Memo To: Subhankar Banerjee
From: Robert H. Gilkeson, Registered Geologist
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Date: February 21, 2012
Re: Great Earthquake Danger at Los Alamos National Laboratory

Hi Subhankar,

There are important reasons to keep the great earthquake danger at the Los Alamos National Laboratory (LANL) in the news. The decision by the Department of Energy (DOE) to abandon the construction of the $6 Billion Nuclear Facility for modernization of nuclear weapons because of the great earthquake danger at LANL draws attention to the great earthquake danger at the large number of existing aged nuclear weapon facilities in the plutonium complex at LANL. In a recent newspaper article, University of New Mexico Professor John Geissman said that a worse-case earthquake could crumble these facilities to smithereens (see the newspaper article at the end of this piece). The existing facilities include the 40-year old plutonium facility (PF-4) and the 60-year old Chemistry and Metallurgy Research (CMR) facility that was to be replaced by the proposed $6 Billion Chemistry and Metallurgy Research Replacement Nuclear Facility (CMRR-NF). The very powerful and poorly understood network of faults in the tectonic setting at LANL are displayed on Figure 1.

The very large earthquake danger at the proposed CMRR-NF was not recognized or investigated. The technical staff at the Defense Nuclear Facilities Safety Board (DNFSB) dismissed Gilkeson's discovery of a LANL report issued in 2004 that described the active concealed faults located close to the proposed Super Wal-Mart-sized $6 Billion CMRR-NF. The DNFSB staff said Gilkeson was digging up old reports (accurate data based in correct scientific principles does not become old and unimportant). The staff also incorrectly said there was only concern for active faults with visible displacements at land surface.

The DNFSB staff still dismissed the Gilkeson concern when he informed them that the concealed active fault very close to and possibly below the proposed CMRR-NF was the extension of the active and very powerful Guaje Mountain (GM) Fault that was considered in the seismic hazard analysis to terminate 2 ½ miles north of the proposed nuclear facility. *See Figure 2.* The DNFSB staff was surprised when Gilkeson pointed out that the unnamed active fault at land surface in Los Alamos Canyon on Figure 2 at a distance ¾-mile north of the proposed facility was a surface displacement of the active GM Fault.

Gilkeson told the DNFSB that there were many data gaps about the earthquake danger at LANL (and specifically at the proposed location of the CMRR-NF) and more detailed field investigations were needed. The staff of the DNFSB told Gilkeson he was a groundwater scientist and a "novice" about seismic hazard. The DNFSB staff said Gilkeson did not understand that the design for the proposed nuclear facility was **"totally probabilistic"** and the expert opinion of internationally recognized seismic hazard experts could be used for the design of new DOE nuclear weapon facilities when data were sparse.

In fact, Gilkeson has the academic and experience credentials that are required by the Nuclear Regulatory Commission (NRC) for seismic hazard experts. In 2001, Honeywell Corporation asked Gilkeson to apply for the position as their expert on seismic hazard. He declined the offer because at that time Gilkeson was involved with the study of seawater intrusion into the Everglades in Florida.

Presidential Executive Order 12699. After discussions with the technical staff in the DNFSB, Gilkeson discovered the assessment of the earthquake danger at the proposed CMRR-NF at LANL Technical Area 55 was not in compliance with the 1990 Presidential Executive Order 12699.

The 1990 Presidential Executive Order 12699 – ***Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction*** – signed into law by President George Bush on January 5, 1990 and published in the Federal Register on January 9, 1990 required the use of Industry Standards for the detailed investigation of the seismic hazard at the proposed CMRR-NF as follows:

From Section 1: **Requirements for Earthquake Safety of New Federal Buildings.**

> Each Federal agency responsible for the design and construction of each new Federal building shall ensure that the building is designed and constructed in accord with appropriate seismic design and construction standards. This requirement pertains to all building projects for which development of detailed plans and specifications is initiated subsequent to the issuance of the order. Seismic design and construction standards shall be adopted for agency use in accord with sections 3(a) and 4(a) of this order.

From Section 3(a):

> Sec. 3. Concurrent Requirements. (a) In accord with Office of Management and Budget Circular A - 119 of January 17, 1980, entitled "Federal Participation in the Development and Use of Voluntary Standards," nationally recognized private sector standards and practices shall be used for the purposes identified in sections 1 and 2 above. . .

The four nationally recognized private sector standards are as follows:

- 1. American Society of Civil Engineers (ASCE) Industry Standard ASCE/SEI 43-05 – *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*, Approved in 2005.
- 2. American Nuclear Society (ANS) Industry Standard ANSI/ANS-2.26-2004 – *American National Standard Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design,* Approved December 2, 2004 (Reaffirmed May 27, 2010)
- 3. ANS Industry Standard ANSI/ANS-2.27-2008 – *American National Standard Criteria for Investigations of Nuclear Facility Sites for Seismic Hazard Assessments* – Approved July 31, 2008
- 4. ANS Industry Standard ANSI/ANS-2.29-2008 – *American National Standard Probabilistic Seismic Hazards Analysis*– Approved July 31, 2008

The four Industry Standards are for <u>new</u> nuclear facilities. ANSI/ANS-2.27-2008 defines nuclear facilities as follows:

> A nuclear facility is a facility that stores, processes, tests, or fabricates radioactive materials in such form and quantity that a nuclear risk to the workers, to the off-site public, or to the environment may exist. These include, but are not limited to, nuclear fuel manufacturing facilities; nuclear material waste processing, storage, fabrication, and reprocessing facilities; uranium enrichment facilities; tritium production and handling facilities; and radioactive materials laboratories.

DOE Standard 1189-2008 required DOE and LANL Contractors to use the three NAS Industry Standards and the ASCE Industry Standard listed above for the detailed study of the seismic hazard at LANL for the determination of the design basis earthquake (DBE) to be used for the engineering design of the proposed CMRR-NF **but this was not done.** In fact, Presidential Executive Order 12699 and the four industry standards were not mentioned in any of the NEPA documents for the proposed nuclear facility. The public were denied knowledge of Executive Order 12699.

Appendix A.1 in DOE Standard 1189-2008 documents that the four seismic industry standards listed above were initiated by DOE and that DOE and the DNFSB provided staff for the working groups that developed the four standards. Several of the staff in the working groups for the three ANS seismic industry standards were key staff for the assessment of the seismic hazard at the proposed $6 Billion nuclear facility at LANL.

In fact one of the technical staff at the DNFSB that provided oversight for the seismic hazard at the proposed CMRR-NF was on the working group for writing the Industry Standards. The previous career of this person was with the DOE Nuclear Weapons Operations as an advocate for the DOE in the writing of the NRC guidance for the **"totally probabilistic"** characterization of the seismic hazard at the DOE nuclear weapons facilities. However, the new Industry Standards do not allow the totally

probabilistic methodology. The new Industry Standards do not accept "expert opinion" as a substitute for detailed field investigations.

Nevertheless, the characterization of the seismic hazard at the proposed facility **ignored** the requirements in the Industry Standards and was based on expensive "expert opinion" when detailed field investigations were required for assessment of the seismic hazard to provide a safe engineering design and an accurate estimate for total cost.

Indeed, the seismic hazard experts identified many deficiencies in the required knowledge and many data gaps. These became recommendations for ***"future studies"*** at an unspecified date. The delayed studies included accurate knowledge of the key parameter Kappa, detailed field investigation over large regions on and away from the LANL site, and a robust kinematic model for the seismic hazard. In addition, the conclusions from field studies at a DOE site in a totally different geologic setting were used to calculate the maximum ground motions at the proposed $6 Billion CMRR-NF. It is very disturbing that the DNFSB (1) did not require the performance of the key studies, (2) allowed the use of inappropriate data from a totally different geologic setting, and (3) did not require implementation of the four Industry Standards as required by Presidential Executive Order 12699.

Some examples of requirements in ANSI/ANS-2.27-2008 ***– American National Standard Criteria for Investigations of Nuclear Facility Sites for Seismic Hazard Assessments –*** Approved July 31, 2008:

> ***Fault location*:** Quaternary fault traces shall be defined, and locations shall be shown in map view with sufficient detail to determine source-to-site distance. In the case of concealed or blind faults, the location of the most shallow extent of the fault shall be indicated on the fault maps [Emphasis Added] (p. 10).
> The potential for surface fault rupture and associated deformation shall be determined. This assessment shall include the evaluation of both primary faults that reach the ground surface as well as secondary ground deformation (e.g., faulting, folding, tilting, warping, etc.) related to concealed or blind faults that do not reach the ground surface [Emphasis Added].

The zones of intense fractures mapped on Figure 3 from the detailed investigations in the 2004 LANL report by LANL scientist Dr. Ken Wohletz are secondary ground deformation from the concealed active faults close to the proposed CMRR-NF that do not reach ground surface. A serious omission is that the active fault map in Figure 2 that was used for the design of the proposed CMRR-NF did not comply with the industry standard ANSI/ANS-2.27-2008 for the seismic hazard to include the concealed faults.

Continued from the requirements in ANSI/ANS-2.27-2008 for ***Fault location*:**

> The investigation of a site and its vicinity for surface faulting shall include the following:

(1) examination for potential Quaternary surface faults at the site or for Quaternary faults that trend toward the site [e.g., the Guaje Mountain Fault]; (2) evaluation of the activity and origin of any Quaternary faults detected at the site or in the site vicinity that trend toward the site and the history of their displacement by the use of appropriate and accepted techniques and methods; (3) evaluation of the width of the Quaternary fault zone, including areas of possible secondary ground deformation [e.g., the zones of intense fractures close to the proposed CMRR-NF in the 2004 LANL report by Wohletz] (p.15).

Quaternary faults were active from 1.8 million years ago to the present and include all faults in the Bandelier Tuff over a region much larger than the 43-square mile LANL site. Figure 2 is the map of the active faults at land surface that was used to assess the seismic hazard at the proposed CMRR-NF. Comparison of Figure 2 with Figure 3 shows that (1) the active concealed Quaternary Guaje Mountain fault located very close to and possibly below the proposed CMRR-NF was not included in the seismic hazard assessment, and (2) the active north-south buried Quaternary fault located 2,000 ft east of the proposed NF was not included in the seismic hazard assessment.

The DOE 2011 final Supplemental Environmental Impact Statement for the CMRR-NF (DOE/EIS-0350-S1, August 2011) (DOE 2011 final SEIS) admitted that detailed field mapping has not been performed for accurate knowledge of the distance from the proposed CMRR-NF to the key Guaje Mountain (GM) Fault as follows:

> Detailed geologic mapping of the area between the mapped southern termination of the Guaje Mountain Fault and the northern side of Los Alamos Canyon [a north-south distance greater than 6,300 ft] has not yet been undertaken (DOE Response to Comment 315-5).

In the above statement, DOE admitted the very serious omission of detailed field mapping for the accurate location of the powerful GM Fault. **Nevertheless, the DOE 2011 final SEIS misrepresented the key GM Fault to terminate at a distance 2 ½ miles north of the proposed CMRR-NF**. In fact, Figure 2 shows surface rupture from the GM Fault ¾-mile to the north and the large zone of intense fractures immediately west of the proposed CMRR-NF on Figure 3 is evidence of ground shaking from the very close location of the active concealed GM Fault.

The DOE 2011 draft SEIS admits another very serious omission that large regions at LANL have not been mapped for seismic hazards:

> Large eastern and southern areas of LANL have not yet been mapped in detail for seismic hazards (p. 3-22).

The detailed mapping of the seismic hazard over a region larger than the entire 43 square mile LANL site is required by Presidential Executive Order 12699; NRC Regulation NUREG/CR-6372; DOE Standard 1189-2008 and the new DOE Standard 1020-2011 re: ANSI/ANS-2.27-2008. For example, ANSI/ANS-2.27-2008 requires detailed field investigations to characterize all Quaternary faults within 40 km (24

miles) of the proposed CMRR-NF. **The required field investigations have not been performed.**

The DOE 2011 final SEIS ignored the important findings from a seismic geophysics field investigation that was published by LANL scientists in 1985.

The 1985 *Subsurface Geology of the Pajarito Plateau, Española, New Mexico* Report (LA-10455-MS) by Dransfield and Gardner described the successful application of seismic reflection surveys in Los Alamos and Mortandad Canyons for mapping the location and geometry of many concealed active faults in the Pajarito Fault System (PFS), including the GM Fault below Mortandad Canyon at a location 2,000 ft north of the proposed CMRR-NF. *See Figure 4.* The 1985 LANL Report described the importance for detailed seismic reflection surveys for accurate knowledge of the seismic hazard at LANL as follows:

> Seismic lines 1 and 2 [on Figure 4 in Mortandad and Los Alamos Canyons north of the proposed CMRR-NF] exhibit numerous subsurface faults, which were not implied by other data. Undoubtedly, shallow seismic reflection profiles across other portions of the Pajarito Plateau would illuminate additional faults. Future seismic lines should extend east-west from the Rio Grande across the Pajarito fault zone to characterize the intra-rift graben [the Velarde Graben on Figure 4] and north-south from Garcia Canyon through Frijoles Canyon to check for transverse structures. A useful seismic hazards analysis of the Pajarito Plateau will not be complete without such additional data [Emphasis Added] (p. 13).

The important seismic reflection surveys described in the 1985 LANL Report have not been performed. Nevertheless, Presidential Executive Order 12699 requires the geophysical surveys for obtaining essential information on the seismic hazard at the proposed CMRR-NF. The reflection surveys will identify the locations of concealed faults and will also provide knowledge about the geometry of the discrete faults in the complex PFS. There is much uncertainty on the angle of dip for the active faults in the PFS at this time. Comprehensive geophysical investigations including seismic reflection, seismic refraction, gravity and aeromagnetic surveys are necessary for the robust kinematic model of the PFS that is described below.

The LANL Seismic Hazards Geology Team described the need for a robust kinematic model of the PFS in a 2009 paper published in the journal *Geosphere* as follows:

> Despite the importance of understanding the geometry of the [Pajarito] fault system and potential linkage among faults for purposes of seismic hazard analysis, a robust kinematic model of the fault system is lacking (*Geosphere;* June 2009; v. 5; no. 3; p. 252).

The DOE 2011 final SEIS Response to Comment 241-9 agreed with the need for a robust kinematic model as follows:

> It is nevertheless prudent to consider such interactive fault models (kinematic and dynamic) in the future for possible application to the Pajarito Fault System [Emphasis Added].

It is prudent and necessary at this time by the 1990 Presidential Executive Order 12699 to have a robust kinematic model of the Pajarito Fault System for the engineering design of (1) the proposed CMRR-NF, and (2) any other new nuclear facility at LANL. Currently, the robust kinematic model does not exist.

DNFSB Public Hearing and Meeting in Santa Fe on November 17, 2011. Director Peter Winokur and the Senior Staff of the DNFSB held a meeting in Santa Fe, New Mexico on November 17, 2011 to hear concerns from the DOE, LANL and the public for the seismic hazard at LANL. Gilkeson made a written and verbal presentation that brought attention to the great earthquake danger at LANL that was misrepresented and ignored in the NEPA documents for the proposed CMRR-NF and the large data gaps in the required knowledge of the seismic hazard for the engineering design and cost of the proposed facility. Gilkeson described the failure of the DOE and the DNFSB to implement the four Industry Standards required by Presidential Executive Order 12699. Director Winokur and the Senior Staff of the DNFSB took notice of my presentation. We understand that after the meeting in Santa Fe, Director Winokur met with the Office of the President about the seismic hazard at LANL.

The great earthquake danger from the existing aged nuclear facilities at LANL. During the November, 2011 meeting in Santa Fe, Director Winokur put on record that the DNFSB considered the earthquake danger at the large plutonium facility (PF-4) at LANL TA-55 to be the most pressing issue in the DOE Nuclear Weapons Complex. This statement was based on maximum ground motions of 0.5 g from a single earthquake. The statement did not take into account the potential for much greater ground motions from synchronous earthquakes and the much greater ground motions from the concealed active fault that crosses TA-55 close to and possibly below the 40-year old PF-4 which is located next door to the proposed CMRR-NF. The PF-4 is the only nuclear facility in the DOE Complex where new plutonium bomb triggers are manufactured.

A serious omission is that the ongoing rehabilitation of the PF-4 at TA-55 is based on the underestimation of maximum ground motions of 0.5 g from a single earthquake that was used for the design of the proposed CMRR-NF at TA-55.

However, the studies by the LANL scientists determined that synchronous earthquakes with maximum ground motions of 0.875 g could occur at TA-55. An additional serious omission is that the engineering design for the seismic rehabilitation of the PF-4 ignores the great danger from the active concealed fault located very close to and possibly below the plutonium facility that was identified by the zones of intense fractures in the 2004 LANL Report by Wohletz.

Presidential Executive Order 12941 of December 1, 1994 ***Seismic Safety of Existing Federally Owned or Leased Buildings***

From page 1 of Executive Order 12941:

> By the authority vested in me as President by the Constitution and the law's of the United States of America, and in furtherance of the Earthquake Hazards Reduction Act of 1977, as amended by Public Law 101-614, which requires the President to adopt "standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government which were designed and constructed without adequate seismic design and construction standards" (42 U.S,C. 77t15b(a)), it is hereby ordered as follows:
>
> **Section 1.** *Adoption of Minimum Standards. The Standards of Seismic Safety for Existing Federally Owned or Leased Buildings* (Standards), developed, issued, and maintained by the Interagency Committee on Seismic Safety in Construction (ICSSC), are hereby adopted as the minimum level acceptable for use by Federal departments and agencies in assessing the seismic safety of their owned and leased buildings and in mitigating unacceptable seismic risks in those buildings.

The ICSSC requires the assessment of the feasibility to rehabilitate the aged LANL plutonium facility PF-4 and the estimated cost of rehabilitation to be based on accurate knowledge of the maximum ground motions that will occur. Therefore, it is unacceptable that the ongoing high cost to rehabilitate the plutonium facility (*see* newspaper article below) are based on maximum ground motions of 0.5 g from a single earthquake and not the very much greater ground motions with potential to be greater than 0.9 g from the combination of the concealed active fault and the synchronous earthquakes that LANL reports describe may occur at the location of the aged plutonium facility.

The available information indicates that the seismic rehabilitation of the 40-year old plutonium facility PF-4 is not feasible. For example, DOE has admitted that seismic rehabilitation of the 60-year old CMR is not feasible. Nevertheless, DOE plans to use the unsafe CMR and the PF-4 nuclear weapon facilities for at least the next ten years and probably even longer now that DOE is not allowed to construct the proposed CMRR-NF because of the great uncertainty for the earthquake danger at LANL. The great earthquake danger to the existing nuclear facilities at LANL was the topic in a recent news article by *Albuquerque Journal* Staff Writer John Fleck:

> What's the real danger from a Los Alamos earthquake?
> By John Fleck / Journal Staff Writer on Thu, Feb 2, 2012
>
> The National Nuclear Security Administration this week sent a fascinating package of memos (pdf) to the Defense Nuclear Facilities Safety Board

regarding upgrades to Los Alamos National Laboratory's 1970s-era Plutonium Facility (better known as PF-4).

The memos document seismic upgrades now underway, and argues that with fixes nearing completion, risk from a worst-case accident scenario will fall back below federal safety guidelines. But one of the memos also raises a question that I've been curious about: given the widespread devastation that would be caused by a major earthquake of the type used to drive the risk analysis, why have we singled out this particular building to invest hundreds of millions of dollars in?

From the memo:

While the risks should be further reduced, they are also very low. An earthquake large enough to significantly damage PF-4 and cause these increases in long-term cancer risk will also cause significant damage and acute injuries and fatalities in the surrounding communities. The latter would likely be the dominant public health concern if the postulated major earthquake occurred.

The memo recalls comments in a story last fall from UNM geologist John Geissman on the cost of seismic defenses at another Los Alamos nuclear building currently in the planning stages:

The resulting design could leave the new plutonium building intact in a worst-case earthquake while many of the rest of the buildings on the plateau office buildings, stores and homes are not, said University of New Mexico geologist John Geissman. "Everything else could be crumbled to smithereens," Geissman said.

Figure 1. Map of the Pajarito Fault System and Embudo Fault System – Southwestern Section in Northern New Mexico showing faults with surface displacements. **Note:** Buried active faults are not displayed on the map. **Source:** Figure 5-4 in LANL 2007 PSHA Report.

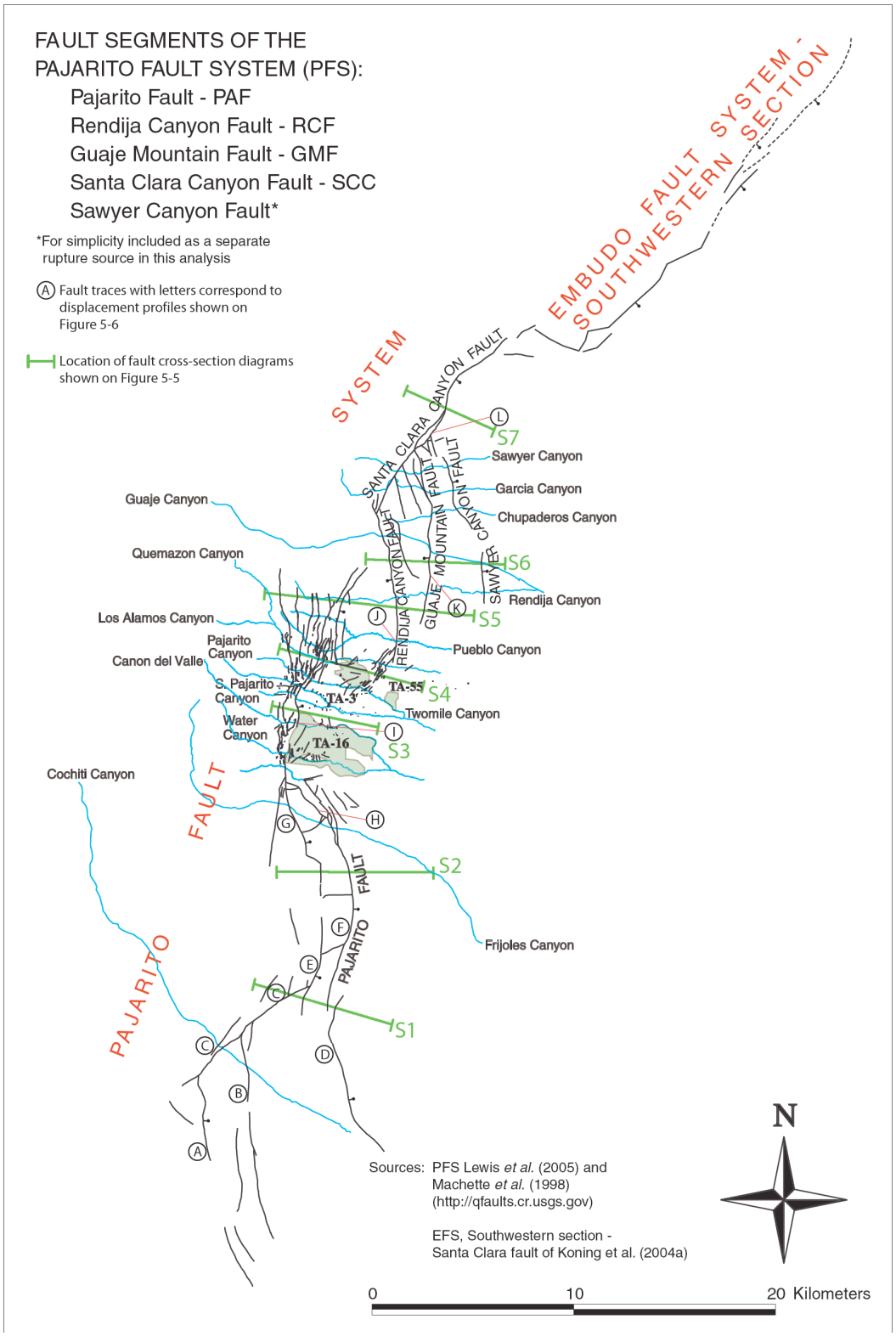


Figure 2. Mapped Faults with vertical displacements at land surface in the Los Alamos National Laboratory area.
Note: The concealed active faults located close to the proposed CMRR-NF are not displayed on the map and were not included in the seismic hazard analysis for the proposed CMRR-NF. *See Figure 3.*
Source: Figure 3-5 in the DOE 2011 final Supplemental Environmental Impact Statement (SEIS) for the proposed CMRR-NF at LANL TA-55.

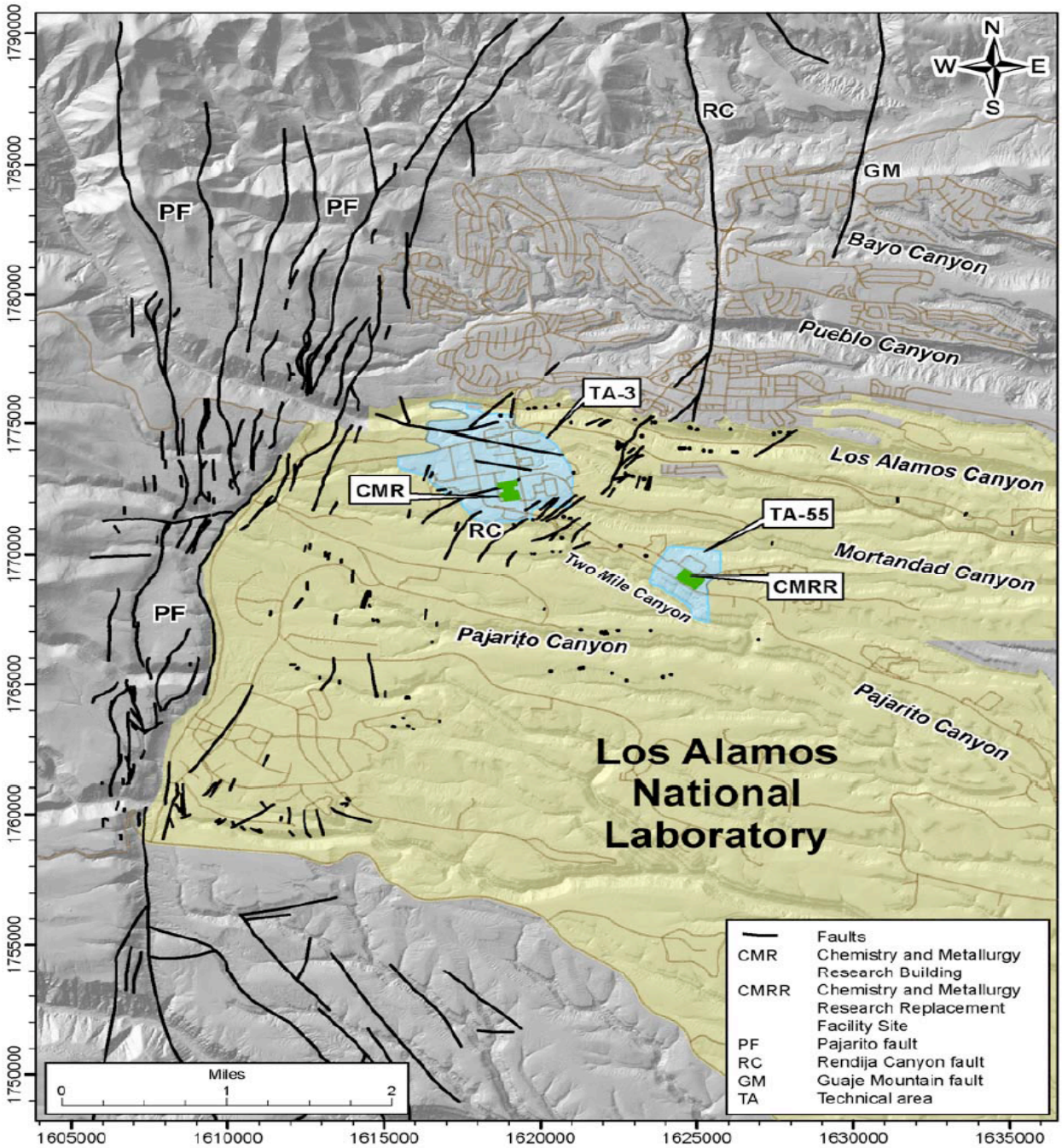
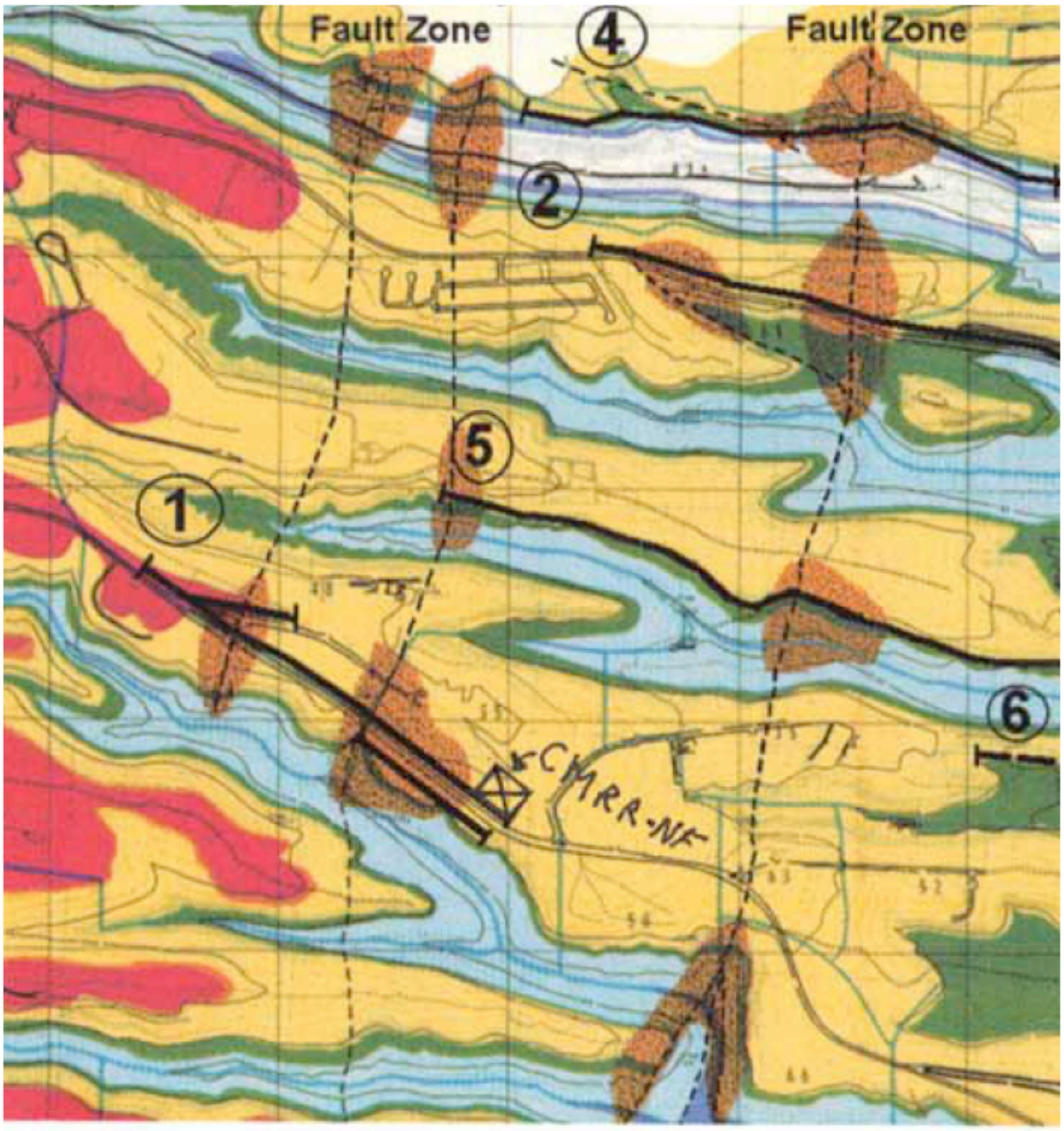


Figure 3. Map showing the inferred locations of the north-south trending concealed active faults 800 ft west and 2,000 ft east of the proposed CMRR-NF.
- The north-south trending fault 800 ft west of the proposed CMRR-NF is the inferred location of the concealed active Guaje Mountain (GM) Fault. The mapped surface exposures of the GM Fault 2 ½ miles north of the proposed CMRR-NF are displayed on Figure 2.
- The north-south trending fault zone 2,000 ft east of the proposed CMRR-NF is the inferred location of the concealed active Sawyer Canyon (SC) Fault. *See Figure 1.* The close locations of the concealed active GM and SC faults were not considered in the engineering design for the proposed CMRR-NF for storage of six metric tons (13,228 pounds) of plutonium.
Source: 2004 *Tuff Fracture Characterization Along Mortandad Canyon Between OU-1114 and OU-1129,* (LANL Report No. LA-UR-04-8337) by K. H. Wohletz, Figure 14.



Scale 0 I- - - - - - - - - - - - - I 2000 - - - - - - - - - I 4000 feet
- Dashed black lines show trend of inferred faults - - - - - - - - -
- Brown patches along dashed black lines are zones of intense fractures
- Circled numbers 1 to 6 have no relation to zones of intense fracture

Figure 4. Map showing the locations of the two east-west seismic reflection lines; line 1 in Los Alamos Canyon and line 2 in Mortandad Canyon.
Note: The two seismic lines reliably detected the active GM Fault to be present within 2,000 ft to the north of the proposed CMRR-NF. Additional seismic reflection surveys and drilling investigations are necessary to identify the exact location and geometry of the buried GM Fault close to the proposed NF and the lateral continuity and geometry of the other faults located east of the proposed NF that were identified by the two seismic reflection lines. There is a special need to characterize the location and geometry of the eastern boundary fault for the Velarde graben – shown as the easternmost fault on the map below.
Source: 1985 LANL Report by Dransfield and Gardner (LA-10455-MS), Map 1.