FIRE, EARTH AND WATER:

An Assessment of the Environmental, Safety and Health Impacts of the Cerro Grande Fire on Los Alamos National Laboratory,

by

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December 2000

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Executive Summary

Summary and Recommendations

Background

Between May 4 and June 10, 2000, a devastating wildfire swept across the Bandelier National Monument in the Jemez Mountains of New Mexico and onto the Department of Energy's Los Alamos National Laboratory (LANL). The Cerro Grande fire burned about 43,000 acres, including 7,500 acres of LANL property. Large areas of vegetation in the Jemez Mountains surrounding LANL were destroyed. The fire left more than 400 Los Alamos residents homeless, destroyed or damaged several hundred structures and disrupted the operation of the entire LANL site. The fire spread over several hundred waste disposal sites and areas contaminated with radioactivity and other hazardous materials.

While it raged, the fire released radioactive and hazardous airborne contaminants from LANL and from burning vegetation and debris. In the fire's aftermath, the magnitude of its destruction significantly changed environmental conditions and has increased the risks of flash floods, surface and groundwater contamination, and large amounts of LANL contaminants entering the Rio Grande.

The Department of Energy (DOE), LANL, other federal agencies, and the State of New Mexico have taken prompt actions to mitigate risks and have made progress in providing the public with prompt and detailed information pertaining to the risks from the fire aftermath. According to a recent assessment, DOE found that the serious environmental and safety problems associated with flash floods, erosion, and contaminant run-off will persist at LANL for three to five years.

The Cerro Grande Fire Aftermath

In the aftermath of the Cerro Grande fire, cleaning up the contaminant burden at LANL warrants a high priority. There are numerous disposal pits, burial grounds, underground tanks, and hundreds of shafts filled with radioactive and hazardous wastes that have accumulated for more than a half a century. Test facilities released large amounts of radioactive materials into the environment, creating severe contamination. All told, there are over 2,120 potential release sites at or near LANL. In June 2000, DOE concluded that the amount of buried transuranic wastes at LANL is approximately 10 times greater than previously estimated. Moreover, LANL expects to generate several hundred thousand cubic meters of additional radioactive and hazardous wastes.

The Pajarito Plateau, on which LANL is located, consists of fingerlike mesas and deep canyon systems. Of particular concern are several canyons, a reactor site, and various heavily industrialized sites. These canyons, including Mortandad, DP, Water, Pueblo, Acid, and Los Alamos, received decades of radioactive and hazardous discharges. Runoff from these canyons can potentially drain well beyond the boundary of LANL and eventually flow into the Rio Grande.

Specific Concerns

Airborne Releases of Contaminants. Fire and winds swept across contaminated waste disposal areas at LANL and may have carried LANL contaminants to areas offsite. LANL found that the increased radioactivity in the ambient air was from naturally occurring radioisotopes that result from the decay of radon. As a result, there may be significant gaps in the data. Additionally, DOE did not deploy aerial monitoring aircraft to measure contaminants in the smoke plume or to assess potential localized "hot spots" that the fire may have created. Another important concern is the potential for the resuspension of LANL contaminants caused by the fire's disruption. Large amounts of smoke containing hazardous constituents from burning trees and debris posed acute health risks to those who may have been exposed to the heavy smoke, particularly to the elderly, the young, and people with respiratory diseases.

Flooding and Erosion Risks. The Cerro Grande fire denuded the mountains surrounding LANL and several watersheds that feed into the Rio Grande. The site's extensive canyon drainage system consists of steep slopes, which accelerate the flow of water, sediment, and debris flow from nearby mountains. This greatly increases the volume and velocity of water, runoff, and debris that could wash through LANL property. Fortunately, this year's monsoon season has ended with only a few powerful storms. Of the watersheds that run through LANL property, those of greatest present concern, include:

- Pajarito Canyon (TA-18). Facilities at risk along this canyon include the nuclear reactor criticality test facilities and a vault containing significant quantities of plutonium and highly enriched uranium. The community of White Rock, New Mexico is directly downstream from this canyon.

- Los Alamos Canyon (TA-41, TA-2). Facilities at risk along this canyon include the defunct, and contaminated, Omega West Reactor. Because the reactor is on a canyon bottom, it is vulnerable to slope instability that could result in mudslides, and the falling of debris and large rocks.

- Pueblo Canyon. Structures at risk along this canyon include the Diamond Drive road crossing and utility facilities for Los Alamos County.

- Water Canyon. Significant amounts of residual high explosives from a firing site and contamination already existing in the canyon bottoms could be carried away during flooding into the Rio Grande.

In addition to the aforementioned canyons, several other canyons also have contaminated sediments that could potentially wash downstream. An additional 77 waste disposal sites and contaminated areas have been identified by LANL as being on potential flood plains.

LANL and other federal agencies have taken several prompt steps to reduce flood and erosion risks by building water retention structures (dams), channels, and barriers.

Erosion and Runoff into Water Supplies. There is a watershed drainage network of twelve canyons that run through LANL property and ultimately feed into the Rio Grande. Experiences with fires elsewhere suggest that the watersheds running though LANL property will dramatically increase their yields of contaminant-bearing sediment.
On July 8, 2000, Concerned Citizens for Nuclear Safety (CCNS) and the Nuclear Policy Project held a one-day conference in Santa Fe, entitled Fire, Water and the Aftermath: The Cerro Grande Fire and Its Effect on the Rio Grande Watershed. At the conference, a LANL soil expert stated that runoff could carry as much as 300,000 cubic meters of contaminated soil, the equivalent of a football field 300 feet high, into the largest fresh water artery in the state. As of September 2000, after modest rainfall, LANL reported that:

- Several dissolved metals were found to exceed screening levels and were being analyzed further.
- Cyanide levels two times above those that are immediately harmful to fish were measured in water and sediments in several canyons and burned areas.
- Low levels of polychlorinated biphenyls (PCBs) were detected in water and sediment samples. Bioaccumulation of PCBs in the food chain is of great concern because there have been numerous high concentration PCB spills from leaking LANL transformers.
- Cesium 137 concentrations in suspended material are five to 20 times higher than pre-fire levels. Plutonium and strontium 90 concentrations increased five to 10 times and two to five times, respectively.

Ground Water Contamination. There are several concerns about LANL's efforts to mitigate flooding and runoff. Impoundments and sediment traps could enhance the downward migration of contaminants into the aquifers beneath the site. On the other hand, erosion can also expose buried wastes. LANL contaminants have already entered alluvial and perched aquifers as well as the main aquifer. Site baseline measurements and the means of detecting migrating contamination to offsite locations is an ongoing weakness at LANL.

Of concern is the Material Disposal Area (MDA) AB at Technical Area-49, where approximately 40 kilograms of plutonium and other materials were released into shallow shafts from test explosions. According to a LANL study, this area has the largest source of environmental radioactivity at the site. Over the years, official assumptions about the subsurface migration of plutonium at DOE sites have proven to be wrong. Recently it was discovered that plutonium at the Nevada Test Site had migrated greater distances than previously assumed because it binds to microscopic particles that travel easily through subsurface barriers.

Offsite Radiological Contamination

Environmental contamination in offsite areas is a continuing problem. Ownership of some inactive waste sites has been transferred to Los Alamos County and private owners. LANL has yet to complete and present to the public a formal risk characterization of all inactive waste sites. In the early 1990s, LANL identified 110 inactive waste sites. Approximately 300 Los Alamos property owners were living and working on or near these areas. LANL did not inform the property owners for more than a year after the situation was analyzed and written up.

Excessive plutonium contamination was recently detected in the south fork of Acid Canyon, a public area in Los Alamos County and situated in the midst of residential dwellings. In 1967, this area was released for unrestricted public use. The south fork was the main discharge point for treated and untreated radioactive and hazardous wastes between the 1940s and the early 1960s.

In April 2000, plutonium concentrations approaching 8,000 picocuries per gram (pCi/gm) were found by LANL in Acid Canyon. Contaminant levels such as these are normally found inside restricted areas at weapons sites where workers are provided protective measures, including clothing and equipment. An example of compliance with the Environmental Protection Agency Guidance for plutonium levels is soil is that of the U.S. Defense Department which set a cleanup limit of 13 pCi/gm in the soil at the Johnston Atoll. In addition to risks to area residents, particularly children who may be exposed, plutonium in Acid Canyon could commingle with storm water runoff coming from Pueblo Canyon and be transported to the Rio Grande.

Recommendations

A Strategic Plan for Environmental Risk Reduction. In the aftermath of the Cerro Grande Fire, a unique and unprecedented set of questions presents themselves.

- What are the risks to human health from the release of airborne contaminants from the LANL site?
- Are the DOE and LANL prepared to address the dangers of flash floods washing down denuded terrain through canyons?
- How have fire and post-fire efforts to control erosion and flooding influenced the subsurface migration of contaminants?
- What is the nature and extent of the contaminant burden from LANL operations in the Rio Grande? How much will be added to this burden?
- What are the environmental and health impacts and risks from LANL contaminants in the Rio Grande?

DOE and LANL lack an overall long-term strategic environmental protection and risk reduction plan. A number of activities to analyze and assess the environmental impacts after the Cerro Grande have been instituted by several federal agencies, DOE, LANL, and the State of New Mexico. A major concern about these activities is that they are mostly palliative, short-term, and lack clearly articulated environmental protection goals. The environmental protection goals for the strategic plan include:

- The quantification of the nature and extent of the environmental, safety, and health risks associated with the fire and its aftermath.
- Protection of the environment and health of those who depend on the air, soil, and water.
- Development of a strong scientific and ecological basis for operational, siting and cleanup decisions.
- Improvement of the overall water quality of the Rio Grande Watershed as a strategic artery for the nation.
- Independent monitoring and oversight by members of the public and LANL workers with an emphasis on trust and transparency.
- Targeted reduction of the burden of contaminants at and near the LANL site.

An Airborne Contaminant Risk Assessment. A dose reconstruction study of potential exposures from airborne contaminants should be undertaken. At present, screening levels for the ambient air monitoring systems have not been validated by actual data. At the minimum, source terms[1] for areas hit by the fire and winds should be established so that a comparison can be made between the source terms and the actual air monitoring data. The risks LANL radioactive and hazardous contaminants in the smoke from burning vegetation and debris should be included in this review.

Quantification of Environmental Source Terms. Accurate inventories of the contaminant burden from buried waste sites and discharges into canyons have not yet been developed by LANL. While it may not be feasible to develop source term estimates for all 2,120 potential release sites, it is essential to determine inventories for the most heavily contaminated areas, including burial grounds, test areas, and canyons. Without a reasonable quantification of the contaminant burdens or source terms that could migrate into surface and groundwaters from LANL operations, transport, uptake, and risk assessments will be tenuous at best.

Enhanced Vadose Zone Characterization.[2] There are major concerns about the adequacy of LANLs program to characterize the impact of subsurface contaminants on surface and groundwater quality. Major issues that should be addressed include:

- At present, the seep-spring recharge mechanisms are not well understood.
- There is an inadequacy of site baseline measurements and the means of detecting migrating contamination from offsite locations.

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[1] Source term is the "quantity of material released and parameters such as exhaust temperature that determine the downwind concentration, given a specific meteorological dispersion condition." LANL Final Site-Wide Environmental Impact Study, p. 10-20.

[2] The vadose zone is an unsaturated zone or zone of aeration. "The partially saturated or unsaturated region above the water table that does not yield water to wells. Water an/or gases contained are usually under less than atmospheric pressure." Groundwater Protection Management Program Plan for LANL, p. 9-4.

- There is a lack of water well data about the effect of the faults on groundwater recharge and directional flow, potential infiltration zones, and seismic history on both sides of the fault zone at the site.
- There is an inadequacy of characterization data regarding surface flow contaminants infiltrating into perched aquifer zones in Los Alamos Canyon, which ultimately outcrop as seeps and springs at the confluence of the Rio Grande.
- There is an inadequacy of data regarding contaminant transport pathway mechanisms, and the impact of contaminants on canyon-specific perched aquifer systems.

Mass Budget Modeling of Contaminants in the Rio Grande. As sediments bearing radionuclides and other contaminants from LANL enter the Rio Grande and then move to reservoirs and eventually to the Gulf of Mexico, significant portions are deposited and stored in river sediments and on flood plains. A mass budget analysis determines the amount, types, and locations of LANL contaminants distributed in and around the Rio Grande compared to how much is moved to reservoirs and the ocean. Such an analysis requires information about the water and sediment movement over large areas because contaminants move with the sediments. In particular, bedload transport models are important for predicting the movement of contaminants.

Wildlife Uptake and Effects Assessments. The impact of contaminants on the wildlife in the Rio Grande watershed system can provide valuable, direct, and timely data. Plants and animals absorb and concentrate contaminants in river environments and therefore should be carefully studied. For many years, research about the effects of man-made contaminants on wildlife health, mortality, and propagation have been done. These studies serve to enlighten efforts to protect endangered species, reduce human health risks, and to validate compliance with environmental standards.

In addition to studying the biota on and near LANL property, the uptake and effects on fauna and flora biota in the river, the flood plain and sediment deposit areas, such as the Cochiti Dam, should be incorporated into measuring the transport and deposition of LANL contaminants and ascertaining their effects.

Human Impact Assessment. There are several ways in which LANL's radiation pollution adversely affects the people of Northern New Mexico. At risk is human health, ecologic viability, cultural vitality with particular regard to the many diverse, rural communities surrounding LANL, and the economic well-being of the entire region which depends upon agriculture and tourism. The issue of human health is complicated. The scientific database regarding the destructive potential of ionizing radiation is well-established. At issue is the question of low dose radiation pollution occurring over a long period of time via multiple environmental pathways such as air, water and food supplies.

Two types of data contribute to our understanding of this problem. The first is epidemiologic studies that extrapolate from large and disastrous radiation exposures such as Nagasaki, Hiroshima and Chernobyl to understand the risks of low dose exposures. A growing body of epidemiologic data is derived from at-risk low dose populations such as employees in nuclear industries and residents exposed to industry pollution and waste products. These studies depend upon accurate dose information (reconstruction) which requires meticulous measurements of pollutant emissions and vigorous record keeping by industry. Needless to say, the nuclear industry has been neither conscientious nor cooperative regarding such efforts. The second type of data regarding the harmful effects of chronic low dose radiation pollution comes from basic science research that conclusively demonstrates that radiation creates DNA-damaging ionization tracts through human and other biologic tissue. The creation of these tracts and the DNA damage they cause are not dependent upon dose. Lower doses simply create fewer ionization tracts—not less damaging ones.

In this case, human health risks are largely based on extrapolations using risk models that generally take into account the amounts of contaminants released, their transport pathways and ecological uptake, human uptake, dose, and risk estimation. Understanding the limitations of studying a small population, we recommend an epidemiologic study of the exposed versus non-exposed groups. The most vigorous study involves accurate dose data and reconstruction. This information exists for LANL employees, recent past and present. A vigorous and comprehensive study of LANL employees (which has not yet been done) presents the ideal opportunity to add to the database. Studies of the communities living around LANL are also important, not only to respond to the health concerns and suspicions of the people in these communities, but also to investigate the various environmental pathways that are transporting LANL's radioactive waste materials into other areas such as the state's main waterway, the Rio Grande.

This type of study would be difficult for several reasons but should still be done because it is morally imperative. The small size of these populations, in addition to the low doses of radiation, means the study results would most likely not reach statistical significance. But notable trends could be followed over a period of years. In addition, there is very little dose data due to the lab's inadequate record keeping and dearth of environmental science involving the pathways. An epidemiologic investigation requiring information of these types would give scientific and political impetus to begin a more vigorous examination of these things.

Specific attention needs to be given to the many diverse, rural communities surrounding LANL. Due to their traditional proximity to the land (and its contaminants), the these communities may be in contact with unique environmental pathways that need to be studied. Other methods involve the collection of human health information, such as symptoms, disease incidence and mortality, which is statistically compared with unexposed groups. Also, a follow-up study should be done to ascertain if hazardous smoke from the fire caused acute harm to human health.

Independent Monitoring and Oversight

The CCNS Clean Air Act Compliance Model for LANL. To answer these questions, an integrated effort with a strong scientific underpinning and public credibility is essential. A model that could achieve these objectives is the independent technical audit and oversight program established to ensure LANL's compliance with federal Clean Air Act radionuclide emission standards established by Concerned Citizens for Nuclear Safety (CCNS) as a result of their citizens' suit against DOE in 1994. The overall process has yielded multiple benefits relative to achieving and validating Clean Air Act compliance in a way that has strong public support and credibility.

The CCNS Clean Air Act Audit Model for LANL contains:

- Comprehensive independent technical audits to verify whether LANL is in full compliance with the Clean Air Act radionuclide emission standard. 40 CFR 61, Subpart H.
- An independent auditor (Risk Assessment Corporation (RAC)) chosen by the agencies and citizens and is paid for by DOE.
- A scope of work to be determined by the independent auditor (RAC).
- Technical consultants to the audit process who are responsible to the citizens and are paid for by DOE through the Department of Justice.
- A draft final report written and submitted to the parties for comments. The comments and the responses by the independent auditor are included in the final report.

A Proposal for Independent Auditing and Oversight. In the context of the Cerro Grande fire aftermath, a Clean Air Act-type audit model could be structured in the following manner:

- Technical Audits. DOE, through the New Mexico Environment Department, should fund a series of technical audits. The audits would review the major technical activities at LANL with respect to risk mitigation and environmental safety, and health assessments being done by the laboratory in the aftermath of the Cerro Grande fire. The technical audit team would prepare draft final report with opportunity to comment. Comments and responses to comments will be included in final report

- Cerro Grande Fire Citizen Oversight Panel. A "Cerro Grande Fire Citizen Oversight Panel," consisting of affected groups, such as the Pueblos, farmers, recreational river businesses, and citizen groups, would oversee these audits through independent technical experts that review the work of the auditors. The Oversight Panel would be responsible for reviewing the work scope, spot-checking ongoing work, and review of the final work products.

- Independent Expert Review of the Audits. Each technical audit would have independent technical expertise and report to the Cerro Grande Fire Citizen Oversight Panel. These experts would be paid from the funding of each technical audit. Commensurate with the technical audit teams, the independent experts would be responsible for review of work scope, spot-checking ongoing work, and the final reports.

Background

On May 4th of this year, National Park Service employees set what they planned to be a "controlled burn" to reduce and eliminate drying under-brush and dead growth in the Bandelier National Monument in northern New Mexico. It quickly got out of control and by May 8th out-of state firefighters were called in to battle a major wildfire. Over the ensuing days, the Cerro Grande fire became the largest wildfire in the history of New Mexico, blazing around and on the Department of Energy's Los Alamos National Laboratory (LANL).

On July 8th Concerned Citizens for Nuclear Safety and the Nuclear Policy Project convened a conference in Santa Fe, New Mexico. The purpose of the conference was to address the environmental, safety and health implications of the Cerro Grande fire and its aftermath. Conference participants included representatives of the Department of Energy, LANL, the State of New Mexico, Indian Nations, business people, citizen groups and concerned citizens. As a follow up to this conference, this "white paper" was prepared.

The risks of wildfires have a higher probability of occurring than any other natural danger at Department of Energy nuclear sites around the country. In addition to the Cerro Grande fire, there were two other major wildfires that impacted DOE sites this year. The Hanford wildfire in Washington burned over 192,000 acres in late June. In late July a wildfire cut a swatch about twelve miles long and four miles wide at DOE's Idaho National Engineering and Environmental Laboratory, coming close to large amounts of stored nuclear wastes, and forcing the evacuation of 1,800 workers.

DOE sites have buried wastes and extensive surface contamination whose migration and dispersion in the environment is retarded by soil and vegetation. Nuclear-site wildfires burn off protective layers of soil and vegetation, causing radioactive and other hazardous materials to be carried over great distances. Fires can disrupt safety systems at nuclear facilities, leading to loss of power and ventilation. They can ignite waste areas containing solvents, hydrogen and flammable forms of nuclear materials.

Since 1954, there have been five major fires that burned in the Los Alamos Laboratory area—the Water Canyon fire in 1954, the La Mesa Fire in 1977, the Dome fire in 1996, the Oso fire in 1998,[3] and the Cerro Grande fire in 2000. In 1998, after being urged by Concerned Citizens for Nuclear Safety, DOE and LANL performed a formal site-wide wildfire risk assessment, [4]which led to the reduction of vegetation around nuclear areas. Had this not been done, the Cerro Grande Fire probably would have had much more serious radiological consequences to public health and the environment.

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[3] Los Alamos National Laboratory, A Special Edition of the Site Wide Environmental Impact Statement Yearbook, Wildfire 2000, September 2000.

[4] U.S. Department of Energy, Albuquerque Operations Office, Final Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory, DOE/EIS-0238, Appendix G, January 1999. (here to fore known as "SWEIS")

The Cerro Grande fire burned about 43,000 acres, including 7,500 acres of Laboratory property. Large areas of vegetation in the Jemez Mountains surrounding the Laboratory were destroyed. The fire left more than 400 Los Alamos residents homeless, destroying or damaging 235 structures in the city of Los Alamos. On the laboratory site the fire destroyed or damaged 112 structures, and disrupted the operation of 237 facilities.[5] It spread over 343 waste disposal sites and areas contaminated with radioactivity and other hazardous materials.

The Los Alamos National Laboratory

The Los Alamos National Laboratory (LANL) was established in 1943 and occupies about 43 square miles of land situated on the Pajarito Plateau east of the Jemez Mountains of north-central New Mexico. The Laboratory's primary mission is focused on nuclear weapons. As the birthplace of the first nuclear weapons, LANL has for more than a half century played a central role in the design, development, production and testing of America's nuclear arsenal. Currently LANL has a major role in the DOE's. nuclear weapons stockpile stewardship and management program.

The University of California has managed Los Alamos National Laboratory since World War II. The recently created National Nuclear Security Agency, nested within the DOE, has the lead management responsibility. The annual operating budget for LANL is about $2.5 billion, about 15 percent of the total budget for the Department of Energy. The Laboratory has over 11,000 contractor and DOE employees.

LANL is divided into 49 separate Technical Areas. It has over 2,000 structures of which 425 contain radioactive and hazardous materials. These include radio-chemical processing and laboratory facilities, high-explosive production and testing facilities, small nuclear reactors in Technical Area –18, buried wastes, accelerators, and nuclear material processing and storage facilities.[6] According to a 1994 DOE plutonium vulnerability assessment, about 2.6 metric tons of plutonium are stored at 24 facilities at the Laboratory.[7]

Waste Storage and Disposal

LANL has been disposing radioactive and non-radioactive hazardous wastes since 1944. Throughout the history of the Laboratory, the principal means of disposal has been pits and hundreds of shafts. Waste areas also include former test facilities where radioactive and non-radioactive hazardous materials were released to the environment. These areas include uranium ordinance testing areas, hydronuclear and weapons components experiments.

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[5] ibid
[6] SWEIS, Vol. I.
[7] Plutonium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage, U.S. Department of Energy, November 1994, Washington, D./C. (DOE/EH-0415)

The vast preponderance of environmental contamination at LANL is in the subsurface. Like other nuclear weapons sites, the underlying design basis for waste management, for many decades, was to use the environment the Laboratory occupied as a disposal and storage medium. Contaminants were regulated at the point at which they reached the site boundary, not at the point of discharge – creating significant and irreversible contamination concentrations in soil, sediment and water.

Various facilities at the laboratory generate radioactive and non-radioactive wastes at 33 technical areas. The wastes types generated at LANL include: transuranic waste, and mixed transuranic waste, low-level and low-level mixed radioactive wastes, hazardous chemical waste, metals, biological waste, medical waste and sanitary solid and liquid waste. Radioactive and toxic wastes include Laboratory trash (mostly combustible), equipment, chemicals, oil, animal tissue, chemical treatment sludge, cement paste, hot-cell waste, classified materials, liquid discharges, sludge as well as building debris, large pieces of equipment and soil or rock generated or uncovered during site cleanup.[8]

The wastes are contaminated with transuranic radionuclides (plutonium-238, plutonium-239, or Americium-241), uranium (enriched, depleted or normal or U-233), fission products, induced activities or tritium, metals (beryllium), and organic compounds (PCBs , solvents).[9]

Until 1973, when DOE's predecessor, the Atomic Energy Commission, issued more stringent waste disposal standards,[10] few, if any, attempts were to segregate wastes in disposal areas. For many years, the preferred storage container for a significant amount of Laboratory wastes was the cardboard box. Drums were not stacked and were allowed to leak, and waste oils and solvents contaminated with transuranic elements were buried in numerous pits.[11]

According to the Department of Energy's 1996 Baseline Environmental Management Report :[12]

- LANL has over 2,120 radioactive and hazardous waste disposal and contaminated areas known as "potential release sites," including past burial sites, septic system discharges, chemical spill sites, and inactive underground storage tank locations. These areas are contaminated with radionuclides, high explosives, organic compounds and heavy metals.
- The site has an estimated inventory of transuranic wastes mixed with other hazardous materials , equivalent to 55,000 drums (55 gallon), with the equivalent of 1000 additional drums of these wastes generated annually.

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[8] Margaret Anne Rogers, History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A,B,C,D,E,F.G and T) LA-6848-MS, Vol I, June 1977.
[9] Ibid.
[10] U.S. Atomic Energy Commission, AEC Manual Chapter 0511 – Radioactive Waste Management
[11] Op. Cit. Ref. No. 6.
[12] U.S. Department of Energy, Baseline Environmental Management Report, Los Alamos National Laboratory, Office of Environmental Management, November 11, 2000.

- There are seven low level radioactive and mixed waste storage and disposal areas of which one – Area G – remains operational. Low-level radioactive waste has been land filled since 1957 in shafts and large pits. About 6,300 cubic yards is buried annually in Area G.
- LANL is estimated to generate a large amount of radioactive and hazardous wastes, including 279,669 cubic meters of low-level radioactive waste, 102,917 cubic meters of hazardous waste, 272 cubic meters of transuranic and 278 cubic meters of mixed transuranic wastes.

Of particular concern are the areas containing several canyons on the Pajarito Plateau, a reactor site, and various heavily industrialized sites. For decades radioactive and hazardous discharges were made in several canyons including Mortandad , DP , Pueblo, Acid and Los Alamos. All canyons on the site on drain into the Rio Grande.

Off Site Contamination from Inactive Waste Sites

Environmental contamination in areas offsite from the laboratory is a continuing problem. It results mostly from existing inactive waste sites on property, which was transferred, to Los Alamos County and private owners. LANL has yet to complete and present to the public a formal risk characterization at all inactive waste sites.

In the late 1980's and the early 1990's, the Laboratory identified some 110 inactive wastes sites located on property previously owned by the DOE. [13]Approximately 300 Los Alamos property owners were located on these inactive waste sites. Many of the property owners included new condominium projects completed in Los Alamos after the Laboratory had first prepared a report on this problem in 1987. According to a "Tiger Team" Assessment of the Los Alamos National Laboratory performed by the DOE in 1991:

" DOE and LANL did not notify Los Alamos homeowners in a timely manner that they were located on or near inactive waste sites, nor were these homeowners given an opportunity to comment on or provide early input into the corrective action process."[14]

Nearly a decade later, this problem is reoccurring as excessive radiological contamination is being found in public areas in the township of Los Alamos. The south fork of Acid Canyon was released for unrestricted use and is in the midst of residential dwellings in the city of Los Alamos. This fork of the canyon was the main point for treated and untreated radioactive and hazardous discharges from the 1940's to the early 1960's from a waste processing facility in TA-45.

The south fork of Acid Canyon was transferred for recreational use to Los Alamos County in 1967. It is now is open to hiking and is close to a public skateboard park.

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[13] U.S. Department of Energy, "Tiger Team Assessment of the Los Alamos National Laboratory," September 23 –November, 8, 1991, Office of Environment, Safety and Health. FINDING IWS/CF_3: Management of Transferred Inactive Waste Sites. (Here after known as "Tiger Team Report")
[14] ibid.

Recently, at the urging of the State of New Mexico, the Laboratory issued a report, which indicates that plutonium, contamination in this canyon in amounts significantly higher and pervasive than previously believed. Concentrations of plutonium approaching 8,000 picocuries per gram (pCi/gm) were found in the canyon's sediments. [15]

These are contaminant levels that are normally present inside restricted areas at weapons sites such as the defunct Rocky Flats plutonium foundry near Denver, Colorado. By contrast, this level is several thousand times higher than background from nuclear weapons test fallout. It is substantially higher than proposed by the EPA. A limit (13 pCi/gm) was adopted by the Defense Department to cleanup contaminated soil at the Johnston Atoll based on the proposed EPA guidance.[16]

TA-45 itself is now located in the Los Alamos town site. It underwent remediation in the mid 1960's and the early 1980's, which involved decontamination and decommissioning (D&D) of buildings and drain lines and removal of contaminated soil, sediments, and tuff. According to the 1991 DOE "Tiger Team" Assessment:

"TA-45 is used as an unpaved storage and stockpile area for equipment and fill materials. Large volumes of miscellaneous soil and fill materials from undocumented locations, including at least one steel tank, have been disposed of in TA-45 and have been dumped over the canyon edges…. Continued disposal of uncharacterized materials at former TA-45 will impair the ability of LANL to characterize residual contamination from past operations, to conduct remedial actions, and to determine liability for remedial actions."[17]

Plutonium contamination in the south fork of Acid Canyon did not result from the wildfire. However, there are concerns that contaminants in Acid Canyon could commingle with storm water run-off coming from Pueblo Canyon. This problem raises questions about health risks, the quality of past characterization efforts and the importance of more extensive environmental remediation of laboratory waste areas.

It appears that the 1991 DOE "Tiger Team Assessment still is germane as it concluded: " LANL does not have a formal, consistent, and documented program for risk management to ensure continued protection of public health and the environment at inactive waste sites."[18]

The Cerro Grande Fire Aftermath

In the aftermath of the Cerro Grande fire there are several environmental, safety and health issues of concern. The fire changed the environmental circumstances, which have

[15] Interim Report on Sediment Contamination in the South Fork of Acid Canyon. LA-UR-00-1903. Steven L. Reneau, et.al., April 27, 2000.
[16] E. T. Bramlitt, "Plutonium mining for cleanup," Health Physics, v. 55, no. 2, August 1988. pp. 451-453.

[17] Op. Cit. Ref. 10.
[18] Ibid.

increased the risks for destructive flash floods, the release of additional airborne contaminants, increased surface runoff that carry contaminated sediments into water supplies and erode soil, and expose buried wastes. Also, the migration of subsurface contaminants may lead to their increased infiltration into aquifers.

Airborne releases of contaminants—Fire and winds swept into waste disposal areas and areas of contamination from laboratory activities, which could have carried laboratory contaminants to offsite areas. During the fire, monitoring for airborne contaminants was carried out by the U.S. Department of Energy (including LANL), the Environmental Protection Agency and the New Mexico Environmental Department. The single largest in-place system deployed to measure ambient airborne contaminants came from the AIRNET system maintained by LANL for ongoing monitoring of the lab's operations. Increased radioactivity in the ambient air was detected from this network, which was found by LANL to be from naturally occurring radioisotopes that result from the decay of radon. The NEWET system maintained by LANL to detect increases in external penetrating gamma radiation, did not measure significant gamma radiation increases. Other systems deployed by the DOE, EPA and the state of New Mexico found similar results.

However, all systems were down for 48 hours during the peak of the fire as it swept across the Laboratory. Therefore, there may be significant gaps in the data. Also, the Department of Energy did not deploy aerial monitoring assets to measure contaminants in smoke or to assess potential localized "hot spots" that the fire may have created. Another important concern is the potential for the resuspension of laboratory contaminants caused by the fire's disruption. There are many outdoor locations at LANL that are known, or suspected to be contaminated with uranium or other radioactive materials. It is not clear, based on publicly accessible data, that additional monitoring was or is being deployed to ascertain if localized areas of contamination, disrupted by the fire, may be a source of resuspended airborne contamination. Hazardous constituents in smoke from burning vegetation posed potentially serious health risks.

Flooding risks – Precipitation and elevation provide the energy that is the primary driving force behind river processes in the Northern Rio Grande Basin. The laboratory sits on the Pajarito Plateau, which is 8 to 16 miles wide and 30 to 40 miles long, lying between the Sierra de los Valles to the west and the Rio Grande River to the east. The plateau slopes eastward from an elevation of 7,800 feet to 6,200 feet adjacent to the Rio Grande. There are numerous deep cut streams or watersheds, which flow to the southeast. The eastern part of the plateau, which feeds into the Rio Grande is about 1000 feet above the River. [19]

Los Alamos has a semiarid temperate mountain climate with average annual precipitation of about 18 inches. Three fourths of this precipitation falls during monsoon season from May to October, with storm activities peaking in August. The average winter yields about 50 inches of snow with as much as 6 inches or more falling in 24 hours. Vegetation

[19] William L. Graf, *Plutonium and the Rio Grande: Environmental Change and Contamination in the Nuclear Age*, Oxford University Press, 1994, pp-32-59. (here-to-fore known as "Graf.")

consists of desert shrubs and drought resistant grasses. The most widely distributed type of vegetation on the site is the Pinon, Juniper and ponderosa pines.[20]

At Los Alamos, the Cerro Grande fire denuded the mountains surrounding the Laboratory and several watersheds that feed into the Rio Grande. This loss of vegetation and soil disruption greatly increases the volume, velocity and rate of water, run-off and debris that could wash from the mountains through the site's extensive and steep-sloped canyon drainage system.

The design basis that the Environmental Restoration Team at the Laboratory is using assumes a rainstorm of 6 hours duration that would occur once every 100 years. The hydrological model used by LANL and the Army Corps of Engineers to calculate peak flows and water surface elevations still contain major uncertainties.

For instance, modeling by the DOE and the Army Corps of Engineers (COE) of the flow expected from a rainfall event of .69 inches on June 28th greatly under predicted the actual flow. At TA-18 the LANL/COE model anticipated a peak flow was 11 cubic feet per second, compared to the actual flow of 150 cfs. (+ or – 30 cf/seconds) – a rough order of magnitude difference.[21] This demonstrates that the risks and consequences of flash floods can be high and severe. There are three small nuclear reactors, used for nuclear criticality tests, along this flood path.

Fortunately, this years' monsoon season is concluding with a low frequency of powerful storms that could cause significant floods and run-off from the LANL site. However, because of the magnitude of the destruction of vegetation in the mountains surrounding the Laboratory, flooding and run-off risks will be major concerns for several years. Of the watersheds that run through the Laboratory, those of greatest concern at this time include:

- **Pajarito Canyon (TA-18).** Facilities at risk along this canyon include the nuclear weapons criticality test facilities or reactors which contain "high energy burst assemblies," and a vault containing significant quantities of plutonium and highly enriched uranium. The community of White Rock, NM is directly downstream from this canyon. The DOE has issued an Environmental Assessment to consider the transfer of these facilities to another DOE site.

- **Los Alamos Canyon (TA-41, TA-2).** Facilities at risk along this canyon include the defunct and contaminated Omega West Reactor. Because the reactor is on a Canyon bottom, it is vulnerable to slope instability that could result in mudslides, and the falling of debris and large rocks. Between 1944 and 1993 there were twenty-four separate rock fall incidents in this area from

[20] Ibid.
[21] U.S. Department of Energy, Defense Nuclear Facilities Safety Board, Staff Issue Report, August 9, 2000, Flood Mitigation Measures at Los Alamos National Laboratory, Washington, D.C.

rocks ranging in size from 300 to 21,000 pounds.[22] The risks of falling rocks also extend to residential housing in homes and apartments in lower Los Alamos Canyon.

- **Pueblo Canyon**. Structures at risk along this Canyon include the Diamond Drive road crossing and utility facilities, such as the Bayo Treatment Sewage Treatment Plant for the town of Los Alamos.

- **Water Canyon**. Significant amounts of residual high explosives from a firing site and contamination already existing in the canyon bottoms could be carried away during flooding into the Rio Grande.

In addition to these canyons, several other canyons also have contaminated sediments that could potentially wash down stream. An additional 77 waste disposal sites and contaminated areas have been identified by LANL as being on potential flood plains. Currently, the Emergency Rehabilitation Team (ERT) at Los Alamos is responsible for addressing these risks and are coordinating projects aimed at reducing flood risks and contaminant movement. Among the major actions taken are :

- Construction by the Army Corps of Engineers (COE) of a 70-foot flood retention dam in Pajarito Canyon upstream of TA-18 and White Rock.

- Installation of about 1000 feet of sheet piling, 5-feet high to protect “Kiva 1” a nuclear reactor criticality test facility at TA-18.

- Construction of a diversion channel to increase stream capacity.

- Construction of armoring road crossings by the COE in canyons upstream of TA-18 so they will act as small retention basins.

- Removal of 700 cubic meters of contaminated sediment in Los Alamos Canyon near the Omega West reactor.

- Removal of the cooling tower and evaporator of the old Omega West Reactor.

- Installation of an 86-inch culvert at Diamond Drive road crossing.

- Contour felling of trees, rock-check dams and hydro seeding of the mountain slopes above the Laboratory site.

Erosion and Runoff into water supplies – The northern portion of the Rio Grande , which is the largest fresh water artery in New Mexico, flows near the lab. The drainage

[22] U.S. Department of Energy, Albuquerque Operations Office, Draft Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory, DOE/EIS-0238, April 1998, p.4-32.

network of the 71,700- sq-km area, which contains the lab, is the primary means by which contaminants from LANL are transported and deposited in the river system. [23]

The LANL site lies on volcanic rocks erupted from two significant eruptions that deposited ash and pumice, which is referred to as the Bandelier Tuff (slightly welded to welded ash, tuff breccia, and crystal fragment tuff). The Bandelier Tuff overlays the Puye Formation of the Santa Fe Group sediments. The upper member of the Puye Formation's, the Fanglomerate Member, consists of silts and sands, and pebble to boulder breccia of volcanic rocks. The Puye Formation's lower member, the Totavi Lentil, consists of sands, pebbles, and boulders of quartzite, granite, latite, dacite, and other volcanic rocks. The Tesuque formation, consisting of sand, silt, clay, and some interbedded gravels, underlies the Puye Formation. Generally, the Totavi Lentil is overlain by basalt flows of the Chino Mesa on the eastern portion of the plateau. The Puye Formation is interbedded with volcanic rocks of the Tschicoma Formation on the western portion of the plateau, the Sierra de los Valles.

The steep slopes of the canyons on the Laboratory site shed their debris and associated contaminants more rapidly than moderately sloping terrain. There is a drainage network of twelve canyons that run through Los Alamos Laboratory and ultimately feed into the Los Alamos Canyon – the main entry point for site contaminants into the River. Many years of erosion has created unstable side slopes along the canyons running through LANL – causing sediment particles ranging from sand to gravel as well as clay-size particles to be transported into the river. The river channel processes affecting the mobility of contaminants from LANL within landforms, soils geology, climate and vegetation.

Studies conducted by LANL show that stream sediments contain the main source of radioactivity from waste disposal activities and that runoff processes are moving sediments downstream.[24] Onsite, the water in an effluent discharge area in at least one canyon, Mortandad, has been severely impacted. The TA-50 Low-Level Waste Treatment Plant was constructed in the early 1960s to process industrial liquid radioactive wastes resulting from various processes throughout LANL's facilities. Treated liquid effluent was discharged through an outfall pipe to the ground surface at the upper portion of Mortandad Canyon.

Radiologically contaminated effluents to Mortandad Canyon were above concentration guide values for many years, on an average annual basis. Nitrate levels were measured as high as 117 mg/L (the drinking water standard is 10 mg/L) in 1989 and 86 mg/L in 1990. Other high contaminant levels identified in Mortandad Canyon include total dissolved solids (maximum of 1780 mg/L), sodium (maximum of 320 mg/L) and sulfate (maximum of 107 mg/L). [25] It is not clear if the potential impact of such high pollutant levels on possible uses of the water by wildlife has been evaluated.

[23] Op. Cit. Ref. No. 10.
[24] Graf. P. 12.
[25] Tiger Team Report, FINDING SW/CF_6: Effluent Monitoring and Environmental Surveillance Programs.

Elevated levels of uranium and plutonium isotopes have also been detected in sediments in onsite canyons. Tritium, cesium-137, strontium-90, and americium-241 have been detected in Los Alamos and Mortandad Canyon sediments. Also, plutonium isotope concentrations have been detected in Pueblo Canyon both on-site and off-site. Uranium isotope concentrations have been detected in Los Alamos Canyon both on-site and off-site in soils at the TA-14, TA-15, and TA-36 firing sites. [26]

In just one storm at Los Alamos, surface water run off transported 1 to 2 percent of the entire sediment-bound inventory of plutonium.[27] According to a 1998 Laboratory monitoring report, offsite concentrations of laboratory radionuclides in the river sediment near the San Il Defonso Pueblo "often exceeded the DOE dose concentration guidelines."[28]

Once contaminated sediment particles enter stream channels, their distribution is uneven. However, bottom sediments appear to store a significant amount of the contaminant burden in the Rio Grande. A recent study now indicates that 50 percent of the plutonium deposited in sediments in the Cochiti Reservoir 18 miles downstream from LANL have come from laboratory operations.[29] Previously the Laboratory assumed that only 10 percent of the plutonium in this reservoir came from its operations.[30] Cochiti sediment data collected by the U.S. Geological Survey also raises concerns about releases of uranium from the laboratory. According to a recent report on this subject "historical uranium releases by LANL into Canyons draining into the Rio Grande are a concern." [31]

Fate and Transport in the River—However, official assumptions about the contaminant risk to the Rio Grande contain strong elements of speculation. Major uncertainties arise from the absence of a mass budget analysis of the fate and transport of lab contaminants in the river. The contaminant burden in on-site sediments on the site from laboratory operations has not been quantified in terms of mass balance estimates of discharges, matched up with sediment characterization data. These are basic and elemental requirement for any comprehensive assessment of the fate and transport of laboratory contaminants into the Rio Grande. This is further complicated by the absence of validated source term estimates. Source terms provide basic data as to the nature and extent of the contaminant inventory in sediments, which could be released. Several

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[26] Tiger Team Report, FINDING SW/BMPF_1: Radioactive Liquid Waste Treatment Plant _ Characterization of Effluent Quality in NPDES Permit Re:Application.

[27] Graf. P. 30.

[28] U.S. Department of Energy, Los Alamos National Laboratory, *Environmental Surveillance at Los Alamos during 1998*, p.135.

[29] B.M. Gallaher, D.W. Efurd, D.J. Rokop, T.M. Benjamin, Plutonium and Uranium Atom Ratios and Activity Levels in Cochiti Lake Bottom Sediments Provided by Pueblo de Cochiti, Los Alamos National Laboratory, May 1999, LA-13605-MS.

[30] William L. Graf, Transport and Deposition of Plutonium-Contaminated Sediments by Fluvial Processes, Los Alamos Canyon, New Mexico, Geological Society of American Bulletin, Vol. 108, No. 10, pp.1342-1355.

[31] Jennifer T. Wilson and Peter C. Van Metre, Deposition and Chemistry of Bottom Sediments in Cochiti Lake, North Central new Mexico, U.S. Geological Survey, Water Resources Investigations Report 99-4258. Albuquerque, NM, 2000.

canyons contain an array of radioactive and non-radioactive hazardous materials from decades of discharges and disposal. Characterization of some canyons is being done. Experience with fires elsewhere suggest that the watersheds running through the Laboratory will dramatically increase their sediment yields. In comparison with other streams that feed into the Rio Grande, such as the Rio Chama and Jemez Rivers, the total amount of sediments discharged will probably be small as far as the total Rio Grande system is concerned. However, concentrations of contaminants in LANL runoff is very high compared with the other drainages, so the contaminant loading is likely to be far greater than the other contributions.

At the July 8th conference in Santa Fe, a laboratory soil expert stated that runoff could carry as much as 300,000 cubic meters of contaminated soil, the equivalent of a football field 300 feet high, into the largest fresh-water artery in the state.[32] Higher-than-average levels of plutonium and other contaminants are already showing up in the river.

As of September of this year, the Laboratory reported that about 25 percent of the runoff volume is sediment.[33] The evaluation of metals in water and sediment samples is an early stage. As of September of this year, several dissolved metals were found by the Laboratory to exceed its screening levels and are being analyzed further.[34]
High-levels of cyanide were measured in water and sediments in several canyons and burned areas on LANL property. Levels two times above those that are immediately harmful to fish were found in ash-laden runoff waters both above and across the Laboratory. Toxic levels of cyanide may persist. The likely source is inconclusive. [35]
Low -levels of PCBs (polychorinated biphenols) were detected in the water and sediment samples and is of concern because of the bioaccumulation of this contaminant in the food chain.[36] There have been numerous high concentration spills of PCB's from leaking transformers at the Laboratory. [37]

The levels of radioactive substances dissolved in water are comparable to or possibly elevated above pre-fire levels, and are below EPA drinking water limits. However, cesium-137 concentrations in suspended material are 5 to 20 times higher than pre-fire levels. Plutonium is 5 to 10 times and strontium 90 concentrations are increased by 2 to 5 times. [38]

The Laboratory suggests that the increases may be mainly due to the bioaccumulation of radioactive fallout in trees, which was concentrated into ash by the fire. In a 1997 study, the National Cancer Institute estimated radioactive iodine "hotspots" in northern New

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[32] Steve Reneau, Statement at the Conference on the aftermath of the Cerro Grande Fire, July 8, 2000. Santa Fe, NM.
[33] Bruce Gallaher, Water Quality of Post Fire Storm Water, Emergency Rehabilitation Team Public Meeting, September 15, 2000.
[34] Ibid.
[35] Ibid.
[36] Ibid
[37] Tiger Team Report, FINDING TCM/CF_5: Management of Polychlorinated Biphenyl (PCB) Spill Cleanups
[38] Op, Cit. Ref. 24.

Mexico are from nuclear weapons tests exploded at the Nevada Test Site.[39] Radioactivity from Laboratory operations could also have spread to the nearby forests only to return as ash from the Cerro Grande Fire.

Hydro-Geological Issues – Historical and ongoing operations at LANL are impacting groundwater. Contaminant sources include historical and current industrial and sanitary wastewater discharges; surface impoundments and lagoons; underground storage tanks; waste burial and storage areas; and runoff from active and inactive waste sites, including landfills and firing sites.

In the aftermath of the Cerro Grande Fire, the risks of accelerated migration of subsurface contaminants in increased. Erosion reduces sediments which holds up radionuclides, and can expose buried wastes. Also, efforts by the Laboratory to mitigate flooding and run-off, such as impoundments and sediment traps could enhance the migration of contaminants into the aquifers beneath the site. The LANL site is hydrogeologically complex, considering the mountainous terrain of volcanic origin, complex recharge and discharge regimes, extensive geologic faulting, and highly variable stratigraphy. The presence of springs, high groundwater production flow rates in the vicinity of LANL, and steep vertical groundwater gradients add to the complexity of the hydrogeologic regime.

The area between the surface of the laboratory site and the water table is known as the “vadose zone” – a geological term for dry subsurface areas. The vadose zone beneath LANL, in general terms, contains several different rock and sediment formations that were the result of volcanic and sedimentary processes.

Groundwater beneath the laboratory site can occur near the surface in perched formations or at deeper levels. The full extent of these perched and alluvial groundwater supplies is not known or characterized. The main aquifer, which has sufficient amounts of water that can be used for human activities, varies in depth from 900 feet in the Southwest portion of the Laboratory to 600 feet (artesian conditions near the Rio Grande) along the eastern edge below the surface of the Parajito plateau. The aquifer is recharged through intermountain basins formed by the Valle de Caldera and the Sierra de Los Valles. The main aquifer discharges through springs in White Rock Canyon into the Rio Grande.

Perched water occurs in the interbedded basalts of the Puye Formation near the eastern edge of the site in Pueblo, Los Alamos and Sandia Canyons. Recharge of perched water zones is somewhat uncertain, but it is generally assumed that are replenished from small water sources in the soil layers above them in the three canyons. The main aquifer is a regional aquifer of erosional outwash sediments consisting mostly of sand and gravel, which were deposited within an ancient river valley coincident with the top of the Rio Grande Rift. The undisturbed direction of groundwater flow in the Los Alamos vicinity is generally eastward towards the Rio Grande. Recharge to the main aquifer is thought to

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[39] U.S. National Cancer Institute, Estimated Exposures and Thyroid Doses Received by the American People from Iodine-131 in Fallout Following Nevada Atmospheric Nuclear Bomb Tests, a report from the U.S. Department of Health and Human Services, National Institutes of Health, October 1997.

be largely from infiltration of precipitation that falls directly on the western perimeter of LANL in or near the Valle Grande.

Groundwater in the LANL area is used as the source of potable water for LANL as well as the County of Los Alamos and the surrounding communities of White Rock and Pajarito Acres. Additionally, LANL operates the Water Canyon Gallery field to supply groundwater for nonpotable purposes such as steam plant makeup water. The earliest characterization of main aquifer was based on data collected from water supply wells installed by the U.S. Geological Survey (USGS). It should be noted that these wells were designed for potable water supply, not as part of a groundwater monitoring program. The main aquifer was the focus of subsequent investigations conducted by the USGS until 1970 and by LANL since 1970. The U.S. Geological Survey prior to 1960 largely developed the existing groundwater monitoring well network at LANL. It was developed to mostly facilitate and assess the siting of facilities and was not part of site-wide a Ground Water Management Plan. This network is not considered adequate to determine the complex hydrogeologic conditions of the Pajarito Plateau. [40]

According to DOE's internal standards, [41] the Laboratory is required to prepare a Groundwater Protection Management Program Plan. Specific elements of this plan should include the "documentation of the groundwater regime with respect to quality and quantity, design and implementation of a monitoring program, a management program for groundwater protection and remediation, a summary of areas that may be contaminated, and strategies for controlling sources of these contaminants. The groundwater protection program should be summarized, including a review of the monitoring program that describes the number of wells."

The Laboratory established a Groundwater Integration Team several years ago, which is currently focused on measuring the degree to which contaminants remain stored in soil and sediment, the vertical flow of water over time, and to provide data for subsurface modeling efforts. More recently, the Laboratory initiated a monitoring program to measure the spread of contaminants in the subsurface from efforts to reduce run-off. In this regard some 150 upstream subsurface monitoring wells are planned along weirs built to retard run-off and erosion. Three wells have been drilled to date.[42] The program's objectives are to: monitor water infiltrating through the subsurface; characterize the hydrology and chemistry of perched ground water; and characterize the subsurface soil, sediment and rock formations above the ground water and to assess the impact of contaminants migrating in the subsurface from floods in Los Alamos Canyon.

Contaminants from the Laboratory have entered the alluvial and perched aquifers as well as the main aquifer. The shallower aquifers have been impacted by historic discharges to areas such as Mortandad Canyon, which has a significant contaminant burden in

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[40] Tiger Team Report, FINDING GW/CF_1: Groundwater Protection Management Program Plan

[41] DOE Order 5400 General Environmental Protection Program, Chapter III, Section 4.a., DOE Order 5400.1, Chapter IV, Section 9, DOE 5400.1, Chapter II, Section 10.

[42] Gilles Bussod, Charlie Nylander, Bill Stone, Los Alamos National Laboratory, Los Alamos Canyon Low-Head Weir Monitoring Site, October 4, 2000.

sediments. Leaks from the Omega Reactor and releases from Technical Area 21 released significant radiological contaminants into the Los Alamos Canyon and underlying alluvial aquifer. The surface flow from the Los Alamos County-operated Bayo sanitary wastewater treatment facility effluent in Pueblo Canyon infiltrates into the perched alluvial groundwater resulting in a transfer of radionuclides. These radionuclides leach into the perched alluvial groundwater offsite via Los Alamos Canyon. The relationship between the alluvial and perched aquifers and the main aquifer in terms of contaminant migration is uncertain. However, the Laboratory indicates that groundwater movement from the alluvial and perched formations is a contaminant transport pathway to the deeper main aquifer.

LANL discharges uncontaminated liquids to surface and subsurface soils that have been contaminated with radioactive material from past practices. Liquid discharges, even though uncontaminated, are prohibited by DOE orders from being discharged to contaminated sites to prevent the spread of radionuclides.

For instance, discharges from the TA-50 Liquid Waste Treatment Plant over the years has resulted in soil contamination adjacent to the outfall and to the Mortandad canyon below. Liquid sanitary effluent was discharged into two lagoons previously contaminated at the TA- 53 Los Alamos Nuclear Science Facility. These lagoons were not decontaminated after the radiological liquid effluent discharge into these lagoons was discontinued. The two original sanitary lagoons are lined with clay. Tritium was detected at a depth of 80 feet in soil below the lagoons, which indicates that discharges of uncontaminated liquids may have caused subsurface soil contamination.[43]

Understanding the fate and transport of Laboratory contaminants in the vadose zone beneath the site is, perhaps, the most uncertain effort to address potential environmental and health risks at the laboratory. Gaps in characterization data poses the most significant challenge. Significant quantities of long-lived radionuclides discharged into soil and the deliberate plutonium releases in subsurface wells above ground water supplies, underscores the need for a more aggressive vadose zone characterization and modeling program.

Subsurface contamination at LANL is extensive and includes topsoil sediments, deliberate releases of large amounts of plutonium and other contaminants in subsurface tests, burial grounds, underground tanks, liquid discharges.

A case in point is the Material Disposal Area (MDA) AB in Technical Area-49. Between 1959 to mid-1961, MDA AB was the location of some 70 hydronuclear and related experiments. These experiments involved high explosive disposal of highly enriched uranium and plutonium 239, as well as lead beryllium and uranium 238 at the bottom of shallow shafts. Approximately 40 kilograms of plutonium, 93 kilograms of uranium 235, 170 kilograms of uranium 238, over 90,000 kilograms of lead, 11 kilograms of beryllium and an unreported amount of high-explosives were released into the shafts. According to

[43] Ibid.

a LANL study, the plutonium in these shafts constitute the single largest source of radioactivity in the environment at the laboratory.[44]

In once instance, an experimental detonation in 1960 spread significant subsurface contamination through fractures into a nearby shaft, which was inadvertently excavated—resulting in surface contamination from drainage that extends beyond the boundary of TA-49.

In an other instance, water infiltration and contamination in a test hole has been occurring since the mid-1970's. [45] Over the years, official assumptions about the subsurface migration of plutonium at DOE sites have often been shown be incorrect. As early as 1958, it was recognized at Los Alamos that the mixing of plutonium with organic chemicals could enhance its migration.[46] Past models have failed to take into account changes in the physical and chemical forms of plutonium, preferential flow mechanisms in the subsurface and other interactive phenomena. For instance, plutonium migration at the Nevada Test Site from underground nuclear tests, greatly exceeded modeling assumptions because the plutonium was found bound in a colloidal form.[47] Plutonium could escape the filtration in volcanic rock similar to that at the Nevada Test Site beneath the Laboratory and be transported on microscopic colloidal particles. At the minimum, these data raise the question as to whether plutonium in the bottom of the hydronuclear test wells is in a similar physical state and whether it is migrating at a rate much faster than assumed.

These problems call for more extensive characterization to determine the lateral and vertical extent of surface, near surface and deeper subsurface contamination at TA-49. Potential transport pathways need to be identified in the vadose zone which may pose risks to ground water.

The Need for a Comprehensive Assessment

A number of activities to analyze and assess the environmental impacts after the Cerro Grande fire are underway by several federal agencies, the Laboratory, and the state of New Mexico. A major concern is that these efforts are mostly reactive, short-term. There does not appear to be formally documented data base and decision process used to reach the assumptions about post-fire risks. Quantifying the nature and extent of the environmental, safety and health risks associated with the fire and its aftermath, must be in support of overarching environmental protection policies. They include:

- Reducing the contaminant burden at the Los Alamos National Laboratory site.

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[44] Los Alamos National Laboratory, TA-49 Operable Unit RFI Work Plan, MDA AB, Chapter 7, May 1992.
[45] Ibid.
[46] Op Cit. Ref. No. 6.
[47] A. B. Kersting, D. W. Efurd, D. L. Finnegan, D. J. Rokop, D. K. Smith & J. L. Thompson, "Migration of plutonium in ground water at the Nevada Test Site," Nature, v. 397, 7 January 1999. pp.56-59.

- Protecting the health and environment of those who that depend on the air, soil and water of in affected areas.
- Developing a strong scientific and ecological basis for operational, siting and cleanup decisions.
- Improving the overall quality of the Rio Grande at a time when water quality and availability are have strategic importance for the nation.
- Building trust through openness, transparency and participation by affected workers and members of the public through independent monitoring and oversight.

Currently, the Laboratory is beginning to undertake more comprehensive approaches to assess the fate, transport, uptake and risks associated with the migration of Laboratory contaminants. These decisions have been based on information regarding historical equations, which may not be complete, or on a limited analytical data base. These activities are commendable but, given the comprehensive nature of the challenge posed by the aftermath of the Cerro Grande Fire, an overall integration of technical work should, at the minimum, include:

An Airborne Contaminant Pathway Risk Assessment – A dose reconstruction study of potential exposure pathways from airborne contaminants should be undertaken. The data from the ambient monitoring systems represent screening levels, which have yet to be validated through comparisons with the actual environmental inventories of contamination that may have been released. At the minimum, source terms for areas hit by the fire and winds should be established to compare and validate the monitoring data. The fire hit several areas or source terms, which were unmonitored. Collection of additional monitoring data for potential resuspension of contaminants should also be considered. Hazardous constituents from burning vegetation should also be factored into this risk assessment.

Quantification of Environmental Source Terms – Accurate inventories of the contaminant burden from buried waste sites and discharges into canyons have not yet been developed at the Laboratory. While it may not be feasible to develop source term estimates for all 2,120 waste sites, it is essential to determine inventories for the most heavily contaminated areas, including burial grounds, test areas, and canyons. This should be done by employing a mass balance approach where discharges are reconstructed and matched up with environmental characterization data. A review of historical operations in terms of material throughput, process flow, and waste discharges has yet to be done. It is necessary to accurately quantify contaminant inventories in the environment of the site. Without a reasonable quantification of the contaminant burdens or source terms that could migrate into ground and surface waters from Laboratory operations, transport, uptake and risk assessments will continue to be tenuous at best.

Enhanced Vadose Zone Characterization – The risks of groundwater contamination from Laboratory contaminants is not an abstract issue. Measurements of ground water beneath the site show varying degrees of contamination from radioactive and hazardous materials. The geological conditions beneath the laboratory site are complex and full of uncertainties. There are major questions whether LANL's site wide hydrogeological groundwater monitoring well network and vadose zone characterization program is extensive enough to characterize the impact of DOE operations on groundwater quality as required by DOE orders. They include:

- A thorough understanding of the seep-spring recharge mechanisms.
- The adequacy of site baseline measurements and the means of detecting migrating contamination from offsite locations.
- Lack of well data to better understand the effect of the faults on groundwater recharge and directional flow, potential infiltration zones, and seismic history on both sides of the fault zones at the site.
- The adequacy of characterization data regarding surface flow contaminants infiltrating into perched aquifer zones in Los Alamos Canyon, Water Canyon, Pajarito Canyon and Rendija Canyon which ultimately outcrop as seeps and springs at the confluence of the Rio Grande.
- The adequacy of data regarding contaminant transport pathway mechanisms and the impact of contaminants on canyon-specific perched aquifer systems.

Mass Budget Modeling of Contaminants in the Rio Grande—As sediments bearing radionuclides and other contaminants from the Laboratory enter the Rio Grande and then move to reservoirs and the ocean, a significant portion is deposited and stored in river sediments and on flood plains. Determining the amount, types and locations of the Laboratory contaminants distributed in and around the Rio Grande verses how much is moved to reservoirs and the ocean is the basis for a mass budget analysis. Because contaminants move with the sediments, such an analysis requires information about the water and sediment movement over large areas. In particular, bed load transport models are important to predicting movement of contaminants.

According to Dr. William Graf, who performed a major study of the fate and transport of plutonium in the Rio Grande, understanding how contaminated sediments are distributed in the river depend on " (1) the characteristics of the sedimentary environments along the channels, (2) the physical properties of the contaminated sediments that influenced their transport and mixing of contaminated and uncontaminated materials. This argues that environmental managers and planners at LANL could take into account these points in general, if not a precise, quantitative way."[48] An accurate account of stream flow is also essential to the development of a basin-wide mass balance or "budget" for water, sediment and contaminants.

River budgets have provided important insights about river contamination in Germany, Netherlands and the United States. For instance, an investigation of lead and arsenic loading along a portion of the Belle Fource River in South Dakota revealed that flood plains have stored one third to one half of the contaminants entering the system from mine tailings from the Homestake mine.[49]

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[48] Graf. P. 12-13.
[49] Graf. P. 14-15

In terms of enhancing the current river monitoring system, studies of slope, drainage basin, channel, and flood plain processes are a key to the development of sampling and monitoring programs for a mass budget approach. In particular, direct water and sediment sampling stations should be established at the lower reaches of Bayo, Rendija, Pueblo, Los Alamos, Sandia, Mortandad, Canada del Buey drainages at the very least. Potrillo and Water Canyons in Technical Area-49 are important too, though perhaps from a more standard heavy metal perspective rather than only radionuclides. The basic principals for establishing a sampling and monitoring program for LANL contaminants are thoughtfully articulated by Graf.

"Obtain an accurate inventory of sediment-bound contaminants at the source location. A precise assessment of the original mass of polluted sediment is critical to accurate predictions of potential concentrations downstream in the natural river system.

"Obtain an accurate understanding of temporal trends in the erosion of contaminants from the source areas. Without knowing the rate of introduction, subsequent research on the main river and on receiving areas is not likely to be accurate.

" Become familiar with the geography of contaminants in sediments in the vicinity of the source of pollution and be able to make detailed maps of sediments and their contaminant content.

"Investigate the distribution of sediments and LANL contaminants in the nearest downstream reservoir. A sampling scheme for reservoir sediments must take into account the process history of the materials and specify the location on the reservoir floor. "[50]

A monitoring protocol could involve as few as 60 samples of active sediment and 40 or so of inactive sediment. In many respects, the location of samples is more important than the number. In terms of active sediments, care should be taken so that contaminant concentrations are not missed, as is the case when material is collected from the downstream side of an obstruction, like a boulder. Contaminants such as heavy metals usually have the highest concentration in the finest sediment. For this reason, the finest sediments available should be sampled where they are collected, such as those on the floors of pools in the river channel. Effluent monitoring needs to be representative of the discharge for all outfalls and samples from multiple source monitoring should be flow weighted for reporting to the public and the regulators.

Wildlife Uptake and Effects Assessments—The study of wildlife in the Rio Grande system can provide valuable more direct and prompt data on contaminant impacts. Plants and animals absorb and concentrate contaminants in river environments. Health, mortality and propagation effects of human-made contaminants on wildlife have been studied for many years, and serve to enlighten efforts to protect endangered species, reduce human health risks, and to validate compliance with environmental standards.

[50] Graf. P 228.

The most abundant mammal in the Los Alamos area is the Western Harvest Mouse. Also in the northern New Mexico area are elk, deer, and bear as the predominant large mammals. Bobcat, raccoon, and skunk are the predominant medium-size mammals. There are numerous amphibians, reptiles, waterfowl, and birds, including the Golden Eagle and Cooper's Hawk. Additionally, the Rio Grande , which flows to the east of the LANL site and forms part of the site's eastern boundary, supports a large variety of aquatic wildlife.

The U.S. Fish and Wildlife Service developed a program where a wildlife effects assessment is used as an important tool to address the cleanup and land use parameters for the Rocky Mountain Arsenal in Colorado. Fish and Wildlife effects studies are serving to assess EPA's Superfund cleanup activities at the DOE's Hanford site in Washington.

In addition to biota on and near the Laboratory, the uptake and effects on fauna and flora biota in the river, in the flood plain and sediment deposit areas, such as the Cochiti Dam, should be incorporated into measuring the transport and deposition of laboratory contaminants and ascertaining their effects. For instance, current studies of uranium uptake in fish in the Cochiti reservoir raise important questions as to the source of this contamination.[51] State and federal agencies have done wildlife studies. But, in the face of potential for significantly increased volumes of contaminated sediments from the laboratory, wildlife studies have yet to be incorporated into an overall river assessment modeling effort.

Human Impact Assessment – The risks to people from increased migration of contaminants from the Los Alamos National Laboratory has several facets. They tend to fall into the categories of human health, cultural, and economic impacts.

In this case, human health risks are largely based on extrapolations using risk models that generally take into account: amounts of contaminants released, their transport pathways and ecological uptake, human uptake, dose and risk estimation. Other methods involve the collection of human health information, such as symptoms, disease incidence and mortality, which is statistically compared with unexposed groups. Current risk studies do not necessarily factor in the culture and lifestyles of native people who may have more direct contact with contaminants.

There may have been immediate health impacts from the inhalation of smoke. Efforts should be made to review hospital and medical data that may exist from people who sought medical assistance due to smoke-related respiratory problems, particularly in the communities nearest to the fire.

The potential risk to human health from Los Alamos radioactive and hazardous contaminants is likely to be diluted and may be expressed over a period of many years --- making risks very difficult, and sometimes impossible to quantify. This is not to say that such risks do not exist. Rather, current scientific measuring tools are not necessarily able

[51] Personal communication with William Graf, September 2000.

to measure this risk without large uncertainties. For these reasons, the technical viability of human health risk assessment in the context of the Cerro Grande Fire and its aftermath is very dependent on quantifying what is not known . Regardless of these uncertainties, human health risk assessment should not be viewed in a vacuum because it can a provide valuable insights from an overall comprehensive perspective.

In terms of cultural risks, several Indian Pueblo Nations have lived along the Rio Grande for many centuries and maintain strong ties to their cultural heritage and a strong affinity with the natural environment. In addition to depending more directly on the land and water than non-Indians, numerous sacred areas exist where religious ceremonies are celebrated. The gathering of plants for religious purposes is also an important factor. The changed environmental circumstances created by the Cerro Grande Fire clearly have important implications for tribal cultures. The risks to the cultural quality of the Pueblos along the Rio Grande from the migration of laboratory contaminants should be a key element of any risk assessment endeavor.

In this case, economic impacts from are largely influenced by evidence of risk and perception of risk. The influx of fire debris and contaminant run-off into the Rio Grande can deter people from pursuing recreational and tourist activities. The perception created by ash from the Cerro Grande Fire depositing on farms can lead to consumer rejection of the crops. These kinds of risks should not be ignored and should be factored in.

Independent Monitoring and Oversight

In the aftermath of the Cerro Grande Fire, a unique and unprecedented set of questions present themselves. What are the risks to human health from the release of airborne contaminants from the Laboratory site? Is the DOE and the Laboratory prepared to address the dangers of flash floods coming down denuded terrain and washing through canyons? How has fire and post fire mitigation efforts influencing the subsurface migration of contaminants? What is nature and extent of the contaminant burden from Laboratory operations in the Rio Grande, and how much will be added to this burden? What are the environmental and health impacts and risks from Laboratory contaminants in the Rio Grande?

The Los Alamos Clean Air Act Compliance Model—To answer these questions, an integrated effort with a strong scientific underpinning and public credibility is essential. A model that could achieve these objectives is the independent technical audit and oversight program established to ensure compliance by the Los Alamos National Laboratory with federal Clean Air Act radionuclide emission standards.

This endeavor was established under a consent decree by the Federal District Court in Albuquerque, NM in order to resolve a lawsuit brought against the DOE by Concerned Citizens for Nuclear Safety. It involves an independent technical audit of the laboratory's emission sources, monitoring and abatement activities. The independent technical audit is reviewed by CCNS experts through an iterative process, in terms of workscope, ongoing analysis and final work product. The overall process has yielded multiple benefits relative to achieving and validating Clean Air Act compliance in a way that has strong public support and credibility.

A Comprehensive Assessment – The DOE and the Laboratory should establish an overall integration of the assessment work underway which addresses the environmental, safety and health implications of the Cerro Grande Fire. There are five distinct areas which should be formalized and integrated. They include:

- a dose reconstruction of air emissions pathways resulting from the fire.
- the development of comprehensive source term estimates;
- a safety review of efforts to mitigate risks of floods, major erosion and run-off.
- vadose zone and subsurface contaminant characterization.
- an assessment of the impacts on the Rio Grande, including a mass budget analysis, and impact and risk assessment of Laboratory contaminants in the Rio Grande on biota and humans.

A Proposal for Independent auditing and Oversight -- In the context of the environmental, safety and health implications of the Los Alamos site and the Cerro Grande Fire, the Clean Air Act audit model could be structured in the following manner:

- Technical Audits – A series of technical audits would be funded by the DOE, through the New Mexico Environment Department. The audits would review the five major technical activities of the laboratory with respect to risk mitigation and environmental safety, and health assessments being done by the Laboratory, the New Mexico Environment Department, the New Mexico Department of Health, the U.S. Environmental Protection Agency and the University of New Mexico in the aftermath of the Cerro Grande Fire.

- Citizen Oversight – An "Oversight Consortium" made up affected groups, such as the Indian Pueblos, farmers, recreational river businesses, and citizen groups would oversee these audits through independent technical experts that review the work of the auditors. The Oversight Consortium would be responsible for reviewing the work scope, spot-checking ongoing work, and review of the final work products.

- Independent expert review of the audits – Each technical audit, would have independent technical expertise which reports to the "oversight" consortium. These experts would be paid as part of each technical audit. They would be required to have expertise of the various disciplines, including radioecology, engineering, flood safety, morphology, hydrogeology, hydrology and risk assessment. Commensurate with the technical audit teams, the independent experts would be responsible for review of work scope, spot-checking ongoing work, and the final reports.