4.5 Geology and Soils

4.5.1 Introduction

This section presents existing geologic conditions at the Computational Research ad Theory Facility (CRT) project site and analyzes the potential for the project to be affected by those conditions. Information presented in the discussion and analysis presented below was drawn from site visits, the 2006 Long-Range Development Plan (LRDP) EIR, and environmental documents associated with previous Lawrence Berkeley National Laboratory (LBNL) projects.

In response to the Notice of Preparation for this EIR, several commenters expressed concern regarding past landslides near the project site. Several commenters expressed concern with respect to the project's proximity to the Hayward Fault and the probability of an earthquake occurring on that fault. All of these scoping comments are addressed in the impact assessment presented below.

4.5.2 Environmental Setting

The sections below present a detailed description of the environmental setting of the LBNL site related to geology and soils, concentrating primarily on aspects that are specific to the CRT project site.

Geology

LBNL is located within the California Coast Ranges geomorphic province that parallels the boundary between two major tectonic plates—the Pacific and North American plates. The predominant rock types within this province are marine sedimentary and volcanic rocks that were originally part of the intact, overriding (North American) plate. The units were uplifted after the plate margin changed from a subduction zone to a transform fault, approximately 25 million years ago (Alt and Hyndman 2000).

The proposed CRT project site is located on an unnamed Cretaceous sandstone/shale unit within the Great Valley sequence. Bedrock exposures along Cyclotron Road near the site indicate that the rock is mostly sandstone, with some interbedded layers of mudstone (Fugro 2002). These layers have been uplifted and deformed as a result of movement along the Hayward Fault. A very steep dip (80 degrees) to the east-southeast has been recorded for this unit at a nearby location (Graymer and others 1996).

Topographic Setting

The CRT project site is located primarily within the North Fork Strawberry Creek watershed, north of the 'Cafeteria Creek' tributary, at an elevation between about 620 feet (just east of Cyclotron Road) and 760 feet above mean sea level. The existing land surface at the site slopes to the west at an average of

about 40 percent, although the upper portion of the site is slightly less steep (average grade of about 35 percent).

Mineral Resources

LBNL is located in an area where no significant mineral or aggregate deposits are present (LBNL 2007).

Soils

The CRT project site lies almost entirely on an area of Maymen loam soils, although the easternmost portion overlies soils within the Xerorthents-Millsholm complex. Both are relatively thin soils (less than 2 feet) on bedrock, and are well drained with rapid runoff and high erosion potential due to steep slopes. In addition, both soil types have low shrink-swell potential. Soils in the eastern portion of the project area have likely been highly disturbed due to past grading and construction of Buildings 50, 50A, 50B, 70, and 70A and associated parking areas and roads.

Groundwater

Due to the high relief and the varying geologic units at the site, depth to groundwater within the LBNL site varies considerably, both spatially and seasonally, between 0 and over 100 feet below the ground surface (bgs). Depth to water at the CRT site varies from approximately 12 feet bgs to approximately 30 to 40 feet bgs. This variation is due primarily to the complex geology of the site and the low permeability of the units. A complete discussion of the groundwater setting of the CRT site is provided in Section 4.7, Hydrology and Water Quality.

Seismicity and Faults

The proposed CRT project is located approximately 400 feet west of the eastern trace of the Hayward Fault, one of several major fault zones present within the San Francisco Bay Area. The project site is located within the Hayward Fault zone, as defined by the Alquist-Priolo Earthquake Fault Zoning map. A fault investigation did not identify any active fault traces at the CRT project site (Kleinfelder 2006b).

The most recent major earthquake on the Hayward Fault occurred in 1868 (on the southern portion of the fault, near Mills College). The United States Geological Survey (USGS) Working Group on California Earthquake Probabilities estimates that there is a 27 percent chance that the Hayward–Rodgers Creek Fault System[1] will experience an earthquake of magnitude 6.7 or greater by 2032 (USGS 2003). A major

[1] The Hayward Fault is associated with the Rogers Creek Fault, located north of San Pablo Bay, and the two faults are often combined into one shear zone when discussing regional tectonics.

earthquake on the Hayward Fault is anticipated to produce violent to very violent ground shaking within the LBNL site and correspondingly at the site of the CRT facility.

Additionally, the San Andreas Fault parallels the Hayward Fault approximately 17 miles west of LBNL, and the Great Valley-Concord-Calaveras fault zone is located about 13 miles to the east. Taken together, along with other faults in the area, there is a 62 percent probability of at least one magnitude 6.7 or greater earthquake striking the San Francisco Bay Area before 2032 (USGS 2003). The intensity of ground shaking at LBNL would be reduced as the distance from the epicenter of the earthquake increases; however, a major earthquake on any of the active Bay Area faults could still produce violent shaking at the CRT project site.

Another potential seismic hazard is that of earthquake-induced settlement. Buildings constructed on compressible sediment may be subject to differential settlement of soils during an earthquake, depending on the distribution of the building weight, the type and condition of the underlying sediment, and the intensity or style of ground shaking experienced at the site. Primary areas of concern regarding differential settlement include the Bay Mud present near San Francisco Bay and other areas of deep sediment deposits, as well as areas of poorly engineered fill. The CRT project site is located on relatively thin soils underlain by bedrock material, and most (if not all) of the unconsolidated sediment under the building will be removed during construction, so earthquake-induced settlement is not expected to be a hazard in this location.

Landslides

LBNL is located in an area with a high occurrence of landslides and other slope instability. The California Geological Survey Seismic Hazard Zones map (California Geological Survey [CGS] 2003), shows that much of LNBL is located within areas of previous landslide movement or conditions that indicate a high probability of ground displacement (Figure 4.5-1, Seismic Hazard Zone Map).

Wentworth and others (1997) provided a summary of the distribution of landslides delineated within Alameda County. They mapped the majority of the LBNL site (including the area of the proposed CRT project) as having “few, if any, large mapped landslides” but locally containing scattered and small landslides.

LBNL has completed a detailed mapping of slope instability within the campus (LBNL 1999). The map shows that the proposed CRT project area contains two areas of potential slope instability that have been designated a ‘medium risk’ area of landslide movement. Additionally, the western portion of the project site (near Blackberry Gate) is underlain by a small area where past work has repaired slope instability.

The portion of the project overlying this repaired area is designated as a walkway; the main building would be located approximately 100 feet to the east.

Soil trenches conducted as part of the fault-trace investigation identified evidence of a dormant landslide at the site of the CRT project (Kleinfelder 2006b). The landslide slip surface is up to 8 feet below the ground surface and a small amount of water was seen seeping from the lower contact. The landslide deposits were identified in both trenches, which were located approximately 150 feet apart.

An array of hydraugers is present beneath the CRT site between Cyclotron Road and the southern portion of the Building 50 complex. These drains were installed in the late 1980s and serve to drain groundwater from the slope to help limit the potential for landslide movement.

Other Geologic and Seismic Hazards

Several other types of geologic and seismic hazards are unlikely to affect the LBNL site, including tsunami, seiche, and liquefaction. These hazards, correspondingly, are not likely to affect the proposed CRT facility, and are therefore not discussed within this EIR.

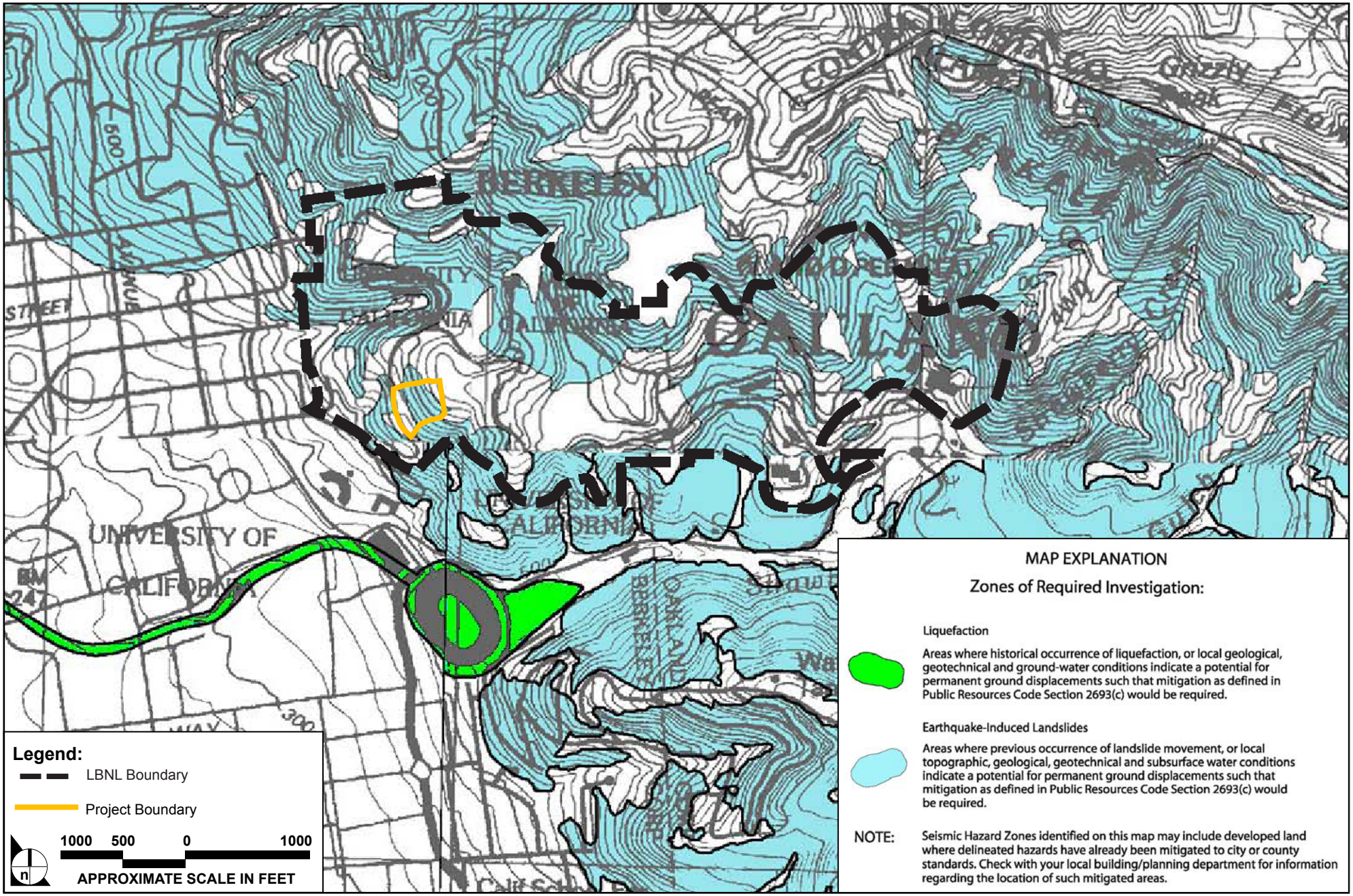
4.5.3 Regulatory Considerations

This section briefly summarizes the regulatory requirements that govern proposed projects within LBNL, expanding where necessary to describe how the regulations specifically affect the proposed CRT project.

State Regulations

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (originally enacted in 1972) is intended to regulate development on or near active fault traces to reduce the hazardous effects of fault rupture. The act prohibits the construction of most buildings intended for human occupancy across active fault traces, and therefore requires that site-specific fault-trace studies be conducted for projects within delineated fault zones to identify potential active fault traces. The site of the proposed CRT facility is located within an Alquist-Priolo Zone associated with the Hayward Fault, and therefore a fault trace study was conducted by Kleinfelder (Kleinfelder 2006b).



SOURCE: California Department of Conservation, California Geologic Survey, 2003; LBNL 2006 Long Range Development Plan

FIGURE **4.5-1**

Seismic Hazard Zone Map

924-002•11/07

Seismic Hazards Mapping Act

The State Geologist has delineated various seismic hazard zones related to ground shaking, liquefaction, landslides, and other ground failure to better regulate development in hazard-prone areas. Geotechnical investigations conducted within Seismic Hazard Zones must incorporate standards specified by CGS Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards (CGS 1997c).

The CGS has designated much of the LBNL site as a seismic hazard zone for earthquake-induced landslides. The proposed CRT facility is located within this zone (see Figure 4.5-1) and a site specific geotechnical study has been conducted to address potential seismic landslide hazards (Kleinfelder 2006b).

California Building Code

The California Building Code requires extensive geotechnical analysis and engineering for grading, foundations, retaining walls, and other structures, including criteria for seismic design. The San Francisco Bay area is located within Zone 4, which is expected to experience the greatest effects from earthquakes, and requires the most stringent requirements for seismic design. The CRT facility has been designed according to the latest seismic design standards (see Section 3.0, Project Description, for details), and would meet all relevant California Building Code requirements for seismic safety.

Local Plans and Policies

The proposed project would be located at LBNL, which is operated by the University of California and conducts work within the University's mission on land that is owned or controlled by The Regents of the University of California. As a state entity, the University is exempted by the state constitution from compliance with local land use regulations, including general plans and zoning. However, the University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. LBNL is located in both the City of Berkeley and the City of Oakland; the CRT project site is located entirely within the City of Berkeley. The following sections summarize objectives and policies in the LBNL 2006 LRDP, LBNL Design Guidelines, the City of Berkeley General Plan, and local ordinances that relate to geology and soils.

University of California Seismic Safety Policy

The University of California Seismic Safety Policy requires that all "new buildings…comply with the current provisions of the California Building Code, or local seismic requirements, whichever is more stringent" and that "no new University structures… [will] be constructed on the trace of a known active fault."

2006 LRDP Principles and Strategies[2]

The 2006 LRDP outlines a series of development strategies to meet the core planning principles to "Preserve and enhance the environmental qualities of the site as a model of resource conservation and environmental stewardship" and to "Build a more campus-like research environment." As listed in the 2006 LRDP, the strategies most relevant to geology and soils include:

- Protect and enhance the site's natural and visual resources, including native habitats, streams, and mature tree stands by focusing future development primarily within the already developed areas of the site.
- Increase development densities within the most developed areas of the site to preserve open space, enhance operational efficiencies and access.
- To the extent possible site new projects to replace existing outdated facilities and ensure the best use of limited land resources.
- To the extent possible site new projects adjacent to existing development where existing utility and access infrastructure may be utilized.
- Site and design new facilities in accordance with University of California energy efficiency and sustainability policy to reduce energy, water, and material consumption and provide improved occupant health, comfort, and productivity.

LBNL Design Guidelines

The LBNL Design Guidelines (Appendix B to the 2006 LRDP EIR; LBNL 2007) provide guidelines to meet the planning principles and strategies listed in the 2006 LRDP. The primary guidelines that pertain to geologic resources include:

- Minimize impacts of disturbed slopes.
- To the degree practicable cut and fill slopes will be minimized. Cut and fill slopes exposed to view shall be promptly restored, using best management practices to minimize erosion. New vegetation should be planted in a manner to return the visual quality of the slope to a condition similar to its original state or better.
- Building footprints shall be designed with long-narrow aspect ratios in parallel to natural terrain to the degree consistent with program needs.
- Reduce the amount of impermeable surfaces at the Berkeley Lab.

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2 While this Environmental Impact Report presents a "stand alone" impact analysis that does not rely upon tiering from any programmatic CEQA document, Berkeley Lab does actively follow the 2006 Long Range Development Plan (LRDP) as a planning guide for Lab development. Accordingly, relevant 2006 LRDP principles and strategies are identified in this section.

Berkeley General Plan

About 95 acres, or almost half of the LBNL site, is within the City of Berkeley. The Safety Element of the Berkeley General Plan contains the following policies relevant to the proposed CRT project:

Policy S-14 Land Use Regulation: Require appropriate mitigation in new development, redevelopment/reuse, or other applications.

Action S-14 A: When appropriate, utilize the environmental review process to ensure avoidance of hazards and/or mitigation of hazard-induced risk.

Action S-14 B: Require soil investigation and/or geotechnical reports in conjunction with development/redevelopment on sites within designated hazard zones such as areas with high potential for soil erosion, landslide, fault rupture, liquefaction, and other soil-related constraints.

Action S-14 C: Place structural design conditions on new development to ensure that recommendations of the geotechnical/soils investigation are implemented.

Action S-14 D: Encourage owners to evaluate their buildings' vulnerability to earthquake hazards, fire, landslides, and floods, and to take appropriate action to minimize the risk.

Policy S-15 Construction Standards: Maintain construction standards that minimize risks to human lives and property from environmental and human-caused hazards for both new and existing buildings.

Action S-15 A: Periodically update and adopt the California Building Standards Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known fire, flood, landside, and seismic risks in both structural and non-structural building and site components.

Action S-15 B: Ensure proper design and construction of hazard-resistant structures through careful plan review/approval and thorough and consistent construction inspection.

Policy S-18 Public Information: Establish public information programs to inform the public about seismic hazards and the potential hazards from vulnerable buildings.

4.5.4 Impacts and Mitigation Measures

Significance Criteria

The impact of the proposed project on the geology and soils environment would be considered significant if it would exceed the following Standards of Significance, in accordance with Appendix G of the California Environmental Quality Act (CEQA) Guidelines and the UC CEQA Handbook:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area, or based on other substantial evidence of a known fault (refer to CGS Special Publication 42);
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil;
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;
- Be located on expansive soil, as defined in Table 18-1-B of the California Building Code, creating substantial risks to life or property; or
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

Issues Not Discussed Further

The CRT Initial Study found no impacts associated with wastewater infiltration facilities. The project site is currently surrounded by developed land uses and sewers are available for the disposal of wastewater. No septic systems or other infiltrating wastewater disposal systems are proposed as part of the CRT project. Therefore, implementation of the project would not require the construction of septic tanks for wastewater disposal. This issue is not discussed further in this section.

Mitigation Measures included in the Proposed Project

The following mitigation measures, adopted as part of the 2006 LRDP, are required by the LRDP for the proposed project and are thus included as part of the proposed project. The analysis presented below

evaluates environmental impacts that would result from project implementation following the application of these mitigation measures. These mitigation measures that are included in the project would be monitored pursuant to the Mitigation Monitoring and Reporting Plan that will be adopted for the proposed project.

LRDP MM GEO-1: Seismic emergency response and evacuation plans shall be prepared for each new project at LBNL that is developed pursuant to the 2006 LRDP. These plans shall incorporate potential inaccessibility of the Blackberry Canyon entrance and identify alternative ingress and egress routes for emergency vehicles and facility employees in the event of roadway failure from surface fault rupture.

Note: a Draft Plan has been prepared, and this plan is described in Section 4.6, Hazards and Hazardous Materials, of this EIR.

LRDP MM GEO-2: A site-specific, design-level geotechnical investigation shall occur during the design phase of each LBNL building project, and prior to approval of new building construction within the LBNL hill site. This investigation shall be conducted by a licensed geotechnical engineer and include a seismic evaluation of potential maximum ground motion at the site. Geotechnical investigations for sites within either a Seismic Hazard Zone for landslides or an area of historic landslide activity at LBNL, as depicted on [LRDP] Figures IV.E-2 and IV.E-3, or newly recognized areas of slope instability at the inception of project planning, shall incorporate a landslide analysis in accordance with CGS Publication 117. Geotechnical recommendations shall subsequently be incorporated into building design.

LRDP MM GEO-3a: Construction under the LRDP shall be required to use construction best management practices and standards to control and reduce erosion. These measures could include, but are not limited to, restricting grading to the dry season, protecting all finished graded slopes from erosion using such techniques as erosion control matting and hydroseeding or other suitable measures.

LRDP MM GEO-3b: Revegetation of areas disturbed by construction activities, including slope stabilization sites, using native shrubs, trees, and grasses, shall be included as part of all new projects.

Project Impacts and Mitigation Measures

CRT Impact GEO-1: The proposed project would construct a research facility within the Hayward Fault zone but would not expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death due to rupture of the Hayward Fault. (Less than Significant)

Much of the proposed CRT facility falls within the Hayward Fault zone, as defined by the Alquist-Priolo Earthquake Fault Zoning Map. The University Seismic Safety Policy precludes the construction of a new building over an active fault trace [LRDP, IV.E-11]. The LRDP requires a specific fault trace study for any project located with an identified fault zone. Kleinfelder conducted a fault-trace study for the CRT project that included review of geologic maps and reports for the area and excavation of two test trenches to assess the potential for fault traces to be present on site. The study found that no active fault traces cross the site of the proposed CRT facility (Kleinfelder 2006a), and impacts from fault rupture would not occur. The impact, therefore, is less than significant.

Mitigation Measure: No project-level mitigation required.

CRT Impact GEO-2: The proposed project would expose people and structures to substantial adverse effects related to seismic ground shaking. (Potentially Significant; Less than Significant with Mitigation)

The CRT project site is located in a seismically active area. Seismic ground shaking could damage the proposed buildings, roadway, retaining walls, and other ancillary facilities such as stormwater detention vaults, and the development of the proposed project would expose future facility users to seismic ground shaking. The proposed CRT facility is expected to be occupied by up to approximately 300 people on a day-to-day basis. Approximately 210 people, including UC Berkeley students and staff, would be relocated from the adjacent Building 50 complex, which was constructed in various stages during the 1970s, or from UC Berkeley buildings that were constructed between the 19th century and the 1970s. Another 70 people would be relocated from the LBNL Oakland Scientific Facility, a 1970s-era building in downtown Oakland. Seismic shaking hazards would generally be reduced for these people, as they would be moving from older buildings within seismically active areas that were built under similar or less stringent seismic safety codes. The remaining 20 people would be either new staff or existing staff relocated from an unknown location. For these 20 people, the conservative assumption must be made that they will be relocating from less seismically active areas. Even though the CRT facility would be constructed under the latest and most stringent seismic guidelines, this additional population may be at an incrementally greater risk of injury due to seismic shaking. As discussed in the 2006 LRDP EIR,

compliance with LRDP Mitigation Measure GEO-2 and the UC Seismic Safety Policy would reduce seismic risks to a less than significant level. The CRT project incorporates these measures into project design.

The University of California Seismic Safety Policy prescribes that all new buildings be constructed to "comply with the current seismic provisions of CCR, Title 24, California Building Standards Code, or local seismic requirements, whichever requirements are more stringent."[3] Following this policy the CRT project also includes "provisions…for adequate anchorage for seismic resistance of nonstructural building elements—including, but not limited to, glass, fixtures, furnishings, and other contents, equipment, material storage facilities, and utilities (gas, high-temperature water, steam, fire protection water, etc.)—with respect to potential hazards to persons in the event of seismic disturbances."

In compliance with CGS Publication 117 (Guidelines for Evaluating and Mitigating Seismic Hazards) and LBNL's "Force Design Criteria RD3.22" the CRT facility has been designed to resist seismic loading. The design ground motions shall have no more than a 2 percent chance of being exceeded within a 50-year period. Although conformance to the highest seismic provisions does not constitute any guarantee that structural damage would not occur in the event of a maximum credible earthquake, it is reasonable to expect that structures built in compliance with the seismic requirements would not collapse or cause loss of life in a major earthquake. Furthermore, in order to reduce the risk of injury during seismic events, the LBNL job hazards questionnaire recommends that new employees take a 1.5-hour earthquake/wildland fire safety course to teach employees how to take the appropriate actions to protect themselves from the harmful effects of a major earthquake (or wildland fire) in the Bay Area. UC Berkeley through its Office of Emergency Preparedness also implements programs focused on emergency planning, training, response, and recovery. This includes education of all UC building occupants. The Berkeley Lab or UC Berkeley would take the lead in implementing the training programs for CRT facility occupants. All new employees at the CRT facility would be provided training which would further reduce the potential for significant adverse impacts on those individuals from a major seismic event.

Additionally, there are seismic shaking hazards beyond that associated with building collapse, including falling debris, fire, gas leaks, and others that are difficult to quantify given the potential magnitude and unpredictable nature of seismic events. The UC Seismic Safety Policy dictates stringent standards intended to limit the impacts of such hazards; and the LBNL Master Emergency Program Plan (LBNL, 2005) outlines the procedure for assessing damages to buildings and infrastructure following large seismic events. Following major earthquakes the LBNL Damage Assessment Team, composed of

3 See http://www.ucop.edu/facil/fmc/facilman/volume1/rpsafety.html for more details.

engineers and the Department of Environmental Health and Safety (EH&S) safety specialists, will inspect buildings for structural and other infrastructure damage.

Beyond potential damage to the building itself, there are associated facilities that, if damaged in an earthquake, could cause significant environmental impacts. Of specific concern for the CRT project are the hydromodification vaults proposed to control stormwater runoff for the project. While these structures would also be built to withstand seismic shaking hazards, following the UC seismic safety code and based on site-specific geotechnical recommendations, minor damage during one event could weaken the structures such that they would be more likely to fail during a subsequent event or events. Failure of the stormwater drainage system or hydromodification vaults could serve to infiltrate stormwater on steeply sloped areas not suitable for infiltration. This is a potentially significant impact. Because of this concern, CRT Mitigation Measure GEO-2 expands the damage assessment component to include assessment of the hydromodification vaults following major earthquakes.

CRT MM GEO-2: In addition to damage assessment of the CRT building structural elements (which is covered in the LBNL Master Emergency Program Plan), assessment of stormwater conveyance systems and hydromodification vaults shall be conducted by the Damage Assessment Team following earthquakes strong enough to cause damage.

Significance after Mitigation: Less than significant.

CRT Impact GEO-3: The proposed project would not expose people and structures to substantial adverse effects associated with seismic-related liquefaction or landslides (Less than Significant)

The project site is not located in an area underlain by liquefiable soils. Therefore, the potential impact due to liquefaction at the site is not significant.

As described above, the proposed CRT building is located in a CGS-defined seismic landslide hazard area, and shallow landslide deposits have been identified at the project site. In compliance with LRDP Mitigation Measure GEO-2, a site-specific geotechnical investigation was conducted to address potential landslide hazards. The investigation found that bedrock underlying the site has a steep dip opposite the prevailing ground-surface slope, so deep-seated landslides in the area are unlikely. A shallow landslide deposit was detected during the fault investigation (Kleinfelder 2006a). The portion of this landslide deposit within the building footprint would be removed and replaced with compacted fill during site preparation. The geotechnical investigation recommended that the structure be supported by a combination of spread footings directly on bedrock and piers drilled at least 10 feet into the underlying

bedrock. These recommendations have been included in the facility design; and therefore, the potential seismic landslide hazard impacts are considered less than significant.

Mitigation Measure: No project-level mitigation measure required.

CRT Impact GEO-4: The proposed project would not result in substantial soil erosion or loss of topsoil. (Less than Significant).

The building is proposed in an area of very steep slopes (an average slope of 2:1, horizontal to vertical), and therefore the site is highly susceptible to erosion during construction. Furthermore, project construction would involve substantial cuts and fills and earthmoving activities. As required by the 2006 LRDP and LRDP EIR, the project would include control measures to meet the conditions of the Lab's Storm Water Pollution Prevention Plan (SWPPP) (2006) that addresses construction-related erosion control practices, and would include the development and implementation of a site-specific erosion control plan following the outlined practices in the general LBNL SWPPP.

Additionally, LRDP Mitigation Measure GEO-3a and 3b require individual projects to incorporate construction site best management practices and standards to control and reduce erosion, and require that all disturbed areas be revegetated with native plants following completion of the project. These measures have been incorporated into the project, and erosion-related impacts would therefore be less than significant.

Mitigation Measure: No project-level mitigation measure required.

CRT Impact GEO-5: The proposed project is located on a geologic unit that may be unstable or could become unstable as a result of the project. (Less than Significant)

The discussion of CRT Impact GEO-3 above highlights potential landslide hazards at the building site due to seismic conditions. Additional instability of underlying units may be attributed to differential settlement, soil creep, or the triggering of localized slumps or landslides in response to grading at the site. The site-specific geotechnical report states that the building foundation will be on spread footings lying directly on bedrock and piers drilled at least 10 feet into the underlying bedrock, which will minimize differential settling and structural impacts due to hillslope soil creep. Storm drainage systems at the project site would be designed to avoid infiltration of stormwater into subsurface soils that could potentially be destabilized by increased infiltration. With incorporation of these design features, the potential impact would be less than significant.

Mitigation Measure: No project-level mitigation measure required.

CRT Impact GEO-6: The CRT building would not be located on expansive soils. (Less than Significant)

As described above, the soils at the CRT project site have low shrink-swell potential and therefore pose little risk to life or property due to expansion and contraction of the soil. In addition, the building foundation would rest on bedrock, and would not be subject to soil shrink-swell. The impact is therefore considered less than significant.

Mitigation Measure: No project-level mitigation measure required.

4.5.5 References

Alt, D., and Hyndman, D.W. 2000. Roadside Geology of Northern and Central California. Missoula, Montana: Mountain Press Publishing Company, 369p.

California Geological Survey (CGS). 2003. Seismic hazard zones, Richmond quadrangle, official map. Seismic Hazards Mapping Act publication, California Department of Conservation.

Fugro West, Inc. 2002. Geotechnical investigation, proposed Building 50x, Lawrence Berkeley National Laboratory, Berkeley, California. Consulting report prepared for Lawrence Berkeley National Laboratory, 15p. + figures, plates and appendices.

Graymer, R.W., Jones, D.L., and Brabb, E.E. 1996. Preliminary geologic map emphasizing bedrock formations in Alameda County, California: A digital database. U.S. Geological Survey Open-File Report 96-252, 33p + plates.

Kleinfelder, Inc. 2006a. Preliminary geotechnical investigation report, Computation Research and Theory building, Lawrence Berkeley National Laboratory, Berkeley, California. Draft consulting report prepared by Kleinfelder, Inc. for the LBNL, 45p.

Kleinfelder, Inc. 2006b. Fault investigation, Computation Research and Theory building, Lawrence Berkeley National Laboratory, Berkeley, California. Consulting report prepared for LBNL, 44p.

Lawrence Berkeley National Laboratory (LBNL). 2007a. 2006 Long Range Development Plan Draft Environmental Impact Report, SCH No. 200102046, July 2007.

LBNL. 2005. Quarterly progress report and annual status summary, fourth quarter fiscal year 2004 (July 1 to September 30, 2004) for the Lawrence Berkeley National Laboratory Hazardous Waste Facility Permit. Monitoring report prepared by the LBNL EH&S and Earth Sciences Divisions, 528p.

LBNL. 2007b. Quarterly progress report, first quarter fiscal year 2007 (October 1 to December 31, 2007) for the Lawrence Berkeley National Laboratory Hazardous Waste Facility Permit. Monitoring report prepared by the LBNL EH&S and Earth Sciences Divisions, 136p.

LBNL. 2007c. Quarterly progress report and annual status summary, fourth quarter fiscal year 2006 (July 1 to September 30, 2006) for the Lawrence Berkeley National Laboratory Hazardous Waste

Facility Permit. Monitoring report prepared by the LBNL EH&S and Earth Sciences Divisions, 556p.

LBNL. 2006. Groundwater monitoring and management plan for the Lawrence Berkeley National Laboratory Environmental Restoration Program. Report prepared by LBNL EH&S and Earth Sciences Divisions, 51p. + figures and appendices.

LBNL. 1999. Slope Stability Evaluation Map.

U.S. Geological Survey (USGS) Working Group on California Earthquake Probabilities. 2003. Earthquake Probabilities in the San Francisco Bay Region: 2003–2032 – A Summary of Findings. http://quake.usgs.gov/research/seismology/wg02/summary.

Wentworth, C.M., Graham, S.E., Pike, R.J., Beukelman, G.S., Ramsey, D.W., and Barron, A.D. 1997. Summary distribution of slides and earth flows in Alameda County, California. Map created from USGS Open File Report 97-745, San Francisco Bay Region Landslide Folio, Digital Database.