Chapter

7

Los Alamos National Laboratory

History and Mission

As a part of the Manhattan Engineering District atomic bomb project for the Second World War, Los Alamos National Laboratory (LANL) was established in 1943 to design, develop, and test nuclear weapons. The first atomic bomb was built at LANL and detonated at Alamogordo, NM. Subsequently, this site was involved in the development of an estimated 65 percent of the US nuclear arsenal. LANL is one of the three laboratories in the Department of Energy's nuclear weapons complex that have worked together to develop nuclear warheads.[1] (The other two are Lawrence Livermore National Laboratory and Sandia National Laboratory.) The current mission of the site entails:

- Nuclear weapons research, development, testing and evaluation;
- Testing to ensure the nation's nuclear deterrent;
- Manufacturing of weapons components for detonators and the stockpile plutonium pits;
- Ensuring reliability and safety in the US nuclear weapons stockpile;
- Developing technical solutions to reduce the threat of weapons of mass destruction.

Location and Land

LANL is located in Los Alamos County, contiguous to the town of Los Alamos (population 11,000) and neighboring the city of White Rock (population 6,000). The site is 25 miles northwest of Santa Fe (population 62,200) and 60 miles northeast of Albuquerque (population 448,600), situated on 43 square miles (27,520 acres) of land.[2] LANL is owned by the Department of Energy (DOE) and operated by the University of California, Board of Regents.[3] (See Figure 1.)

Situated atop a volcanic mesa known as the Pajarito Plateau, LANL lays between the Jemez Mountains to the west and the Rio Grande Valley to the east[4]. The 5000-foot gradient between the mountain range and the river below results in a diverse ecosystem.[5] On the eastern boundary of the site is the San Ildefonso Pueblo, to the northeast is the Santa Clara Pueblo; the surrounding areas are rural and largely undeveloped. To the south is Bandelier National Park, and to the west and north is Santa Fe National Forests. Initially, the Los Alamos area was chosen for a nuclear weapons design and test center due to its isolation. This was thought to be

appropriate for the testing of weapons components deep in the canyons and on any of the relatively remote mesas.[6]

Number of people living within 50 miles of LANL: Approximately 148,000[7]; 10 million people downstream from LANL use the Rio Grande for drinking, agriculture and recreation

Current employees at LANL: Approximately 10,500 employees as of 2000[8]

The Site is divided into 47 Technical Areas, 42 of which are actively in use. (See Figure 2.) Facilities in these areas include plutonium and tritium processing plants, depleted uranium and explosive test facilities, a research reactor that has been shut down, metal production and fabrication sites, and various laser and high explosives buildings, in addition to buildings for administration.[9]

Water Sources

Surface Water

Eight watersheds flow onsite and drain into the Rio Grande River. These watersheds allow for the travel of contaminants, already in the environment, into surrounding areas. Surface water does not flow continuously across the site into any of the many canyons. The flow pattern results from two different causes: Runoff from the snowmelt in the spring, and heavy runoff due to thunderstorms in the summer. The runoff attributed to snowmelt occurs over weeks at a low discharge rate and sediment load, while runoff from thunderstorms occurs over a few hours at a high discharge rate and sediment load. The intermittent flow has deposited alluvium into streams with the deposits up to 100 feet thick. This alluvium is extremely permeable.[10] The threat of potential contaminant migration is much higher after the catastrophic Cerro Grande Fire in 2000. This fire reduced ground cover and has enhanced erosion and runoff.

Water that travels onsite is ingested by wildlife only and is not directly used for any municipal or agricultural purposes,[11] although it has been so used in the past and could be in the future. However, offsite the Rio Grande River is used for irrigation of crops, including fruits, vegetables, grains and hay and alfalfa crops.[12]

Aquifer

Groundwater occurs in three modes beneath the site: water found in shallow alluvium in the canyons, perched water that is discontinuous, and the main aquifer.[13] The main aquifer serves as the only source of municipal water for the cities of Los Alamos and White Rock. Located within the Tesuque Formation, the depths of the aquifer range from 600 feet to 1200 feet beneath the soil.[14] The aquifer partially discharges into the Rio Grande through springs in White Rock Canyon,[15] The thickness of the Tesuque Formation is estimated to be approximately 3,900 feet.[16] Until as recently as five years ago, LANL used to protect the "myth" that the volcanic tuft overlying the deep groundwater was impermeable, therefore groundwater contamination was impossible. More recent data completely dispels this myth.

Groundwater flow: Easterly at a rate of 1 foot per day, aside from the pumping wells[17]

Average Annual Precipitation: 18 inches per year, at the higher elevation of LANL[18]

Water from LANL is a possible source of recharge to the aquifer as well as to the perched aquifer; runoff from heavy rainstorms in the summer or heavy snowmelt[19] also recharge the aquifer. Recharge onsite occurs in the canyons and heavily in the western portion of the site. The flow of water throughout the remainder of the year is minimal.

Contamination

The extent of groundwater contamination is unknown including the locations of the groundwater plumes, most of which remain to be identified. One known groundwater plume emanates from Technical Area 16, which was a center for research in high explosives. Tritium has been found in the deep aquifer beneath LANL [20] along with high explosives contaminants and perchlorates. The extent of the plume has not been determined.[21]

Many of the laboratory's operations required hazardous chemicals and radioactive materials, such as plutonium and uranium and high explosives. Use of these materials resulted in the contamination of the facilities and, in some cases, of the surrounding environment. Waste discharged or buried from past operations contributes greatly to the contamination. The principal method of release of contaminants is through surface water runoff.[22] Due to the semi-arid climate and great depth of groundwater beneath the site, on site contamination is primarily confined to the soils and surface water.[23] However, alluvial aquifers are locally heavily contaminated and perched waters are somewhat contaminated, as well.

Contaminants of potential concern found in the aquifers:
Volatile Organic Compounds:
Perchloroethylene
Metals:
Beryllium, barium, sodium
Radionuclides:
Americium, cesium, plutonium, strontium, tritium, and uranium[24]

In May 2000 one of the largest fires in the history of New Mexico, known as the Cerro Grande Wildfire, occurred. It began as a prescribed fire set by officials in the Bandelier National Forest. As a result of the fire 112 laboratory structures were damaged, but few buildings were harmed.[25] After the fire, a seventy-foot dam was constructed onsite to prevent leaking contaminants from leaving the site, according to LANL. But this dam is in Pajarito Canyon, only one of 7 major canyons cutting across LANL, therefore it does not greatly decrease potential flow from onsite. The pond that has formed behind the dam may be serving as a pathway of contamination to groundwater.[26] A couple of smaller gabion weirs farther downstream in a couple of canyons, may be more useful in restraining contaminants.

Approximately 18 million cubic feet of radioactive and chemical solid wastes onsite were disposed of since 1943. "All of the radioactive waste and most of the chemical waste have been buried on the mesas of the Pajarito Plateau, where LANL is located. Radioactive liquid wastes were discharged to the canyons, initially with little treatment."[27] For many years, one method of

disposal was "kick-and-roll". The back of a truck was brought to the edge of a hole and the barrels of waste were kicked. Wherever the barrels rolled to was their final resting place. No protection was put in place to ensure contaminants did not spread from the barrels. It is not clear that today's practices are more protective. An estimated 989,000 curies of low-level and transuranic wastes were buried at Los Alamos.[28] It is difficult to estimate exactly the quantity of radionuclides buried onsite due to the inaccurate record keeping and alterations in the definitions of low-level waste in the intervening years. Disposal continues today in unlined pits and shafts, a practice declared illegal by the New Mexico Attorney General's office in 2001. In 1995, the New Mexico Environment Department (NMED) ordered LANL to create a hydrogeologic workplan for investigating groundwater contamination. Twenty-three regional monitoring wells have been drilled; the last 6 of which were drilled in 2003.

Through the years, many canyons onsite have served as disposal areas for both treated and untreated liquid effluent. Again poor record keeping makes it difficult to assess the amount and location of dumped materials. The use of canyons as disposal areas continues. "LANL discharges 20,000 gallons of treated liquid radioactive waste into Mortandad Canyon every day." [29] Mortandad Canyon's perched aquifers have been extensively contaminated. Effluent from the Radioactive Liquid Waste Treatment Facility at Technical Area 50 has been released to this canyon for 40 years. The Technical Area 50 facility began operations in 1963 and levels of radionuclides have often exceeded allowable levels set by the DOE.[30] Additionally, nitrate discharges have chronically exceeded state standards. Perchlorates have likewise been discharged into this canyon in as yet unknown, but significant, quantities.

Pueblo and Los Alamos Canyons received the majority of the radioactive wastes discharged from the early operations at LANL.[31] The original disposal site for liquid wastes generated onsite was Acid Canyon, a small tributary of Pueblo Canyon. The dumping of untreated radioactive industrial effluent from plutonium pit production directly into Acid Canyon occurred from 1943 to 1951. Upon completion of the Technical Area 50 treatment plant in 1951, effluent disposed into Acid Canyon began to be treated, but wastes dumped into both canyons still contained residual radionuclides. Dumping into Acid Canyon ceased in 1964. Although efforts have been made to clean up this area, residual contamination still remains in the sediments of Acid, Los Alamos and Pueblo Canyons. The Los Alamos/Pueblo canyon system contains about 20 grams of Pu, among other contaminants. In January 2003, NMED reported Pu-239 stormwater sampling results in Pueblo Canyon at the fork with Los Alamos Canyon as the highest ever recorded. The median Pu concentration found in six storm samples was 94 pCi/L or approximately 100 times the storm water concentrations LANL reported for 1995-1999 and more than three times DOE's own guidelines. Tritium, perchlorate and nitrate have been found in springs (Spring 4 series) at the confluence of Pajarito Canyon and the Rio Grande. This may indicate a pathway from the waste treatment plants TA-50 and TA-54.

Tons of plutonium were processed at LANL in the early years of development and again in the 1980s.[32] After the Savannah River Site, LANL contains the second largest volume of plutonium-238 in the US nuclear weapons complex; this type of plutonium has a 90-year half-life, a very high activity and is extremely hazardous.[33]

Approximately twenty-six disposal sites exist and contain buried solid wastes. These disposal sites are primarily unlined pits dug into the porous volcanic tuff surface.[34] Other burial techniques include shafts and trenches. Cesium-137 and many different types of plutonium and uranium were buried in these areas.

Area B

This area was a burial site from 1944-1948 for alpha-contaminated wastes. The area was not maintained and underbrush overgrew the burial ground for the next 30 years. The result is a significant concentration of cesium, plutonium, and uranium in the plants in the surrounding area.[35]

Other areas leaking contaminants into the environment include Technical Area 50, Technical Area 53, and Bayo Canyon. Technical Area 50 is also known as the Central Liquid Waste Treatment Plant.[36] Technical Area 53 contains radioactive materials from tritiated water in a former lagoon system. High-explosive research was conducted in Bayo Canyon. Contaminated materials were mostly removed from Bayo Canyon in 1963.[37]

Area G

Area G, also known as the Low-Level Radioactive Solid Waste Storage and Disposal Facility, was opened in 1957. Located directly to the west of the city of White Rock, this area has received over 10.7 million cubic feet of radioactive waste buried in dozens of giant pits scraped into the mesa with bulldozers. The unlined pits vary in size but are typically found to come close to 100 by 600 feet at a depth of 25 to 45 feet. More than 200 deep vertical shafts (60 feet) are also located in Area G. Wastes buried included plutonium, tritium, thorium, uranium, highly activated accelerator targets, spent reactor fuel, decommissioned experimental reactors, PCBs, organic solvents, and other hazardous materials.[38] (See Figure 3.)

The process of expanding Area G from 63 acres to 133 acres through the addition of pits and shafts has been delayed but may commence soon in support of expanded nuclear weapons activities. Perched aquifers are found beneath and just south of the landfill. At least one plume of contaminants originates from Area G. "Areas of the dump 'breathe' radioactive tritium."[39] No engineered cap is currently in place for this landfill. As a result, plutonium and other materials leave this site via erosion or transport by vegetation and animals. Plutonium has been found in site soils, vegetation, and in runoff and sediment washed from Area G.[40]

Underground storage tanks

In 1988, 39 underground storage tanks of contaminated materials were in use. During 1998, 5 of the 7 remaining underground storage tanks onsite were closed. Contaminated soil in the surrounding areas was excavated.[41]

As of February 6, 1996, 2.7 metric tons of plutonium and 610 kg [0.61 metric tons] of plutonium in waste remained onsite.[42] During the dry periods of the year, contamination is fairly stable, but with the snowmelt and runoff from rain, the contaminants can be spread quickly. Contaminants are washed from the disposal areas and carried offsite. With numerous disposal facilities carelessly run throughout years of operation, lower level contamination has begun to spread. In the future, the material disposal areas will eventually be breached on a time scale that cannot be predicted.

Remediation

In all actuality, remediation of contaminated materials is merely beginning at LANL; the majority of funding for remediation is allocated towards characterization, and to overhead. A 1997 DOE Inspector General Audit found that out of $386 million spent on "remediation" by 1995, only 21% had gone to actual cleanup.[43] DOE's cleanup in the South Fork of Acid Canyon (SFAC), a Los Alamos county park, left an average of 280 pCi/g of plutonium in the soil. In the year 2001, DOE again remediated the SFAC, leaving an average of 206 pCi/g Pu. DOE claims it cleans its own land to 25 pCi/g.[44] The cleanup criterion at DOE's Lawrence Livermore Labs is 2.5 pCi/g. Radionuclides, high explosives, volatile organic compounds, metals, and nitrates are the main contaminants of concern resulting from operations onsite.

Los Alamos conducts tests on methods of remediation that they believe may help resolve the daunting nuclear waste problem for the rest of the country. One such method under study and development is known as transmutation. The idea is to separate out longer-lived fission products, such as I-129, from high-level waste, then bombard these radionuclides with a neutron beam from an accelerator. [45] Of course the process of separating longer-lived radionuclides produces additional large volumes of high-level waste. Producing electricity to operate the neutron beam accelerator generates additional high-level waste. The Materials Disposal Areas will be capped and covered with a few feet of soil while the wastes are left buried. Natural attenuation (meaning "dilution is the solution") is the method of remediation for groundwater.[46] Although by 2013 "remediation" is expected by DOE to be completed, currently, no plans are in place to stabilize or remediate any of the contaminated sites, other than Materials Disposal Area P, the contents of which have now been removed. (See Figure 4.) However, there is no commitment to doing anything at the other Materials Disposal Areas; capping with soil is generally discussed but there is no actual binding plan or even any detailed proposal, nor any open process to get such. The risk at the sites may turn out to be dominated by man-made events, and it is not clear that capping of this type will greatly reduce it.

Challenges

Although the site is relatively secluded, the threat of spreading contaminants remains and has been exacerbated in the short term by the Cerro Grande Fire. Eventually, the Cerro Grande fire's effects will be reduced when the land reforests itself. The region will then transition back to the cyclic fire-influenced geomorphic processes that have always been present at the site and always will be. Careless dumping of liquid effluent and solid waste, plus other unsafe disposal practices and the lack of complete cleanup, has resulted in residual contaminants in the site's many canyons. Flash floods in the canyons and arroyos present a challenge with the increasing rate in the spread of contamination to areas onsite as well as offsite. The canyons were initially formed by rapidly flowing water moving through the area. Tuff slumping and consolidation after pyroclastic flows generally reproduced pre-eruption drainage paths. Contaminants have been dumped in the canyons which nature will eventually erode away when flooding occurs. The canyons are an extremely poor place for the wastes to have been dumped.

Another challenge arises with the fractures beneath the surface that may present a pathway for contaminants to travel into the aquifer. One Los Alamos study suggests that an

earthquake of a magnitude of 5 or greater on the Richter scale can occur once every 100 years. The threat of earthquakes may seem infrequent, but given the thousands of years during which the long-lived wastes stored on site must be sequestered, the time frame is of concern. The Jemez Mountains were originally created by volcanic activity and the site itself is located on a volcanic shelf.[47] The Pajarito Plateau is a depositional feature of volcanic centers to the immediate west formed from a variety of volcanic and fluvial processes, creating a geology that is heterogeneous on a very small scale, making the creation of useful predictive models something that can only be done by averaging over large areas – i.e. not so useful in predicting events at any local site. Fractured vadose zone flow is not just unknown but unknowable, because the effort to know the mesas will change them.

Earthquakes are a small source of fractures compared to cooling fractures. Fracture spacing in Los Alamos' rocks is on the order of 1-10 m in the nominally vertical direction.

LANL and its diverse landscape create challenges to remediation. Canyons and mesas full of contaminated waste and hazardous materials increase the difficulty of characterization and cleanup. A sudden change in weather only worsens the spread of contamination through flash flooding. Surface contamination must be cleaned up so that the risk is eliminated. Groundwater must be remediated to the extent possible to reduce the risk to the residents of Los Alamos and neighboring communities.

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[18] US DOE. "Environmental Survey Preliminary Report", January 1988: 2-6.
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[31] US DOE. "Environmental Surveillance at Los Alamos during 1998", <http://lib-www.lanl.gov/la-pubs/la-13633.pdf>.
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[36] Coyle et al. *Deadly Defense: Military Radioactive Landfills*, 1988: 62.
[37] Coyle et al. *Deadly Defense: Military Radioactive Landfills*, 1988: 62.
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[40] Los Alamos Study Group. "LANL Area G Background Information", <http://www.lasg.org/inforg_b.html>.
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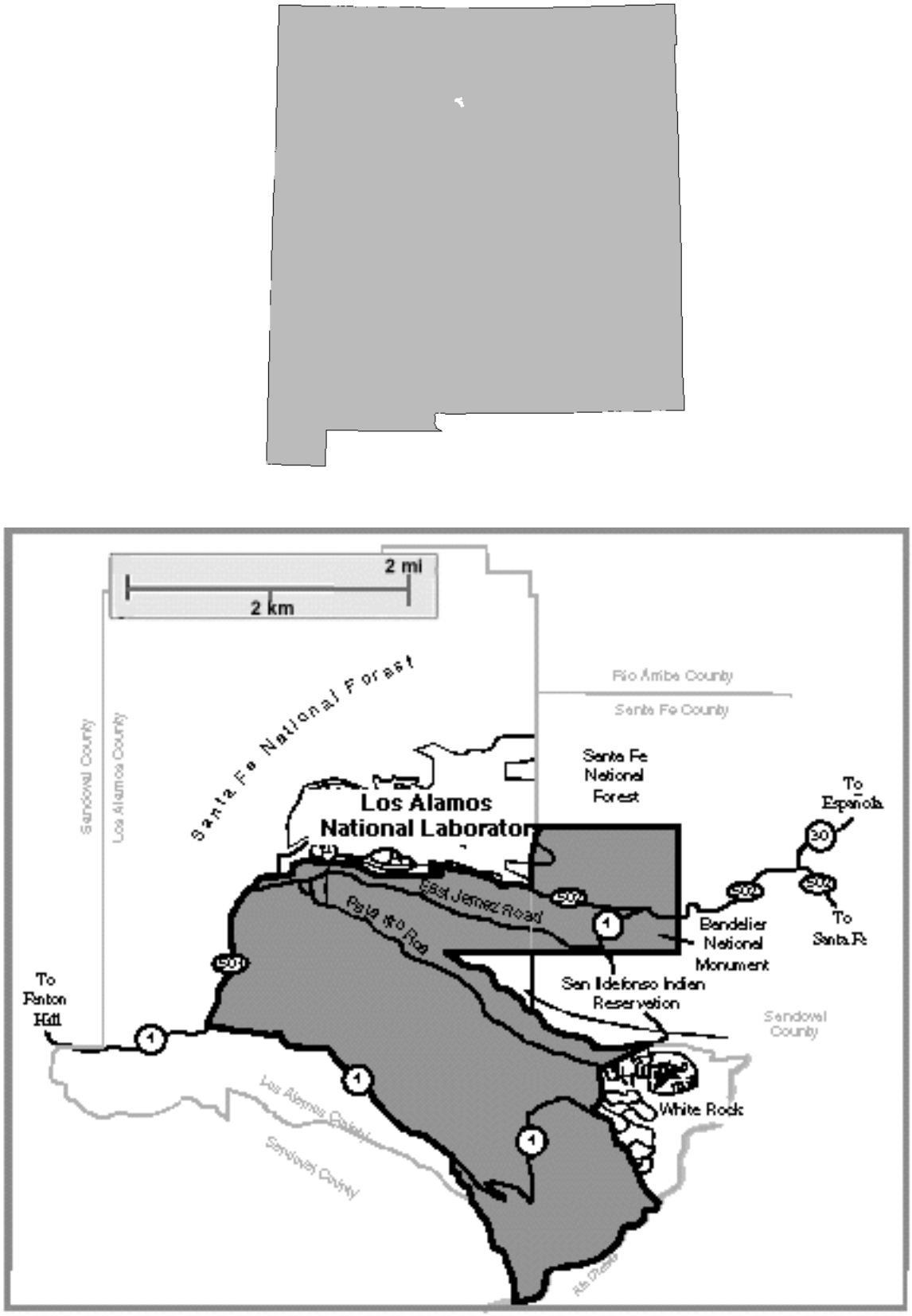

Figure 1: Location and Site Map of Los Alamos National Laboratory

Source: http://www.em.doe.gov/aoc2006/states/nm2map.html

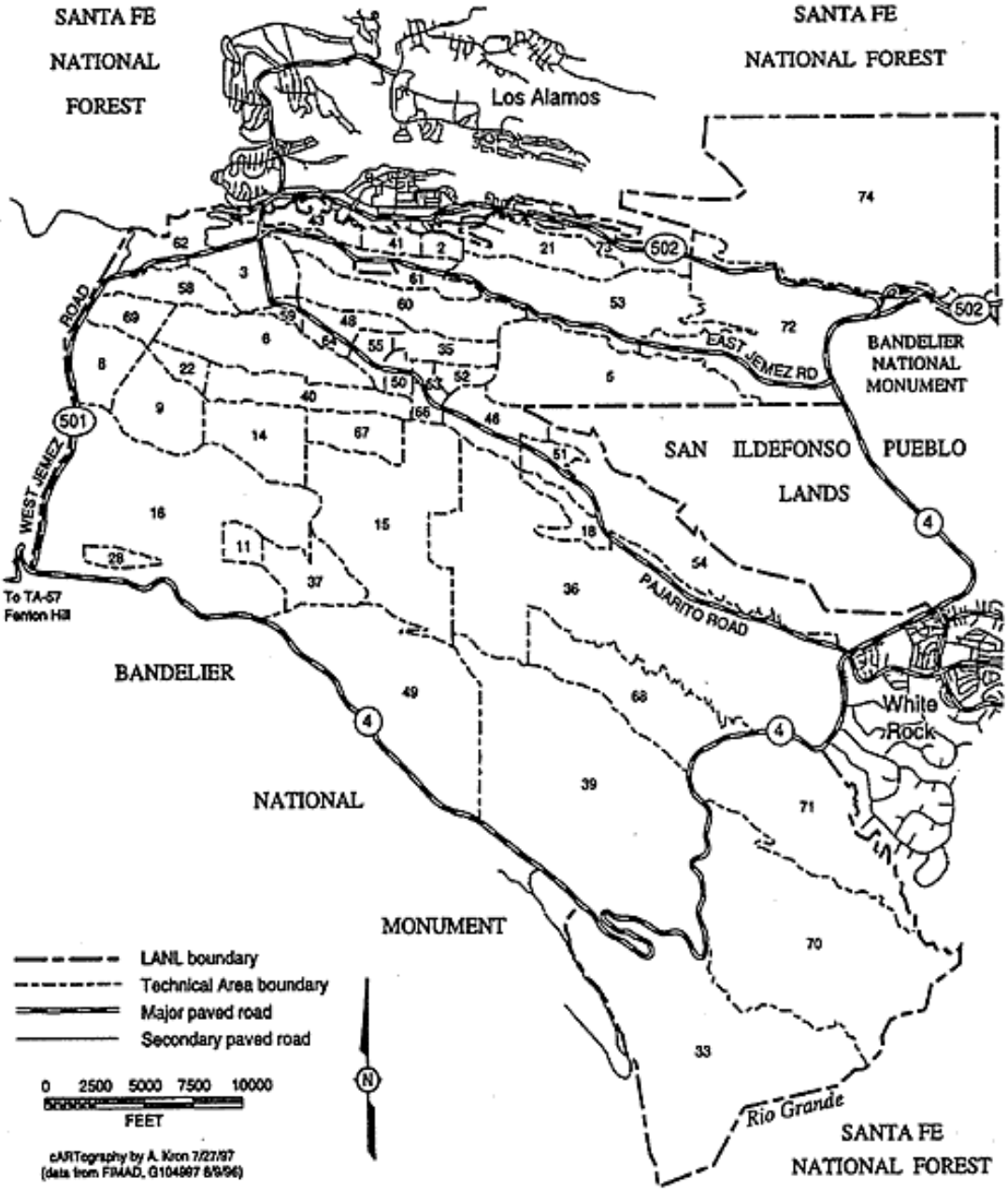

Figure 2: LANL Site Map and Location of Technical Areas (numbered)
Source: Los Alamos Study Group, http://www.lasg.org/genfrm_b.html

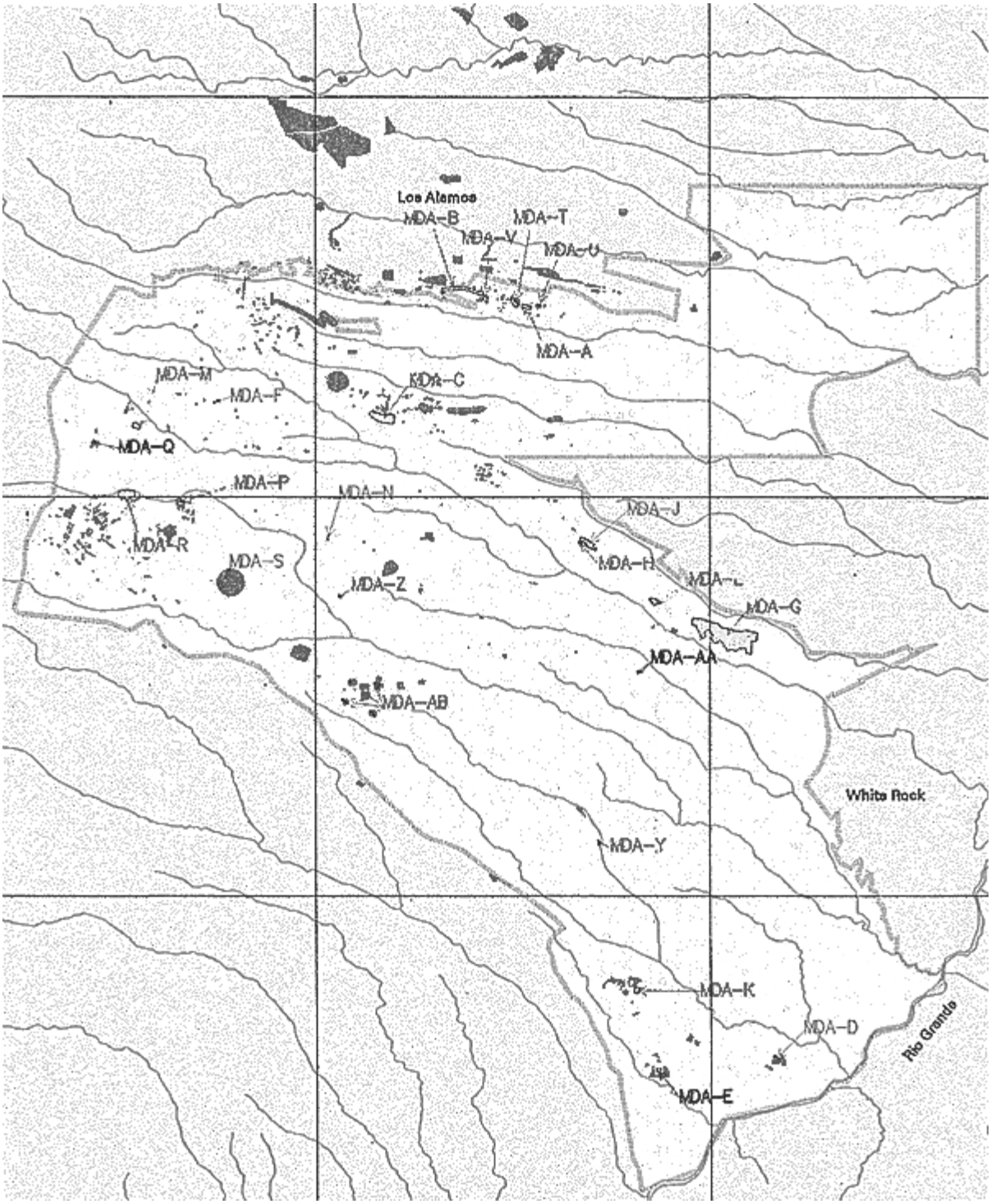

Figure 3: LANL Site Map and Location of Material Disposition Areas (MDAs)
Source: Los Alamos Study Group, http://www.lasg.org/mdafrm_b.html

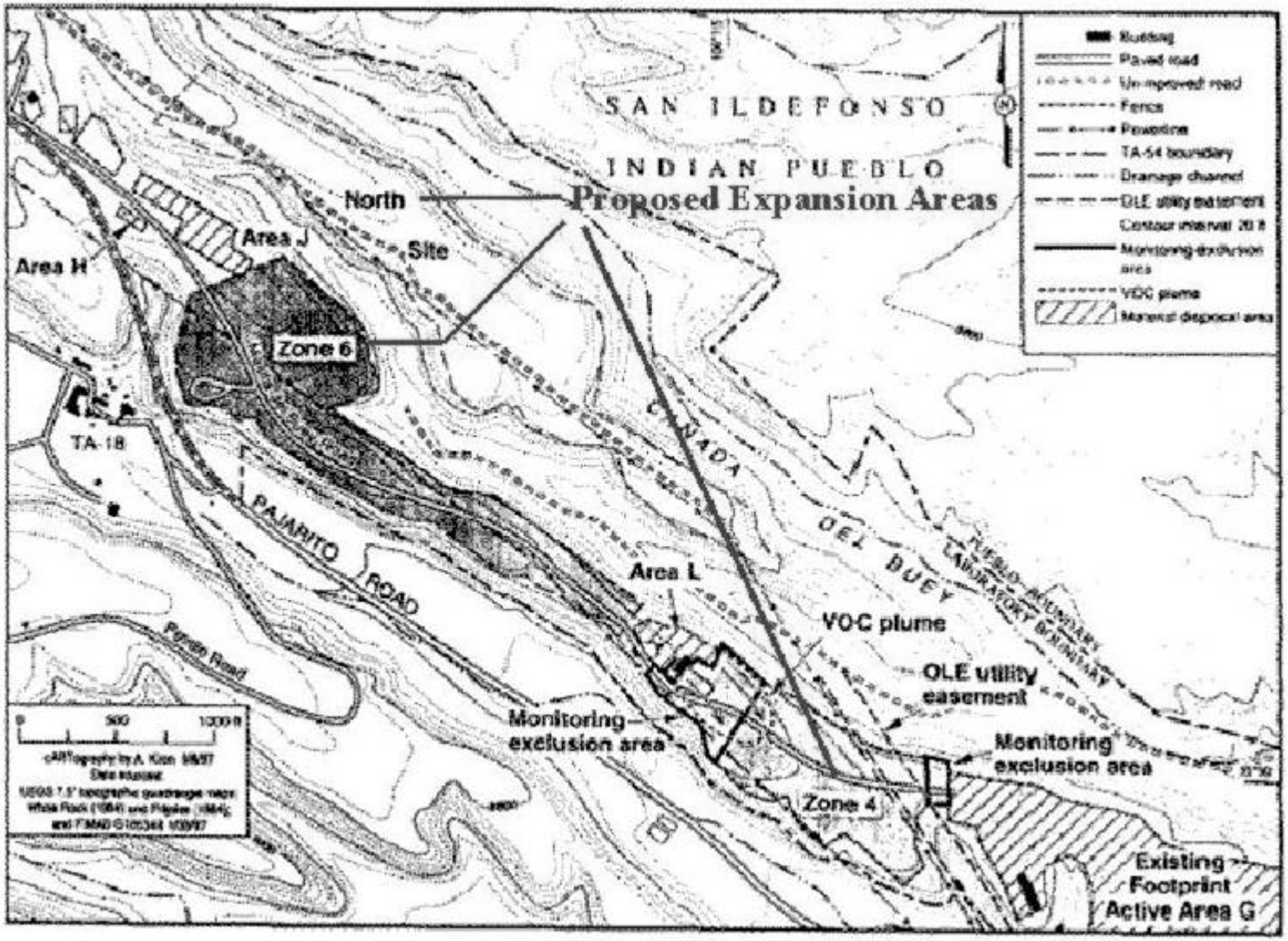

Figure 4: Area G low-level radioactive waste disposal site and proposed expansion
Source: Los Alamos Study Group, http://www.lasg.org/gfrm_b.html