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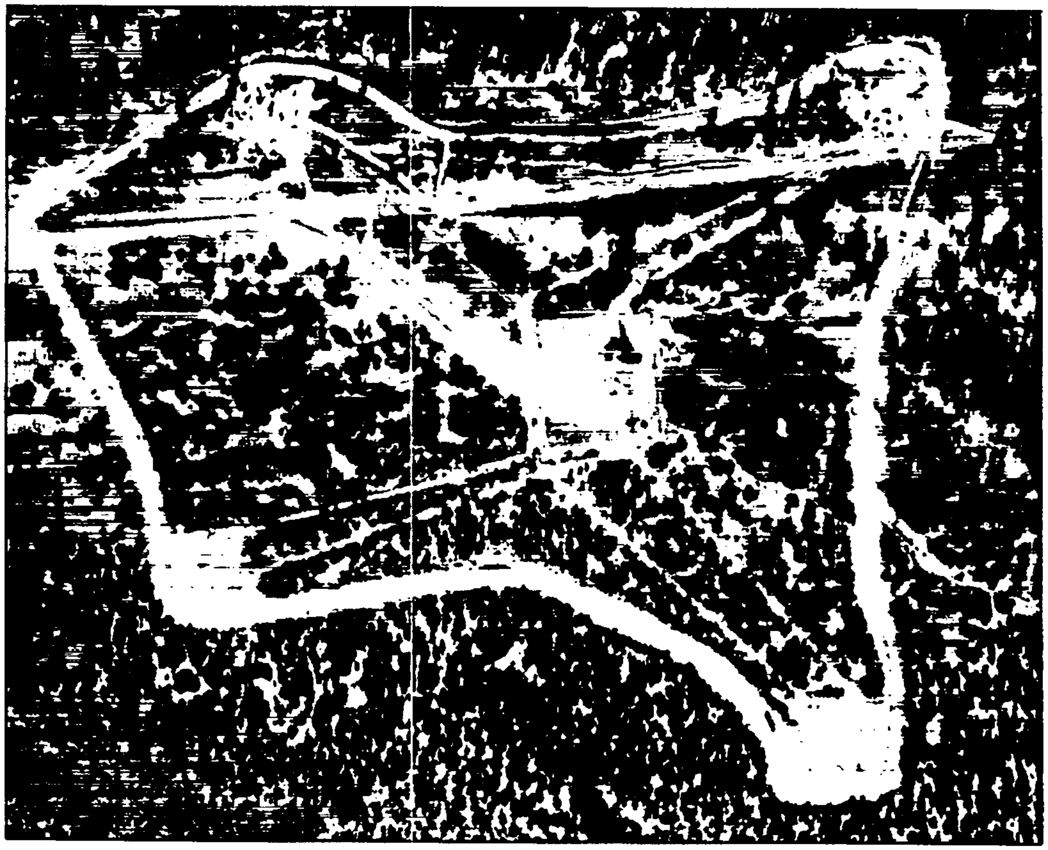
Environmental Status of Technical Area 49, Los Alamos, New Mexico



Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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ENVIRONMENTAL STATUS OF TECHNICAL AREA 49, LOS ALAMOS, NEW MEXICO

by

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Alan K. Stoker

ABSTRACT

In 1960 and 1961 a series of experiments involving high explosives and radioactive materials were conducted at Los Alamos, New Mexico, primarily to understand certain safety aspects of operational nuclear weapons. The experiments were conducted underground in large diameter holes as deep as 120 ft. The experiments were conducted in an area that was extensively studied in advance by the U. S. Geological Survey. The location was selected because it had geologic and hydrologic characteristics that assured complete containment of the experiments and precluded any possible contamination of groundwater. Important features verified by the USGS included the absence of any recharge and about 1200 feet of dry rock above the groundwater aquifer.

Residual materials dispersed by detonation of the high explosives remain at the bottom of the experimental holes. The materials of significance from an environmental standpoint include about 40 kg of plutonium, 93 kg of enriched uranium, at least 82 kg of depleted uranium, 13 kg of beryllium, and an undetermined amount of lead. The area is presently identified as a radioactive and hazardous material disposal area for purposes of compliance with Department of Energy and Environmental Protection Agency requirements.

Environmental monitoring has been carried out regularly since the time of the experiments. Results of measurements confirm that there has been no contamination of groundwater. Minor surface soil contamination dating from the time of the experimental operations has been detected in small surface drainages near the experimental area. None of the surface contamination has been measurable at Laboratory boundaries or points of public access on a state highway. Additional environmental studies will be conducted in the future under auspices of Department of Energy programs designed to assure appropriate management of buried transuranic waste and full compliance with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act.

I. HISTORY AND BACKGROUND

A. Hydronuclear Experiments

Hydronuclear experiments were conducted underground at the Los Alamos Scientific Laboratory (LASL; the word "Scientific" was included in the name until 1980 when it was changed to "National"), Los Alamos, New Mexico, in 1960 - 1961. The experiments were conducted at Technical Area 49 (TA-49), located on Frijoles Mesa in the southwest corner of the Laboratory (Fig. 1). The experiments, conducted at the direction of President Eisenhower, were primarily to answer fundamental questions regarding certain safety aspects of four weapon systems that became operational in 1958. These experiments involved a combination of conventional (chemical) high explosives, usually in a nuclear weapon configuration, and fissile material whose quantity was reduced far below the amount required for a nuclear explosion. Between January 1960 and August 1961, a total of 35 hydronuclear experiments and 9 related calibration, equation-of-state, and criticality experiments, all involving some fissile material, were conducted (Thorn 1987). Other experiments involving high explosives and possibly some small amounts of radioactive tracers, but no fissile materials, were conducted starting in October 1959 and extending through the same period. The aerial photograph on the cover of this report shows TA-49 in late 1959.

B. Operations

The experiments involving fissile materials were conducted in 3- or 6-ft-diameter experimental holes at depths of 31 to 108 ft. Some of the other experiments were conducted in holes as deep as 120 ft. Several such experimental holes were augered and prepared for use in sequence. The experimental configuration was emplaced at the bottom of the hole, which was then stemmed (backfilled) with sand to contain the physical force of the high-explosive detonation. As the experiment was detonated, measurements and samples were taken through access tubes or pipes. After completion of measurements and sample collection, the experimental holes were backfilled with additional sand and sealed with concrete. Results of analyses were used to modify the next configuration in the series. The first series of nine hydronuclear experiments was conducted between January 12 and February 11, 1960 (Thorn 1987).

C. Materials Left in Place

All presently known remaining contamination at TA-49 is described in the next three sections.

1. Experimental Areas. Most materials were left in the experimental holes in which the experiments were conducted. The principal materials of interest from an environmental standpoint include plutonium, uranium, beryllium, and lead. A total of about 40.1 kg of plutonium, 93 kg of enriched uranium, at least 82 kg of depleted uranium, and 13 kg of beryllium were utilized. (No estimate of the amount of lead left from the experiments is presently available but will be determined from detailed review of engineering drawings during followup studies described later in Section IV of this report.) A small amount of fission products (less than 1 millicurie) would also be present.

Physical properties of the tuff and sand readily absorbed the energy of explosions and confined most of the materials within a maximum distance of 10 to 20 ft from the location of the experimental configuration. This confinement is indicated because in only one case was contamination from an

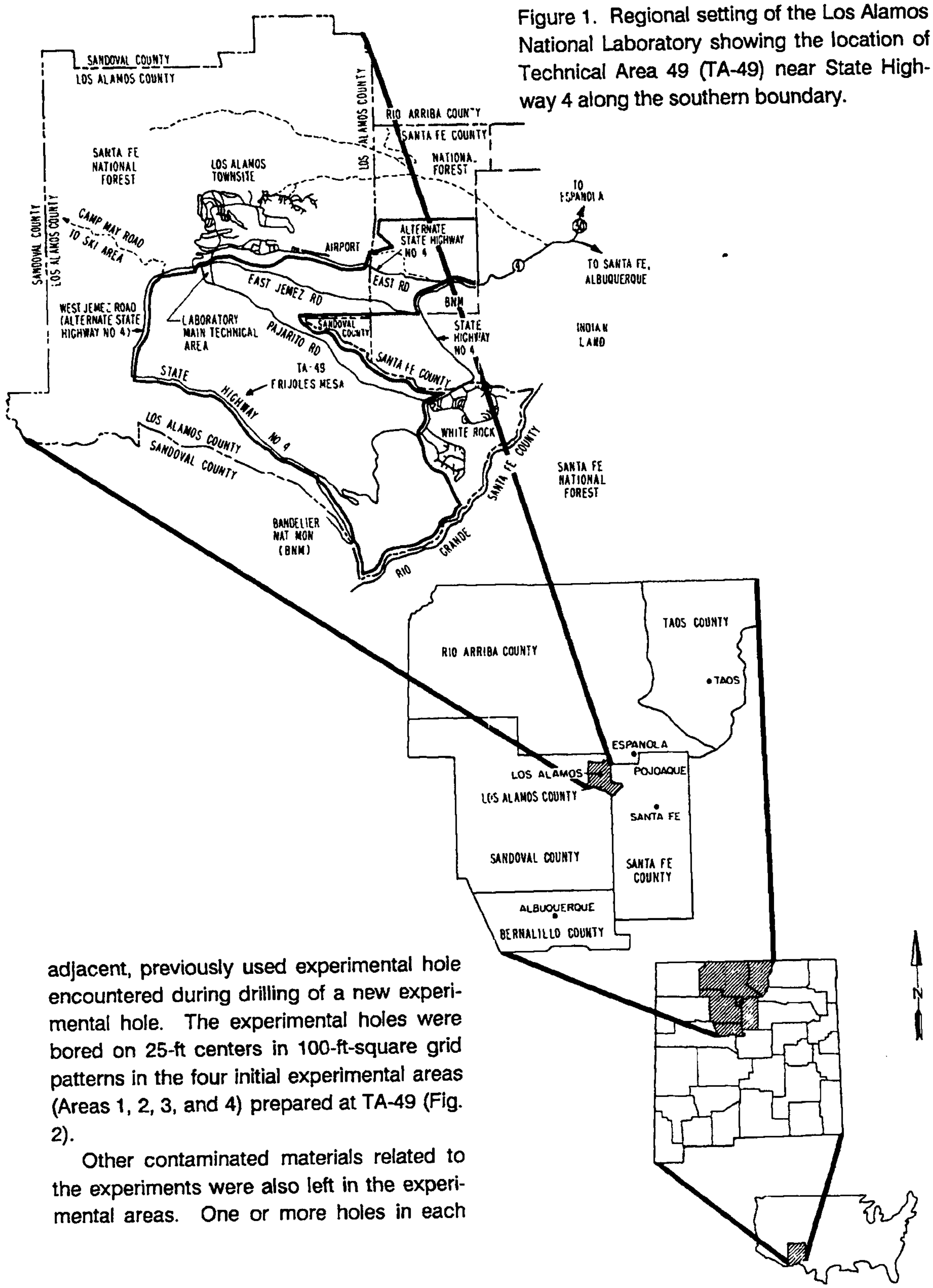

Figure 1. Regional setting of the Los Alamos National Laboratory showing the location of Technical Area 49 (TA-49) near State Highway 4 along the southern boundary.

adjacent, previously used experimental hole encountered during drilling of a new experimental hole. The experimental holes were bored on 25-ft centers in 100-ft-square grid patterns in the four initial experimental areas (Areas 1, 2, 3, and 4) prepared at TA-49 (Fig. 2).

Other contaminated materials related to the experiments were also left in the experimental areas. One or more holes in each

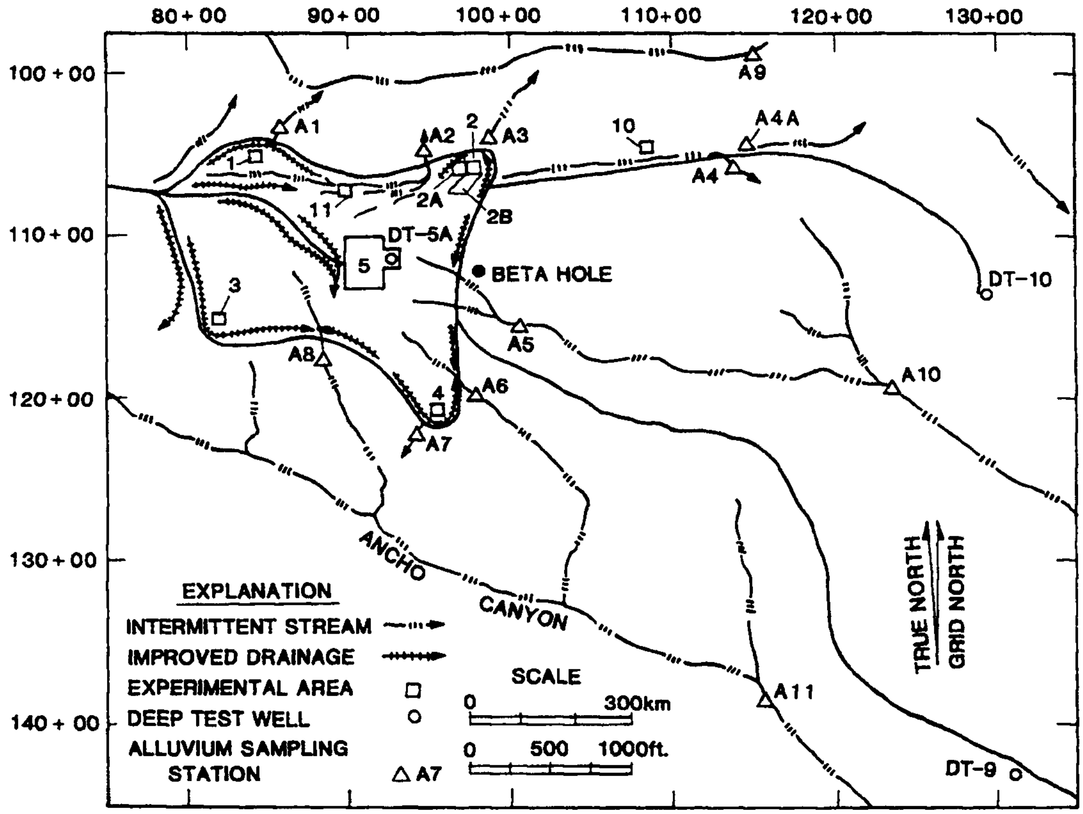

Figure 2. Map of TA-49 showing experimental areas, core holes, deep test wells, and sediment sampling locations.

experimental area were used to permit expansion of gases passing through the sample collection devices and probably contain some particulate contamination. Some of the holes were used to dispose of pipes and other equipment contaminated during the experiments. Steel boxes buried adjacent to the experimental holes were used to contain sample collection equipment and often became contaminated. These were filled with concrete and left in place.

2. Surface Contamination. Some plutonium contamination was measured at the surface in experimental Area 2 in December 1960 and was traced to cuttings from experimental hole 2-M drilled during October and November. Plutonium had apparently been dispersed through fractures in the tuff by detonation of an experiment in an adjacent experimental hole. All surface soil contamination measurable by standard procedures and instruments of the time was collected and placed back in experimental hole 2-M. The experimental hole was then filled with clean sand and capped with concrete. The entire surface of Area 2 was covered with 6 ft of compacted aggregate in January 1961 and sealed with a 4- to 6-in.-thick asphalt pad in September 1961. The asphalt pad can be seen in the upper right portion of the aerial photograph in Fig. 3, which was taken in

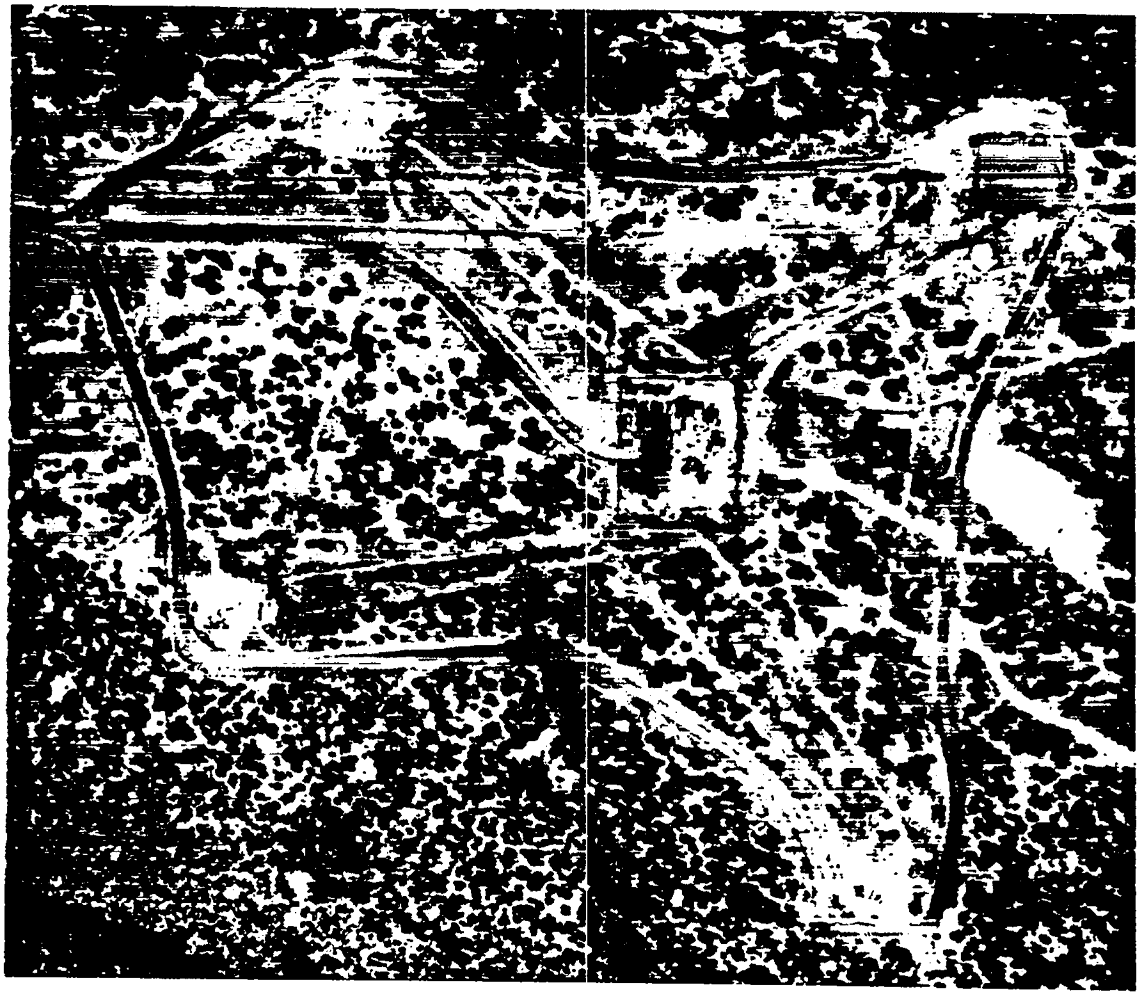

Figure 3. Aerial photograph of TA-49 from 1965. Note asphalt pad covering experimental area 2 in upper right.

1965. This inadvertent contamination incident left some remaining trace amounts of plutonium on the surface in the vicinity of TA-49. After closure of the original 100-ft-square experimental Area 2, additional experimental holes were constructed to the west (Area 2A) and south (Area 2B) as indicated in Fig. 2.

3. Contaminated Structures. Structures located in Area 11 (Fig. 2) of TA-49 were used for radiochemistry. They were decontaminated, demolished, and removed in September of 1971. Close inspection of the aerial photograph in Fig. 4, which was taken in 1974, shows the absence of the structures in Area 11. Contaminated materials were packaged and transported to the Laboratory's radioactive waste disposal facility at TA-54. Uncontaminated materials and debris were buried in a landfill about 1/2 mile northwest of the TA-49 experimental area. A contaminated subsurface drain field that served the radiochemistry facility was left in

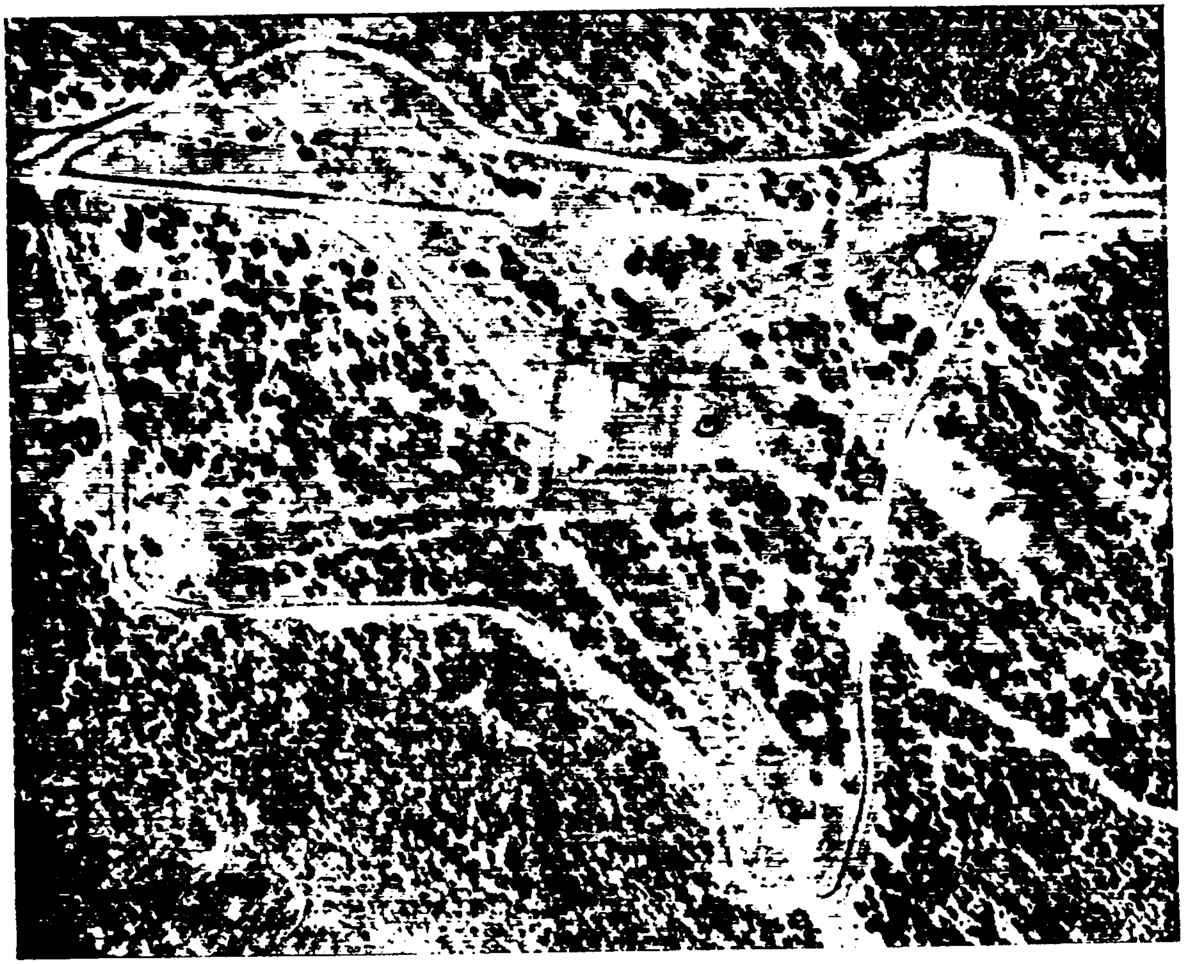

Figure 4. Aerial photograph of TA-49 (1974). Note absence of structures in experimental area 11 in top center when compared was photograph in Figure 3 (1965).

place and represents a source of near-surface contamination remaining in the TA-49 vicinity.

II. SITE SELECTION AND EVALUATION

A. Reconnaissance Survey

The Water Resources Division of the U.S. Geological Survey (USGS), in cooperation with the U.S. Atomic Energy Commission (AEC) and LASL, in 1947 began a series of geologic studies and hydrologic investigations related to developing a water supply for Los Alamos and disposing of low-level radioactive liquid effluents. Because of this expertise, in January 1959, AEC and LASL requested the USGS make a preliminary study to locate a site for the hydronuclear experiments. The site was to be within the Laboratory at a distance from the Los Alamos townsite, have a flat area large enough to accommodate the experimental facilities, be able to contain the experiments, and have geologic and hydrologic characteristics that would retain any residuals or contaminated materials from the experiments and preclude contamination of the water supply.

The study identified Frijoles Mesa as a favorable site. The mesa was relatively flat and large enough to accommodate the experimental facilities. The area was believed to have about 1200 ft of unsaturated tuff and sediments above the main aquifer. The mesa was not considered to be a source of recharge to the underlying aquifer. The mesa was selected as the site pending development of additional data related to the geology and hydrology. A detailed study was initiated by USGS in September 1959 at AEC's request.

B. Detailed Hydrogeologic Investigation

The USGS performed a detailed geologic and hydrologic investigation of Frijoles Mesa (TA-49). The field work began October 1959 and the most intensive part was finished by mid-May 1960.

The fundamental conclusion of the study was that "Recharge to the ground water from Frijoles Mesa is very small or nonexistent; thus no contaminants in solution are likely to be carried to the ground water beneath TA-49" (Wier 1962).

The hydrogeologic investigation of the mesa was focused on assuring containment of residual materials that would be left in the experimental holes. Three deep test wells ranging from 1409 to 1821 ft were drilled into the main aquifer of the Los Alamos area to determine thickness of the tuff and volcanic sediments and hydrologic characteristics of the aquifer. Deep test well DT-5A is located near the center of the four experimental areas (Fig. 2). Wells DT-9 and DT-10 are located down the groundwater gradient to the east. In addition, four core holes ranging in depth from 300 to 500 ft deep were drilled in the centers of the four experimental areas to detail the geology and hydrologic characteristics of the tuff beneath the areas. These holes were cased and left in place for future monitoring. Surface geology of the area was mapped and correlated with subsurface geology determined from logs of the test wells and core holes.

Soil moisture studies were made in 23 moisture access holes ranging from 10 to 49 ft deep, which were drilled on the mesa surface. Soil thickness was measured and mapped. The holes were logged with a neutron probe to determine moisture content of the soil and tuff near the mesa surface.

Data on soil and tuff characteristics were examined and mapped for a number of the 6-ft holes drilled for the experiments. Data were also collected from two holes, one drilled 692 ft into the tuff and the other drilled 968 ft deep through the tuff and into the top of the volcanic sediments. These two holes were later abandoned. Two 2-ft-diameter holes were drilled to a depth of about 189 ft, one on the mesa surface and the other in the adjacent canyon to the north. Both were completed in the tuff. None of the holes contained any perched water. Samples of tuff were collected for analyses of hydrologic properties (Wier 1962).

The geologic studies documented that the Bandelier Tuff is about 930 ft thick in the vicinity of TA-49 (Fig. 5). It is composed of three members (Griggs 1964). The upper member, the Tshirege Member, is about 640 ft thick composed of 6 units of nonwelded to welded ashflow tuffs (welded tuff exhibits higher density and cohesion) and a waterlaid sand between two ashflows (Fig. 6). The middle member, the Otowi Member, is composed of two nonwelded ashflows or ashfalls that are about 200 ft thick. The lower member, the Guaje Member, is an ashfall of pumice with a thickness of 90 ft. The volcanics and volcanic sediments, the Puye

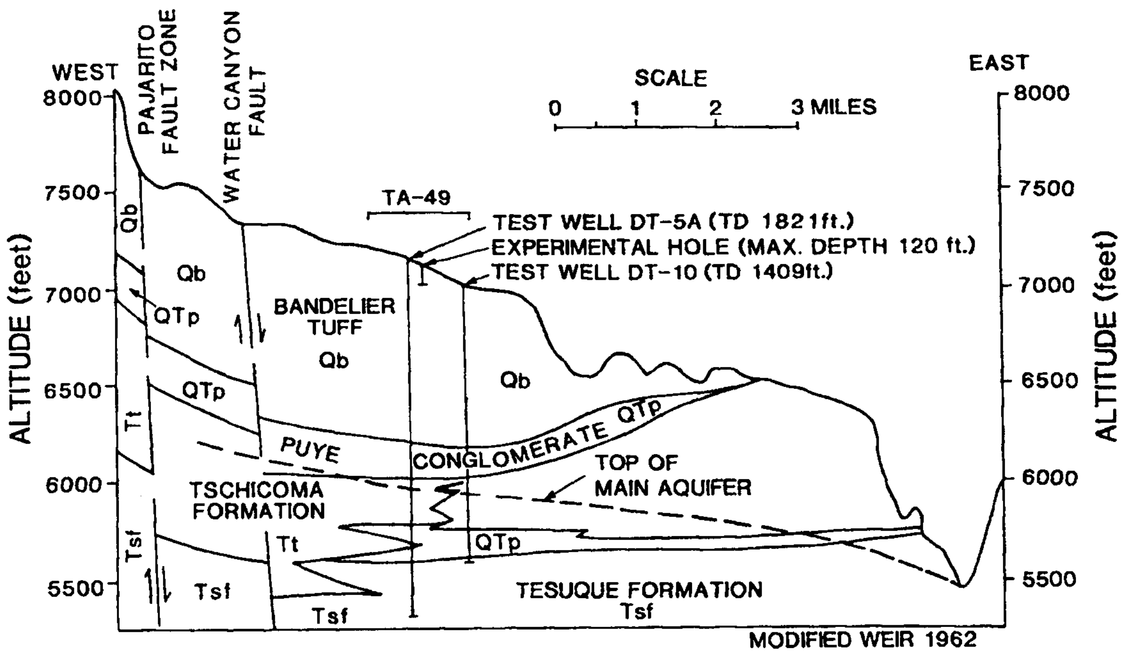

Figure 5. Geologic cross section through TA-49 from the Pajarito fault zone to the Rio Grande.

Conglomerate and the Tschicoma Formation, underlying the tuff are about 600-ft thick. They are in turn underlain by siltstones and sandstones of the Tesuque Formation, which exceeds a thickness of 2300 ft in the area (Fig. 5).

The three deep test wells indicated that the top of the main aquifer was at a depth of about 1170 ft near the center of the four experimental areas. The test wells and other holes drilled in the area indicated no perched water in the tuff or volcanics above the main aquifer in spite of the presence of potential perching beds. This absence of perched water indicates that no recharge to the main aquifer occurs through the plateau in the vicinity of TA-49.

The direction of groundwater movement in the deep aquifer is to the east-southeast toward the Rio Grande where a part of the water is discharged into the river through seeps and springs (Fig. 7). The rate of movement of the water determined from aquifer tests was estimated to be about 400 ft/yr for the upper 400 ft of the aquifer (Wier 1962). The aquifer tests indicated the average specific capacity of 15 gpm/ft of drawdown, an average field coefficient of permeability of 83 gpd/ft^2, and a transmissivity of 36,000 gpd/ft (Wier 1962).

As an additional benefit, these extensive hydrologic study data were utilized to develop an improved water supply for Los Alamos. The data resulted in siting and drilling high-yield (greater than 1000 gpm) water supply wells for the Laboratory and for the community on the Pajarito Plateau, 2 to 4 miles northeast of TA-49 (Purtymun 1969). In 1986 these wells accounted for 56 percent of the total water production for Los Alamos.

Hydrologic characteristics of the main aquifer on the Pajarito Plateau and at Frijoles Mesa were re-evaluated in 1984 using data from 5 water supply wells and 10 test holes. The rate of movement of water in the upper 490 ft of the aquifer was calculated to be

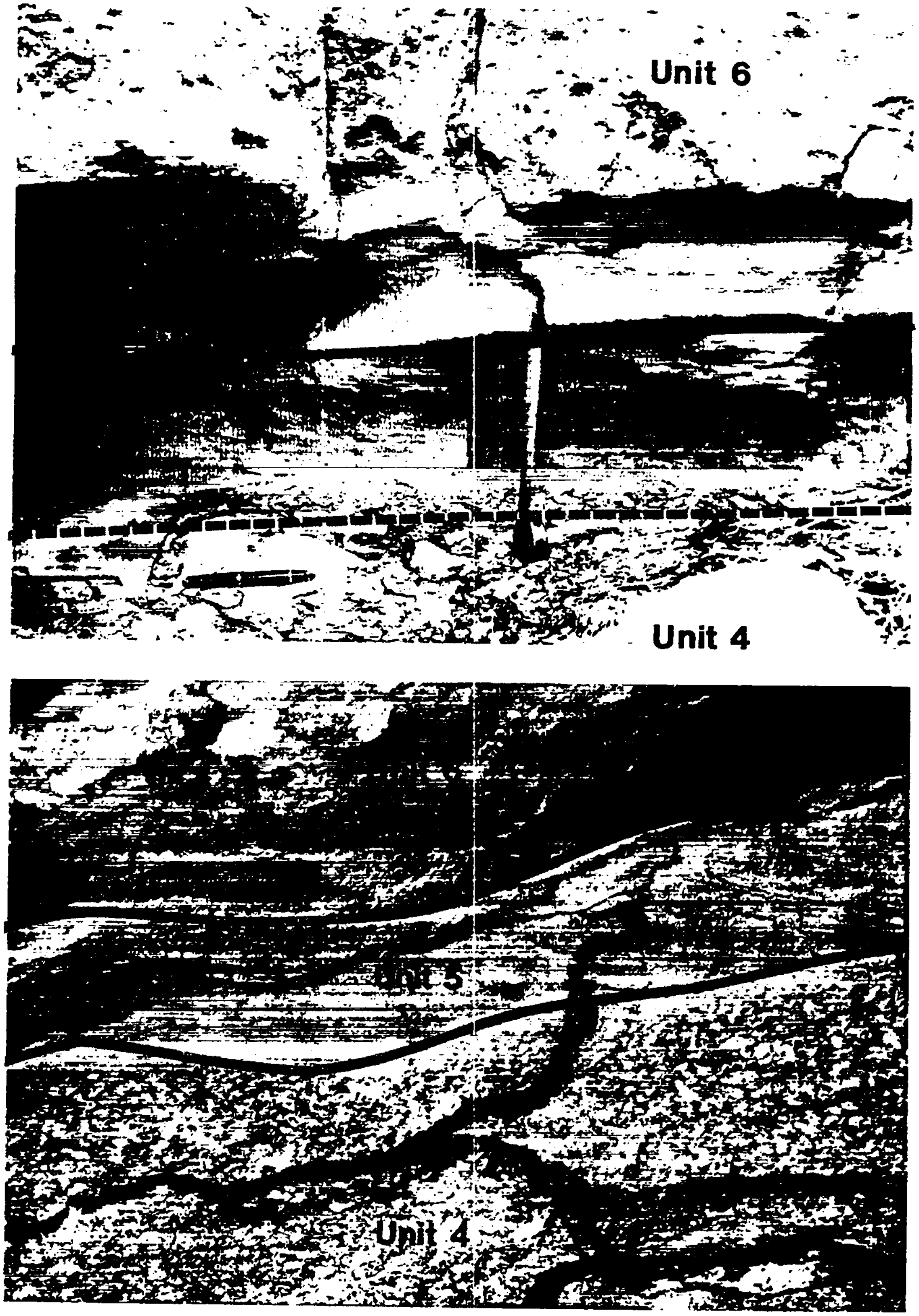

Figure 6. Ashflow units 4 and 6, and sand unit 5 of the Tshirege Member of the Bandelier Tuff at TA-49. Upper photograph shows outcrop one quarter mile northwest of Well DT-9; lower photograph shows units as penetrated by an Experimental Hole in TA-49 at about 60-foot depth.

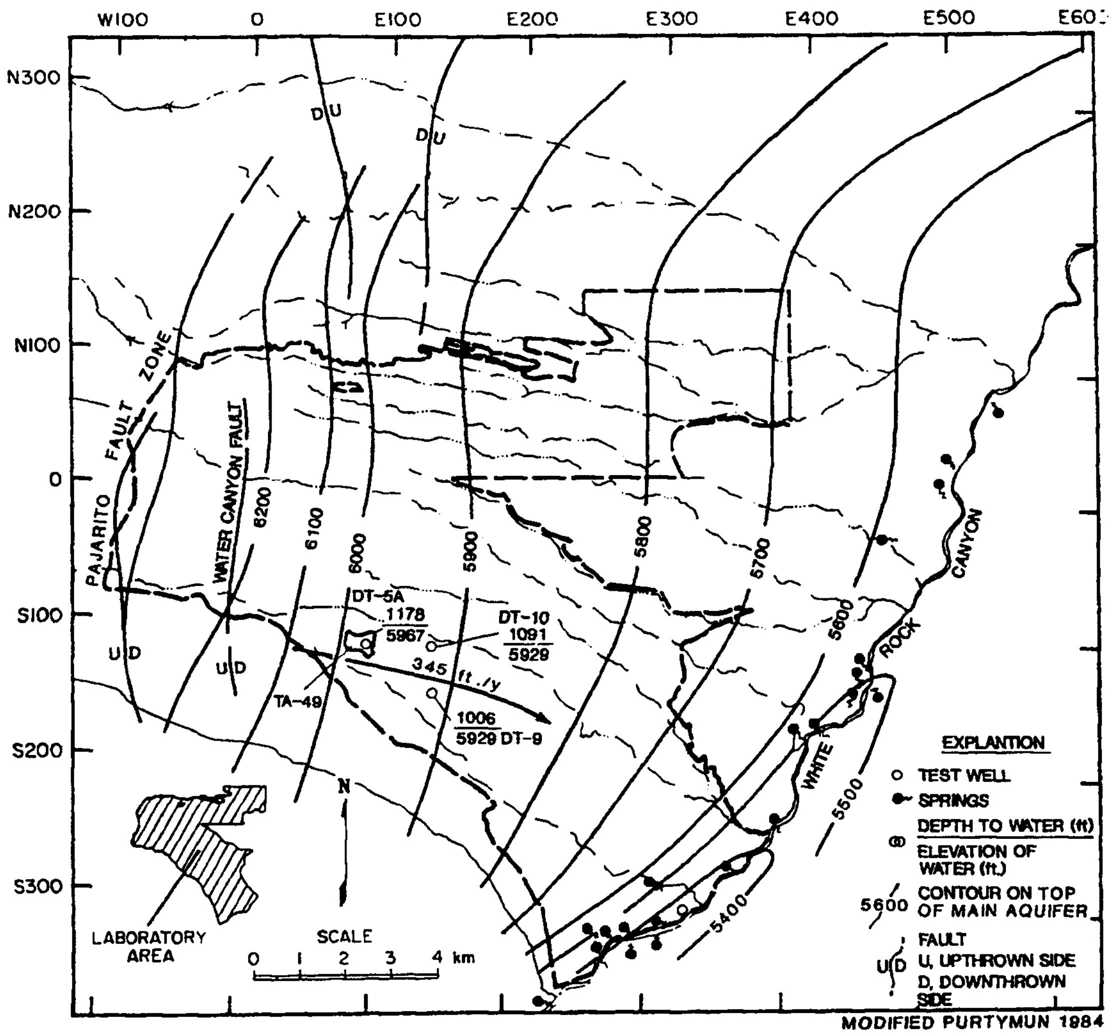

Figure 7. Map showing generalized contours on top of main aquifer and annual rate of movement of groundwater in the vicinity of TA-49.

about 345 ft/yr, which is similar to the rate calculated in 1960. The water is a sodium-bicarbonate type with total dissolved solids ranging from 124 to 142 mg/L.

A water-level recorder was operated from 1960 to 1968 and from 1970 to 1982 on well DT-9. The record indicated that the main aquifer is very sensitive to atmospheric pressure changes, earth shocks (earthquakes), and probable earth tide effects (Purtymun 1984). The water-level trends over a 22-year period indicate a general water-level decline from about 1003 to 1006 ft below the surface. The decline indicates deficient recharge, with only one period (1971) of recharge exceeding the normal discharge of the aquifer through springs in White Rock Canyon. The major recharge area for the aquifer is the intermountain basin formed by the Valles Caldera beyond the Sierra de los Valles, about 10 miles west of Frijoles Mesa (Purtymun 1984).

Laboratory analyses of the tuff from the core holes indicated very complex hydrologic properties. These properties depend strongly on the degree of welding of the tuff, which ranges from nonwelded to welded. The porosity of the tuff at Frijoles Mesa ranged from 19 to 54 percent by volume, specific retention ranged from 11 to 27 percent, and specific yield from about 1 to 43 percent. The laboratory permeability ranged from less than 0.05 to 22 gpd/ft^2. The permeability of the tuff is related to the degree of welding of the tuff because porosity is governed by pore size and interconnection of pores. Lower permeabilities occur in welded tuffs and the larger permeabilities occur in the nonwelded tuffs. The striking characteristic of the tuff is its low moisture content. The tuff contains no free water; natural moisture content ranges from less than 4 to about 8 percent by volume.

Tuff has the capacity to retain plutonium, thereby limiting its movement, even if water were present, by the chemical process of ion exchange. Ion exchange capacity of the tuff was measured by both the USGS and LASL. The USGS results indicated a range of 0.5 to about 4 meq/100 g. LASL results indicated a range of about 0.7 to 2.8 meq/100 g. Calculations based on an ion exchange capacity of 1 meq/100 g indicated 100 g of tuff could retain 60 mg of plutonium. Laboratory experiments confirmed retention of at least 1 mg/100 g and suggested higher capacity but were terminated at that level.

Soil cover on the mesa surface is composed of layers starting with a weathered zone of tuff and clay, then a pumice, and finally an upper clayey soil zone. Measurements made with neutron moisture gaging equipment in the spring, summer, and fall of 1960 indicated little if any movement of precipitation into the tuff underlying the soil cover (Abrahams 1961). Annual evapotranspiration is greater than annual precipitation. Natural moisture content of the tuff ranges from less than 4 to about 8 percent by volume, indicating that movement of water could occur only in the vapor phase by diffusion. There is insufficient moisture available to move contaminants from the experimental holes toward the main aquifer. Data collected from Frijoles Mesa during drilling of experimental holes, test wells, surface and subsurface mapping, moisture monitoring of soil and tuff, as well as laboratory analyses of tuff, indicate the soil cover "...forms an almost perfect seal over the mesa surface and the near-surface joints" (Wier 1962). The mesa is not a recharge area for the main aquifer (Abrahams 1961 and Cushman 1965).

III. ENVIRONMENTAL SURVEILLANCE SINCE 1961

A. U. S. Geological Survey Surveillance (1961-1970)

From the time of the initial hydrogeologic study until about 1970, a joint cooperative effort between the USGS and LASL continued to perform periodic monitoring of the conditions in the vicinity of TA-49. This included measuring water levels and sampling the water in the main aquifer by the three deep test wells in 1963, 1967, 1969, and 1970. No changes in concentrations of naturally present radionuclides occurred and no plutonium was observed.

Water from the main aquifer discharges from Ancho Springs and other springs in White Rock Canyon about 4 miles east of TA-49 (Fig. 7). Water samples collected from Ancho Springs in 1961, 1962, 1963, 1965, and 1969 contained only background radioactivity showing no effect of the experiments at TA-49. Sediment samples taken in 1965 from Water Canyon and Ancho Canyon drainages adjacent to TA-49 and several other stations downgradient toward the Rio Grande showed no indication of plutonium contamination.

B. Los Alamos Surveillance (1971-1986)

Environmental surveillance of the entire Laboratory environs has been conducted by the Laboratory's Environmental Surveillance Group and reported annually since 1971 in a series of publicly available reports. Some of the data pertinent to TA-49 have been documented in these annual reports. Specifically, analyses of the main aquifer water samples from the deep test wells and springs have been reported regularly. Results for surface water and sediment samples at the Laboratory boundaries have been reported. Airborne radioactivity at a station near TA-49 has been reported. No data have shown any indication of contamination of the main aquifer or any offsite transport of plutonium contamination from TA-49 by surface water or airborne transport. The supplementary onsite monitoring and special studies in the immediate vicinity of TA-49 have been documented in a series of periodic internal memorandum reports.

C. Surface Conditions

Many radionuclides have an affinity for fine clay and silt particles in soil or sediments. These fine clay and silt particles with attached radionuclides are subject to transport with storm runoff. Sediment sampling stations were established downgradient from TA-49 in Water Canyon (the drainage area includes the north side of experimental Areas 1 and 2; Fig. 2) at State Road 4 (SR-4), and at the Rio Grande (Fig. 8). Other stations are located in Ancho Canyon (the drainage area includes the east and south portions of experimental Areas 3 and 4) at SR-4 and at the Rio Grande. There have been no data from measurements of radionuclides in samples from these stations that can be attributed to the hydronuclear experiments at TA-49. Data from these stations have been reported in the annual environmental surveillance report under sections on Perimeter and Onsite Sediment Stations (Environmental Surveillance Group 1986, 1987).

Eleven sediment stations were established in the immediate vicinity of TA-49 during 1975 in natural drainages from the four experimental areas (Areas 1, 2, 3, and 4; Fig. 2) and in three canyons downgradient from the experimental areas. A twelfth sediment station was added in 1981 as the drainage in the area was modified (Fig. 2). Sediments are typically collected in late fall after spring and summer runoff. The data collected annually indicate that only three onsite stations exhibit plutonium in excess of worldwide fallout. These stations are downgradient from and drain Area 11, the former site of the chemistry building (removed 1971), and the area adjacent to Area 2 where some surface plutonium contamination occurred during the experiments conducted in 1960.

Station A3 (Fig. 2) has shown the highest concentrations. The plutonium-239 concentrations for 12 analyses between 1975 and 1986 have ranged from 0.01 to 17 pCi/g with a mean of 3.5 pCi/g and standard deviation of 5.2 pCi/g. The plutonium-239 concentration in the 1986 sample was 10.7 pCi/g. Results over the past 12 years at the stations have shown no particular trend.

Background or fallout concentrations of plutonium on sediments in northern New Mexico are about 0.01 pCi/g (Environmental Surveillance Group 1986). The Environmental Protection Agency proposed screening level, to assure meeting proposed dose limits to the public for exposure to transuranic contamination over a large area, is about 15 pCi/g (USEPA 1977). Plutonium attached to sediments transported by storm runoff into Water or Ancho canyons is dispersed over a large area resulting in concentrations indistinguishable from background.

Beryllium analyses were first made in 1985. Surface runoff samples in 1985 from Water Canyon at SR-4 had levels less than detection limits for both water (50 mg/L) and

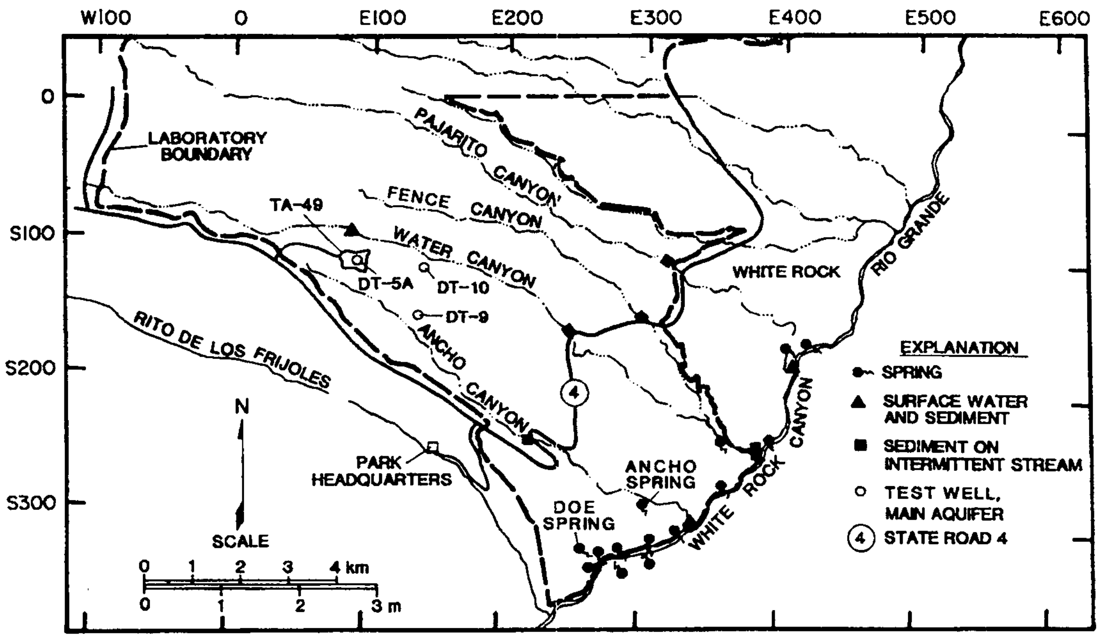

Figure 8. Sediment sampling stations in Water and Ancho Canyons, deep test wells at TA-49, and springs in White Rock Canyon.

suspended sediments (10 mg/L) (Environmental Surveillance Group 1986). Measurements of sediment samples from both Water and Ancho Canyons at SR-4 in 1986 also showed beryllium concentrations to be less than the limit of detection (Environmental Surveillance Group 1987).

The supplementary monitoring and special studies at TA-49 have been documented in a series of periodic internal memorandum reports.

D. Surveillance of the Main Aquifer

The three deep test wells described earlier were drilled from the surface of Frijoles Mesa into the main aquifer of the Los Alamos Area (Fig. 2). These test wells and the springs along White Rock Canyon of the Rio Grande are sampled to monitor water quality in the main aquifer. Pumps were temporarily installed in the test wells to perform aquifer tests in 1960. Water samples were collected at that time to establish background water quality. The pumps were removed upon completion of the tests. After 1960, water samples were bailed from the wells until permanent pumps were installed to facilitate and permit more frequent sampling. A pump was installed in well DT-5A in 1970 and one was installed in well DT-10 in 1978. Test well DT-9 is scheduled to receive a pump in 1987.

There has been no significant change in the chemical or radiochemical water quality parameters measured since the first samples were collected from the wells in 1960. All measurements are consistent with expectations for natural variation. Neither has there been any significant change in measurements of the water from the springs since the first samples were collected in 1964. The water samples from the wells and springs show no effects of the hydronuclear experiments at TA-49. These data have been reported in the annual environmental surveillance report under sections on Onsite Monitoring and White Rock Canyon (Environmental Surveillance Group 1986, 1987).

E. Maintenance and Special Studies

In March 1975 the asphalt pad over experimental hole 2-M in Area 2 was found collapsed leaving an opening in the asphalt and underlying clay and gravel about 8 ft long, 6 ft wide, and 3 ft deep. In September 1976, the opening was filled with a rock and clay mixture, compacted, sealed with asphalt, and the entire asphalt pad above Area 2 was repaved.

Before being repaired, the opening in the pad apparently allowed water to move into experimental hole 2-M and through the fractures into the adjacent core hole 2 (USGS CH-2). The 500-ft-deep, 4-1/2-in.-diameter core hole had been drilled with mud in 1959 and was cased to the bottom with 2-in.-diameter galvanized pipe including a 20-ft slotted section at the bottom. About 50 ft of water was observed in the bottom of the hole in February and December of 1975. Unfiltered samples of water bailed in October 1977 and August 1978 contained 1.7 to 3.1 pCi/L of plutonium-239. In April and May 1979 and April through June 1980 the amount of water standing in the core hole was measured several times to be about 150 ft. The water, about 24 gal., was removed from the cased hole by bailing in June 1980. Three filtered samples of the bailed water contained a maximum plutonium-239 concentration of 5.5 pCi/L and the suspended sediment contained a maximum of 0.7 pCi/g. (These concentrations are small compared with guidance issued by the Department of Energy [DOE] for controlled areas of 100,000 pCi/L [US Department of Energy 1981]). This indicated water had moved plutonium from the experimental hole into the core hole. After the core hole was bailed dry, it did not yield any additional water. It has remained dry through April 1986, the time of the last inspection.

Concern related to the presence of water in the core hole resulted in initiating a special hydrologic investigation in the spring of 1980 to locate the source of the water, determine whether it resulted from infiltration through the broken asphalt above experimental hole 2-M, or whether water was moving into the tuff beneath the experimental area on a larger scale. This investigation focused on the upper 50 to 78 ft of the tuff at Area 2 and the sand unit that separates the two ash flows of moderately welded tuff units (Fig. 6). The sand unit is located at depths ranging from 70 to 80 ft and is up to 2 ft in thickness. The widespread sand unit is quite permeable and could transmit water to the core hole if sufficient water was available.

For the first part of the investigation, five 4-in.-diameter holes were augered to a depth of 123 ft, about 50 to 60 ft away from the edges of Areas 2, 2A, and 2B, to determine if the sand unit could be conducting water into the three experimental areas. These holes penetrated an upper moderately welded ashflow unit, the sand unit, and the underlying moderately welded unit. Cuttings from the holes were monitored for plutonium and the moisture contents were determined. The holes were also logged with the moisture neutron equipment. The sand and tuff penetrated by the auger holes contained no plutonium. The moisture of the cuttings and tuff determined in the laboratory and by the neutron logging indicated normal moisture concentrations ranging from less than 4 to 8 percent by volume. The data collected from the holes indicated that there was no recharge moving into the tuff beneath the three experimental areas nor was there any movement through the areas.

The second part of the investigation addressed six experimental holes that remained unused in Areas 2A and 2B when the experiments of 1959-61 ended. Because of concern for safety, these experimental holes had been filled with sand in 1963. Thus there was a possibility that these sand-filled experimental holes were pathways for water from precipitation or run-off to enter core hole 2 in Area 2. Moisture access tubes were installed in the sand of three of these experimental holes and penetrated into the underlying tuff where possible. Moisture contents of the sand and tuff were determined with neutron moisture logging equipment. The moisture content of the sand in the unused experimental holes showed unsaturated conditions and therefore could not contribute to the presence of water in the core hole.

The conclusion from both parts of the special investigation was that the water in the core hole came through the depression formed by the collapse of asphalt above experimental hole 2-M. Apparently the water that was present was confined to the immediate vicinity of the core hole because of the seal formed by the mud used during the drilling. However, to limit any future possibility of infiltration, the integrity of the unused experimental holes in Areas 2A and 2B was improved by removing the upper 2 to 3 ft of sand and capping them with concrete in August 1981.

The La Mesa Fire in June 1977 burned across Frijoles Mesa and TA-49. The asphalt pad on Area 2 was not damaged. Some remaining buildings, structures, and cable ways from the 1959-61 experimental era and subsequent unrelated activities at TA-49 were damaged or destroyed. In 1984 special funding permitted cleanup of surface debris at TA-49. Debris was removed to a landfill pit at the western end of the mesa and covered with crushed tuff. Additional fill (clay and gravel) was placed over Areas 1 and 4. Cracks in the asphalt pad of Area 2 were sealed. Surface drainage of the area was improved.

IV. APPLICABLE ENVIRONMENTAL REGULATIONS AND DOE REQUIREMENTS

Federal regulations promulgated pursuant to the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) impose requirements for some actions in relation to TA-49. A number of DOE Orders also require certain environmental monitoring, waste management, and evaluation studies. The following sections describe recent and planned future actions and programs responsive to the various requirements.

A. Designation as Hazardous Waste Site Under RCRA (Section 3016)

In accord with requirements of RCRA and DOE Order 5480.2, Hazardous and Radioactive Mixed Waste Management, the Laboratory identified TA-49 to DOE as a hazardous waste site for reporting to EPA in January 1986 as part of the biannual Federal Facility Hazardous Waste Activities Inventory. The four experimental areas have been collectively designated as Material Disposal Area AB. The information on Material Disposal Area AB reported to the EPA is presented in Appendix A. This information will be used by the EPA to maintain the required lists of Federal Hazardous Waste Activities. As new information is developed by the planned studies described in the subsequent sections, it will be incorporated in the biannual updates required by Section 3016 of RCRA.

B. Required Future Action Under CERCLA

In accord with the requirements of CERCLA and DOE Order 5480.14 CERCLA Program, TA-49 is being studied under the DOE

Albuquerque Operations Office Comprehensive Environmental Assessment and Response Program (CEARP). As part of the Phase 1 CEARP evaluation, TA-49 was evaluated for potential migration of contaminants by the EPA Hazard Ranking System (HRS) for chemical contaminants and the DOE's modification (mHRS) of that system for evaluation of radioactive contaminants. The overall migration mode scores were derived to be 6.7 based on the beryllium and 5.3 based on the plutonium. The HRS/mHRS scoring forms are reproduced as Appendix B. These scores reflect relatively low potentials for migration of contaminants. Facilities evaluated by the EPA must have scores of 28.5 or higher to be considered for inclusion on the National Priorities List. The site will receive additional field study under Phase 2 of CEARP. This will lead to an evaluation of risk that will form the basis for a decision on what, if any, remedial measures should be recommended for TA-49. The information provided to EPA as required by RCRA for the Federal Hazardous Waste Activities Inventory probably will be placed on the Federal Facility Docket required by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

C. Routine Environmental Monitoring

The routine monitoring of groundwater in the main aquifer, surface water run-off, and sediments as described earlier in Section III.B of this report will be continued as part of the annual environmental surveillance program carried out by the Environmental Surveillance Group. These results will continue to be reported in the annual environmental surveillance reports (Environmental Surveillance Group 1986, 1987b). This monitoring satisfies the requirements of DOE Orders 5480.1, Environmental Protection, Safety, and Health Protection Programs, and 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements. Supplementary onsite monitoring results will be included in periodic reports prepared for the Interim Waste Management Program or CEARP as appropriate.

D. DOE Radioactive Waste Area Monitoring

The Laboratory's Health, Safety, and Environment (HSE) Division conducts a continuing environmental surveillance program sponsored by the Interim Waste Management Program of DOE's Office of Defense Waste and Transportation Management. This program provides supplementary monitoring for the radioactive waste disposal areas within the Laboratory boundaries meeting the requirements of DOE Order 5480.2, Radioactive Waste Management (Environmental Science Group 1987). This cooperative effort among the Environmental Science, Environmental Surveillance, and Health and Environmental Chemistry Groups has an established program schedule whereby each designated waste area receives an intensive characterization at 5-year intervals and routine monitoring during other years. Designated Waste Disposal Area AB at TA-49 will be included in this program starting in 1987.

E. CEARP Remedial Investigation

Preliminary, summary information on TA-49 will be included in the CEARP Phase 1, Installation Assessment, document for Los Alamos, which is expected to be released in 1987. A detailed plan for field investigation of TA-49 will be prepared during 1987 under the auspices of the CEARP. This will result in a CEARP Phase 2, Confirmation, Site-Specific Monitoring Plan (US Department of Energy 1986). The Site-Specific Monitoring Plan will include detailed evaluation of all known existing data. This evaluation will be the basis for developing a detailed sampling plan that will meet all the guidelines required by DOE under its applicable programs (including the Defense Buried TRU Waste program described in the following section) and those required by EPA for a Remedial Investigation under CERCLA. The Site-Specific Sampling Plan will be made available to the EPA and appropriate New Mexico agencies for information and review.

F. DOE Defense Buried TRU Waste Evaluation

Under the Defense Buried Transuranic (TRU) Waste Management Program, wastes resulting from defense programs with concentrations of transuranic elements greater than 100 nCi/g receive special attention. A significant portion of the contaminated sand and tuff at the bottoms of the experimental holes is presumed to have concentrations of plutonium exceeding this criterion. A crude estimate of the maximum volume of material meeting or exceeding the TRU criterion can be calculated by assuming the plutonium is distributed uniformly through an approximately 100 m^3 spherical volume (diameter between 5 and 6 m) at the bottom of each of 44 experimental holes for a total volume of about 4400 m^3. The approximately 2890 curies (total alpha activity in 40.1 kg of weapons grade plutonium assuming 0.072 Ci/g) would be distributed at an average level of 0.65 Ci/m^3 throughout the 4400 m^3. Using an average density of about 1.5 g/cm^3 for tuff, leads to a concentration estimate of about 430 nCi/g.

A similar crude estimate of the total volume of contaminated material that might have to be removed to get all the TRU waste can also be made. Assuming uniform distribution of the plutonium throughout rectangular solids having the same area as the experimental hole grid patterns and a thickness of 5 m results in an estimated volume of about 36,000 m^3. This volume would have an average concentration of about 50 nCi/g.

The Los Alamos National Laboratory (LANL) is presently preparing a Site Long-Range Plan (SLRP) for buried TRU waste. This plan will be part of a nationwide DOE program to provide a description of the approach, resources, and schedules to ensure uniform, coordinated CERCLA response at all DOE buried TRU waste sites. At LANL this will be accomplished largely by addressing all buried TRU waste sites in coordination with the CEARP, described in the previous section. TA-49 is on the list of designated buried TRU waste disposal areas at Los Alamos. It will be evaluated along with the other buried TRU waste disposal areas at Los Alamos for risk and possible remedial action from a consistent basis.

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US Department of Energy, "Comprehensive Environmental Assessment and Response Program Phase 2: Generic Monitoring Plan" (Draft), Albuquerque Operations Office, U.S. DOE, Albuquerque, New Mexico.

US Environmental Protection Agency, "Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment," U.S. Environmental Protection Agency, Office of Radiation Programs, Criteria and Standards Division, Report EPA 540/4-77-106, Washington D.C., 1977.

J. E. Wier and W. D. Purtymun, "Geology and Hydrology of Technical Area 49, Frijoles Mesa, Los Alamos County, New Mexico," US Geological Survey Open-File Report (1962).

APPENDIX A
INVENTORY OF FEDERAL AGENCY HAZARDOUS WASTE ACTIVITIES

A. RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585

1. Responsible Field Organization: DOE - Los Alamos Area Office

2. Address: Los Alamos, N.M. 87545
(Street, City, State, Zip)

3. DOE Site Contact: Harold E. Valencia

4. Phone Number: (505) 667-5105 (Commercial) 843-5105 (FTS)

B. INSTALLATION/SITE LOCATION

1. Installation name: Los Alamos National Lab (LANL)

2. Federal Facility ID Number (GSA No.): NM0890010515

3. Address: P.O. Box 1663, Los Alamos, N.M. 87545
(Street, City, County, State, Zip Code)

4. Number of sites on this installation: 20

5. Site name and/or site number: Material Disposal Area AB

6. Address: Same as B.3. above (Street, City, County) ______ (State, Zip Code)

7. Coordinates: 35°49' 051" 106°14' 015"
(For a rural site with no street address)

C. HAZARDOUS WASTE MANAGEMENT STATUS

1.		O	C	Date closed
Storage:	Containers	| |	| |	
	Tanks	| |	| |	
	Surface impoundments	| |	| |	
	Waste Piles	| |	| |	

Installation LANL

Site Area AB

		O	C	
Treatment:	Tanks							
	Surface impoundments							
	Incinerators							
	Other (describe)							
Disposal:	Landfill					X		Prior to 1980
	Land Treatment							
	Surface impoundment							
	Underground Injection Wells							
	Waste Piles							

O = Operating C = Closed

If the above space is not sufficient, or if the site has one or more operating or closed units in any technique, provide the necessary information in an attachment labelled Attachment C and enter "Attachment C" in the space provided for each technique.

2. Is Attachment C included with the inventory? Yes | | No | |

3. Indicate if any of the following forms were submitted for this site and, if so, the date of the original submittal:

	Yes	No	Date Submitted
RCRA S3010 Notification				|X|	
RCRA Part A				|X|	
RCRA Part B				|X|	
RCRA Closure Plan				|X|	

Installation LANL

Site Area AB

RCRA S3019 Exposure Assessment | | |X| ______

CERCLA S103 Notification | | |X| ______

4. If a RCRA Part B was submitted, what is its current status?

Permit Issued | | Permit Denied | | No Final Action | |

5. If a closure plan was submitted, what is its current status?

Closure Approved | | Closure Denied | | No Final Action | |

6. If the closure plan was approved, has closure been certified?

Yes | | No | |

7. If the site is no longer used for hazardous waste management, what other activities are currently carried on at the site? (e.g., pasture, building site, park): ______

8. Is this a RCRA site, a CERCLA site, or both?

RCRA | | CERCLA |X| Both | |

D. WASTE TYPE

1.

	Waste Code	Estimated Amt. Handled FY85 (Amt/unit of measure)	Unit(s) Involved (Form Attachment C)		Waste Code	Estimated Amt. Handled FY85 (Amt/unit of measure)	Unit(s) Involved (Form Attachment C)
1				6			
2				7			
3				8			
4				9			
5				10			

Installation LANL

Site Area AB

Submit, as Attachment D, the following information: summarize the results of all waste analyses in tabular form, including the presence and approximate concentration ranges of measured hazardous constituents. See the guidance to this form for additional instructions.

If the above additional waste analysis information was submitted previously in a form indicated in C-3, indicate the kind of submittal, the date of the submittal and the location of this information in that submittal. Label this information "Attachment D." If any previously submitted information must be updated, update that information in Attachment D.

2. Is Attachment D included with the inventory? Yes |X| No | |

E. ENVIRONMENTAL CONTAMINATION

1. Has this site had releases to the environment? Yes | | No |X|

2. If yes, indicate in which media the release(s) occurred:

Air | | Surface Water | | Groundwater | | Subsurface Gas | |

3. If yes, when did the release(s) occur: ______________________

4. If yes, type and concentration of wastes or waste constituents involved in the release(s): ______________________

____

5. If yes, give the extent of the release(s) in terms of the lateral extent of release, environmental impact of the release, and any other information necessary for EPA to assess the extent of the release: ______________________

____

If the above space is not sufficient to answer each question, submit the necessary information in an attachment labeled Attachment E. If the information was submitted previously in a form indicated in C-3, indicate in Attachment E the kind of submittal, the date of the submittal and the location of the information in that submittal. If the previously submitted information needs to be updated, update that information in Attachment E.

6. Is Attachment E included with the inventory? Yes | | No |X|

Installation LANL

Site Area AB

F. ENVIRONMENTAL MONITORING DATA

1. Does this site have environmental monitoring data?

Yes |X| No | |

2. What statistical and analytical methods were used to analyze the data? Monitoring is for materials not regulated under RCRA.

3. How was the data obtained (e.g., grab sample, etc.)?

Groundwater (bailing); surface and drilled samples.

4. When was it obtained: 1960 - present

5. If the site is a land disposal site and it does not have environmental monitoring data, why not?

If the above space is not sufficient to answer each question, submit the necessary information in an attachment labelled Attachment F. If the information was submitted previously in a form indicated in C-3, indicate in Attachment F the kind of submittal, the date of the submittal and the location of the information in that submittal. If the previously submitted information needs to be updated, update that information in Attachment F.

6. Is Attachment F included with the inventory? Yes | | No | |

G. RESPONSE ACTIONS

1. Have response actions been undertaken for this site?

Yes | | No | |

2. Have response actions been studied for this site?

Yes | | No | |

3. Are these actions part of a CERCLA effort? Yes | | No | |

4. What kind of actions are already underway:

Study | | PA/SI | | RIFS | | Remedial Investigation | |

Remedial Action | | Removal | |

Installation LANL

Site Area AB

If the above space is not sufficient to answer each question, submit the necessary information in an attachment labelled Attachment G. If the information was submitted previously in a form indicated in C-3, indicate in Attachment G the kind of submittal, the date of the submittal, and the location of the information in that submittal. If the previously submitted information needs to be updated, update that information in Attachment G.

5. Is Attachment G included with the inventory? Yes | | No |X|

H. FOR DISPOSAL SITES ONLY

1. Describe the hydrogeology of the site: The main aquifer is 1200 ft below the site with an eastward flow of an average flow rate of 0.3 m/day.

2. Indicate the location of withdrawal wells and surface water within one mile of the site: There is intermittent streamflow in Water Canyon located about 2000 ft north of the site.

If the above space is not sufficient to answer each question, submit the necessary information in an attachment labelled Attachment H. If the information was submitted previously in a form indicated in C-3, indicate in Attachment H the kind of submittal, the date of the submittal, and the location of the information in that submittal.

If the previously submitted information needs to be updated, update that information in Attachment H.

3. Is Attachment H included with the inventory? Yes | | No |X|

ATTACHMENT D

Installation: LANL Site: Area AB

EPA Hazardous Waste Number Code (from 40 CFR 261.21-.33)	Type of Analyses Used to Identify This Waste (Example: Analysis of waste stream directly, analysis of landfill leachate or other environmental monitoring result, analysis of surface impoundment contents, etc.)	Principal Constituents	Minimum Concentration (mg/l)	Maximum Concentration (mg/l)
P015	Analysis of material at disposal time.	Beryllium		

APPENDIX B

HAZARD RANKING SYSTEM/MODIFIED HAZARD RANKING SYSTEM (HRS/mHRS)

HRS/mHRS SUMMARY COVER SHEET

SITE NAME: Area AB, TA-49 LOTUS FILE NAME:

(AFTER KEYING IN SITE NAME, PRESS "ALT" & "A" KEYS SIMULTANEOUSLY)

FIELD OFFICE: Los Alamos Area Office. U.S. Department of Energy

EPA REGION: Region VI-Dallas

PERSON(S) IN CHARGE OF SITE: Harold Valencia, Area Manager

U.S. Department of Energy

NAME OF REVIEWER: J. Lynn Scholl DATE: February 17, 1987

GENERAL DESCRIPTION OF THE FACILITY:

(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency.action, etc.)

The main concern at this area is beryllium, lead, high explosives, and radioactive material in shafts.

SCORES:	CHEMICAL	RADIOACTIVE	MAXIMUM
Sm =	6.67	5.26	6.67
Sgw =	11.53	9.11	11.53
Ssw =	0.00	0.00	0.00
Sa =	0.00	0.00	0.00
Sfe =	0.00	0.00	0.00
Sdc =	0.00	0.00	0.00

GROUND WATER ROUTE WORKSHEET Site: Area AB, TA-49

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	0 45	0	1	0	45	3.1	No observed release.
If Observed Release is Given a Score of 45, Proceed to Line 4							
If Observed Release is Given a Score of 0, Proceed to Line 2							
2. ROUTE CHARACTERISTICS						3.2	
A. Depth to Aquifer of Concern	0 1 2 3	0	2	0	6		Depth to top of aquifer approx. 1200 ft (LA-9957-MS, fig. 4; ENG-R 5277/6)
B. Net Precipitation	0 1 2 3	0	1	0	3		20 in. total annual precip.; 46 in. total evap. (40 CFR 300, App.A, figs. 4, 5)
C. Permeability of the Unsaturated Zone	0 1 2 3	2	1	2	3		Measurements range from 2E-5 to 5E-4 (LA-8962-MS, p.21)
D. Physical State	0 1 2 3	2	1	2	3		Powder.
TOTAL ROUTE CHARACTERISTICS SCORE				4	15		
3. CONTAINMENT	0 1 2 3	3	1	3	3	3.3	No liners.
4. WASTE CHARACTERISTICS						3.4	
Chemical							
A. Toxicity/Persistence	0 3 6 9 12 15 18	18	1	18	18		Beryllium, lead, high explosives.
B. Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1	1	1	8		Quantity assumed to be less than forty drums.
Radioactive							
A. Maximum Observed	0 1 3 7 11 15 21 26	0	1	0	26		
B. Maximum Potential	0 1 3 7 11 15 21 26	15	1	15	26		Plutonium, uranium, americium.
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				19	26		
RADIOACTIVE				15	26		
5. TARGETS						3.5	
A. Ground Water Use	0 1 2 3	3	3	9	9		
B. Distance to Nearest Well/Population Served	0 4 6 8 10 12 16 18 20 24 30 32 35 40	20	1	20	40		Distance to nearest supply well less than three miles. Population served greater than 10000. (LA-9957-MS, figs. 5, 10; LA-10721-ENV, p.13; ENG-R 92)
TOTAL TARGETS SCORE				29	49		
6. CALCULATION							
If Line 1 is 45, Multiply 1 x 4 x 5							
If Line 1 is 0, Multiply 2 x 3 x 4 x 5							
CHEMICAL				6612	57330		
RADIOACTIVE				5220	57330		
7. NORMALIZATION							
Divide Line 6 by 57330 and Multiply by 100							
CHEMICAL Sgw =				11.53	100.00		NOTE: NE means Not Evaluated.
RADIOACTIVE Sgw =				9.11	100.00		
MAXIMUM Sgw =				11.53	100.00		

SURFACE WATER ROUTE WORKSHEET Site: Area AB, TA-49

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	0 45	45	1	45	45	4.1	Observed release. (WDP 1983)
If Observed Release is Given a Value of 45, Proceed to Line 4							
If Observed Release is Given a Value of 0, Proceed to Line 2							
2. ROUTE CHARACTERISTICS						4.2	
A. Facility Slope and Intervening Terrain	0 1 2 3	NE	1	NE	3		
B. 1-yr. 24-hr. Rainfall	0 1 2 3	NE	1	NE	3		
C. Distance to Nearest Surface Water	0 1 2 3	NE	2	ERR	6		
D. Physical State	0 1 2 3	NE	1	NE	3		
TOTAL ROUTE CHARACTERISTICS SCORE				ERR	15		
3. CONTAINMENT	0 1 2 3	NE	1	NE	3	4.3	
4. WASTE CHARACTERISTICS						4.4	
Chemical							
A. Toxicity/Persistence	0 3 6 9 12 15 18	18	1	18	18		Beryllium, lead, high explosives.
B. Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1	1	1	8		Assume quantity less than forty drums.
Radioactive							
A. Maximum Observed	0 1 3 7 11 15 21 26	0	1	0	26		
B. Maximum Potential	0 1 3 7 11 15 21 26	3	1	3	26		Plutonium, uranium, americium.
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				19	26		
RADIOACTIVE				3	26		
5. TARGETS						4.5	
A. Surface Water Use	0 1 2 3	0	3	0	9		No surface water use within three miles.
B. Distance to Sensitive Environment	0 1 2 3	0	2	0	6		No sensitive environments within one mile.
C. Population Served/ Distance to Water Intake Downstream	0 4 6 8 10 12 16 18 20 24 30 32 35 40	0	1	0	40		No surface water intake within three miles.
TOTAL TARGETS SCORE				0	55		
6. CALCULATION							
If Line 1 is 45, Multiply 1 x 4 x 5					64350		
If Line 1 is 0, Multiply 2 x 3 x 4 x 5							
CHEMICAL				0			
RADIOACTIVE				0			
7. NORMALIZATION							
Divide Line 6 by 64350 and Multiply by 100							
CHEMICAL Ssw =				0.00	100.00		NOTE: NE means Not Evaluated.
RADIOACTIVE Ssw =				0.00	100.00		
MAXIMUM Ssw =				0.00	100.00		

AIR ROUTE WORK SHEET Site: Area AB, TA-49

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	0 45	0	1	0	45	5.1	No observed release.
Date and Location:							
Sampling Protocol:							
If Line 1 is 0, the Sa = 0. Enter on Line 5							
If Line 1 is 45, Then Proceed to Line 2.							
2. WASTE CHARACTERISTICS						5.2	
Chemical							
A. Reactivity and Incompatibility	0 1 2 3	0	1	0	3		
B. Toxicity	0 1 2 3	0	3	0	9		
C. Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	0	1	0	8		
Radioactive	0 2 5 8 12 16 20	0	1	0	20		
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				0	20		
RADIOACTIVE				0	20		
3. TARGETS							
A. Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	0	1	0	30		
B. Distance to Sensitive Environment	0 1 2 3	0	2	0	6		
C. Land Use	0 1 2 3	0	1	0	3		
TOTAL TARGETS SCORE				0	39		
4. CALCULATION							
Multiply 1 x 2 x 3							
CHEMICAL				0	35100		
RADIOACTIVE				0	35100		
5. NORMALIZATION							
Divide Line 4 by 35100 and Multiply by 100							
CHEMICAL Sa =				0.00	100.00		NOTE: NE means Not Evaluated.
RADIOACTIVE Sa =				0.00	100.00		
MAXIMUM Sa =				0.00	100.00		

SUMMARY CALCULATION OF TOTAL MIGRATION SCORE

		CHEMICAL	RADIOACTIVE	
Ground Water Route	(Sgw)	11.53	9.11	
Surface Water Route	(Ssw)	0.00	0.00	
Air Route	(Sa)	0.00	0.00	
Sum of Squares		133.02	82.90	
Square Root of Sum		11.53	9.11	
TOTAL MIGRATION SCORE	(Sm)	6.67	5.26	Square Root of Sum Divided by 1.73

DIRECT CONTACT WORKSHEET Site: Area AB, TA-49

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED INCIDENT	0 45	0	1	0	45	8.1	
If Observed Incident is Given a Score of 45, Proceed to Line 4							
If Observed Incident is Given a Score of 0, Proceed to Line 2							
2. ACCESSIBILITY	0 1 2 3	0	1	0	3	8.2	
3. CONTAINMENT	0 15	0	1	0	15	8.3	
4. WASTE CHARACTERISTICS							
Chemical Toxicity	0 1 2 3	0	5	0	15	8.4	
Radioactive	0 1 2 4 6 9 12 15	0	1	0	15		
5. TARGETS							
A. Population Within a 1-Mile Radius	0 1 2 3 4 5	0	4	0	20	8.5	
B. Distance to a Critical Habitat	0 1 2 3	0	4	0	12		
TOTAL TARGETS SCORE				0	32		

6. CALCULATION

If Line 1 is 45, Multiply 1 x 4 x 5

If Line 1 is 0, Multiply 2 x 3 x 4 x 5

CHEMICAL	0	21600
RADIOACTIVE	0	21600

7. NORMALIZATION

Divide Line 6 by 21600 and Multiply by 100

CHEMICAL Sdc =	0.00	100.00
RADIOACTIVE Sdc =	0.00	100.00
MAXIMUM Sdc =	0.00	100.00

NOTE: NE means Not Evaluated.

FIRE AND EXPLOSION WORKSHEET Site: Area AB, TA-49

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	1 3	0	1	0	3	7.1	
2. WASTE CHARACTERISTICS						7.2	
A. Direct Evidence	0 3	0	1	0	3		
B. Ignitability	0 1 2 3	0	1	0	3		
C. Reactivity	0 1 2 3	0	1	0	3		
D. Incompatibility	0 1 2 3	0	1	0	3		
E. Waste Quantity							
Chemical	0 1 2 3 4 5 6 7 8	0	1	0	8		
Radioactive	0 1 2 3 5 6 8	0	1	0	8		
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				0	20		
RADIOACTIVE				0	20		
3. TARGETS						7.3	
A. Distance to Nearest Population	0 1 2 3 4 5	0	1	0	5		
B. Distance to Nearest Building	0 1 2 3	0	1	0	3		
C. Distance to Sensitive Environment	0 1 2 3	0	1	0	3		
D. Land Use	0 1 2 3	0	1	0	3		
E. Population Within 2-Mile Radius	0 1 2 3 4 5	0	1	0	5		
F. Buildings Within 2-Mile Radius	0 1 2 3 4 5	0	1	0	5		
TOTAL TARGETS SCORE				0	24		
4. CALCULATION Multiply 1 x 2 x 3							
CHEMICAL				0	1440		
RADIOACTIVE				0	1440		
5. NORMALIZATION Divide Line 4 by 1440 and Multiply by 100							
CHEMICAL Sfe =				0.00	100.00		NOTE: NE means Not Evaluated.
RADIOACTIVE Sfe =				0.00	100.00		
MAXIMUM Sfe =				0.00	100.00		

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*Contact NTIS for a price quote.