Serber, University of California theoretical physicist, Theoretical Division, leader of T-2 Group, September 1943 to November 1945.

Thomas L. Shipman, physician, leader of the Los Alamos Laboratory Health Division, 1948 to 1969.

Simon Shlaer, Los Alamos biophysicist, leader of Biophysics Section, Radiologic Safety Group (H-1), March 1947 to September 1967.

Ralph G. Steinhardt, Jr., health technician for early Bayo Canon operations, February 1944 to March 1946.

Thomas N. White, Los Alamos physicist, leader of Radiologic Safety Group (H-1), August 1948 to December 1951; leader of Special Dosimetry Group (H-6), July 1951 to September 1955.

P. H. Wykoff, director of the 4.0 Program (for Operation Greenhouse), AFCRL.

Appendix A. Bayo Canyon RaLa Shots and Radiation Measurements

A-1. Tabular Summary of Bayo Canyon RaLa Shots

A-2. Discussion of Specific Shots and Radiation Measurements

A-3. References (Shot Numbers) for Appendix A-2

A-1. Tabular Summary of Bayo Canyon RaLa Shots

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
1	09/21/44	~1610	~25[b]	C				
2	10/04/44	1937	120	C				
3	10/14/44	1651	60	C				
4	10/26/44	1540	185	C				
5	11/03/44	~1645	113	C				e
6	12/01/44	1630	280	C				e
7	12/10/44	0635	90	C				e
8	12/14/44	2158	110	C				e
9	12/20/44	1445	82	C				e
10	12/28/44	1535	47	A				e
11	02/07/45	1310	220	C				e
12	02/13/45	1945	240	C				e
13	02/18/45	1626	240	E				e
14	02/24/45	1644	135	E				e
15	03/03/45	2226	70	E				e
16	04/01/45	1645	290	E				e
17	04/09/45	0120	530	C	ESE			e
18	04/15/45	2035	215	C	ESE			e
19	04/20/45	1841	220	E				
20	04/26/45	2143	150	C				
21	05/22/45	1547	620	E				
22	05/26/45	1700	450	E				
23	05/30/45	1500	342	C				
24	06/04/45	1630	900	C				
25	06/08/45	1545	795	E				
26	06/13/45	1535	569	C				
27	06/16/45	1508	367	C				e
28	06/22/45	1530	1060	E				
29	06/26/45	1724	737	E				
30	06/29/45	1700	393	E				

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
31	07/06/45	1718	343	E				
32	07/14/45	1715	190	C				
33	08/03/45	2145	471	E				
34	08/10/45	1531	240	B				
35	08/15/45	1530	168	B				
36	08/24/45	1556	1200	E				
37	09/01/45	1620	1050	E				
38	09/08/45	1740	628	C				
39	09/13/45	1615	440	C				
40	09/20/45	1415	380	C				
41	09/25/45	1740	1291	E				
42	10/01/45	1716	772	E				
43	10/06/45	1605	446	C				
44	10/12/45	1620	516	C				
45	12/14/45	1655	345	C				
46	12/28/45	1620	1340	E				
47	01/04/46	1628	954	E				
48	01/11/46	1600	647	E				
49	01/17/46	1530	459	C				
50	01/24/46	1610	1712	E	W		0.046 mR/h at 2 miles	[e]
51	01/31/46	1555	1057	C				
52	02/07/46	1537	654	E				
53	02/14/46	1602	454	C				
54	03/21/46	1520	1034	E				
55	03/28/46	1447	848	E				
56	04/12/46	1555	315	C				
57	04/25/46	1520	1324	E				
58	05/02/46	1500	890	E				
59	05/09/46	1440	600	C				
60	05/16/46	1535	279	C				
61	05/23/46	1440	1274	E				
62	05/29/46	1450	931	E				

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
63	06/06/46	1445	539	E				
64	06/27/46	1440	1494	E				
65	07/03/46	1625	976	E				
66	07/11/46	1423	702	C				
67	07/18/46	1530	516	C				
68	08/28/46	2245	1026	E				
69	12/19/46	1640	1261	E				
70	12/27/46	2202	610	E				
71	01/03/47	1920	467	E				
72	03/10/47	2200	570	E				
73	03/14/47	1758	720	E				
74	03/19/47	1952	630	E				
75	04/11/47	0140	480	E				
76	04/16/47	1832	640	E				
77	05/06/47	1540	1341	E				
78	05/13/47	1655	1141	E				
79	05/21/47	1926	574	E				
80	06/18/47	1438	170	E				
81	06/25/47	1319	1290	E				
82	07/02/47	1800	1320	E				
83	07/10/47	1703	851	B				
84	07/30/47	1850	1070	E				
85	08/06/47	1706	700	E				
86	08/13/47	1545	680	B				
87	08/27/47	2022	1610	E				
88	09/04/47	1655	925	E				
89	09/11/47	1625	670	E				
90	09/18/47	1420	438	B				
91	10/29/47	1543	1670	E				
92	11/05/47	1522	946	E				
93	11/12/47	1543	730	E				
94	11/27/47	1755	720	E				

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
95	12/03/47	1735	1056	E				
96	12/10/47	1816	706	E				
97	12/18/47	1529	619	E				
98	01/29/48	1436	1240	E				
99	02/05/48	1906	1010	E				
100	02/19/48	1459	590	E				
101	02/27/48	1440	310	E				
102	04/01/48	1630	980	E				
103	04/09/48	1517	620	E				
104	04/16/48	1455	400	E				
105	08/04/48	1626	590	E				
106	08/12/48	1540	771	E	SW			e
107	08/19/48	1625	547	E				
108	09/10/48	1721	1735	E				
109	09/21/48	1543	1006	E				
110	09/28/48	1538	487	E				
111	10/07/48	1410	362	E				
112	10/14/48	1442	205	E				
113	10/21/48	1411	123	A				
114	12/01/48	1608	480	E	S			e
115	12/08/48	2039	463	E				
116	12/15/48	1345	317	E	E	10	0.76 mR/h at 0.25 miles	
117	01/25/49	0405	452	D				
118	02/01/49	1630	487	E				
119	03/04/49	1359	693	E				
120	03/08/49	1413	604	E				
121	03/31/49	1647	1096	E				
122	04/20/49	1846	422	E				e
123	04/27/49	2045	1244	E				
124	05/04/49	2045	1740	E				
125	05/11/49	1950	1393	E				
126	05/17/49	2030	871	E				

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
127	05/20/49	1830	588	E	ESE	10		e
128	06/02/49	1417	1933	E	N	12	1.5 mR/h at 1.5 miles	e
129	06/06/49	2206	1630	E	SE		1.5 mR/h at 2.5 miles	e
130	06/10/49	0933	1280	E	NW	6		e
131	07/28/49	1204	1387	E	N, NE			
132	08/03/49	1258	936	E	N, NE			
133	08/09/49	0957	713	E	N, NE			
134	08/31/49	1200	715	E				
135	09/14/49	1202	356	E				e
136	09/23/49	1018	346	E	SE	8		e
137	10/19/49	1007	1385	E	N, NE	15-20		e
138	11/02/49	1205	1614	E	W		0.8 mR/h at 2.5 miles	e
139	11/08/49	1243	1064	E	NE	7-9		e
140	12/08/49	1532	2635	E	NE	8-12	0.6 mR/h at 2 miles	
141	12/16/49	1739	1539	E	NW	2-3		e
142	12/22/49	1632	1132	E	SW	3-5		e
143	01/13/50	1248	2065	E	E, SE	25		
144	01/17/50	1347	1715	E	N to E	4-7		
145	01/24/50	1138	1737	E	E, NE	25-30		e
146	01/31/50	1417	981	E	E, NE	9-17		
147	03/24/50	1323	1665	E	E	28-42		
148	03/29/50	1416	1743	E	W, WNW, NNE, NE, E	2-8	0.2 mR/h at 3 miles	e
149	04/06/50	1330	1306	E	NNW, NNE	18-37		
150	04/20/50	1431	3334	E	N, NW	4-12		
151	04/26/50	1400	2496	E	E, SE	5-30		
152	05/12/50	1359	1355	E	S, SW	10-15		
153	05/24/50	1152	391	E	NE	6-15		
154	07/13/50	1410 DST	1000	E	NE to N	8-26		
155	03/26/52	1652	270	B	SE	20	0.15 mR/h at 1.5 miles	e
156	08/11/52	1755	2400	B				e

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
157	08/21/52	1151	2900	B	N			e
158	08/29/52	1259	800	B	E, NE			e
159	06/10/53						shot not fired, explosive burned	
160	08/14/53	1402	600	B	SE	10		e
161	09/10/53	~1400	250	A				
162	10/09/53	~1300	215	A				
163	02/12/54	1620	2730	B	NE			e
164	03/08/54	1615	2000	B	E			
165	03/19/54	1130	150	B				
166	04/14/54	1345	190	B	SE		no radiation detected	e
167	07/31/54	1605	1400	B	SE		1.5 mR/h at 2.25 miles	e
168	08/05/54	1830	1500	B	NE		0.4 mR/h at 2.5 miles; 0.15 mR/h at 12 miles	e
169	09/09/54	1518	265	B	S		1.1 mR/h at 1 mile; 0.45 mR/hr at 2 miles; 0.3 mR/hr at 2.5 miles; 0.18 mR/hr at 4 miles	e
170	09/16/54	1458	300	B	NW		no radiation detected	e
171	11/04/54	1335	2200	B	N	7	0.3 mR/h at 1.5 miles	e
172	11/16/54	1500	2440	B	E		0.3 mR/h 3.5 miles; 0.2 mR/h at 5 miles	e
173	12/02/54	1645	1585	B	NNW		1 mR/h at 1.5 miles	e
174	12/09/54	1604	500	B				
175	12/30/54	1445	320	B	NE		no radiation detected	e
176	01/06/55	1415	134	B	NE		0.7 mR/h at 1.5 miles	e
177	01/12/55	1415	180	B	NNE		0.12 mR/h at 1.3 miles	e
178	03/17/55	1255	3160	C	NE		no radiation detected	e
179	03/23/55	1315	2260	B	NE	10-15	0.3 mR/h at 3 miles	e
180	03/30/55	1315	2642	B	NE	7-10	0.6 mR/h at 2 miles	e
181	04/07/55	1522	2080	B	N	5	0.7 mR/h at 1.2 miles	e
182	04/22/55	1810	700	B	N		0.4 mR/h at 1.5 miles	e
183	04/28/55	1515	3200	B				
184	05/05/55	1540	2560	B	NE		0.2 mR/h at 2 miles	e

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
185	05/12/55	1625	2100	B	NE	10	no radiation detected	e
186	05/20/55	1845	1470	B	NE		0.5 mR/h at 1.5 miles	e
187	05/26/55	1154	520	B	N	4-7	1 mR/hr at 1.2 miles	e
188	06/02/55	1345	490	B	NE	10	0.16 mR/h at 1.5 miles	e
189	09/16/55	1455	2600	B	E		0.2 mR/h at 2 miles	e
190	09/28/55	1631	2600	B	NE	10		
191	10/07/55	1515	2200	B	NNE	light	2 mR/h at 1.5 miles	e
192	10/19/55	1720	2000	B	E		0.5 mR/h 6 miles	e
193	10/26/55	1630	3987	B	NE		1 mR/h at 3 miles; 0.1 mR/h at 10 miles	e
194	11/03/55	1605	3500	B	NNE	7	1.6 mR/h at 1.5 miles; 3.0 mR/h at 2 miles; 0.2 mR/h at 5 miles	e
195	11/17/55	1354	1600	A	NE	8-10	0.65 mR/h at 1.5 miles; 0.3 mR/h at 2 miles	e
196	11/29/55	1535	780	A	NE	5-7	0.7 mR/h at 1.5 miles; 0.4 mR/h at 2 miles	e
197	01/27/56	1443	1300	A	E		no radiation detected	e
198	02/21/56	1805	2100	B	E		0.7 mR/h at 3 miles	e
199	03/01/56	1540	1400	B	NE	7	1.0 mR/h at 2 miles	e
200	03/09/56	1730	435	B	E	10-12		
201	03/14/56	1345	560	B			no radiation detected	e
202	03/22/56	1330	389	B	NNE		0.15 mR/h at 2.2 miles	e
203	04/07/56	1730	1520	A	ESE	8	1.0 mR/h at 4 miles	e
204	04/12/56	1455	3740	A	N	12	0.7 mR/h at 1.5 miles; 0.07 mR/h at 5.5 miles	e
205	04/20/56	1436	3200	B	NNE	8	0.4 mR/h at 2.5 miles	e
206	04/26/56	1140	2195	A	NE	5	no radiation detected	e
207	05/10/56	1145	1070	A			no radiation detected	e
208	05/21/56	1300	4000	A	NW		0.15 mR/h at 1.5 miles	e
209	05/25/56	1155	4195	B	N		0.8 mR/h at 1.5 miles; 1.2 mR/h at 2 miles	e
210	06/07/56	1455	2907	B	NE		0.7 mR/h at 1.5 miles	e
211	06/14/56	1305	1840	B	WSW	light (5)	no radiation detected	e
212	10/05/56	1428	2200	A	NW, N	13	1.3 mR/h at 1.5 miles; 1.3 mR/h at 2 miles	e

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
213	10/16/56	1534	1400	A	NNW	5	0.8 mR/h at 2 miles	e
214	10/27/56	1420	300	B	N	10	0.5 mR/h at 1.5 miles	e
215	11/01/56	1023	200	B	N	9	0.3 mR/h at 1.5 miles; 0.15 mR/h at 2.3 miles	e
216	12/05/56	1500	800	A	N	17	1.0 mR/h at 1.5 miles	e
217	12/20/56	1450	225	A	W, SW	3	1 mR/h at 0.6 miles; 0.3 mR/h at 1 mile; 0.5 mR/h at 2 miles	e
218	03/16/57	1245	2140	A	N	15		
219	03/29/57	1250	3079	A	E	6	0.1 mR/h at 3 miles; 0.07 mR/h at 7 miles	e
220	04/17/57	1630	3249	B	E	12	0.4 mR/h at 4.5 miles	e
221	05/09/57	1600	1000	B	SE	7	no radiation detected	e
222	06/20/57	1540	1000	B	NE	12	no radiation detected	e
223	07/10/57	1625	2257	A	NNW	8	0.6 mR/h at 1.5 miles	e
224	07/23/57	1306	1520	A	N	8	0.6 mR/h at 1.5 miles; 1.0 mR/h at 2.2 miles; 0.08 mR/h at 4 miles	e
225	09/27/57	1607	1960	B	N		0.8 mR/h at 1.5 miles	e
226	10/10/57	1726	1153	B	NE	7	0.3 mR/h at 2.2 miles	e
227	01/30/58	1302	1340	A	E	13	0.16 mR/h at 3 miles	e
228	02/19/58	1545	1850	A	NNW	5	5 mR/h at 1.5 miles	e
229	03/07/58	1655	1800	A	NNW		1.0 mR/h at 1.5 miles	e
230	04/03/58	1505	1100	B	NW, NE	5	no radiation detected	e
231	05/01/58	1430	1134	B	NNW	10		
232	06/03/58	1450	1316	B	NE	12	0.18 mR/h at 2 miles	e
233	12/08/58	1545	1305	A	N		1.4 mR/h at 1.5 miles	e
234	02/20/59	1335	1250	A	N		0.18 mR/h at 1.5 miles	e
235	03/13/59	1405	1070	A			no radiation detected	e
236	04/02/59	1635	980	A	ESE		0.6 mR/h at 3 miles	e
237	04/14/59	1250	1140	B	N		0.4 mR/h at 1.7 miles	e
238	05/15/59	1547	1040	B	ESE			e
239	06/04/59	1527	995	B	ENE		0.4 mR/h at 2.7 miles	e
240	06/26/59	1400	954	B	E		0.12 mR/h at 2.5 miles	e

A-1. Tabular Summary of Bayo Canyon RaLa Shots continued

Shot Number	Date	Time[a]	RaLa Curies	Explosive Quantity[c]	Cloud Track Direction[d]	Wind Speed (mph)	Maximum Radiation Measured at Distance (mR/h)	Remarks
241	10/07/59	1438	893	B	ENE	12	0.12 mR/h at 3 miles	[e]
242	03/08/60	1648	908	B	S		0.4 mR/h at 2.5 miles	[e]
243	05/04/60	1618	957	B	ENE		1.3 mR/h at 2.1 miles	[e]
244	09/01/60	1300	1120	B	N, NW		0.3 mR/h at 1.2 miles; 0.3 mR/h at 2 miles	[e]
245	10/11/60	1408	1100	A				[e]
246	11/22/60	1214	1475[f]	B				[e]
247	02/17/61	1650	7090[f]	A				[e]
248	05/19/61	1314	3902[f]	A				[e]
249	06/20/61	2019	5300[f]	A				[e]
250	10/11/61	1302	3870[f]	A				[e]
251	11/17/61	1430	4150[f]	A				[e]
252	01/30/62	1908	6077[f]	A				[e]
253	02/02/62	1341	1590[f]	A				[e]
254	03/06/62	1330	5940[f]	A				[e]

[a] The times listed here were taken directly from documents prepared by the original Los Alamos investigators involved in the RaLa experiments.

[b] Also recorded as ~30, 40, and 60 curies.

[c] TNT equivalent: A—20 to 100 lbs
B—101 to 200 lbs
C—201 to 350 lbs
D—351 to 600 lbs
E—601 to 750 lbs

[d] Direction fallout would travel.

[e] See A-2 for additional information.

[f] For these experiments, the configuration was such that the RaLa source remained intact. There was no dispersion of radioactive material.

A-2. Discussion of Specific Shots and Radiation Measurements

This section draws extensively from historical documents, such as reports and memos, prepared by the experimenters and other people involved in the radioactive lanthanum (RaLa) shots. Where a shot number is missing in the text below, no measurements or fallout data were found in the historical documents reviewed. To help locate places mentioned in the text, please refer to the map at the end of this section.

During the time of the RaLa experiments (1944 to 1962), radiation readings presented in milliroentgens per hour were abbreviated as mr/hr. Therefore, direct quotes from the original documents have radiation measurements in mr/hr, whereas the rest of the text uses today's convention, mR/h.

All radiation readings were taken with an open-shield Geiger-Mueller (GM) detector calibrated to radium. Readings were taken at waist height, and natural background radiation was not subtracted unless otherwise noted. Those readings are recorded when known.

Shots #5-16 For each of these shots, an air sampler was set up at the edge of Los Alamos Mesa at dwelling T-846, near the present corner of Rim and Canyon Roads, which was the nearest habitation to the firing point. The purpose was apparently to detect any radioactivity that might be carried to the Los Alamos town site, although whether or not Los Alamos was downwind was not recorded. The air samplers were run during each shot and for some time after the shot was fired. The results of each sample were negative, indicating that no radioactivity from these shots reached the town site. The date for one of the air samples was recorded as March 31, 1945; however, no shot was fired on that date. Since shot #16 was fired on April 1, 1945, the March 31, 1945, date is believed to be in error. (Ref. A.1)

Shot #17 An air sampler was run on Los Alamos Mesa (location unknown) during the shot and for 8 hours afterward. No activity was found. (Ref. A.2)

Shot #18 An air sampler was run at Technical Area 1 (TA-1, the main technical area) for 24 hours to check for contamination. A reading of 50 counts per minute (cpm) gamma radiation was found. "This was the first time that any airborne contamination [associated with Bayo Canyon] was picked up on the mesa." (Ref. A.3)

Shot #27 A high-capacity air sampler was run at the edge of Los Alamos Mesa in front of civilian dwelling T-843 (probably T-846). Thirteen thousand five hundred (13,500) liters of air were sampled, and the beta plus gamma activity on the filter was less than 10 cpm (background). Another sampler was set up at TA-1 in front of Q Building. Results were also negative. (Ref. A.4)

Shot #50 The cloud from the shot drifted toward TA-1. Gamma radiation measurements throughout the technical area ranged from 0.028 to 0.046 mR/h. Normal background is about 0.028 mR/h. (Ref. A.5)

Shot #106 No activity above background was measured in the vicinity of the airstrip (now Los Alamos Airport). The roads north and south of the airstrip were checked. A film badge planted at the east end of the airstrip had only 0.003 R exposure, which is close to the limit of sensitivity for this device. (Ref. A.6)

Shot #114 T. N. White (leader of H-1) observed the cloud to drift a few points west of south and most of it appeared to settle down into Pueblo Canyon, just north of main hill road. White also saw a wisp go over Emilio Segré's old laboratory (East Gate Laboratory) at the extreme eastern end of Los Alamos Mesa. White went there with a Victoreen Model 263 radiation survey meter and was able to locate activity at the tip of the mesa. A few specks gave a reading that was close to the maximum with the beta shield open (20 mR/h). There was no activity a hundred feet or more to the west of the mesa tip. Following this observation, White expressed concern to D. Mueller, the leader of the Bayo Canyon experimenters, that it was undesirable to set off shots without regard to wind direction and velocity. (Ref. A.7) Mueller answered White's memo: "I assume that no direct danger is indicated by this first observation of activity outside the canyon [actually this was the third time radioactivity had been detected out of the canyon; see shots #18 and 50]. I do feel that this observation makes it desirable to conduct further surveys on the contamination patterns for Bayo shots, as a function of meteorological situations." (Ref. A.8)

Shot #122 A monthly progress report of the Health Division stated, "The radioactive cloud from the Bayo shot of April 20 passed over and contaminated the area of the main gate to Los Alamos. The Fire Department washed off the most heavily contaminated section of the road shortly thereafter." No survey report has been found. (Ref. A.9)

Shot #126 A day after the last Bayo Canyon shot (#126) "activity was discovered at a point about two miles north of the Bayo firing site. The general background activity [meaning contamination] in this area was of the order of 1 mr/hr beta plus gamma . . . " (presumed to be at waist height). (Ref. A.10)

Shot #127 The cloud from the shot crossed State Road 4 between Station 101 (a temporary guard gate at the access road to Bayo Canyon) and the McKee Trailer Camp on State Road 4. Roadblocks were established at the Main Gate and lower Bayo Canyon road junction with the main hill road. Following the shot, the blocked-off section of the road and a section running about one mile east were monitored and found to be free of contamination; the roadblocks were removed. Shortly thereafter a second monitoring patrol discovered contamination on the road to the east of Frijoles Junction (the White Rock Y at the intersection of main hill road and State Road 4), which had previously been thought to be clean. Roadblocks were re-established at the Main Gate. The most heavily contaminated stretch of road ran about 0.75 miles east of Frijoles Junction. The highest readings were 5 to 10 mR/h and were believed to be taken 12 inches from the ground rather than at waist height. (Ref. A.11) In a memo to N. Bradbury (Laboratory director), T. Shipman (leader of the Health Division) further explained the events of May 20, 1949, and the need for the road blocks. (Ref. A.12)

Shot #128 "Flypaper and pans [adhesive fallout collectors] distributed in Guaje Canyon previous to the shot were collected approximately two hours afterwards and were found to have no contamination. The following afternoon, however, approximately 15 mr/hr beta and gamma background [assumed at 12 inches] was found in the region over which the cloud passed." Because "the meteorologist estimated that the cloud reached this position about five minutes after the shot," the conclusion can be reached that the flypaper and pans were not located in the main path of the fallout. (Ref. A.13)

Shot #129 Adverse weather continued until after the shot. "An attempt was made by Health Division personnel to postpone the shot until such time that conditions were more favorable, but the decision was made to continue." Immediately after the shot it became apparent that a portion of the main road to Los Alamos (today designated as State Road 502) would become contaminated. Road blocks were placed at the west end of the airstrip, the junction of State Road 4 and Sandia Canyon, and above Totavi Camp. Monitoring operations were begun immediately on the main road. The main area of contamination was found to be from the pump house at the Bayo Canyon turnoff to 0.5 miles above Totavi, a distance of about 1.5 miles. The highest reading obtained was about 15 mR/h beta plus gamma at the main hill road and State Road 4 junction. Note that this measurement was taken at 12 inches above the road surface rather than at the usual 3 feet as was adopted later. (Ref. A.13)

Shot #130 "Considerable effort was made by all persons involved to plan this particular operation so that the difficulties encountered in previous operations would not be present." Continuous weather predictions were done until after the shot. "The cloud drifted off in a northwesterly direction.... Although the main portion of the cloud did not pass over any of the previously placed trays and flypaper in Guaje Canyon, a small amount of background was found seven hours later on two of them located at one edge of the cloud path." (Ref. A.13)

Shot #135 Flypapers placed on North Ridge (the closest northern approach to Bayo Canyon, about 0.5 miles north, a little west, and 400 feet above of the firing site) about 50 paces apart read 3 to 4 mR/h at 1 inch with a closed-shield GM survey meter. (Ref. A.14)

Shot #136 Nine flypapers placed on North Ridge read 0.15 to 1.0 mR/h at 1 inch with a closed-shield GM survey meter; the maximum reading was recorded 300 paces from the eastern-most station; the pattern appears to be skewed to the west. (Ref. A.14)

Shot #137 Flypapers placed on North Ridge read from 0.1 to 0.3 mR/h at 1 inch, measured with a closed-shield GM survey meter. The maximum flypaper reading was recorded 150 paces west of the eastern edge of the array. The ground measured 0.07 mR/h near and in good agreement with one of the flypapers, which read 0.1 mR/h. The dose rate recorder at the same location reached 1.5 mR/h as the cloud passed. A survey made the next day in Rendija Canyon about a mile east of the Sportsman's Club showed a maximum of 0.07 mR/h. (Ref. A.14)

Shot #138 T. Shipman reports, "An abrupt and temporary shift in the wind . . . resulted in blowing the cloud . . . across the Technical Area [TA-1]. As far as health and safety are concerned, no significant levels of radiation have been found. There is, however, sufficient contamination so that the background in certain counting procedures may be disturbed." (Ref. A.15). "Demonstrable contamination was found as far away as Camp May, a distance of ten miles [west], but at no place were levels of contamination found to be very high." (Ref. A.16) During this document review, no survey results were found. Levels of radiation were three times background at the Base Radio Station on North Mesa. The tip of Center Mesa (an unidentified area in the town site) read 0.6 mR/h; the Chapel Apartment area on Rose Street of the town site read 0.8 mR/h; Manhattan Loop (eastern residential area) read 0.3 to 0.4 mR/h; the peak at the main gate was 1.0 mR/h gamma (1.5 mR/h, beta plus gamma). Measurements made on North Ridge were all background. (Ref. A.17)

Shot #139 The cloud moved west up canyon and then northeast, missing the North Ridge flypaper array. No record of radiation measurements in surrounding areas was found. (Ref. A.14)

Shot #140 Readings from the North Ridge flypapers ranged from background to 2.5 mR/h at 1 inch measured with a closed-shield GM survey meter. The maximum reading was found on the station placed 50 paces from the eastern end of the nine-station array. Air samplers and recording gamma detectors placed close to the air sample filter during collection were operated at Points Claim, Wallop, and Pluto, located on "a broad mesa to the north and a little under two miles from the point of dispersal" (Bayo Canyon). These locations are not known precisely, but Point Claim, also labeled 24 in Ref. A.14, is the furthest east, 0.3 miles west, and 400 feet above Point 35 (which is in Guaje Canyon). Point Wallop (labeled 21 in Ref. A.14) recorder data were suspect, and the collected air sample showed only background activity.

The Point Pluto (labeled 23) recorder showed cloud passage and the collected air sample was "3X normal = 0.015 mr/hr." At Point Claim, the cloud passed, and a sample read "0.6 mr/hr gammas only." Guaje Canyon was monitored the next day and a maximum of 0.2 mR/h was found "opposite Pt. Claim." Also recorded are some "GMX-5 data giving 1.2 mr/hr in Rendija Canyon N of 12 and 0.5 mr/hr N of 10." (GMX-5 is the experimental group that conducted the RaLa tests.) Locations 12 and 10 are unknown. A calculation using the Point Claim air sample compared the results to the then-accepted tolerance levels and was found to be a small fraction of these tolerance levels. Also, one cascade impactor run showed over half of the activity collected to be about 1 micron in diameter. (Refs. A.14, A.18–A.21)

Shot #141 The maximum reading on flypaper on North Ridge read 1 mR/h at 1 inch, measured with a closed-shield GM survey meter. The cascade impactor at Point Claim showed most of the activity to be collected on the final (filter) stage, 0.7-micron particles if density 2.5 is assumed. Another handwritten description of the December 16 shot exists and has some valuable contemporary thinking comparing RaLa with radium and some dimensional help. But, again, all discussion was aimed, as were the previous flypaper measurements, at showing whether providing an asphalt pad under the shots would reduce fallout. It apparently did. The writer calculated the effect of the worst-case (wind conditions, RaLa source size) fallout on the Guaje reservoir (a partial source of Los Alamos water at that time) to be 0.1 µCi/L. This measurement from Hamilton's Table, Chapter XII of the Project Handbook (the contemporary tabulation of permissible levels of radioactivity), gives 1 mR/day for continuous intake. (Refs. A.14 and 18)

Shot #142 A "mild degree of contamination" was recorded in some parts of TA-1. No health hazard occurred; however, background activity may have been elevated enough to affect some TA-1 laboratory counting procedures. (Ref. A.22)

Shot #145 The cloud from the shot remained in Bayo Canyon. (Ref. A.23)

Shot #147 A B-17 flight took place.

Shot #148 ". . . a slight amount of contamination from fall-out was observed throughout the town site and Tech Area [TA-1]" following shot #148. It was obvious that weather conditions would not be ideal at shot time, but there was reluctance to cancel the shot for the day since weather predictions for the remainder of the week were no better. The Health Division authorized continuation of the operation. "The vast majority of it [the cloud] apparently moved out to the northwest toward the upper portions of Guaje Canyon. A small portion of the cloud . . . took a southerly course and left detectable contamination in parts of the Los Alamos housing area (particularly in the Denver steel area), [which was the housing area closest to Bayo Canyon] and also in the Tech Area. The average levels of activity found were in the vicinity 0.2 mr/h [Beta + gamma]. . . .There certainly is no reason to feel that the situation produced any health hazard whatsoever." (Ref. A.24)

Shot #149 A B-17 flight took place.

Shot #151 The Point Myrtle weather observer was directly under the cloud as it passed over but "he experienced no contamination." (Ref. A.25)

Shot #154 The cloud motion observer's report stated "The cloud track given herein applies to only a small segment of the cloud. The bulk of the cloud seemed to dissipate without ever rising above the canyon walls." (Ref. A.26)

Shot #155 Radiation monitoring started from Point Weather westward and included the northern part of the Los Alamos housing area; 0.04 mR/h was recorded 0.1 miles from Point Weather. No activity above background was detected elsewhere on return to TA-1. A second monitor started from the Main Hill Road intersection with State Road 4 and found no activity except "0.15 mr/h in the vicinity of the first large bend in the road east of the main guard gate." No activity was detected in TA-1. (Ref. A.27)

Shot #156 Monitoring began from Point Weather, where activity of 0.05 mR/h was recorded. At the picnic grounds (on North Mesa), background activity was recorded. At the Sportsman's Club and 35th and Diamond Drive, less than 0.1 mR/h was recorded. Throughout North Community, activity was less than 0.05 mR/h. The survey sheet noted "... before shot background was 0.15, after shot 0.1 mr [sic]." (Ref. A.28)

Shot #157 High-volume air samplers located at Station 20 (on Puye Road), White Rock, Well #3 (just east of Guaje pumice mine), and Totavi gave the following results: 239, 689, 460, and 931 cpm, respectively. Five-stage cascade impactor data were as follows: at White Rock, all five stages—0 cpm; at Well #3, 4th stage—31 cpm, 5th stage (Whatman #41 paper)—4 cpm; Totavi, 5th stage (molecular filter)—16 cpm. (Ref. A.29)

Shot #158 Air samplers run in Española and on Puye Road showed activity in the 30- to 100-nCi range. (Refs. A.30-A.31) "Good coverage was obtained on the last Bayo shot [#158] and evaluation of these data has been completed showing no hazard in any inhabited areas." (Ref. A.32)

Shot #160 Fallout trays on the main hill road and one high-volume air sampler in Guaje Canyon showed measurable activity. (Refs. A.33-A.35) The monthly progress report of H-1 (the Health Physics Group) stated, "Although the east project access road [main hill road] was contaminated, the levels were low enough that they did not constitute a health hazard." (Ref. A.33)

Shot #163 Two air-sampling count data sheets provided the following information: one for Puye [Road], background activity; one for Española, 44 net cpm; no conversion to disintegrations per minute are given. (Ref. A.36)

Shot #166 Fallout was monitored starting at the main gate. Otowi ruins, White Rock, Mora's Castle (also known as the Duchess' Castle), Otowi Bridge, and 5 miles up Española highway (State Road 5) were surveyed from the main hill road. No readings above background were obtained. (Ref. A.37)

Shot #167 The cloud started to the northeast with very little velocity; the wind shifted shortly after the shot took place and spread fallout to the southeast and south. A rain shower occurred in Bayo Canyon 35 minutes after the shot. Activity was detected between State Road 4 and the Sandia Canyon guard station, one-half mile east of State Road 4. Measurements in White Rock showed background activity. Several other surveys were made. The next evening, 1 mR/h was measured at Otowi ruins. A hand-drawn fallout map was made from which D. Meyer deduces, "Fallout area was approximately 4 square miles . . . average reading was 0.5 mr/hr with shield open at waist level. This equals to about 1 mr/hr at contact shield open or 0.15 mr/hr shield closed at 6" from ground." (Ref. A.38)

Shot #168 The team made background readings in Rendija Canyon to the north and northeast several hours before the shot, finding elevated background activity from the previous shot (#167). After the shot, a counterclockwise survey began, reaching Totavi at 1845. The team returned up Guaje Canyon, encountering new fallout measuring 0.4 mR/h at the pumice mine (background in the morning was 0.04 mR/h) but found no further increase over the earlier background activity as far as the junction of Guaje and Rendija canyons. The team returned down Guaje Canyon and proceeded toward Española, encountering activity 4.5 miles south of Española with a maximum of 0.2 mR/h at the Puye Road turnoff. Activity was 0.15 mR/h at Santa Clara Pueblo and 0.1 to 0.15 mR/h in Española. The team returned to Puye Road the next morning and found slightly lower readings than the day before. (Refs. A.39-A.40)

Shot #169 The survey team passed the Los Alamos airstrip at 1538, where fallout was encountered; a maximum of 1.1 mR/h was recorded 1.4 miles east of the airport. Team members completed the survey including west up Guaje Canyon; all readings were background, which varied between 0.03 and 0.05 mR/h. More readings were taken the next day on other roads further south; a fallout map was prepared showing a relatively narrow fall-out pattern to the south-southwest over laboratory property, crossing Sandia Canyon, 0.45 mr/hr, and other east-west roads in the laboratory area. (Refs. A.41–A.43)

Shot #170 The team started a clockwise survey from TA-1 before 1500 and continued on to Española and Riverside (east side of Española). No fallout above background was detected. A map was made. (Refs. A.44–A.46)

Shot #171 The team started a clockwise perimeter survey from TA-1 at 1600; background activity was 0.03 mR/h. All readings were background to State Road 4. The team returned up Guaje/Rendija Canyons and measured 0.3 mR/h for about 0.5 miles beginning 1.5 miles east of the Sportsman's Club. Apparently the activity was missed or had not yet arrived on the first pass. (Refs. A.47-A.48)

Shot #172 The team began a clockwise perimeter survey at 1538 and encountered fallout in Guaje Canyon about 1.1 mile west of State Road 4 with a maximum of 0.2 mR/h at 1 mile west of State Roads 4. The team checked Totavi, background, and then started north on the Española Road (State Road 5). Very low readings (0.04 to 0.075 mR/hr) were found in the first 1.9 miles north of State Road 4 and 5 junction. The team returned west up Guaje Canyon; the measured maximum of 0.3 mR/h was again found 1 mile up canyon, essentially the same as before. Background seemed quite variable on this survey. (Refs. A.49-A.50)

Shot #173 Team members began a clockwise survey from TA-1 before 1730; background was 0.04 to 0.05 mR/h. They encountered fallout at the Sportsman's Club, which continued for 2.5 miles; the maximum reading of 1.0 mR/h was recorded 0.5 miles west of the Rendija Canyon gate. (Refs. A.51-A.52)

Shot #175 The team surveyed Rendija and Guaje canyons. No readings above background were found, though spurious readings were encountered between the Sportsman's Club and the Rendija Canyon gate. These readings were explained as residual from previous shots. Although we have no fallout data on the previous shot, it seems unlikely that this explanation is valid because of the decay time. (Refs. A.53-A.54)

Shot #176 A clockwise perimeter survey monitored Rendija and Guaje canyons as far as the well-drilling site below the Guaje pumice mine. Readings were 2 times background (0.07 mR/h) from the Rendija Canyon gate to 0.6 miles east of the gate. All other readings were background. (Refs. A.55-A.56)

Shot #177 Two surveys were made in Rendija and Guaje canyons to about 1 mile past the pumice mine. Twice background, 0.07 mR/h, was measured from the Rendija Canyon gate about 0.6 miles east. All other readings were background. (Refs. A.57-A.58)

Shot #178 A northern perimeter survey was done in Rendija and Guaje canyons, down and back. All readings showed background activity. (Refs. A.59-A.60)

Shot #179 A clockwise perimeter survey starting about 1400 found only background activity in Rendija and Guaje canyons. The team encountered fallout just east of Totavi (0.1 mR/h), which increased through Totavi and reached 0.3 mR/h at 0.2 miles west of Totavi and continued for 0.3 miles. The team retraced its route to check further east of Totavi to Otowi Bridge; readings showed background activity. Activity at the White Rock Y (intersection of main hill road and State Road 4) measured 0.1 mR/h; measurements taken towards and in White Rock were all background. A reading of 1 mR/h was recorded at Otowi ruins by another team. A rough map was drawn. (Refs. A.61-A.63)

Shot #180 The general background activity in the Los Alamos area was elevated because of fallout from the Nevada Test Site (NTS). Background activity of 0.5 mR/h was measured in TA-1, 0.1 to 0.2 mR/h on State Road 4 to Totavi, and 0.1 to 0.15 mR/h on North and Tank (Barranca) mesas. The Guaje-Rendija survey passed the Sportsman's Club at 1415, where the background due to NTS fallout was 0.3 mR/h. The team found readings in excess of this background and attributed these readings to activity from this shot for about 1 mile west of the Guaje pumice mine to the mine. The highest reading of 0.6 mR/h was taken 0.3 miles west of the. (Refs. A.64–A.67)

Shot #181 The team started the Rendija and Guaje canyons survey from TA-1 at 1600; encountering activity 1.9 miles past the Sportsman's Club. This activity continued for about 1 mile, with a maximum of 0.07 mR/h measured 0.1 miles east of the Rendija Canyon gate to 0.5 miles past the Guaje pumice mine. Here the team turned around and retraced its path. At 1654, the reading at the Sportsman's Club had increased to 0.075 mR/h. It was noted that "residual readings of 0.04 to 0.06 mr/hr from NTS test fallout a week ago prevailed throughout the survey area." (Refs. A.68-A.69)

Shot #182 The team began to survey Rendija and Guaje canyons at 1845; background activity was 0.03 mR/h. Activity was encountered 2.3 miles past the Sportsman's Club and continued for about 1 mile, with a maximum of 0.4 mR/h 2.3 miles past the Sportsman's Club. (Refs. A.70-A.71)

Shot #184 A team surveying Rendija and Guaje canyons passed the Sportsman's Club at 1625; background was 0.02 to 0.04 mR/h. The team encountered fallout 2 miles further at Rendija Canyon gate; fallout continued to 0.7 miles past the Guaje pumice mine. A maximum reading of 0.2 mR/h was measured 0.4 miles east of the junction of Rendija and Guaje canyons. All other readings were background. (Refs. A.72-A,73)

Shot #185 Rendija and Guaje canyons were surveyed. All readings showed background activity. (Refs. A.74-A.75)

Shot #186 Rendija and Guaje canyons were surveyed. Activity at the Rendija Canyon gate was 0.18 mR/h. At 0.2 miles east of the Rendija Canyon gate, the reading was 0.5 mR/h. All other readings were 0.08 to 0.1 mR/h. (Refs. A.76-A.77)

Shot #187 Rendija and Guaje canyons were surveyed. All readings were background, which was noted as "elevated from previous shot." A reading of 1 mR/h was recorded at Otowi ruins. (Refs. A.78-A.79)

Shot #188 Rendija and Guaje canyons were surveyed. The path of fallout extended 0.3 miles west of the Rendija Canyon gate to 0.8 miles east. The highest reading was 0.16 mR/h. D. Meyer's handwritten note says, "no fallout found"; we assume he interpreted the fallout as resulting from previous shot(s). (Refs. A.80-A.81)

Shot #189 The team began a clockwise perimeter survey from Point Weather at 1500; background was 0.03 mR/h. The highest reading of 0.2 mR/h was measured at Point Weather (which must have been direct radiation from the firing pad, reading 65 R/h at a meter above the firing pad after the shot). Fallout was encountered in Guaje Canyon at the pumice mine, continuing for 1.2 miles with a maximum of 0.2 mR/h recorded 0.3 miles east of the pumice mine. (Ref. A.82)

Shot #191 The team began a clockwise survey from TA-1 at 1555; background was 0.03 mR/h. Fallout was encountered 1.4 miles east of the Sportsman's Club, which continued about 0.6 miles down Rendija Canyon. The team continued west up Guaje Canyon, encountering fallout 0.2 miles west up canyon; this fallout continued for 1.1 miles with a peak of 1 mR/h recorded 0.8 miles west up canyon. The team completed the survey down Guaje Canyon and returned through Totavi. All activity was background. (Ref. A.83)

Shot #192 The team began a counterclockwise survey past the main gate at 1800; background was 0.01 to 0.03 mR/h. The team encountered activity 0.4 miles north on Española Road (State Road 5), which continued for about 3 miles. A maximum reading of 0.5 mR/h was measured. The team surveyed around the gravel pits near the Rio Grande, south of Pajarito Village; a maximum of 2 mR/h probably was influenced by several particles, judging from the lower readings on State Road 5. One particle read 1.4 mR/h beta plus gamma at "contact," and another read 11 mR/h gamma at 6 inches, using a Cutie Pie ion-chamber survey instrument. A resurvey the next morning found the area still contaminated; the survey was extended across the river on State Road 4 to El Rancho and back around San Ildefonso Pueblo. Only background activity was found. Later, photomicrographs, autoradiographs, and activity determinations of two particles were made; each particle measured over 300 microns in the longest dimension. (Ref. A.84)

Shot #193 The team began a counterclockwise perimeter survey from TA-1 at 1725; background was 0.03 mR/h. All readings showed background activity until 5.4 miles past Totavi on Española Road (State Road 5), where fallout was encountered that continued to Santa Clara Pueblo; a maximum of 0.15 mR/h was found at Puye Road. The team returned up Guaje Canyon, encountering fallout 1.8 miles west up canyon, which continued for about 1 mile. The maximum reading of 1.0 mR/h was recorded 1 mile east of the Guaje pumice mine. The remainder of the perimeter survey readings showed background activity. (Ref. A.85)

Shot #194 The team began a clockwise perimeter survey from TA-1 at 1645; background activity was 0.04 mR/h. Fallout was encountered 2.1 miles past the Sportsman's Club and continued for about 1 mile. A maximum reading of 1.6 mR/h was recorded 0.3 miles further on. The team went west up Guaje Canyon, encountering fallout 0.3 miles up canyon. The fallout continued for about 1 mile, with a maximum of 3.0 mR/h recorded between 0.6 to 0.7 miles west up canyon. The remainder of the perimeter survey was completed down Guaje Canyon, through Totavi, and back to TA-1. All readings showed background activity. The following morning Puye Road was surveyed, with readings fluctuating between 0.1 and 0.2 mR/h from the Española Road (State Road 5) to the Puye Ruins. (Ref. A.86)

Shot #195 The team began a clockwise perimeter survey from TA-1 at 1430; background was 0.03 mR/h. Fallout was encountered 0.7 miles past the Sportsman's Club and continued for 1.4 miles, with a maximum of 0.65 mR/h recorded 1.7 miles past the Sportsman's Club. The team surveyed west up Guaje Canyon; a maximum of 0.3 mR/h was recorded 2 miles up the canyon. (Ref. A.87)

Shot #196 The team began a clockwise perimeter survey from TA-1 at 1625; background was 0.03 mR/h. Fallout was encountered at the Rendija Canyon gate and continued for 0.8 miles, with a maximum of 0.7 mR/h measured 0.4 miles beyond. The fallout pattern also crossed upper Guaje Canyon with a maximum of 0.4 mR/h about a mile west up canyon. Above-background readings were recorded for about 3 miles to Guaje Canyon gate, where the team completed the survey through lower Rendija and Guaje canyons to Totavi. Only background activity was found. (Ref. A.88)

Shot #197 The team began a special survey from TA-1 at 1500; background activity was 0.05 mR/h. Since the cloud remained in Bayo Canyon, the team surveyed only in the eastern part of the canyon to the Otowi ruins, recording a maximum of 0.4 mR/h at 0.3 miles west up Bayo Canyon from State Road 4. A rough sketch was made. (Ref. A.89)

Shot #198 The team began a clockwise perimeter survey from TA-1 at 1830; background activity was 0.05 mR/h. The picnic grounds and stables (on North Mesa), and Tank Mesa (Barranca Mesa) were surveyed; background activity was recorded. Fallout was encountered 1.1 miles past the Guaje pumice mine and continued for 1.3 miles with a maximum of 0.7 mR/h recorded 0.6 miles past the mine. (Ref. A.90)

Shot #199 The team began a counterclockwise perimeter survey from TA-1 at 1630; the background activity was 0.03 to 0.05 mR/h. Fallout was encountered in Guaje Canyon just east of the pumice mine and continued for almost 3 miles. A maximum of 1.0 mR/h was recorded about 0.2 miles past the Rendija/Guaje Y. The team returned west up Rendija Canyon, measuring 0.1 to 0.2 mR/h for about 0.8 miles. Tank Mesa (Barranca Mesa) and North Mesa were surveyed; only background activity was noted. (Ref. A.91)

Shot #201 The team began a counterclockwise perimeter survey from TA-1 at 1408; the background activity was 0.05 mR/h. All measurements were background. (Ref. A.92)

Shot #202 The survey team left TA-1 at 1420; background radiation was 0.03 mR/h. A reading of 0.04 mR/h was recorded at the picnic grounds (on North Mesa), 0.15 mR/h at "overlook of Bayo" [tip of Otowi Mesa, called also "North Ridge"—probably direct radiation from the firing pad, which was reading 40 R/h waist high above the pad shortly after the shot]. Readings on the "mesa north of previous measurement (0.15 mr/hr)," (Deer Trap Mesa, northeasternmost Barranca Mesa) were background. At 2.7 miles east of the Sportsman's Club, fallout of 0.12 mR/h was encountered. At 2.9 miles, fallout was 0.15 mR/h, and at Booster #1 (near Guaje/Rendija Y) it was 0.08 mR/h. About 0.5 miles up Guaje Canyon, fallout was 0.13 mR/h. The team returned near to the Guaje/Rendija Y and up the shelf road to the mesa top toward the north above Guaje pumice mine. A maximum reading of 0.15 mR/h was recorded on the mesa top and near background activity was recorded 1 mile east. The team returned to Guaje Canyon and completed the perimeter, measuring only background activity. (Ref. A.93)

Shot #203 The team departed TA-1 at 1812; background activity was 0.03 mR/h. Background activity was measured until the team reached the "tip of Tank Mesa [Barranca Mesa]," where the reading was 0.3 mR/h (direct radiation from the firing pad may have affected this measurement). A clockwise perimeter survey was continued. Background activity was recorded until the Guaje Canyon road junction with State Road 4; at that point, the reading was 0.10 mR/h. Background activity was recorded further east to the junction of State Roads 4 and 5. Readings increased to 1.0 mR/h at Roy's Service Station (Totavi); continuing 0.6 miles west, only background activity was found to TA-1. The cloud did not rise above the Bayo Canyon walls and apparently followed the canyon to Totavi. (Refs. A.94-A.95)

Shot #204 The team began a clockwise survey from TA-1 at 1555; background activity was 0.03 mR/h. Down Rendija Canyon, 2 miles past the Sportsman's Club, the team encountered fallout measuring 0.05 mR/h, with a maximum of 0.7 mR/h recorded 2.5 miles beyond. Activity slowly decreased to background activity within half a mile. The team continued down Guaje Canyon to State Road 4 and north to Puye Road junction and then west, encountering 0.07 mR/h 6 to 6.4 miles west on Puye Road, essentially directly in line with the previous encounter in Guaje Canyon. The next morning the team monitored in Española, Riverside, and Fairview (areas east and north of Española); only background activity was detected. (Ref. A.96)

Shot #205 The team began a clockwise survey from TA-1 at 1506; background activity was 0.03 mR/h. Team members encountered fallout about 0.7 miles past the Sportsman's Club. Activity was 0.09 mR/h, falling to 0.05 mR/h in the next 0.3 miles. Only background activity was found at Booster #1 (3 miles east past the Sportsman's Club) and for 2.3 miles west up Guaje Canyon. At 2.3 miles, fallout was encountered, which increased to a broad maximum of 0.4 mR/h for 0.4 miles, continued at this level for 0.4 miles, and then decreased to 0.15 mR/h at the Guaje Canyon gate. The team returned east down Guaje Canyon to State Road 4 and back to Los Alamos, encountering only background activity. An interesting observation (but not the only time observed) was that fallout was more intense in Guaje Canyon than in Rendija Canyon. This part of Guaje Canyon is about 1.5 miles further from Point Able. (Ref. A.97)

Shot #206 The survey team left TA-1 at 1223; background activity was 0.03 mR/h. The team made the complete perimeter survey and found no readings above background. The cloud was observed to start to the north and then spread east along the canyon rim. (Ref.A. 98)

Shot #207 The survey team left TA-1 at 1310; background activity was 0.03 mR/h. The perimeter survey was completed with no readings above background recorded. (Ref. A.99)

Shot #208 The team began a clockwise perimeter survey from the Administration Building (TA-3, SM-43) at 1340 (note the new starting point); background activity was 0.03 mR/h. Fallout was encountered from 0.9 to 1.2 miles east of the Sportsman's Club, and the maximum activity was 0.15 mR/h beyond the Sportsman's Club. The team completed the survey route, finding only background activity. The cloud was observed to move to the south Bayo Canyon wall and then rise and move north. (Ref. A.100)

Shot #209 The survey team left Point Weather at 1200 (only 5 minutes after the shot) and immediately measured 13 mR/h (probably direct radiation from the cloud, not fallout). On the continuing clockwise perimeter survey, fallout (0.1 mR/h) was encountered 1.4 miles east of the Sportsman's Club and continued above background with peaks of 0.8 mR/h at the Barranca (Rendija) gate and 1.2 mR/h 0.4 miles west up Guaje Canyon. The remainder of the survey found no activity above background. (Ref. A.101)

Shot #210 The team left the Administration Building (SM-43) at 1416; background activity was 0.03 mR/h to Point Weather, where the reading was 0.07 mR/h (probably a direct reading from the firing pad). Fallout was encountered 0.6 miles past the Sportsman's Club, with a maximum of 0.7 mR/h recorded 1.8 miles east. It continued above background for another 0.6 miles. The team completed surveying the rest of the perimeter, encountering only background activity. (Ref. A.102)

Shot #211 The survey team left the Administration Building (SM-43) at 1315; background activity was 0.03 mR/h; activity at Point Weather was 0.07 mR/h. Only background activity was encountered on the perimeter survey. The section of State Road 4 road toward White Rock was also checked and background found. (Ref. A.103)

Shot #212 The team began a clockwise survey from the Administration Building (SM-43) at 1555; background activity was 0.03 mR/h; activity at Point Weather was 0.5 mR/h. Fallout was encountered 1.3 miles east of the Sportsman's Club and continued for 3.1 miles, with a peak between 1.0 and 1.3 mR/h recorded 2.1 miles east of the Club. Fallout also crossed Guaje Canyon beginning 0.5 miles west up Guaje Canyon and continuing above background for 2.1 miles. A maximum reading of 1.3 mR/h was recorded 1.1 miles west up canyon. (Ref. A.104)

Shot #213 The team began a clockwise survey from the Administration Building (SM-43) at 1605; background activity was 0.03 mR/h. Fallout was encountered 2.4 miles east of the Sportsman's Club (0.1 mR/h) and 0.8 miles west up Guaje Canyon (0.8 mR/h). During the remainder of the clockwise perimeter survey, only background activity was detected. (Ref. A.105)

Shot #214 The team began a clockwise survey from the Administration Building (SM-43) at 1501; background activity was 0.04 mR/h. Fallout was encountered 1.3 miles east past the Sportsman's Club, with a peak of 0.5 mR/h occurring 0.5 miles further on. The peak reading was caused by a one-foot-square contaminated area measuring 6 mR/h at 6 inches (probably one or more particles). (Ref. A.106)

Shot #215 The team began a clockwise survey from the Administration Building (SM-43) at 1100; background activity was 0.03 mR/h. Fallout was encountered 0.5 miles east of the Sportsman's Club, with a peak of 0.3 mR/h occurring 1.7 miles past the Sportsman's Club. Above-background readings continued to the Rendija/Guaje canyons junction and then increased west up Guaje Canyon, with a peak of 1.5 mR/h occurring 1.8 miles up the canyon and continuing above background for about 1 mile. The team completed the perimeter survey down Guaje Canyon to Highway 4 and returned to the Administration Building; only background activity was detected. (Ref. A.107)

Shot #216 The team began a clockwise survey from the Administration Building (SM-43) at 1515; background activity was 0.03 mR/h. Fallout was encountered 1 mile past the Sportsman's Club and continued for 0.8 miles, with a peak of 1.0 mR/h occurring 1.4 miles past the Sportsman's Club. The perimeter survey was completed with positive readings recorded 1 mile east of the main gate. Peak activity of 0.4 mR/h occurred at the entrance to the East Gate Lab. No explanation was offered for these later readings, which are in the opposite direction from which the main cloud was detected. Operations at the East Gate Laboratory are suspected (see shots #238, 240, and 242). (Ref. A.108)

Shot #217 The team began a counterclockwise survey from the Administration Building (SM-43) at 1510; background activity was 0.05 mR/h. A reading of 0.3 mR/h was recorded at the dump site near the Los Alamos Airport. The team completed the perimeter survey; all readings showed only background activity. A town site survey began at 1700; a peak of 0.15 mR/h was recorded at the eastern end of Manhattan Loop (eastern residential area). Activity up to 0.075 mR/h was recorded at the DP Road trailer court (south of the airport). At 0.1 miles west of Point Weather, activity from 1 mR/h to 0.5 mR/h was recorded to the ballpark (on North Mesa), where background activity was measured. A detailed survey of the town site made the next day confirmed elevated levels throughout much of the eastern town site. Several fixed-area monitors throughout town showed elevated readings. (Ref. A.109)

Shot #219 The team began a counterclockwise survey from the Administration Building (SM-43) at 1330; background activity was 0.03 mR/h. A reading of 0.1 mR/h was recorded at the stables (on North Mesa), but it was questioned on the survey sheet as not being reasonable, probably because the cloud was reported to have gone to the east. Fallout of 0.07 mR/h was encountered in Guaje Canyon 0.7 miles past the pumice mine, continuing for about 0.5 miles, with a peak of 0.1 mR/hr halfway between. Activity between 0.5 and 0.07 mR/h was recorded north on State Road 5, 3.2 miles from the junction. (Ref. A.110)

Shot #220 The team left the Administration Building (SM-43) at 1650; background activity was 0.03 mR/h. During the counterclockwise perimeter survey, fallout (0.04 mR/h) was encountered at the junction of the Main Hill Road/ White Rock cutoff. It increased to a maximum of 0.4 mR/h at 0.3 miles before the junction of Guaje Canyon and State Road 4. At Otowi Bridge, activity was 0.08 mR/h; at the Española Highway (State Road 5) to Puye Road, it was 0.08 to 0.09 mR/h for 3 miles. At the entrance to Guaje Canyon, activity was 0.2 mR/h and persisted to the Guaje pumice mine, where the 0.08 mR/h reading was attributed to contamination on the vehicle since the reading continued at this level until the team returned to the Administration Building. Weather observations confirmed that the cloud did not rise above the canyon walls to reach the southwest winds. (Ref. A.111)

Shot #221 The team began a clockwise survey from Administration Building (SM-43) at 1630; background activity was 0.04 mR/h. A clockwise perimeter survey was completed that included Puye Road; no measurable fallout was detected. Weather observations of the cloud support these findings. The cloud remained in Bayo Canyon. (Ref. A.112)

Shot #222 The team left the Administration Building (SM-43) at 1625; background was 0.03 mR/h. A counterclockwise survey included the Puye pumice mine; the survey team returned through Guaje Canyon. The recorded instrument readings fluctuated between 0.02 and 0.05 mR/h but were considered negative. Weather observations confirmed that the cloud remained in the canyon. (Ref. A.113)

Shot #223 The team began a clockwise survey from Administration Building (SM-43) at 1640; background activity was 0.05 mR/h. Fallout was encountered 0.4 miles east past the Sportsman's Club, with a maximum of 0.6 mR/h recorded just beyond and falling to background 0.8 miles past the Sportsman's Club. (Ref. A.114)

Shot #224 The team began a clockwise survey from Administration Building (SM-43) at 1335; background activity was 0.05 mR/h. Fallout was encountered 1.2 miles east past the Sportsman's Club, with a maximum of 0.6 mR/h recorded 1.4 miles past the Sportsman's Club. The same reading was recorded 2.0 miles past the Sportsman's Club. A reading of 1.0 mR/h was recorded 1.6 miles west up Guaje Canyon; 0.08 mR/h was recorded at the Puye pumice mine, although the same reading was recorded at the Administration Building, which does not seem reasonable. Contamination on the detector or the vehicle is suspected. (Ref. A.115)

Shot #225 The team began a clockwise survey from the Administration Building (SM-43) at 1707; background activity was 0.05 mR/h. Fallout was encountered 1.4 miles east past the Sportsman's Club, with a maximum of 0.8 mR/h recorded 1.5 miles past the Sportsman's Club. (Ref. A.116)

Shot #226 The team began a clockwise survey and reached the Sportsman's Club at 1814; background activity was 0.03 mR/h. Fallout was encountered 0.2 miles past the Rendija/Guaje junction, with a maximum of 0.3 mR/h recorded 0.4 miles down canyon. Activity continued above background until past the Guaje pumice mine. During the rest of the survey, only background activity was recorded. (Ref. A.117)

Shot #227 The team began a clockwise survey from the Administration Building (SM-43) at 1343; background activity was 0.02 mR/h. Fallout was encountered at Well #1 and continued for 1.8 miles, with a maximum of 0.16 mR/h recorded 1.3 miles west up canyon from State Road 4. (Ref. A.118)

Shot #228 The team began a clockwise survey from the Administration Building (SM-43) at 1625; background activity was 0.02 mR/h. Fallout was encountered at the Sportsman's Club, with a maximum of 5 mR/h recorded one mile east past the Sportsman's Club. Above background readings continued to Booster #2 at the junction of Rendija and Guaje canyons. (Ref. A.119)

Shot #229 The team began a clockwise survey from the Administration Building (SM-43) at 1743; background activity was 0.03 mR/h. Fallout was encountered 1.9 miles east past the Sportsman's Club, with a maximum of 1.0 mR/h recorded 2.1 miles past the Sportsman's Club. Above-background activity was recorded to the junction of Rendija/ Guaje canyons. (Ref. A.120)

Shot #230 The team began a clockwise survey from the Administration Building (SM-43) at 1535 for a clockwise perimeter survey. All readings showed background activity. (Ref. A.121)

Shot #232 The team began a clockwise survey from the Administration Building (SM-43) at 1535; background activity was 0.05 mR/h. Fallout was encountered at the Rendija/Guaje junction, with a maximum of 0.18 mR/h recorded 0.7 miles down canyon. The remainder of the survey recorded background activity. (Ref. A.122)

Shot #233 The team began a clockwise survey from the Administration Building (SM-43) at 1600; background activity was 0.03 mR/h. Fallout was encountered, twice background, in the "new housing area" (Barranca Mesa), and 1.0 mR/h was recorded at the end of Tank Mesa (Barranca Mesa, overlooking the firing site). Back on the clockwise perimeter survey route, fallout was encountered 1.2 miles east past the Sportsman's Club, with a maximum of 1.4 mR/h recorded at the Guaje Canyon gate. The remainder of the survey route showed background activity. (Ref. A.123)

Shot #234 The team began a clockwise survey from the Administration Building (SM-43) at 1405; background activity was 0.04 mR/h. Fallout was encountered 0.5 miles past the Sportsman's Club and continued for 2 miles, with a maximum of 0.18 mR/h recorded at Booster #2, which is 1.2 miles east of the Sportsman's Club. (Ref. A.124)

Shot #235 The team left the Administration Building (SM-43) at 1426; background activity was 0.05 mR/h. The team completed the counterclockwise survey; all readings showed background activity. (Ref. A.125)

Shot #236 The team left the Administration Building (SM-43) at 1750 to conduct a clockwise survey; background activity was 0.03 to 0.04 mR/h. Fallout was encountered at the intersection. The fallout continued west along State Road 4 for 3 miles, with a maximum of 0.6 mR/h recorded 1.5 miles west of the Guaje/State Road 4 intersection (12 mR/h was recorded at an isolated spot). The remainder of the survey showed background activity. The cloud was observed to go over the north Bayo Canyon wall. (Ref. A.126)

Shot #237 The team left the Administration Building (SM-43) at 1401; background activity was 0.03 to 0.04 mR/h. Fallout was encountered 1.2 miles past the Sportsman's Club, and readings remained elevated to the White Rock junction on State Road 4. A maximum of 0.4 mR/h was recorded 2 miles past the Sportsman's Club. (Ref. A.127)

Shot #238 The team left the Administration Building (SM-43) at 1640; background activity was 0.03 to 0.05 mR/h. A clockwise survey was conducted; only background activity was recorded until fallout was encountered on the Main Hill Road 0.8 miles east of the main gate for about 0.6 miles. A maximum of 1.5 mR/h was recorded beyond the East Gate Laboratory at the entrance to the Camp Hamilton Trail. Because the cloud was reported to go down canyon (east-southeast), the readings are not believed to be related to the Bayo Canyon activity. During this period, a large 120-curie cobalt-60 source located about 400 feet directly north of the Main Hill Road at the East Gate Laboratory (TA-19) was in intermittent use and is believed to explain these readings (see also shots #240 and #242). (Ref. A. 128)

Shot #239 The team left the Administration Building (SM-43) at 1630; background activity was 0.04 mR/h. During the clockwise survey, above-background activity was encountered at Booster #1, 3 miles east of the Sportsman's Club. It continued for 1.4 miles, with a maximum reading of 0.4 mR/h recorded 3.8 miles past the Sportsman's Club. (Ref. A.129)

Shot #240 The team began a clockwise survey from the Administration Building (SM-43) at 1419; background activity was 0.02 mR/h. Fallout was encountered at the Guaje pumice mine and continued for 1.6 miles, with a maximum of 0.12 mR/h recorded 0.8 miles past the mine. Fallout was encountered again on the Main Hill Road 1.3 miles east of the main gate, with a maximum of 1.3 mR/h recorded 0.5 miles east of the gate. Because the cloud was reported to have gone over the north wall of Bayo Canyon, this reading is again attributed to the gamma source at the East Gate Laboratory (see shots #238 and #242). (Ref. A.130)

Shot #241 The team began a clockwise survey from the Administration Building (SM-43) at 1603; background activity was 0.05 mR/h. Questionable activity (only 0.01 mR/h over background) was encountered at Booster #1 for 4.2 miles, with a maximum of 0.12 mR/h recorded 1.5 miles past the Guaje pumice mine. During the remainder of the survey, only background activity was recorded. (Ref. A.131)

Shot #242 The team began a counterclockwise survey from the Administration Building (SM-43) at 1717; background activity was 0.03 mR/h. Since the cloud was observed to travel down canyon, the activity that was encountered 1.7 miles east of the airstrip and continued for about 0.5 miles, with a maximum of 1.5 mR/h recorded 1.9 miles past the airstrip, is believed to be due to the gamma source at the East Gate Laboratory (see shots #238 and #240 above). The remaining readings, beginning about 1.5 miles west of Roy's Service Station (Totavi) and continuing for about 1.3 miles, are attributable to this shot. A maximum reading of 0.4 mR/h was recorded 0.9 miles west of Roy's Service Station. (Ref. A.132)

Shot #243 The team began a clockwise survey from the Administration Building (SM-43) at 1645; background activity was 0.02 to 0.03 mR/h. Fallout was encountered 0.7 miles west of Well #1 and continued for 2.5 miles, with a maximum of 1.3 mR/h recorded 1.3 miles past Well #1. At Well #1, a particle was collected reading 1100 mR/h at "contact" with a Cutie Pie (an ionization chamber instrument). Background readings during this survey seemed to fluctuate. The environmental group reported results of two film badge dosimeters planted at the airstrip, about 1 mile southwest of the firing site, for a period beginning 22 days before and ending 30 days after this shot. They reported the readings averaged 200 mR/mr over this period and attributed the dose to a possible particle from the main cloud, although the main cloud went in the opposite direction. (Ref. A.133)

Shot #244 The team began a clockwise perimeter survey from the Administration Building (SM-43) at 1325; background activity was 0.05 mR/h. Fallout was encountered 0.8 miles east past the Sportsman's Club and continued for 0.8 miles, with a maximum of 0.3 mR/h recorded 1.1 miles past the Sportsman's Club; 2.1 miles west up Guaje Canyon the maximum was 0.3 mR/h. A resurvey the next morning found a "speck" reading of 1.1 mR/h at "contact" on Guaje Road, where the maximum reading was found the day before. (Refs. A.133–A.137)

Shot #245 The team started a survey on Barranca Mesa, completing a clockwise route. All readings were recorded as "00." (Ref. A.138)

Shots #246–254 For these experiments, the configuration was such that the RaLa source remained intact. There was no dispersion of radioactive material.

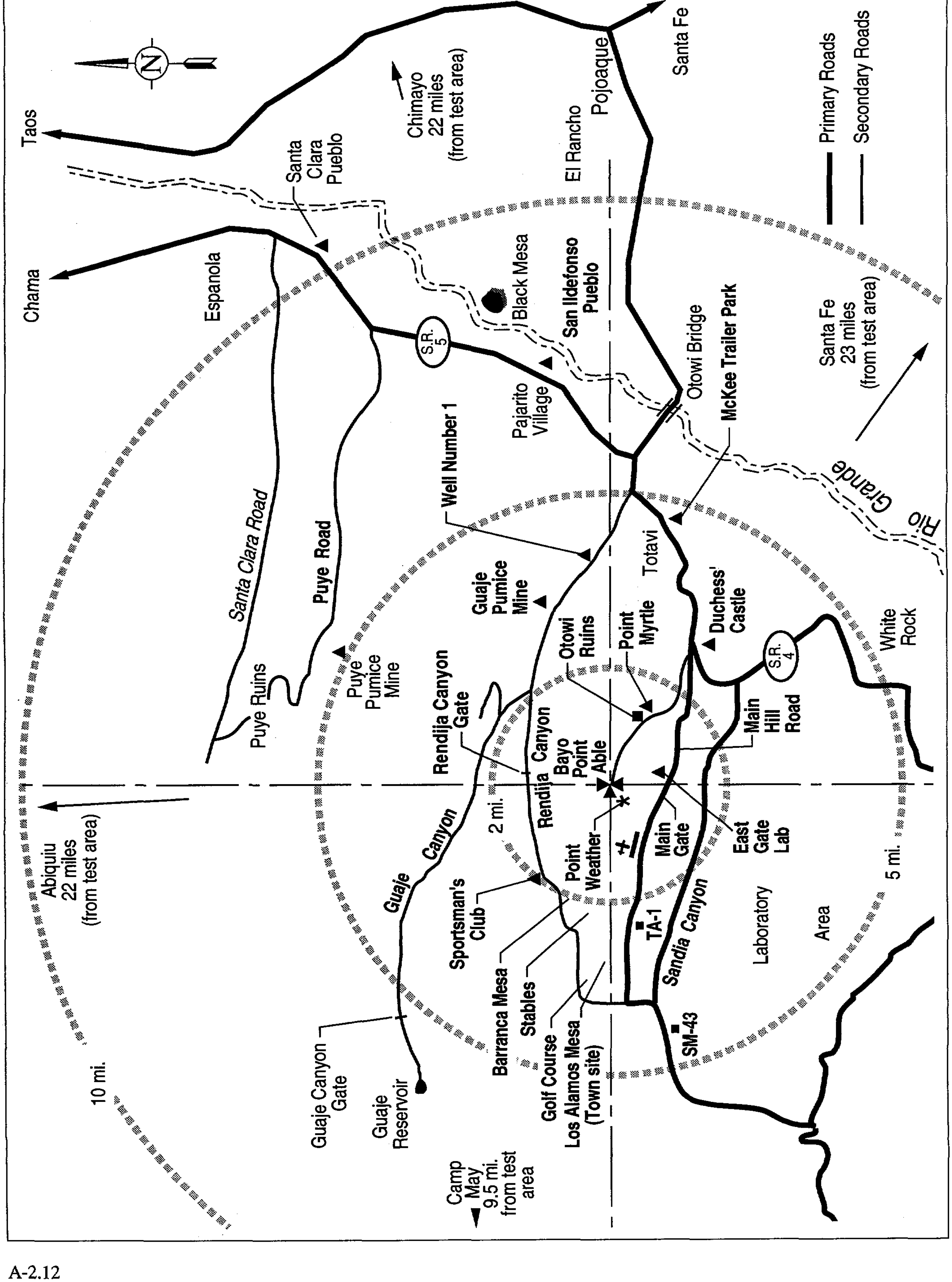

Figure A-2.1. Map of region of interest centered on Bayo Canyon firing site.

A-3 References [Shot Numbers] for Appendix A-2

A.1 **[5 - 16]** Memorandum from P. H. Levine to L. H. Hempleman, *Air Samples Taken on Mesa during Bayo Canyon Shot*, April 9, 1945.

A.2 **[17]** Memorandum by P. H. Levine, *Report on Bayo Canyon Shot of April 9, 1945*, no date.

A.3 **[18]** Memorandum from P. H. Levine to Dr. J. Hoffman, *RaLa Shot at Bayo Canyon*, April 16, 1945.

A.4 **[27]** Memorandum from P. H. Levine to J. G. Hoffman, *Air Samples on Mesa after Bayo Canyon Shot*, June 18, 1945.

A.5 **[50]** Memorandum from A. Reinert, G. Hornberger, and W. Brownell to J. G. Hoffman, *Cloud from January 24 Bayo Canyon Shot*, January 25, 1946.

A.6 **[106]** Memorandum from Carl Buckland to Harry O. Whipple, *Bayo Shot Cloud over Air Strip*, August 18, 1948.

A.7 **[114]** Memorandum from Thomas N. White to Donald Mueller, *Smoke Drift from Bayo*, December 1, 1948.

A.8 **[114]** Memorandum from D. W. Mueller to Thomas N. White, Jr., *Dust Clouds from Bayo Canyon*, December 2, 1948.

A.9 **[122]** Health Division Progress Report, LAMS-889, 20 March—20 April 1949, p. 7; released as Human Studies Project Team Release (HSPT-REL)-94-260, April 15, 1994.

A.10 **[126]** Memorandum from Simon Shlaer to Thomas L. Shipman, *Contamination Resulting from Bayo Activity*, May 19, 1949.

A.11 **[127]** Memorandum from Thomas N. White to Thomas L. Shipman, *Road Blocks, 20 May 1949*, May 23,1949; released as Human Studies Project Team Release (HSPT-REL)-94-053, January 28, 1994.

A.12 **[127]** Memorandum from T. L. Shipman to N. E. Bradbury, *Road Blocks, 20 May 1949*, May 24, 1949; Released as Human Studies Project Team Release (HSPT-REL)-94-052, January 28, 1994.

A.13 **[128 - 130]** Memorandum, unsigned, *Report on Bayo Activities of June 2, 6 & 10*, no date.

A.14 **[135 - 137; 139 -141]** Handwritten, unsigned steno pad notes and calculations regarding flypaper and trays, presumed to belong to S. Shlaer, *Bayo Shots 1949*, December 22, 1949.

A.15 **[138]** Memorandum from Thomas L. Shipman to all division leaders, *Counting Background*, November 3, 1949.

A.16 **[138]** Abstract, *Health Division Progress Report, October 20, 1949, to November 20, 1949*; released as Human Studies Project Team Release (HSPT-REL)-94-307, April 21, 1994.

A.17 **[138]** Handwritten notes, presumed to belong to S. Shlaer and W. DeAlva, *Bayo*, November 2, 1949.

A.18 **[140 - 141]** Handwritten notes, presumed to belong to S. Shlaer, identified as *Shot of December 16, 1949*, undated.

A.19 **[140]** Biophysics Section, *Health Division Progress, Report, November 20 to December 20, 1949.*

A.20 **[140]** Abstract of a report by Simon Shlaer, *Studies of Fall-out from a Cloud Containing Radioactive Particles*, undated.

A.21 **[140]** S. Shlaer, *Studies of Fall-Out from a Cloud Containing Radioactive Particles*, Meeting of Medical and Laboratory Directors of the United States Atomic Energy Commission, September 28-29, 1950; released as Human Studies Project Team Release (HSPT-REL)-94-247, April 15, 1994.

A.22 **[142]** Memorandum from T. L. Shipman to all division leaders, *Bayo Operations*, December 23, 1949.

A.23 **[145]** Memorandum from H-1 Weather Section, *Report of Distribution, 24 January 1950*, undated.

A.24 **[148]** Memorandum from T. L. Shipman to N. E. Bradbury, *Bayo Canyon Operations, March 29, 1950*, March 30, 1950; released as Human Studies Project Team Release (HSPT-REL)-94-054, January 28, 1994.

A.25 **[151]** Memorandum from H-1 Weather Section to Thomas N. White, *Report of Distribution, 26 April 1950*, April 26, 1950.

A.26 **[154]** Memorandum from H-1 Weather Section, *Report of Distribution, 13 July 1950*, July 13, 1950.

A.27 **[155]** Memorandum from Carl W. Buckland to Leo G. Chelius, *Summary and Suggestions Following the Experiment at Bayo Canyon on Wednesday, March 26, 1952*, March 28, 1952.

A.28 **[156]** Handwritten monitoring results, *Road Monitoring—North Community*, August 11, 1952, no author listed.

A.29 **[157]** Handwritten air-sampling data, *Hi Vol Data*, August 22, 1952.

A.30 **[158]** Handwritten air-sampling data, *Hi-Volume Sampler* (6 pp.), August 29, 1952, no author listed.

A.31 **[158]** Memorandum from W. S. Johnson to Leo Chelius, *Results Obtained by H-5 on Bayo Experiment of 8/29/52*, September 3, 1952.

A.32 **[158]** *Health Division Progress Report, August 20 - September 20, 1952*, p. 20; released as HSPT-REL-94-349, April 22, 1994.

A.33 **[160]** *Health Division Progress Report, July 20 - August 20, 1953* (p. 2); released as Human Studies Project Team Release (HSPT-REL)-94-399, April 29, 1994.

A.34 **[160]** Memorandum from William S. Johnson to Leo G. Chelius, *H-5 Participation in Bayo Canyon Experiments*, August 13, 1953.

A.35 **[160]** Memorandum from William S. Johnson to Leo G. Chelius, *Results of H-5 Participation in Recent Bayo Canyon Experiment*, August 19, 1953.

A.36 **[163]** Handwritten air-sampling data, *Hi-Volume Sampler* (2 pp.), February 2, 1954, no author listed.

A.37 **[166]** Memorandum from Jerome Dummer and George Littlejohn to Dean D. Meyer, *Cloud Tracking Survey*, April 20, 1954.

A.38 **[167]** Handwritten notes and map, *Bayo Canyon Shot - 7/31/54 - Saturday,* undated, no author listed.

A.39 **[168]** Memorandum from William S. Johnson to Dean D. Meyer, *Results of Monitoring Following Bayo Experiment of 8/5/54*, August 10, 1954.

A.40 **[168]** Handwritten notes and maps, August 5, 1954, no author listed.

A.41 **[169]** Memorandum from W. S. Johnson to Dean Meyer, *Monitoring Results Following Bayo Canyon Experiment of 9/9/54*, September 14, 1954.

A.42 **[169]** *Monitoring Log and Reporting Sheet*, September 9, 1954.

A.43 **[169]** Hand-drawn maps (2) and monitoring data, September 9, 1954, no author listed.

A.44 **[170]** *Monitoring Log and Reporting Sheet*, September 16, 1954.

A.45 **[170]** Memorandum from William S. Johnson to Dean Meyer, *Monitoring Results on Bayo Canyon Experiment of 9/16/54*, September 23, 1954.

A.46 **[170]** Hand-drawn map, August 16, 1954, no author listed.

A.47 **[171]** *Monitoring Log and Reporting Sheet*, November 11, 1954.

A.48 **[171]** Memorandum from W. S. Johnson to Leo Chelius, *Monitoring Results from Bayo Canyon Experiment of 11/4/54*, November 5, 1954.

A.49 **[172]** Memorandum from W. S. Johnson to Leo Chelius, *Monitoring Results from Bayo Canyon Experiment of 11/16/54*, November 22, 1954.

A.50 **[172]** *Monitoring Log and Reporting Sheet*, November 16, 1954.

A.51 **[173]** *Monitoring Log and Reporting Sheet*, December 2, 1954.

A.52 **[173]** Memorandum from William S. Johnson to Leo Chelius, *Monitoring Results from Bayo Canyon Experiment of 12/2/54*, December 3, 1954.

A.53 **[175]** Memorandum from William S. Johnson to Leo G. Chelius, *Monitoring Results Following Bayo Canyon Experiment of 12/30/54*, January 3, 1955.

A.54 **[175]** *Monitoring Log and Reporting Sheet*, December 30, 1954.

A.55 **[176]** Memorandum from William S. Johnson to Leo G. Chelius, *Monitoring Results Following Bayo Canyon Experiment of 1/6/55*, January 6, 1955.

A.56 **[176]** *Monitoring Log and Reporting Sheet*, January 6, 1954.

A.57 **[177]** Memorandum from Clarence P. Skillern to Leo G. Chelius, *Monitoring Results Following Bayo Canyon Experiment of 1/12/55,* January 12, 1955.

A.58 **[177]** Off-site monitoring report, January 12, 1955, no author listed.

A.59 **[178]** Memorandum from William S. Johnson to Leo G. Chelius, *Monitoring Results Following Bayo Canyon Experiment of 3/17/55*, March 17, 1955.

A.60 **[178]** *Monitoring Log and Reporting Sheet*, March 17, 1955.

A.61 **[179]** Memo from William S. Johnson to Dean Meyer, *Monitoring Results from Bayo Canyon Experiment of 3/22/55*, March 24, 1955.

A.62 **[179]** Hand-drawn map, March 23, 1955, no author listed.

A.63 **[179]** *Monitoring Log and Reporting Sheet*, March 23, 1955.

A.64 **[180]** Memorandum from William S. Johnson to Dean Meyer, *Monitoring Results from Bayo Canyon Experiment of 3/30/55*, March 31, 1955.

A.65 **[180]** *Monitoring Log and Reporting Sheet*, March 30, 1955.

A.66 **[180]** Handwritten monitoring log, March 30, 1955.

A.67 **[180]** Hand-drawn map, March 30, 1955, no author listed.

A.68 **[181]** Memorandum from William S. Johnson to Leo G. Chelius, *Monitoring Results from Bayo Canyon Experiment of 4/7/55*, April 8, 1955.

A.69 **[181]** *Monitoring Log and Reporting Sheet*, April 7, 1955.

A.70 **[182]** Memorandum from C. P. Skillern to Leo G. Chelius, *Monitoring Results from Bayo Canyon Experiment of 4/22/55*, May 2, 1955.

A.71 **[182]** *Monitoring Log and Reporting Sheet*, April 22, 1955.

A.72 **[184]** Memorandum from C. P. Skillern to Leo Chelius, *Monitoring Results from Bayo Canyon Experiment of 5/5/55*, May 6, 1955.

A.73 **[184]** *Monitoring Log and Reporting Sheet*, May 5, 1955.

A.74 **[185]** Memorandum from C. P. Skillern to Leo G. Chelius, *Monitoring Results from Bayo Canyon Experiment of 5/12/55*, May 13, 1955.

A.75 **[185]** *Monitoring Log and Reporting Sheet*, May 12, 1955.

A.76 **[186]** *Monitoring Log and Reporting Sheet*, May 20, 1955.

A.77 **[186]** Memorandum from Clarence P. Skillern to Leo Chelius, *Results of Bayo Canyon Monitoring Run 5/20/55*, May 23, 1955.

A.78 **[187]** Memorandum from C. P. Skillern to Leo G. Chelius, *Monitoring Run on Rendija-Guaje Canyon 5/26/55*, May 27, 1955.

A.79 **[187]** *Monitoring Log and Reporting Sheet*, May 26, 1955.

A.80 **[188]** Memorandum from C. P. Skillern to Leo G. Chelius, *Monitoring Run on Rendija-Guaje Canyon Road Following Bayo on 6/2/55*, June 3, 1955.

A.81 **[188]** Handwritten monitoring note, June 2, 1955, no author listed.

A.82 **[189]** *Monitoring Log and Reporting Sheet*, September 16, 1955.

A.83 **[191]** *Monitoring Log and Reporting Sheet*, October 7, 1955.

A.84 **[192]** *Monitoring Log and Reporting Sheet*, October 19, 1955, and handwritten notes, October 20, 1955.

A.85 **[193]** *Monitoring Log and Reporting Sheet*, October 26, 1955.

A.86 **[194]** *Monitoring Log and Reporting Sheet*, November 3, 1955.

A.87 **[195]** *Monitoring Log and Reporting Sheet*, November 17, 1955.

A.88 **[196]** *Monitoring Log and Reporting Sheet*, November 29, 1955.

A.89 **[197]** *Monitoring Log and Reporting Sheet*, January 27, 1956.

A.90 **[198]** *Monitoring Log and Reporting Sheet*, February 21, 1956.

A.91 **[199]** *Monitoring Log and Reporting Sheet*, March 1, 1956.

A.92 **[201]** Radiation survey sheet, March 14, 1956.

A.93 **[202]** Radiation survey sheet, March 22, 1956.

A.94 **[203]** Memorandum from Carl W. Buckland to Leo G. Chelius, *Informal Report on Bayo Operations from the H-1 Group Office on 4/7/56*, April 9, 1956.

A.95 **[203]** Bayo Shot [radiation survey], April 7, 1956.

A.96 **[204]** Bayo Survey [radiation survey], April 12, 1956.

A.97 **[205]** Bayo Shot [radiation survey], April 20, 1956.

A.98 **[206]** Bayo Shot [radiation survey], April 26, 1956.

A.99 **[207]** Radiation survey, May 10, 1956.

A.100 **[208]** Radiation survey, May 21, 1956.

A.101 **[209]** Radiation survey, May 25, 1956.

A.102 **[210]** Radiation survey, June 7, 1956.

A.103 **[211]** Radiation survey, June 14, 1956.

A.104 **[212]** Bayo shot [radiation] survey, October 5, 1956.

A.105 **[213]** Bayo shot [radiation] survey, October 15, 1956.

A.106 [214] Bayo-cloud-fallout [radiation survey], October 10, 1956.
A.107 [215] Radiation survey, November 1, 1956.
A.108 [216] Radiation survey, December 5, 1956.
A.109 [217] Radiation surveys, December 20-21, 1956.
A.110 [219] Radiation survey, March 29, 1957.
A.111 [220] Bayo fallout [radiation survey], April 17, 1957.
A.112 [221] *Monitoring Log and Reporting Sheet*, May 9, 1957.
A.113 [222] *Monitoring Log and Reporting Sheet*, June 20, 1957.
A.114 [223] *Monitoring Log and Reporting Sheet*, July 10, 1957.
A.115 [224] *Monitoring Log and Reporting Sheet*, July 23, 1957.
A.116 [225] *Monitoring Log and Reporting Sheet*, September 27, 1957.
A.117 [226] *Monitoring Log and Reporting Sheet*, October 9, 1957.
A.118 [227] *Monitoring Log and Reporting Sheet*, January 30, 1958.
A.119 [228] *Monitoring Log and Reporting Sheet*, February 19, 1958.
A.120 [229] *Monitoring Log and Reporting Sheet*, March 17, 1958.
A.121 [230] Radiation survey, April 3, 1958.
A.122 [232] *Monitoring Log and Reporting Sheet*, June 3, 1958.
A.123 [233] *Monitoring Log and Reporting Sheet*, no date.
A.124 [234] *Monitoring Log and Reporting Sheet*, February 20, 1959.
A.125 [235] Bayo Canyon shot [radiation] survey, March 13, 1959.
A.126 [236] *Monitoring Log and Reporting Sheet*, April 2, 1959.
A.127 [237] *Monitoring Log and Reporting Sheet*, April 14, 1959.
A.128 [238] *Monitoring Log and Reporting Sheet*, May 15, 1959.
A.129 [239] *Monitoring Log and Reporting Sheet*, June 4, 1959.
A.130 [240] *Monitoring Log and Reporting Sheet*, June 26, 1959.
A.131 [241] *Monitoring Log and Reporting Sheet*, October 10, 1959.
A.132 [242] *Monitoring Log and Reporting Sheet*, March 8, 1960.
A.133 [243] *Monitoring Log and Reporting Sheet*, May 4, 1960.
A.134 [244] Memorandum from Charles D. Blackwell to Dean D. Meyer, *Perimeter Radiation Survey of Bayo Canyon*, September 6, 1960.
A.135 [244] *Monitoring Log and Reporting Sheet*, September 1, 1960.
A.136 [244] *Monitoring Log and Reporting Sheet*, September 2, 1960.
A.137 [244] *Monitoring Log and Reporting Sheet*, September 2, 1960.
A.138 [245] *Monitoring Log and Reporting Sheet*, October 11, 1960.

Appendix B. Relevant Documents

A number of documents used in the preparation of this report are reproduced here in their entirety, either to provide the complete flavor of a particular reference or as an example of the kind and quality of the material found in the document search.

B.1 Memorandum to Lt. Carroll, Dr. Hempelmann, Lt. McGuire, et al. from David Dow, "Safety Requirements at Bayo Canyon," February 3, 1945.

B.2 (LAMS-917) H-Division Progress Report, May 20, 1949 - June 20, 1949, "Radiological Safety," pp. 8-10.

B.3 Memorandum from T. L. Shipman to Sidney Newberger, "Conditions in Vicinity of Bayo Canyon," August 5, 1949.

B.4 Memorandum from T. L. Shipman, M.D., leader of Health Division, to R. E. Cole, AEC Office of Engineering and Construction, through N. E. Bradbury, Director, LASL, "Health Hazards—Guaje Canyon and Vicinity," April 4, 1950.

B.5 H-1 Program for Bayo Canyon Shots, 4-1-58.

B.6 **[177]** Memorandum from Clarence P. Skillern to Leo G. Chelius, "Monitoring Results Following Bayo Canyon Experiment of 1/12/55," January 12, 1955.

[177] Off-site monitoring report, January 12, 1955, no author listed.

B.7 **[189]** Monitoring Log and Reporting Sheet, September 16, 1955.

B.8 **[211]** Radiation survey, June 14, 1956.

B.9 H-1 Weather Section, "Report of Distribution," 22 December 1949.

B.10 March 16, 1957, Distribution Report.

Appendix B.1

Memorandum to Lt. Carroll, Dr. Hempelmann, Lt. McGuire, et al. from David Dow, "Safety Requirements at Bayo Canyon," February 3, 1945.

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H-1 Bayo Program
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REPOSITORY LANL/RC [redacted]

COLLECTION H-1, TR-908 [redacted]

BOX No. E6, Bx 132

INTER-OFFICE MEMORANDUM

FOLDER #1

UNCLASSIFIED EMS 8.6.87

February 3, 1945

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SB 05-6 10/13/87

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Classification changed to [illegible]
By authority of the U. S. Atomic Energy Commission,
Per William W. [illegible] 12 8 52
(Person authorizing change in classification) (Date)
By Julian W. Emery 12/15/52
(Signature of person making the change, and date)

To: Lt. Carroll
Dr. Hempelmann
Lt. McGuire
D. P. Mitchell
Lt. Rosenman
Captain Ross
Bruno Rossi
Emilio Segre
Major Stevens

From: David Dow

Subject: Safety Requirements at Bayo Canyon

In connection with the increased activities at the Bayo Canyon Site, the Safety Committee has recommended that the main road be closed to all traffic during the time of each large shot in order to insure a cleared area of 2500 yards from the Bayo Canyon site. This will involve closing the main road from the point where the Bayo Canyon road branches off to a point approximately opposite the incinerator west of Gate #1. It will also necessitate the evacuation of personnel from the East Gate Laboratory.

In order to insure the least inconvenience to everyone, the following procedure will be adopted:

1. Mr. Rossi or someone in his group will inform Mr. Dow at least 24 hours in advance of the scheduled time for every such shot. This information will include requested time for restricting entrance to site to those on approved list.

2. Mr. Dow will immediately inform Lt. McGuire, Dr. Hempelmann, Mr. Segre, and Sgt. Jackson. Mr. Dow will also have a short notice read over the public address system informing all persons that it is expected that the main road will be closed for a period of about an hour on the following afternoon.

3. Lt. McGuire will immediately inform MP Headquarters, Major Stevens, and Lt. Carroll. Major Stevens will inform the McKee Contractors' offices.

4. Lt. McGuire will see that four radio jeeps are available at noon on the day of the shot at the Bayo Canyon Site.

5. Mr. Dow will check with Group G-6 on the day of the shot and inform interested persons of any changes of plans and, if possible, the expected hour of the shot.

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6. Approximately one-half hour before the scheduled time for the shot, three jeeps will be dispatched by Mr. Rossi. One jeep will proceed up the canyon at least one and one-half miles above the site. Two jeeps will proceed to the junction of the main road and the Bayo Canyon road. One will stay at that point and stop all traffic coming up either road, and the second will clear the main road from that point to a point approximately opposite the incinerator west of Gate #1. This jeep will also see that all personnel are evacuated from the East Gate laboratory and from Post #1. The fourth jeep will remain at the Bayo Canyon control building and maintain communication with the other three jeeps.

7. The three radio jeeps will report by radio to Bayo Canyon that the roads are clear. After a successful shot the jeeps will be informed by radio from Bayo Canyon and traffic will be permitted to proceed.

8. It is understood that G-6 will make every reasonable effort not to shoot between 5:00 P.M. and 6:30 P.M. when the traffic on the main road is at its highest peak.

David Dow

[redacted]

Appendix B.2

(LAMS-917) H-Division Progress Report, May 20, 1949 - June 20, 1949, "Radiological Safety," pp. 8-10

SPECIAL RE-REVIEW
FINAL DETERMINATION
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H-DIVISION PROGRESS REPORT

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Progress Report - Weapons Data

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Group H-1 - Radiologic Safety

T. N. White

General Remarks

Shortage of personnel in the Biophysics Section on account of vacations again makes it necessary to omit a detailed report by this Section. The accelerated program of RaLa work at Bayo Canyon reached a culmination on 10 June, occupying the full time of available Biophysics and Monitoring personnel somewhat beyond that date. A quiescent period of a few weeks will now permit some attention to be given to other problems.

From the viewpoint of radiologic safety, an outstanding feature of recent Bayo operations has been the excellent quality of the work done by personnel from the Meteorological Detachment at Kirtland Air Force Base. In addition to their regular duties at Kirtland, these men have performed all-night weather observations at Los Alamos prior to shot days. They have provided predictions of phenomenal accuracy, particularly for 10 June, when there was a period of less than one hour that was suitable for a shot.

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The shots of 2 and 10 June were carried out under predicted and actually favorable weather conditions. The prediction for 6 June was unfavorable, but the shot was fired on account of the high priority of the program. The radiologic safety work was especially dependent on the immediate pre-shot weather observations, because the shot was fired after dark and the radioactive cloud could not be tracked visually. The main road East of Los Alamos was contaminated in much the same way as on 20 May (see preceding report). The Security Service provided road blocks, and traffic was kept out of the region of fall-out from the radioactive cloud from the shot. However, due to a concurrent rain squall, many of the approximately 120 cars that passed over this section of road that night picked up considerable contamination on tires and fenders. Most of that night and the following day were occupied in checking these cars, of which about 20% had to be decontaminated.

It has been decided that future shots will be fired only in daylight hours and when there is no danger of fall-out on the main roads and inhabited areas. Since a minimum of about ten hours notice of favorable or unfavorable weather conditions is needed in planning a shot, and since once the preparations are started they can be cancelled only at

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high cost, it is evident that the meteorological work will continue to be very important.

The heavy radio traffic on the Security Service network, and the increased demand by H-1 for the loan of Security Service radio-equipped vehicles during Bayo shot operations, has become a matter of considerable concern. The Security Service has been extremely cooperative, but it is evident that an indefinite continuation of this additional loading of their facilities would be undesirable. Plans are therefore being made to provide the Health Division with radio equipment and vehicles operating on the University of California Technical Network frequency.

Appendix B.3

Memorandum from T. L. Shipman to Sidney Newberger, "Conditions in Vicinity of Bayo Canyon," August 5, 1949.

entered

CK Joel

August 5, 1949 24

Sidney Newburger, AEC SS

T. L. Shipman, M.D., Health Division Leader

CONDITIONS IN VICINITY OF BAYO CANYON

REFERENCE: H

In response to your request, which was transmitted to me by Mr. Morgan, I can give you the following information: It has been agreed that no operations in this canyon will be carried out unless the wind is blowing from a direction to the south of an axis running due east and west. This ruling is primarily to avoid the necessity of establishing a road block or of dropping contaminated material on the townsite, the tech area, the pass gate, the asphalt plant, etc. The time and date of the various operations is planned several days in advance. Operations will not be carried out prior to the planned date. Unfavorable wind predictions, however, might necessitate the postponement of these operations one or more days. If operations, therefore, are planned for, let us say, Tuesday, we can be certain that they will not be carried out on Monday, but they may not take place until Wednesday or Thursday.

We have practically no concern about anyone tramping through the region where fallout has taken place except for the following general precautions:

1. It is unwise for individuals to be in the fallout itself; this means the period immediately following the shot and for anywhere from two to four hours thereafter.

2. We would advise anyone against having a picnic in the fallout area for approximately forty-eight hours after the shot, although no precautions are necessary for people simply walking through this area.

3. The area effected by the fallout varies, of course, with the velocity of the wind. With very calm conditions at the time of the shot, there is little or no contamination more than two miles from the firing site, while with a stronger wind, contamination can easily be found up to a distance of five miles, although less intense than in the former case. The zone of fallout varies from one-quarter to one-half mile in width. The area effected by the fallout can be indicated in most cases quite accurately within an hour of the shot.

Sidney Newburger
LAB-H - 8/5/49

The prevailing winds at this time of year should be generally southwesterly. During recent weeks there seems to have been an overabundance of northerly winds and the last three shots fired at Bayo Canyon had a generally southeasterly wind.

In general, no precautions need be taken except on shot days, and with the understanding that people do not picnic or carry out similar activities in the actual fallout zone during the forty-eight hours following a shot. Practically all detectable activity has disappeared from the area within a week.

ORIGINAL SIGNED BY THOMAS L. SHIPMAN, M. D.

THOMAS L. SHIPMAN, M.D.
Health Division Leader

TLS/kam
cc: Cen. Rec.
File

Appendix B.4

Memorandum from T. L. Shipman, M.D., leader of Health Division, to R. E. Cole, AEC Office of Engineering and Construction, through N. E. Bradbury, Director, LASL, "Health Hazards—Guaje Canyon and Vicinity," April 4, 1950.

TR-908
Pg. 1, #3
Bayo misc.
35

147-6 April 4, 1950

entered

R. E. COLE, AEC Office of Engineering and Construction
through N. E. Bradbury, Director, LASL

T. L. Shipman, M. D., Health Division Leader

HEALTH HAZARDS - GUAJE CANYON AND VICINITY

Concerning your memo requesting information as to the possible health hazards in the areas generally to the north of Bayo Canyon, we are currently in a position to provide you with a reasonably accurate picture of what can be expected. All my comments, however, are based on Bayo Canyon operations as carried out at the present time, and might have to be revised if the sources used in these operations are materially increased in strength. A definite revision of these comments will certainly be in order if a new firing site is selected.

It is our present feeling that any area which is two miles or more from the firing point may be regarded as a non-hazardous area. This statement will have to be qualified to a certain extent, about as follows:

A. Small children in residential areas certainly should not be repeatedly exposed even outside of this two-mile radius.

B. Non-hazardous concentrations of activities could easily upset certain counting operations within the Tech Area.

C. A steady breeze of low velocity (around five miles per hour) could deposit concentrations of activity in a two to five-mile radius to a considerably greater extent than would be the case if the wind were stronger and more gusty.

As you are aware, we ordinarily delay any operations in Bayo Canyon if the wind is in any direction north of a line running east and west. At present the east road and the eastern part of the townsite fall within a two-mile radius. This is also true of the rifle range and the riding stables. Pine Springs is approximately 4 1/2 miles from the firing point, and for this reason is definitely outside of the area which potentially could be hazardous. The pumice quarry, according to my maps, is approximately 3 miles from the firing point. Even though this installation were closer, we would not be too concerned, as it is a small installation and the chances of having it repeatedly in the line of the wind are remote. Actually, during the past nine months I do not believe that the area of this quarry has ever received more than a thoroughly insignificant amount of contamination.

At the present time an understanding has been reached among H Division, the Security Service and the National Parks Service that picnickers will be kept out of the vicinity of the Otowi ruin on shot days, but that they may use the area for picnics, etc. at all other times. The arrangement was that a pedestal type sign would be placed in the Bayo Canyon Road on the morning of the shot day, temporarily closing the area to the public, by the joint authority of the AEC and the National Park Service.

UNCLASSIFIED

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As far as H Division is concerned, GMX-5 may continue to use the Bayo Canyon site indefinitely, provided the strength of the sources is not increased materially and provided they are content to abide by existing restrictions imposed by unfavorable wind conditions.

Consideration is currently being given to the selection of a new firing site, and the region most favorably considered is the mesa top to the north of Guaje Canyon. This seems to be about the only suitable firing site from our point of view, within the Project boundary. This, of course, will be quite close to Pine Springs and also to the Project boundry, although considerably more remote from everything else. I cannot feel that we need worry about stray picnickers or hikers within the Santa Clara land to the north and northwest of this area. The Project boundry, however, should in this case be very clearly posted.

In summary, it is my feeling that you need have no fears or worries about the areas mentioned in your memo, unless a new firing site is selected. The entire problem in this case will need re-evaluation.

ORIGINAL SIGNED BY THOMAS L. SHIPMAN, M. D.

T. L. SHIPMAN, M. D.
Health Division Leader

TLS:es
cc Bradbury

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Appendix B.5

"H-1 Program for Bayo Canyon Shots," 4-1-58.

Entered

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4-1-68

H-1 PROGRAM FOR BAYO CANYON SHOT

A. Weather

1. Daily weather forecasts shall be furnished commencing two days prior to contemplated shot day concerning the weather, favorability of shot day and the hours during which favorable wind conditions will exist.

2. The wind direction must be such that the fallout will be in a favorable sector.

3. In order for the wind condition to be satisfactory, surface winds and all resultant winds from surface to 2000 feet should lie within the favorable sector.

4. Favorable winds for forecasting a shot day shall be from 180° to 270°.

5. Favorable winds for a shot shall be from 150° to 330°.

6. Wind velocity shall never be less than 5 miles per hour and normally not greater than 20 miles per hour for favorable conditions, both on forecast and on the actual shot procedure.

7. There shall be no precipitation at shot time. Evidence of precipitation in the path along which it is thought that the fallout will move is grounds for delaying or cancelling a shot.

8. There will be no shots after sunset as defined by a meterologist.

9. Weather people shall occupy Point Weather during the day of the shot and give last minute forecasts concerning wind direction and velocity. They will use vehicle and station number assigned in duty roster.

10. They will notify the Bayo Canyon monitor in the Battery Shack when the cloud has moved sufficiently to permit opening of the bunker.

11. A plot of the cloud motion will be furnished to H-1 Group Office.

12. They shall act as fire observers for Bayo Canyon. The Battery Shack monitor will be notified of any fires. The Battery Shack monitor will then request the assistance of the fire monitor and the firemen in combating fires when he deems it necessary.

B. H-1 Communications

1. Station is located in H-1 Group Office. Call letters are "Hickory".

2. Checks to make sure that all modes of communications with H Division personnel are intact.

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3. Notifies air-strip, 2-4031, one-half hour before shot time and keeps tower advised of any changes or delays. Plane arrivals or departures shall not be held up for more than ten minutes for firing a shot.

4. The A.E.C. Security Duty Officer, 7-4437, shall be notified one-half hour before shot time.

5. In case of difficulties in communications between various H Division units, he shall relay messages.

6. It shall be the responsibility of this individual to make the final decision that conditions are appropriate from a health standpoint to permit a shot.

7. It shall be the responsibility of this individual to determine when and if road blocks shall be established. He shall be the only person in H Division who has the authority to make this decision.

8. When informed by the personnel monitor that contaminated personnel are being sent in for decontamination, he shall inform the M.D. on duty and the General Monitoring Section.

9. Establish phone hook-up just prior to shot time between Bayo monitor-in-charge, Point Weather, and H-1 communications.

10. Calls GMX-5 Group Office after shot and gives shot time.

C. Bayo Canyon

1. Monitor-in-charge:

(a) Vehicle and station number as specified on duty roster.

(b) Arranges for the posting of the warning sign in the Otowi ruins area when the source enters Bayo Canyon.

(c) Takes background measurements at Battery Shack before shot time.

(d) Sees that all personnel have proper protective clothing, etc. to carry out their jobs safely.

(e) Escorts source from Building 1 to firing site.

(f) Responsible for monitoring all operations involving manipulation of source. He shall keep a constant check for contamination, calculate permitted working time and keep track of dosage.

(g) Monitors all personnel around firing site.

(h) Will be stationed in Battery Shack during shot time. Station in Battery Shack is designated Hickory 9.

(i) After the shot, it will be necessary to ascertain from either Point Weather or H-1 Communications the cloud location prior to leaving the bunker for a background check.

(j) He will then recommend whether the bunker personnel are to leave and how they will leave or tell them how long they may remain without exceeding tolerance.

(k) Conducts a careful survey of the immediate firing point as conditions permit, draws a map of findings, recommends possible decontamination measures, and estimates time required to wait for the next shot in order that the background will be down to a suitable level. The monitor should be careful to keep his exposure to a minimum. The above surveys should not be taken until really necessary.

(l) It shall be his responsibility to call the Duty Officer of the Security Patrol and let him know whether the area can be patrolled or not. It is recommended that patrols not be conducted in areas which exceed 20 mr/hr. A map indicating survey levels and restrictions should be prepared by Bayo Monitor-in-charge before leaving the Canyon on shot day. Three copies of this survey should be made. One copy will go to Station 103, the second to the Protective Force Area Sergeant, and the third to H-1 Group Office.

(m) Sees that the warning sign at the Otowi Ruins area is removed at the end of the day's operation.

(n) Is responsible for seeing that the source is secured in case of an abort. Whenever an operation involves returning a source to the pot, he will check to see that the source is in the pot before other personnel approach.

(o) Makes close check of source truck for contamination after unloading.

2. Building 21 Barricade:

(a) Personnel Monitor:

1) Assures that there is sufficient protective clothing, film badges and respirators to take care of firemen and other personnel involved in Bayo operations. All personnel at Building 21 Barricade at time of shot should be in protective clothing.

2) Charges personnel dosimeters and sees that everyone is issued one as they enter the Bayo area.

3) Remains at Building 1 until just before shot, when he goes to barricade at Building 21; at this time he will aid the Shot Supervisor in checking Bayo Canyon to see that all personnel are clear.

4) In case of excessive radiation to the Bayo monitor-in-charge, he assists at firing pad.

5) After the shot, he returns to Building 1 to check personnel and vehicles for contamination as they leave the area.

6) Informs H-1 communications, Station Hickory, when contaminated personnel are being sent to H-2 for decontamination.

(b) Fire Monitor:

1) Comes to Bayo Canyon approximately one hour before firemen. Uses vehicle and station number as assigned by the duty roster.

2) Issues personnel dosimeters, protective clothing and respirators to the firemen.

3) Approximately 10 minutes before shot time he goes to the barricade at Building 21 with the firemen. In case of anticipated fallout toward Building 21, he moves all personnel inside Building 21. All personnel at Building 21 at time of shot should be in protective clothing.

4) In case of fires he will accompany firemen. Insofar as possible, fire fighting should be done from the fire truck.

5) The fire truck must be monitored before leaving the Bayo area if it is used. The monitor assists in preliminary decontamination of this vehicle.

D. Road Monitor

1. Drives vehicle through fallout pattern when informed by Station Hickory.

2. Vehicle and call letters used will be those assigned by duty roster.

3. The route to be followed will be given by Station Hickory. Readings shall be taken every 0.1 mile.

4. Readings shall be taken with G-M instrument with window open and instrument held at approximately waist height. A positive reading is interpreted as anything above background.

5. Prepares a table showing all positive findings resulting from the above survey. A copy of this survey will be submitted to H-1 Group Office.

6. Immediately informs Station Hickory of any readings above 6 mr/hr.

7. Should carry high level gamma survey instrument and containers to collect soil samples and/or vegetation in case of high level readings.

E. Tank Mesa Monitor

1. Reports to the old burned cabin on Tank Mesa at least one-half hour before anticipated shot time.

2. He shall be assigned vehicle and call letters on the duty roster.

3. Carries sufficient protective clothing, respirators and film badges for both himself and the firemen. He shall also take a G-M instrument and ion-chamber type instrument for checking radiation levels.

4. Sees that both himself and the firemen are properly suited in protective clothing at shot time.

5. Accompanies the firemen on all fires assuring that they do not get excessive dosage or contamination.

6. Checks firemen and equipment for contamination before they leave.

F. Tolerance

1. All personnel leaving Bayo Canyon will be monitored. All persons having body spots greater than 1 mr/hr will be required to shower. If after the completion of the shower all spots are 3 mr/hr or less, the individual will be allowed to leave. Those having spots greater than 3 mr/hr after the second shower will be referred to the Medical Group, H-2, in "A" Wing of the Administration Building. All others will be allowed to leave.

2. The alpha tolerance will be 500 c/m/spot, a spot being interpreted as that area covered by a Pee Wee probe.

3. Body monitoring for beta-gamma will be done with a G-M type instrument with the shield open. A spot will be interpreted as the area covered by the probe of this instrument on body contact.

4. Measurements of beta-gamma background will ordinarily be made with a G-M type instrument with the shield open and held at waist level.

Appendix B.6

Memorandum from Clarence P. Skillern to Leo G. Chelius, "Monitoring Results Following Bayo Canyon Experiment of 1/12/55," January 12, 1955.

Off-site monitoring report, January 12, 1955, no author listed.

Entered

Leo G. Chelius, H-1 January 12, 1955

Clarence P. Skillern, H-5

MONITORING RESULTS FOLLOWING BAYO CANYON EXPERIMENT OF 1/12/55

H-5

Two monitoring runs were made on the Rendija-Guaje Canyon Roads from 1/2 to 1-1/2 hours following detonation. The highest value found was about 4 times background (0.12 mr/hr Beta) a distance 1.5 miles east of the Sportsmans Range. The fall-out path covered an area about 1 mile wide. All of the other readings were background which included all inhabited areas.

rb

Clarence P. Skillern
Test Operations Section

OFF-SITE MONITORING REPORT

Shot 1/12/55

Operator(s)__________

~~[illegible]~~

G.M. tube

Call sign__________

3' open 6" closed

Time	Speedometer Reading	~~Grid Location~~	~~Level~~	Reported Via	Time	To	Initials
14:28	29030-3	Bkgd	Bkgd	~~[illegible]~~ Gate road. Rendezvous Canyon			
14:33	29031-8	✓	✓	Sportsman Club			
1437	29032-8	.05MR	.05MR	1 mile west Sportsman club Rendezvous Canyon			
1442	29033-3	.12 MR	.08MR	.5 mile Water pumping Station			
1449	29033-8	.05 MR	.04MR	Rendezvous Canyon Gate			
1456	29036-2	Bkgd	Bkgd	Pumice Mine			
1500	038.8	"	"	WATER WELL – DRILLING			
1511	039.7	.05MR	.04MR	Rendezvous Canyon Gate			
1515	040.4	.12 MR	.08MR	.7 mile West Canyon Gate			
1520	41.8	Bkgd		Sportsman Club			

Appendix B.7

Monitoring Log and Reporting Sheet, September 16, 1955.

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B.7.2

MONITORING LOG AND REPORTING SHEET

entered

NAME G.J. Littlejohn

RADIO CODE Hickory 5

DATE Sept. 16 1955

INSTRUMENT Model 263 Modified

* detonation

Time	Speedometer Reading	Location	Shield Open 3' Above Ground	Shield Closed 6" Above Ground	Instrument Number
*1445			mr/hr		#106728
1500	1068.6	Point Weather	.20		
1515	1070.0	Stables	.03		
1520	1070.8	Picnic Grounds	.03		
1530	1073.0	Sportsman's Park	.03		
1545	1076.6	Ojo Canyon Pump St.	.03		
1550	1077.4	Pumice Mine	.10		
1600	1077.6	East of mine	.10	.10	# Dean's 809
1603	1077.7	" "	.20	.10	
1607	1077.8	" "	.10	.3 shield open 6" above ground	
1615	1078.6	" "	.08	.15 shield open 6" above ground	
1617	1079.1	" "	.03	.03	
1622	1080.6	Junction Mine Rd #4	.03		
1654		TA-1			

REPOSITORY LANL/RC

COLLECTION TR 908 H-1

BOX No. E6 B13Z

FOLDER 3 Bayo Shots 1955

Area rechecked on 9/17/55 - 9-11 am - results same as above; then [illegible]

18

Appendix B.8

Radiation survey, June 14, 1956.

entered

6-14-56

, Shield open

mileage	Time	position	mr/hr @ 3" of ground
4895.4	1:15 pm	Sm-43	.03
4899.07	1:21	picnic ground	.03
4900.5	1:29	Stables	.03
901.3	1:32	Ft. weather gate	.03
1902.1	1:38	Ft. weather	.07
1906.6	1:51	Sportsman park	.03
1909.5	1:56	Barrancas gate	.03
1909.6	2:02	Booster Sta #1	.03
1910.9	2:06	Pumice mine	.03
1911.6	2:09	Barrancas Rd (well #1)	.03
1913.9	2:18	Barrancas Rd + Route #4	0.3

Checked road to White Rock and returned through Barrancas Canyon as checked and nothing found above background.

Pinkus & Blackwell -
[illegible] negative [illegible] by
[illegible] 4:00-4:30 pm

Appendix B.9

H-1 Weather Section, “Report of Distribution,” 22 December 1949.

opp B.9 (3898)

142

From: H-1 Weather Section

Subject: Report of Distribution, 22 December 194[redacted] #142

VERIFIED UNCLASSIFIED
JB 05-6 10/13/92

1. Weather Forecast:
   - Sky condition: Clear
   - Canyon wind: East southeast 5 mph
   - Mesa-top wind: Southeast 5 mph
   - 500 ft. wind: West northwest 12 mph
   - Winds 1000 ft and above: Northwest 20-25 mph
   - Optimum distribution time: 11-1400.

2. Forecast Verification: (At time of distribution)
   - Sky condition: Clear
   - Canyon wind: Calm
   - Mesa-top wind: East 3 mph
   - 500 ft. wind: East northeast 3-4 mph
   - Winds 1000 ft and above: Northeast 4-5 mph

3. Distribution Data:

   a. Time of Distribution: 1632.

   b. Triangulation data: See chart "A"

   c. Cloud track: See chart "B"

4. Remarks:

   a. Wind directions were approximately as forecasted for the time of distribution reccommended; wind velocities were considerably lower than forecasted. An observed balloon run taken at 1500 showed the following:
      - Mesa-top wind: Southeast 3 mph
      - 500 ft. wind: South southeast 3 mph
      - 1000 ft. wind: West 8 mph
      - 1500 ft and above: Northwest 12-15 mph

      Because of lighter velocities, the forecasted up-canyon wind was virtually non-existent.

   b. Subsequent delay of distribution past reccommended time resulted in shift of winds which became lighter and generally from the northeast. The undersigned was in error in assuming that forecasted winds would hold until 1700.

   c. Error noted in 4b, above, indicates the necessity of more frequent wind checks by weather personnel at Point Weather. This is particularly true of the 30 minute perior prior to distribution. It is further noted, however, that after 1500-1600 wind conditions change rapidly because of terrain features. In the absence of a well-defined wind flow pattern, these winds tend to become lighter and extremely variable.

d. Observation of distribution, in addition to triangulation data, showed the following:

(1) A well defined smoke ring rose to a considerable height above the cloud proper and, becoming detached, moved off in a southeasterly direction apparently hanging over the eastern end of North Mesa and Pueblo Canyon. This ring persisted for approximately 10 minutes before beginning to disintegrate. Smoke ring had a counterclockwise rotation.

(2) Smoke cloud moved west southwest then southwest across North Mesa and over Tech Area at very low rate of movement because of light winds. Cloud persisted for more than 25 minutes but became very diffuse after 12 minutes and was difficult to triangulate.

(3) No fires were started, probably because of the snow cover on ground.

Classification changed to [redacted]
by authority of the U. S. Atomic Energy Commission
Per [illegible] 7-26-55
(Person authorizing change in classification) (Date)
By [illegible] 10-1-57
(Signature of person making the change, and date)

[signature]
VERNON W. WINDELL
OIC, H-1 Weather Section

CHART "A"
TRIANGULATION DATA

of rv- ion	Dist. from Point Able	Dirn From Point Able	Hght of Base above Point Able	Hght of Top above Point Able	Hght of Base above Mesa Tops	Distance from preceding observed position	Direction and Velocity of Movement for preceding minute
30"	260'	WSW	[illegible]	1550'	[illegible]	250 ft.	WSW 3 mph
1'30"	520'	WSW	820'	2000'	400'	260 ft.	W 3 mph
2'30"	780'	WSW	1150'	2350'	710'	310 ft.	WSW 4 mph
3'30"	935'	WSW	1200'	2550'	780'	310 ft.	SW 2 mph
4'30"	1145'	WSW	1320'	3110'	800'	260 ft.	WSW 3 mph
5'30"	1550'	WSW	1550'	3150'	1130'	415 ft.	W 3 mph
6'30"	1870'	WSW	1250'	3840'	850'	355 ft.	SW 4 mph
7'30"	2080'	SW	1250'	3840'	850'	310 ft.	S 4 mph
8'30"	2445'	SW	1310'	4220'	890'	365 ft.	WSW 4 mph
9'30"	2755'	SW	1320'	4170'	900'	310 ft.	SW 4 mph
10'30"	3175'	SW	1355'	4300'	935'	415 ft.	SW 3 mph
11'30"	3590'	SW	1400'	4300'	980'	465 ft.	SW 3 mph

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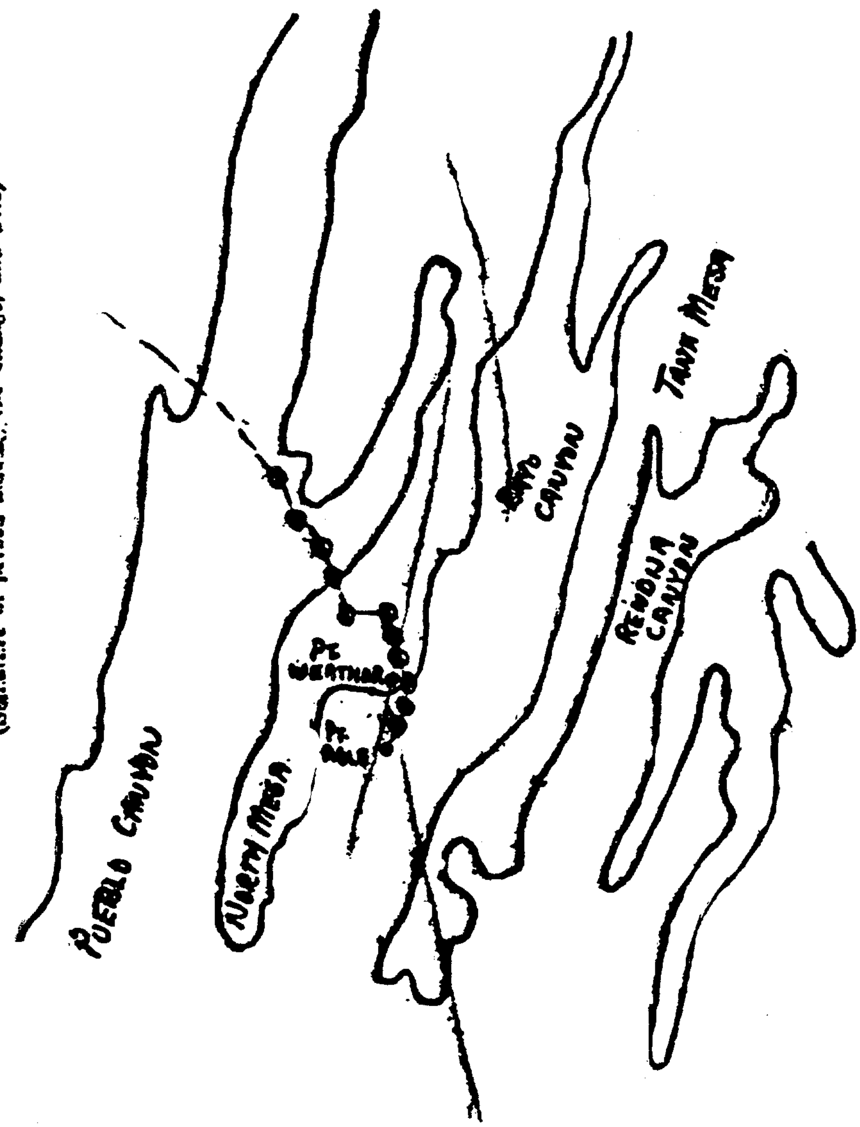
12/22/49

CHART "B"

CLOUD TRACK



[redacted]

Classification changed to
by authority of the U. S. Atomic Energy Commission, 7-26-55
Per [signature]
(Person authorizing change in classification) (Date)
By [signature] 9-30-57
(Signature of person making the change, and date)

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Appendix B.10

March 16, 1957, Distribution Report.

Shot 218

Entered

DATE: March 16, 1957

PROPOSED DISTRIBUTION TIME: 11:00 am.

ACTUAL DISTRIBUTION TIME: 12:45 pm.

REASON FOR DIFFERENCE BETWEEN PROPOSED AND ACTUAL DISTRIBUTION TIMES: Weather asked for delay until 12:00 noon for surface winds to become more westerly. Technical delay to 12:45 pm

SYNOPTIC SITUATION: Surface front in Nev - Ariz. Surface high to east with fairly tight gradient.

ALBUQUERQUE WEATHER BUREAU FORECASTS:

ALBUQUERQUE 8000 FT WIND DIRECTION:	230	SPEED	25
ALBUQUERQUE 10000 FT WIND DIRECTION:	240	SPEED	30
FARMINGTON 8000 FT WIND DIRECTION:	230	SPEED	25
FARMINGTON 10000 FT WIND DIRECTION:	240	SPEED	30

LOCAL WEATHER FORECAST FOR PROPOSED DISTRIBUTION TIME:
SKY CONDITION: Broken PRECIPITATION: None
WIND DIRECTION: SSW SPEED: 10-15 mph

LOCAL WEATHER AT 0800 MST:
SKY CONDITION: Overcast PRECIPITATION: None
WIND DIRECTION: SSE SPEED: 5-10 mph

LOCAL WEATHER AT PROPOSED DISTRIBUTION TIME:
SKY CONDITION: Broken PRECIPITATION: None
WIND DIRECTION: 190 degrees SPEED: 10 mph

LOCAL WEATHER AT ACTUAL DISTRIBUTION TIME:
SKY CONDITION: Broken PRECIPITATION: None
WIND DIRECTION: 210 degrees SPEED: 15 mph

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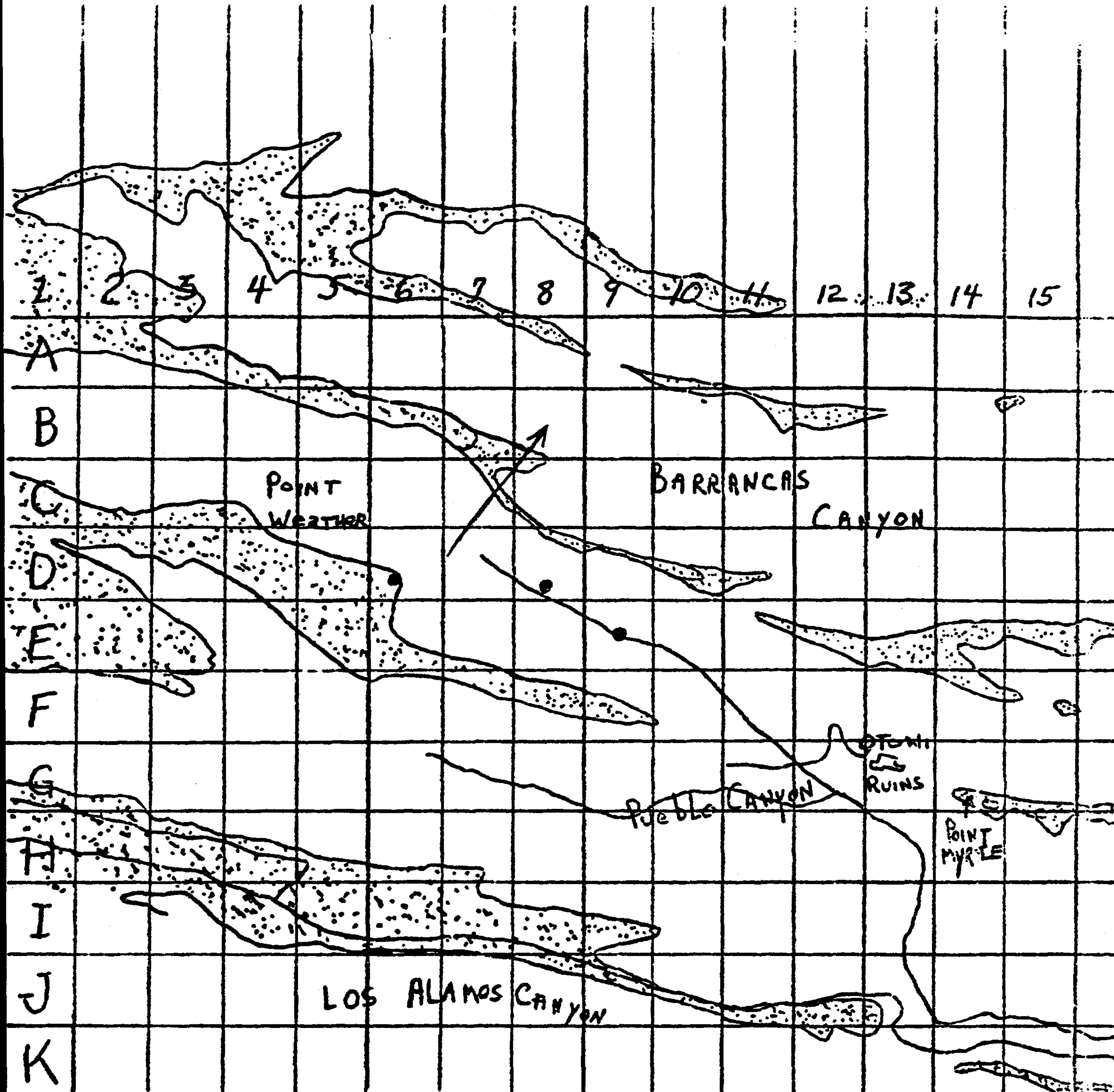

DATE	March 16, 1957
WIND DIRECTION	210 degrees
WIND SPEED	15 mph
SKY CONDITION	Broken

CLOUD CHARACTERISTICS 7-800 ft above mesa, dissipated rapidly.

REMARKS Wind speeds increasing with time - rather gusty at shot time but averaging around 15 mph.

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B.10.3

DATE: ______________________

PROPOSED DISTRIBUTION TIME AND DATE: ______________________

SYNOPTIC SITUATION: ______________________

PRELIMINARY FORECAST:

SKY CONDITION: ______________ PRECIPITATION: ______________

WIND DIRECTION: ______________ SPEED: ______________

DATE: March 15, 1957

PROPOSED DISTRIBUTION TIME AND DATE: 11:00 am, March 16, 1957

SYNOPTIC SITUATION: SW - WSW flow aloft to the west coast with trough just off the west coast, and a surface front in vicinity of Los Angeles area. Surface high over local area moving to the east.

PREPARATION FORECAST:

SKY CONDITION: Broken PRECIPITATION: None

WIND DIRECTION: S - SSW SPEED: 10-15 mph increasing in am
10,000 ft: 240/25-30

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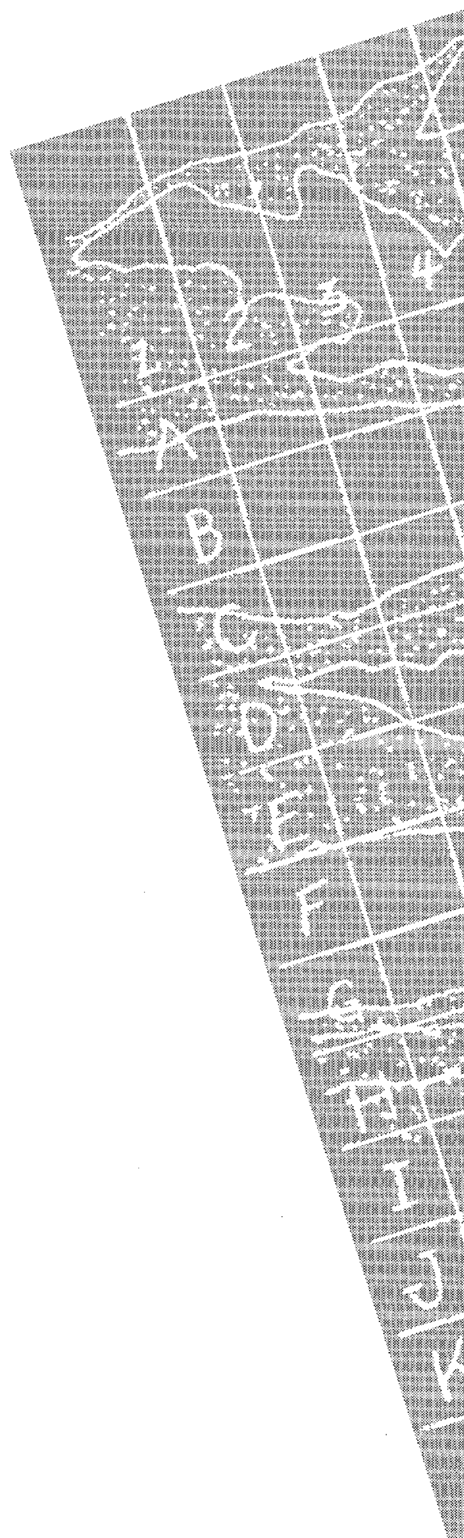
B.10.4

END DATE

6-19-96



Los Alamos
NATIONAL LABORATORY

Los Alamos, New Mexico 87545