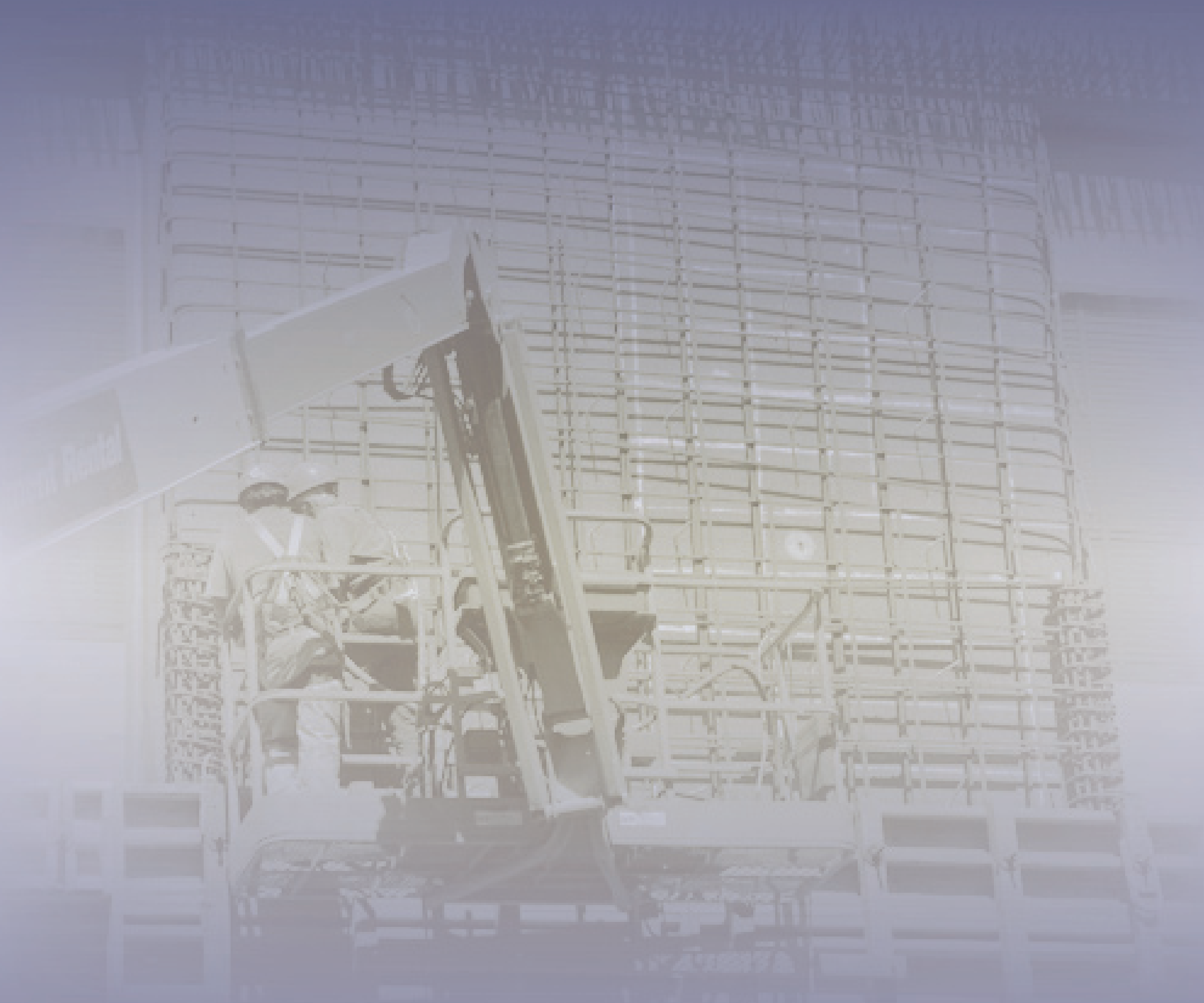
LAWRENCE LIVERMORE NATIONAL LABORATORY

SEISMIC SAFETY STUDY



FRANK J. TOKARZ

DAVID W. COATS

MAY 2006

UCRL-TR-221420

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

May 2006
UCRL-TR-221420

Responsible Manager
Denise Robinson, LLNL Institutional Facilities Manager

TABLE OF CONTENTS

List of Figures and Tables

INTRODUCTION

During the past three decades, the Laboratory has been proactive in providing a seismically safe working environment for its employees and the general public. Completed seismic upgrades during this period have exceeded $30M with over 24 buildings structurally upgraded. Nevertheless, seismic questions still frequently arise regarding the safety of existing buildings. To address these issues, a comprehensive study[1] was undertaken to develop an improved understanding of the seismic integrity of the Laboratory's entire building inventory at the Livermore Main Site and Site 300.

The completed study of February 2005 extended the results from the 1998 seismic safety study[2] per Presidential Executive Order 12941,[3] which required each federal agency to develop an inventory of its buildings and to estimate the cost of mitigating unacceptable seismic risks. Degenkolb Engineers, who performed the first study, was recontracted to perform structural evaluations, rank order the buildings based on their level of seismic deficiencies, and to develop conceptual rehabilitation schemes for the most seriously deficient buildings. Their evaluation is based on screening procedures and guidelines as established by the Interagency Committee on Seismic Safety in Construction (ICSSC).[4]

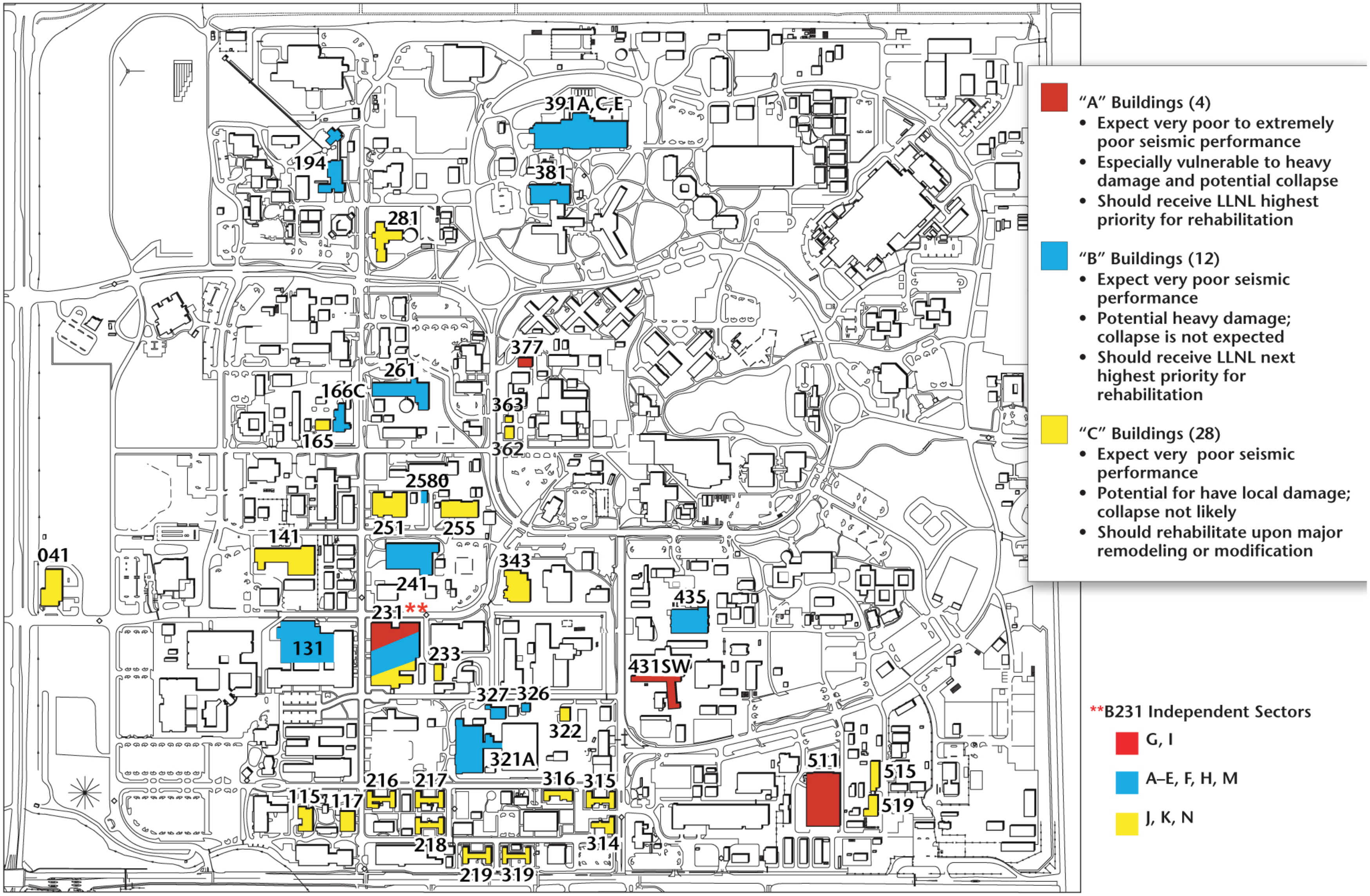
Currently, there is an inventory of 635 buildings in the Laboratory's Facility Information Management System's (FIMS's) database, out of which 58 buildings were identified by Degenkolb Engineers that require seismic rehabilitation. The remaining 577 buildings were judged to be adequate from a seismic safety viewpoint. The basis for these evaluations followed the seismic safety performance objectives of DOE standard (DOE STD 1020) Performance Category 1 (PC1):[5]

> *"A major earthquake may cause significant building damage that may not be repairable, although it is not expected to significantly jeopardize life from structural collapse, falling objects, or blocked routes of entrance or egress."*

The 58 buildings were ranked according to three risk-based priority classifications (A, B, and C) as shown in Figure 1-1 (all 58 buildings have structural deficiencies). Table 1-1 provides a brief description of their expected performance and damage state following a major earthquake, rating the seismic vulnerability (1–10) where the number 10 represents the highest and worst. Buildings in classifications A and B were judged to require the Laboratory's highest attention towards rehabilitation, classification C buildings could defer rehabilitation until a major remodel is undertaken. Strengthening schemes were developed by Degenkolb Engineers for the most seriously deficient A and B classifications (15 total), which the Laboratory's Plant Engineering Department used as its basis for rehabilitation construction cost estimates.[6,7] A detailed evaluation of Building 2580, a strengthening scheme, and a construction cost estimate are pending.

Specific details of the total estimated rehabilitation costs, a proposed 10-year seismic rehabilitation plan, exemption categories by building, DOE performance guidelines, cost comparisons for rehabilitation, and LLNL reports by Degenkolb Engineers are provided in Appendix A.

Based on the results of Degenkolb Engineers' evaluations, along with the prevailing practice for the disposition of seismically deficient buildings and risk-based evaluations, it is concluded that there is no need to evacuate occupants from these 58 buildings prior to their rehabilitation.



IFM-06-0006

Figure 1-1. Livermore buildings not meeting seismic safety standards (Site 300 has 14 "C" buildings but no "A" and "B" buildings).

Table 1-1. Ranking of seismic deficient buildings into A, B, and C classifications.

Classification	Recommended Prioritization	Damage State	Expected Performance	Vulnerability Rating	Summary (Total of 58 Buildings)[1]
A	Highest Priority: Buildings are ranked as exceptionally high risk and require active seismic evaluation and mitigation by RP6.[2]	Especially vulnerable to heavy damage. Potential collapse. Does not meet structural PC1 criteria.	Extremely Poor	10	377
			Very Poor	9	231, 431, 511
B	High Priority: Strengthen buildings as an "active" part of the LLNL seismic mitigation program. Determine cost to strengthen, obtain funding, and perform strengthening as funds are allocated. RP6 does not currently trigger action.	Potential for heavy damage. Collapse not expected. Does not meet structural PC1 criteria.	Very Poor	8	321A, 391, 435
				7	131, 166, 194, 241, 261, 326, 327, 381C, 2580
C	Medium Priority: Strengthen as buildings are remodeled and modernized, or as seismic mitigation funding becomes available.	Potential for life threatening local damage. Collapse not likely. Does not meet structural PC1 criteria.	Poor	6	041, 216, 217, 218, 219, 281, 314, 315, 316, 318, 319, 482[(3)], 519, 810A, 810C, 870
				5	117, 141, 165, 233, 343, 362, 363, 365, 515, 809A, 818A, 826, 827A, 833, 836B, 836D
				4	174[(3)], 251, 255, 322, 439[(3)], 481, 827C, 827D, 827E, 865[(3)]

[1] Rating is for the poorest rated sector in the building (some building sectors have better ratings).
[2] See the reference section of this document (reference 4).
[3] Seismic Evaluation not performed yet. Prioritization is based on walk through and assessment of general performance of building type observed in past earthquakes.

HISTORY OF SEISMIC MITIGATION

Beginning in the 1970s following the San Fernando Earthquake, seismic mitigation efforts at the Laboratory concentrated on the evaluation and upgrades of buildings with higher hazard ratings. Estimates of maximum peak ground accelerations with accompanying response spectra shapes were developed for use in these evaluations.

In the 1980s, following the magnitude 5.8 Greenville Earthquake, considerable effort was expended on seismic repairs and upgrades of buildings and systems. This effort included structural repairs to Buildings 111, 113, 241, 311, 313, 331, 332, 381, 431, and the demolition of the Building 261 vault. These upgrades also included the installation of seismically activated gas shutoff valves, the anchoring of trailers, the installation of bridge-crane earthquake restraints, repair and strengthening of library shelving, elevator repairs, mechanical equipment tie-downs, and the development of interim seismic design standards, including the development of ceiling fixture and computer floor seismic design standards.

During this time frame, the Laboratory also installed a free-field and building strong-motion instrumentation network that is active today.[8] Several geotechnical firms were contracted to develop a comprehensive understanding of seismic hazards as part of the Laboratory's Seismic Safety Program. In addition, a comprehensive independent review of the Laboratory's plutonium facility (B332) was conducted under the oversight of the California Seismic Safety Commission. The findings of this review led to additional strengthening of B332, primarily in the Increment I loft and office areas, and the mechanical equipment room.

In the 1990s structural upgrades were completed on buildings 235, 323, 331, 415, 493, 873, 874, and 875. Also, efforts continued on the refinement of the Laboratory's seismic design criteria as well as the development of DOE complex-wide standards for the design of natural phenomena hazards. From 1996–98, the Laboratory began an inventory and survey of all existing owned and leased buildings to assess "life-safety" concerns as required by Executive Order 12941, which was the precursor to the current 2005 study. Based on a seismic safety viewpoint, 454 of the 562 buildings in the 1998 FIMS database were judged to be adequate and were classified as "exempt" from further consideration. This determination was based on screening procedures and guidelines as established by the ICSSC. The remaining 108 "nonexempt" buildings required further evaluation to confirm their level of seismic vulnerability and if seismic rehabilitation was required.

Since the late 1990s, the Laboratory has further refined and updated its seismic hazards with a completely new update of the probabilistic seismic hazard assessment for the site.[9] Beginning in 2000, seismic upgrades have been completed on buildings 141, 152, 217, 298, and 511. Structural upgrades are under construction on buildings 113 and 321C.

The purpose of the current study was two-fold: (1) to complete the inventory and seismic safety evaluation of all Laboratory buildings as begun in the Executive Order (EO) 12941 effort of 1996 through 1998, and (2) to develop a comprehensive plan of action to mitigate identified seismic safety deficiencies. Appendix A provides a summary of these results (Tables A-1 through A-7).

To conduct this study, Degenkolb Engineers used evaluation and rehabilitation standards as developed by the ICSSC. Executive Order 12941 identified FEMA as the lead agency responsible for developing the standards for evaluation of the seismic safety of existing federally owned or leased buildings, and FEMA in turn charged the ICSSC with this responsibility. The minimum standard for evaluation and mitigation of seismic risks for federal government buildings is defined by ICSSC's RP4 and RP6, "Standards of Seismic Safety for Existing Federally Owned or Leased Buildings." As an update to RP4, RP6 incorporates new knowledge in earthquake engineering gained from research and observed performance of structures in recent earthquakes. It provides guidelines for the seismic vulnerability study and categorizes each structure based on construction type, size, and year built.

The primary objective of both standards (RP4 and RP6) is to reduce the life-safety risk to occupants and to the public. Life-safety has been established as the minimum performance level appropriate for federal buildings:

> *"Building performance that includes significant damage to both structural and nonstructural components during the design earthquake, though at least some margin against either partial or total structural collapse remains. Injuries may occur, but the level of risk for life threatening injury and entrapment is low. People will likely be unable to reoccupy the building for continuous use until repairs are completed."*

The Laboratory follows DOE's minimum seismic safety standard (DOE STD 1020) Performance Category 1 (PC1), which is equivalent to RP4 and RP6. Appendix A (Table A-4) describes PC levels 1 through 4 as specified in DOE STD 1021 for existing and new buildings. DOE standard 1020 provides design and evaluation criteria for structures, systems, and components (SSCs) while DOE STD 1021 provides the methodology required to determine the appropriate PC level for design or evaluation.[10]

Since 1998, the Laboratory's current building inventory in FIMS has increased to 635.* Degenkolb Engineers revisited the Laboratory's entire 635 building inventory during its January 2005 study. Working closely with Laboratory personnel, they conducted onsite walk-downs to assess building seismic safety. They rank ordered the buildings based on their level of seismic deficiencies, using the risk-based priority classifications (A, B, and C), and developed conceptual rehabilitation schemes for the most seriously deficient. Out of the 635 buildings, 58 were identified as requiring seismic rehabilitation with the remaining 577 judged to be adequate from a seismic safety viewpoint (details are provided in Table A-3).

At Site 200, there are 16 buildings that rank as priority classification A and B—requiring the highest attention toward rehabilitation (four in classification A and 12 in classification B). There are 42 buildings in classification C that can defer rehabilitation until a major building remodel is undertaken. At Site 300, there are 14 classification C buildings (no priority classification A or B buildings).

This study focused on building structural systems (non-structural deficiencies e.g., falling hazards were not considered). Potential non-structural hazards that may result from equipment and utility configuration changes are identified and mitigated through periodic walk-downs of Laboratory buildings. As part of the Laboratory's ongoing seismic safety program, these walk-downs are performed by Plant Engineering, Mechanical Engineering, Hazards Control, and Associate Director Facility Managers (ADFMs).

Degenkolb Engineers identified and developed strengthening schemes for the most seriously deficient buildings (priority classification A and B), which were used by Plant Engineering to form the basis for rehabilitation cost estimates. Refer to Appendix A for cost estimates (based on June 2009 midpoint of construction).

Concept level strengthening schemes were developed to achieve a life-safety performance level for an earthquake with a 10% probability of exceedance in 50 years. The basis for the seismic evaluations was ASCE Standard 31-02, "Seismic Evaluation of Existing Buildings" (formally FEMA 310). The basis for seismic strengthening is FEMA 356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings."

---

* There are three reasons for differences in the number of buildings in FIMS: (1) definition of a building (e.g., currently, buildings such as 806A, 806B, and 806C are counted as three buildings, while in 1998 they were counted as one building), (2) buildings removed from the database (demolished), and (3) new buildings.

Seismic strengthening schemes and cost estimates were developed for each sector within the classification A and B buildings. Sectors are seismically independent structures within a building. Additionally, Degenkolb Engineers provided descriptions of potential options for partial strengthening of the classification A and B sectors and buildings. The intent was to identify partial strengthening options that will decrease the seismic vulnerability of each building, but may not meet the life-safety performance level for the entire structure. The partial upgrade options are narrative and qualitative in nature. No sketches or calculations were performed. The goal was to identify opportunities where partial strengthening is practical and beneficial. Table A-1 presents the cost estimates for the classification A and B buildings for both the partial and full upgrade options.

Table A-2 presents a proposed 10-year seismic rehabilitation plan, which identifies each of the classification A and B buildings, the cost estimate for the full life-safety upgrade, the proposed funding year, and the proposed funding source.

OCCUPANT RISK PRIOR TO BUILDING UPGRADES

The mitigation of seismic deficiencies in existing buildings is a complex, time-consuming process, therefore, until there is a seismic upgrade, the question that arises is—*are the building's occupants safe and should they be allowed to continue to work in these buildings?* Unfortunately, there are no easy answers to this question: building codes are undeclared on this issue, and to the best of our knowledge, no definitive guidance exists. Furthermore, this issue is not unique to the Laboratory.

The University of California at Berkeley has conducted comprehensive reviews of its facilities with regard to seismic life-safety issues, which have identified many structures that were rated as "poor" or "very poor". Upgrades to these deficient buildings are made as funding becomes available and have been ongoing for approximately 20 or more years (at an estimated total cost to upgrade at $1.2B). The State of California has recently completed an evaluation of hospitals with respect to two levels of seismic safety concerns: (1) basic life-safety and (2) an enhanced requirement for continued functionality following a major seismic event. Again, many of these facilities were found to be deficient with respect to basic "life-safety" requirements as well as enhanced functionality requirements. The current plan calls for life-safety deficiencies to be mitigated by 2008 and enhanced strengthening to ensure functionality after a major earthquake to be completed by 2030. Because funding of these efforts has become a major issue, the legislature is currently considering a 5-year extension to these deadlines.

In both cases, decision makers were faced with the question of whether to allow occupants of these facilities (e.g., classrooms, administration buildings, hospital facilities) to continue to work in and occupy these seismically deficient buildings. In both of these examples, decisions were made not to require evacuation of these facilities. In part, these decisions were made because of the impracticality of evacuation (not enough classrooms or hospital facilities to allow this), but also because of risk-based, decision-making criteria that relied heavily on the relative rarity of the seismic events, seismic hazard to the site, occupant exposure, and known conservatisms in the evaluation methods.

The Laboratory faces similar issues and constraints. Evacuation of occupants of the 16 buildings of greatest concern would have a potentially significant impact on the Laboratory's ability to carry out its core missions. That said however, the safety of building occupants must still be the primary factor in any risk-based decision as to whether or not any evacuation of these facilities should be made. The primary factors that should be considered in this risk-based decision making process are discussed in the following sections.

Seismic Hazard to the Laboratory

A recently completed seismic hazard assessment for LLNL (Savy and Foxall, April 2002)[9] cites the Greenville Fault as the dominant seismic hazard.

> *"Fault systems such as the San Andreas, Hayward, and Calaveras to the west, are more seismically active than Greenville, and are capable of larger magnitude earthquakes with longer duration of strong motion and more cycles of strong shaking. Nevertheless, their greater distance to the Laboratory substantially mitigates the ground motion levels LLNL might experience from a major earthquake on these faults. Furthermore, their greater distance would have the effect of filtering out the higher frequency components of the motion, resulting in lower frequency-content motions, which would be less detrimental to the majority of the stiff, less flexible buildings at LLNL."*

The Greenville Fault is a relatively inactive fault system (an order of magnitude less than any of the 3 faults to the west) and has only a 3% chance of producing a major earthquake (≥ M6.7) during the next 30 years (USGS Open-File Report 03-214),[11] and drops to 1% chance over the next 10 years.

Because of the relatively small size of the Greenville Fault system (47 ± 24 km in length), the duration of strong ground motion shaking from a major earthquake has been estimated at 3 seconds or less. This is significant since structural collapse or heavy damage typically requires longer duration of strong motions, with many repeated cycles of strong shaking to cause sufficient damage to produce a building collapse mechanism. Large fault systems, such as the San Andreas Fault have estimated durations of strong ground motion as high as 45 seconds, which, were it not for its greater distance from LLNL, would be far more likely to produce sufficient damage to form a collapse mechanism than the shorter durations of strong ground motion typical of smaller faults such as the Greenville.

The 1980 Greenville Earthquake (M~5.8) produced as estimated 0.3g peak ground motion at the Laboratory with no structural damage to any of the 16 classification A and B buildings and had strong ground motion duration of less than 2 seconds.

Seismic “Life Safety” Risk to Building Occupants

The actual seismic “life safety” risk to building occupants depends upon the following:

- The occurrence of a major earthquake,
- Life threatening structural building damage resulting from the event,
- Occupant exposure to the event, and
- The likelihood of serious injury or death to occupants from structural failures.

Degenkolb Engineers’ evaluation of the “life-safety” vulnerabilities of Laboratory buildings was based on the national standard “life safety” ground-motion level having a 10% exceedance probability in 50 years, or approximately 0.2% annually. This approach utilizes ground motion estimates developed by the USGS to develop response spectra for use in evaluation and incorporates the contribution from all relevant faults and magnitude events. When compared with the results of the recently completed seismic hazard assessment for LLNL (April 2002),[9] the USGS ground motion response spectrum used in the evaluation is conservative.

Since earthquakes can occur at any time during the day, and any day of the week, there is a good chance that building occupants will not be present during an earthquake. For a typical workday (8:00a.m.–5:00p.m.) five days a week, there is only a 27% chance annually (assumes no holidays or vacations taken) that a building occupant will be present when an earthquake occurs.

Furthermore, even assuming that a major earthquake occurs while building occupants are present, it is unlikely that there will be a 100% chance of major structural collapse (we have assumed a 70% to 100% chance based on the structural vulnerability score). In addition, the nature of the potential structural failures that would be expected to occur in the 16 Laboratory buildings of concern are such that only a relatively small percentage of building occupants (≤ 20%) might be expected to incur serious injury or death. Based on these considerations, the annual probability that a building occupant in one of the 16 buildings of greatest concern would be seriously injured or killed can be expressed as follows:

$$P = PE \times PO \times PF \times PI \qquad \text{(Eq. 1)}$$

where:

PE = Annual probability of earthquake or damaging ground motion (0.2%)
PO = Conditional probability of occupants in building during event (27%)
PF = Conditional probability of structural failure given the event (70 to 100%)
PI = Percentage of building occupants expected to incur serious injury given structural failure (20%)

If we assume the damaging event to be the national standard "life safety" evaluation level earthquake of 10% exceedance probability in 50 years, the annual risk of serious injury or death to an occupant in one of the 16 buildings of greatest concern ranges annually from approximately 1 in 9,300 to 1 in 13,200. To put these risks into perspective, the U.S. National Center for Health Statistics suggest that the risk of death in the U.S. annually[12] in 2003 was:

All causes	*1 in 120*
Diseases of the Heart	*1 in 410*
Cancer	*1 in 510*
Accidents (All)	*1 in 2,900*
Automobiles	*1 in 6,300*
Homicides	*1 in 14,500*

Although Degenkolb Engineers has attempted to remove conservatism from the analysis used to evaluate the "life-safety" vulnerability of the 16 buildings, there are still many places where conservatism can be introduced. For example, ground acceleration evaluation levels, response spectra amplification, damping values, analysis method, specification of material strengths and capacities, load and importance factors, limits on inelastic behavior, soil-structure interaction, effective peak ground motion, and effects of large foundation or foundation embedment. While it is difficult to assess the effect of the above factors on the evaluation of existing facilities, we believe that overall, there is still some undefined level of conservatism in the evaluations.

Based on our consideration of all of the above factors, and numerous discussions with Degenkolb Engineers, it is our judgment that it is not necessary to evacuate occupants of the seismically deficient buildings at LLNL as we believe that the plan that is being developed to mitigate these risks, and the time frame to implement mitigation measures (≤ 10 years), is consistent with what has, and is, occurring in California in other similar circumstances, where no building evacuations are contemplated.

REFERENCES

1. Degenkolb Engineers, *"Seismic Evaluation and Prioritization Summary,"* February 1, 2005.

2. Degenkolb Engineers, *"Seismic Evaluation Report for Compliance with Executive Order 12941,"* September 1998.

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

4. Interagency Committee on Seismic Safety in Construction, *"Standards of Seismic Safety for Existing Federally Owned or Leased Buildings,"* (ICSSC RP 6) 2002.

5. Department of Energy Standard, *"Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,"* DOE-STD-1020-2002, January 2002.

6. S. Anderson et al., *"Construction Cost Estimates for Seismic 'Life Safety' Upgrade of 14 Laboratory Buildings,"* LLNL Construction Estimators & Planners, Internal Report, March 17, 2004.

7. B. Lindquist, *"Building 261 Seismic Upgrade Construction Cost Estimate,"* LLNL Construction Estimators and Planners, Internal Report, July 2005.

8. A. F. Shakal and R. C. Murray, *"Earthquake Strong-Motion Instrumentation at the Lawrence Livermore National Laboratory,"* UCRL-53246, October 1981.

9. J. B. Savy and W. Foxall (2002), *"Lawrence Livermore National Laboratory Site Seismic Safety Program: Summary of Findings,"* UCRL-53674 Rev. 2, April 2002.

10. Department of Energy Standard, *"Natural Phenomena Hazard Performance Categorization Guidelines for Structures, Systems and Components,"* DOE-STD-1021, July 1993.

11. USGS, *"Earthquake Probabilities in the San Francisco Bay Region: 2002-2031,"* Open File Report 03–214, 2003.

12. *"U.S. National Center for Health Statistics, National Vital Statistics Report,"* **51**(5), March 14, 2003, <http://www.infoplease.com>.

The tables presented in Appendix A summarize key study results and present additional information that formed the basis for many of the study's conclusions.

Table A-1. Total estimated cost (TEC) of the rehabilitation of A and B buildings (full, partial, and sectors). This table shows the construction cost estimates for the priority classification A and B buildings for various partial upgrades as well as a full upgrade intended to bring the deficient building into full conformance with "life safety" standards as defined by the ICSSC standards. Cost estimates are shown for the entire building and for individual building sectors (portions of the building which act structurally independent). These cost estimates are based on an assumed June 2009 midpoint of construction.

Table A-2. Proposed 10-year seismic rehabilitation plan. This table shows a proposed 10-year seismic rehabilitation plan, identifying estimated upgrade costs, funding year, and funding sources.

Table A-3. Building list by "exemption categories." This table provides a listing of buildings at LLNL and Site 300 by "exemption categories" and a description of each category as defined by the ICSSC.

Table A-4. DOE 1021 seismic performance categorization guidelines. This table provides guidelines for the seismic performance categorization of DOE facilities.

Table A-5. Comparison of PC1 and PC2 rehabilitation costs. This table provides a comparison of cost estimates for a PC1 level vs. a PC2 level upgrade for those classification A and B buildings that are at the PC2 level. PC2 seismic rehabilitation costs were available on B131(hi-bay), B231, B241, and B321A/B. These cost estimates are compared with the PC1 estimates in Table A-5 (note the possible wide range of estimated rehabilitation costs).

Table A-6. Reference list of seismic evaluation studies of "nonexempt" buildings. This table provides a list of evaluation reports developed by Degenkolb Engineers and others during the course of this study

Table A-7. Seismic evaluation, rehabilitation, and design criteria for Laboratory buildings. This table identifies the seismic criteria used at the Laboratory for the seismic evacuation, rehabilitation, and design of buildings.

Table A-1. Total estimated cost (TEC)[1] of the rehabilitation of A and B buildings (full, partial and sectors). [2]

Building No.	Name	Sector	Type A or B	Partial Upgrade A to B TEC(K$)	Partial Upgrade B to C TEC(K$)	Partial Upgrade A to C TEC(K$)	Full Upgrade PC1 TEC(K$)
B377	Biology & Biotech Research	NA	A	Not an option	Not an option	Not an option	726
B511	PE/Crafts Shop	NA	A	712	NA	2,452	4,354
B431 (South Wing)	ETA	NA	A	NA	Not an option	NA	819
B231	Development and Assembly	All Sectors	A	---	---	---	18,301
		A-E, H	B	NA	5,535	NA	11,620
		F	B	NA	377	NA	608
		G	A	1,846	NA	2,498	2,782
		I	A	1,870	NA	2,521	2,811
		J	C	NA	NA	NA	59
		K	C	NA	NA	NA	142
		M	B	NA	Not an option	NA	574
		N	C	NA	NA	NA	129
B321 A/B*	Materials Fab Shop2	NA	B	NA	No estimate available	NA	11,073
B241	Material Science	NA	B	NA	3,257	NA	4,075
B391	NOVA	All Sectors	B	---	---	---	2,338
	Laser Bay and Support Labs	A	B	NA	917	NA	982
	Laser Bay, Target Room, Optical Switch Yard	C	B	NA	Not an option	NA	739
	Fan Loft	E	B	NA	406	NA	726
B435 (Wood Mezz)	Fusion Research	NA	B	NA	Not an option	NA	383
B435 (Original)	Fusion Research	NA	B	NA	788	NA	1,059
B131 (Hi-Bay)	Engineering (Hi-Bay)	NA	B	NA	Not an option	NA	1,098
B166C	Develop Laboratory	NA	B	NA	Not an option	NA	146
B194	Accelerator	7	B	NA	Not an option	NA	23
B326	Telecom System Division	NA	B	NA	Not an option	NA	745
B327	Radiography	NA	B	NA	2,041	NA	2,151
B381C	Office/Research	NA	B	NA	Not an option	NA	644
B261	Security	NA	B	NA	No estimate available	NA	220
						Total	48,155

(1) Based on June 2009 midpoint of construction and reflects the mean estimate plus 30%.

(2) Except B2580 that still requires a detailed evaluation, a strengthening scheme, and a TEC.

(3) Refer to Table 1-1 in text, classifications A and B definitions.

Table A-2. Proposed 10-year seismic rehabilitation plan.[1]

Building No.	Name	Type A or B	Full PC1 TEC(K$)	Funding Year	Funding Source
B131 (Hi-Bay)	Engineering (Hi-Bay)	B	1,098	Complete FY04	G&A
B194	Accelerator	B	23	FY04	G&A
B326	ETA	B	745	Vacant Demolition Candidate	TBD
B377	Biology and Biotech Research	A	726	Demolition Candidate	TBD
B261	Security	B	220	Complete FY06	FIRP
B241	Materials Science	B	4,075	<FY10	IGPP
B511	PE/Crafts Shop	A	4,354	<FY10	IGPP
B431 (S Wing)	ETA	A	819	<FY10	TBD
B435 (W Mezz)	Fusion Research	B	383	Demolition Candidate	TBD
B435 (Original)	Fusion Research	B	1,059	Demolition Candidate	TBD
B231	Develop and Assembly	A	18,301	TBD	MSM LI
B321A/B	Materials Fabrication Shop	B	11,073	TBD	TBD
B327	Radiography	B	2,151	TBD	TBD
B391	NOVA	B	2,338	<FY10	PGPP
B166C	Development Lab	B	146	Demolition Candidate	PGPP
B381C	Office/Research	B	644	<FY10	PGPP
B2580	Secure Communication Center	B	Not Available	<FY12	TBD

[1] Note: refer to “History of Seismic Mitigation” for details of structural upgrades.

Table A-3. Building list by "exemption categories."

Exemption	Description of Exemption	Total No.	Building No.
EO	**Building is not exempt.**	58	41, 117, 131, 141, 165, 166, 174*, 194, 216, 217, 218, 219, 231, 233, 241, 251, 255, 261, 281, 2580*, 314, 315, 316, 318, 319, 321A, 322, 326, 327, 343, 362, 363, 365, 377, 381C, 391, 511, 515, 519, 809A, 810A, 810C, 818A, 826, 827A, 827C, 827D, 827E, 833, 836(B,D), 865*, 870
E1	**Building is exempt.** Building is intended for agricultural use, or incidental human occupancy, or occupied by humans for less than 2 hours a day.	18	161, 169, 254, 280, 321D, 419, 803, 806C, 808, 813, 819, 820, 827B, 830, 832(A,C,E), 835
E2	**Building is exempt.** Building is a detached one or two family dwelling located in an area of low seismicity having acceleration coefficients less than 0.15g.	0	
E3	**Building is exempt.** Building is a one-story light steel frame or wood construction with an area less than 3,000 sf.	137	118, 134, 135, 164, 170A, 173, 182, 195, 196, 196A, 198, 213, 230, 232, 252, 293, 294, 297, 297A, 317, 321E, 322A, 328, 328B, 373, 376, 379, 406, 444, 446, 518A, 519A, 520, 533, 534, 619, 622, 639, 651, 652, 801B, 804, 806D, 809C, 811, 812A, 812D, 816, 818C, 821, 823B, 824, 832F, 837, 841, 843B, 845A, 851B, 856, 858, 858A, 859, 860, 865C, 869, 872, 874A, 874B, 876, 877, 878, 879, 895, 899A, 899B, 817(B,D,E,G,H), 828(A,B,C), 834(B,C,E,F,G,H,J,K,L), 854(B,C,D,E,F,G,H), 855(A,B,C), 1407, 1413, 1492, 1526, 1631, 1715, 1727, 1730, 2425, 2529, 2632, 2801, 2802, 2806, 2808, 3175, 3203, 3903, 3904, 3982, 4316, 4406, 4407, 4905, 4906, 4926, 5105, 5125, 5207, 6178, 6525, 6526, 6901, 8340, 8710
E4	**Building is exempt.** Building has been fully rehabilitated to comply with RP4 seismic safety standards.	13	111, 113, 271, 311, 312, 323, 331, 332, 415, 611, 873, 874, 875
E5	**Building is exempt.** The building is a post-benchmark building as defined by RP6.	186	004J, 71, 110, 132N, 132S, 133, 170, 179, 181, 191, 194A, 234, 274, 282, 334, 335, 335A, 335B, 336, 337, 366, 367, 378, 382, 383, 473, 494, 509, 514A, 517A, 522, 523, 525, 532, 597, 612A, 615, 616, 624, 663, 691, 848, 1253, 1280, 1401, 1402, 1403, 1404, 1405, 1406, 1408, 1456, 1477, 1481, 1527, 1578, 1601, 1602, 1632, 1677, 1678, 1680, 1713, 1726, 1736, 1826, 1830, 1878, 1879, 1884, 1885, 1886, 1887, 1888, 1889, 1925, 1927, 2127, 2128, 2177, 2180, 2428, 2512, 2525, 2526, 2530, 2554, 2625, 2627, 2679, 2684, 2685, 2687, 2701, 2726, 2727, 2728, 2775, 2777, 2787, 2804, 2807, 2825, 2925, 3180, 3204, 3226, 3427, 3502, 3520, 3526, 3527, 3550, 3577, 3629, 3649, 3703, 3751, 3775, 3777, 3905, 3907, 3925, , 5104, 5225, 5226, 5425, 5426, 5477, 5626, 5627, 5925, 5926, 5928, 5974, 5975, 5976, 5977, 5978, 5979, 5980, 5981, 5982, 5983, 5984, 5985, 6127, 6179, 6203, 6325, 6501, 6575, 6925, 6926, 6951, 8726, 8801, 8806, 8825, 8826, 8990

Table A-3. (cont'd)

Exemption	Description of Exemption	Total No.	Building No.
E5	**Building is exempt.** The building is a post-benchmark building as defined by LLNL benchmark standards for 1982.	116	152, 153, 154, 190, 197, 235, 256, 433, 490, 491, 492, 493, 510, 551E, 551W, 571, 591, 625, 671, 693, 854J, 867, 882, 892, 1277, 1735, 1739, 4475, 4525, 4675, 5475, 004, 005, 007, 140, 142, 155, 193A, 211, 312A, 452, 471, 501, 581, 582, 597A, 610, 623, 681, 684, 694, 695, 696, 697, 801A, 801D, 809B, 810B, 843A, 845B, 886, 889, 890, 1450, 1541, 1579, 1714, 1802, 2475, 2552, 2598, 2599, 3304, 3340, 3555, 4113, 4128, 4198, 4199, 4297, 4298, 4299, 4352, 4382, 4399, 4997, 4997A, 4998, 4999, 5198, 5299, 5399, 5675, 5997, 5998A, 5999, 6197, 6197B, 6198, 6199, 6199A, 6199B, 6199C, 6205, 6297, 6298, 6498, 6499, 6527, 6870, 6928, 6989, 7990, 8711, 8724, 8991
E6	**Building is exempt.** The building is a pre-benchmark building that has been shown by evaluation to be life-safe in all four compliance categories. The non-structural evaluation has not yet been performed.	93	115, 116, 122, 151, 162, 176, 221, 239, 253, 292, 298, 313, 324, 345, 364, 404, 405, 418, 432, 442, 443, 451, 512, 516, 517, 543, 802A, 812E, 817A, 817F, 825, 836A, 836C, 850, 851A, 851C, 871, M1, M2 M3, M4, M5, M7, M8, M10, M15, M21, M22, M23, M24, M30, M31, M32, M33, M34, M35, M36, M37, M38, M41, M51, M52, M70, M71, M72, M80, M82, M83
E7	**Building is exempt.** Building constructed under ICSSC guidelines/procedures.	0	
E8	**Building is exempt.** The remaining useful life of the building is less than five years.	14	171, 4440, 212, 222, 412, 513, 513A, 612, 618, 805, 806(A,B,D), 807
Other Structures	Non-building structures identified in FIMS database.	89	89 utility and other service structures.
Total		**724**	

Table A-4. DOE 1021 seismic performance categorization guidelines.

Performance Category	Guidelines of Preliminary Performance Categorization of Structures, Systems and Components (SSC)	Example Building Types
PC1[1]	• SSC is a building/structure with potential human occupancy. • SSC failure may cause fatality or serious injury to workers. • SSC failure can be prevented cost-effectively.	General use buildings such as administrative buildings, storage buildings, repair shops, etc.
PC2	• SSC performs emergency functions to preserve health and safety of workers. • SSC is part of building use to assemble ≥ 300 persons in one room. • SSC has been classified as "safety significant"[2]. Has potential for on-site release. • Mission critical	Emergency operations centers, hospitals, fire stations and non-nuclear high, moderate or low hazard facilities depending on the safety significance.
PC3	• SSC failure has adverse release consequences greater than "safety class"[2] SSC guidelines, but not severe enough to place it in PC4. Has potential for off-site release.	Buildings that contain significant amount of hazardous materials. Example – Cat 2 facility.
PC4	• SSC is a "safety-class" item and its failure would result in off-site release consequences greater than or equal to the unmitigated release associated with a large (200MW) Category A reactor severe accident.	Buildings that contain significant amounts of hazardous materials that have potential for major impact offsite. Example – Cat 1 facility.

(1) PC1 is DOE's "life safety" standard.
(2) As defined in facilities Documented Safety Analysis.

Table A-5. Comparison of PC1 and PC2 rehabilitation costs.

Building No.	Sector	PC1 TEC(K$)	PC2 TEC(K$)
B231	All sectors	18,301	22,358
	A-E, H	11,620	13,095
	F	608	1,511
	G	2,782	3,065
	I	2,811	2,992
	J	59	94
	K	142	349
	M	574	TBD
	N	129	507
B321 A/B	NA	11,073	13,063
B241	NA	4,075	5,425
B131 (Hi-Bay)	NA	1,098	17,703

Table A-6. Reference list[1] of seismic evaluation studies by Degenkolb Engineers of “nonexempt” buildings.

Building	Report Reference	Prepared By	Date
41	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
115	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
	Building 115 Seismic Evaluation Report – Draft	Degenkolb Engineers Job No. A20047.11	March 26, 2004
116	Building 116 Seismic Evaluation Report – Draft	Degenkolb Engineers Job No. A20047.11	March 26, 2004
117	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
	Building 117 Seismic Evaluation Report – Draft	Degenkolb Engineers Job No. A20047.11	March 26, 2004
122	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
131 Hi-Bay	Building 131 Hi-Bay Seismic Strengthening Report	Degenkolb Engineers Job No. A10285.00	August 13, 2001
	Building 131 Hi-Bay Seismic Evaluation and Conceptual Strengthening for PC1 Compliance	Degenkolb Engineers Job No. A20047.11	March 31, 2004
	Building 131 Hi-Bay Seismic Evaluation Report – Draft Nonlinear Analysis	Degenkolb Engineers Job No. A20047.19	October 15, 2004
141	Seismic Evaluation Report for Compliance with Executive Order 12941 Seismic Evaluation of Building 141	LLNL Engineering/Degenkolb Engineers	October 1998
151	Seismic Evaluation Report for Compliance with Executive Order 12941 Seismic Evaluation of Building 151	Degenkolb Engineers Job No. 96240.00	February 1997
	Title I, II, III Seismic Evaluation and Strengthening Documents	Degenkolb Engineers Job No. A10289.00 and A10289.01	January 7, 2002
165	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
166C	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
	Building 166C Seismic Evaluation Report – Draft	Degenkolb Engineers Job No. A20047.11	March 29, 2004
174	Seismic Mitigation Study Building 174 ASCE Tier 1 Evaluation Included	Degenkolb Job. No. A20047.18	February 1, 2005
194	Seismic Evaluation Report for Compliance with Executive order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 194 Seismic Evaluation Report—Draft	Degenkolb Engineers Job No. A20047.11	March 29, 2004

(1) List includes all seismic evaluations performed by Degenkolb Engineers.
List does not include references to seismic evaluation and rehabilitation projects by others prior to 1998.

Table A-6. (cont'd)

Building	Report Reference	Prepared By	Date
216, 217, 218, 219, 314, 315, 316, 319	Building 216 Seismic Bracing Construction Documents	LLNL Plant Engineering	September 20, 2000
	Building 217 Seismic Bracing Construction Documents	LLNL Plant Engineering	September 20, 2000
	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Seismic Evaluation of Generic LLNL Barrack Buildings—75% Preliminary Study	LLNL Plant Engineering	August 1, 1999
231	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 231 Seismic Strengthening Report	Degenkolb Engineers Job No. A00531.00	March 1, 2001
	Building 231 HighBay Seismic Pounding Evaluation	Degenkolb Engineers Job No. A00531.00	2001
	Building 231 Seismic Evaluation and Conceptual Strengthening for PC1 Compliance—Draft	Degenkolb Engineers Job No. A20047.11	March 30, 2004
233	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
239	Building 239 Seismic Evaluation Report	Degenkolb Engineers Job No. A00059.00	2000
241	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 241 Seismic Evaluation Report	Degenkolb Engineers Job No. 99440.00	November 1999
	Building 241 Seismic Upgrade Pre-Title 1 Report	Degenkolb Engineers Job No. A20047.17	August 2004
251	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
253 12	Building 253, Increment 2 Seismic Evaluation Report—Draft	Degenkolb Engineers Job No. A20047.11	March 26, 2004
255	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
261	Seismic Mitigation Study Building 261 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
262	Seismic Mitigation Study Building 262 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005

(1) List includes all seismic evaluations performed by Degenkolb Engineers.
List does not include references to seismic evaluation and rehabilitation projects by others prior to 1998.

Table A-6. (cont'd)

Building	Report Reference	Prepared By	Date
272	Seismic Mitigation Study Building 272 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
281	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
318	Seismic Mitigation Study Building 318 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
321A	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
322	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
326	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
327	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
	Building 327 Seismic Evaluation Report—Draft	Degenkolb Engineers Job No. A20047.11	March 29, 2004
329	Seismic Mitigation Study Building 329 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
343	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
362	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
363	FEMA 310 Tier 1 Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
365	Seismic Mitigation Study Building 365 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
377	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 377 Seismic Evaluation Report—Draft	Degenkolb Engineers Job No. A20047.11	July 23, 2004
381C	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 381C Seismic Evaluation and Conceptual Strengthening—Draft	Degenkolb Engineers	March 31, 2004

(1) List includes all seismic evaluations performed by Degenkolb Engineers.
List does not include references to seismic evaluation and rehabilitation projects by others prior to 1998.

Table A-6. (cont'd)

Building	Report Reference	Prepared By	Date
391	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 391 Structural Calculation and Evaluation Summaries	Degenkolb Engineers Job No. 98560.00	April 30, 1999
	Building 391 Seismic Strengthening Consolidated Drawings	Degenkolb Engineers Job No. 98560.01	May 1999
392	Seismic Mitigation Study Building 392 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
412	Seismic Mitigation Study Building 412 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
431	Demolition Feasibility Study Building 431	Degenkolb Engineers Job No. A20047.09	October 2003
	Building 431 South Wing Structural Analysis	Degenkolb Engineers Job No. A20047.10	August 2003
435	FEMA 310 Tier 1 Structural Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
	Building 435 Seismic Evaluation Report—Draft	Degenkolb Engineers Job No. A20047.11	March 29, 2004
436	Seismic Mitigation Study Building 436 ASCE Tier 1 Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
438	Seismic Mitigation Study Building 438 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
439	Seismic Mitigation Study Building 438 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
445	Seismic Mitigation Study Building 445 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
481	Seismic Mitigation Study Building 481 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
482	Seismic Mitigation Study Building 482 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005

(1) List includes all seismic evaluations performed by Degenkolb Engineers.
List does not include references to seismic evaluation and rehabilitation projects by others prior to 1998.

Table A-6. (cont'd)

Building	Report Reference	Prepared By	Date
511	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Building 511 Seismic Evaluation Report	Degenkolb Engineers Job No. 98566.00	March 1999
	Building 511 Seismic Evaluation Report	Degenkolb Engineers Job No. A20047.03	
	Building 511 Phase I Construction Documents	Degenkolb Engineers Job No. A20047.05	April 2003
515	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.05	September 2003
519	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
531	Seismic Mitigation Study Building 531 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
809	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
809C	Seismic Mitigation Study Building 809C ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
810AC	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
812A	Seismic Mitigation Study Building 812A ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
812D	Seismic Mitigation Study Building 812D ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
818C	Seismic Mitigation Study Building 818C ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
823A	Seismic Mitigation Study Building 823A ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
827A	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
827D	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
827E	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
833	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
834A	Seismic Mitigation Study Building 834A ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
836B	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003

(1) List includes all seismic evaluations performed by Degenkolb Engineers.
List does not include references to seismic evaluation and rehabilitation projects by others prior to 1998.

Table A-6. (cont'd)

Building	Report Reference	Prepared By	Date
836D	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
854A	Seismic Mitigation Study Building 854A ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
865	Seismic Mitigation Study Building 865 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
870	FEMA 310 Tier I Seismic Evaluation of 41 Buildings	Degenkolb Engineers Job No. A20047.08	September 2003
2580	Seismic Mitigation Study Building 2580 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
4440	Seismic Mitigation Study Building 4440 ASCE Tier I Evaluation Included	Degenkolb Engineers Job No. A20047.18	February 1, 2005
All Buildings	Seismic Evaluation Report for Compliance with Executive Order 12941 Final Report	Degenkolb Engineers Job No. 96240.00	October 1998
	Seismic Mitigation and Prioritization Study	Degenkolb Engineers Job No. A20047.02	January 22, 2003
	Seismic Mitigation Study	Degenkolb Engineers Job No. A20047.18	February 1, 2005

(1) List includes all seismic evaluations performed by Degenkolb Engineers.
List does not include references to seismic evaluation and rehabilitation projects by others prior to 1998.

Table A-7. Seismic evaluation, rehabilitation, and design criteria for Laboratory buildings.

Performance Level	Existing Building Evaluation	Existing Building Rehabilitation	New Building Design
PC1	ASCE 31-02 “Life Safety”	FEMA 356 “Life Safety” or IBC 2000 Use Group I	IBC 2000 Use Group I
PC2	ASCE 31-02 “Immediate Occupancy”	FEMA 356 “Immediate Occupancy” or IBC 2000 Use Group III	IBC 2000 Use Group III
PC3	DOE 1020-2002	DOE 1020-2002	DOE 1020-2002
PC4	DOE 1020-2002	DOE 1020-2002	DOE 1020-2002