LINAC COHERENT LIGHT SOURCE-II
ENVIRONMENTAL ASSESSMENT (DOE/EA-1975)

SLAC National Accelerator Laboratory
2575 Sand Hill Road
Menlo Park, California 94025

U.S. Department of Energy
Office of Science

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Cover Photo: SLAC's Undulator Hall

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List of Acronyms and Abbreviations

$\mu g/m^3$	micrograms per cubic meter
AADT	annual average daily traffic
ACHP	Advisory Council on Historic Preservation
ACS	Access Control System
ADT	average daily trips
ALARA	as low as reasonably achievable
ALOHA	Areal Locations of Hazardous Atmospheres
AMSL	above mean sea level
APE	Area of Potential Effect
AQMD	Air Quality Management District
BAAQMD	Bay Area Air Quality Management District
BCS	Beam Containment System
BESAC	Basic Energy Sciences Advisory Committee
bgs	below ground surface
BLS	Bureau of Labor Statistics
BMP	best management practice
BSY	Beam Switch Yard
BTH	Beam Transport Hall
CalARP	California Accidental Release Prevention Program
CARB	California Air Resources Board
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CDP	Census Designated Place
CEQ	Council on Environmental Quality
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CHP	California Highway Patrol
Ci	Curies
CO_2	carbon dioxide
CRLF	California red-legged frog
CUPA	Certified Unified Program Agency
cy	cubic yards
DART	Days Away, Restricted, or Transferred

dBA	A-weighted decibels
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DREP	Dosimetry and Radiological Environmental Protection Group
EA	Environmental Assessment
EBD	Electron Beam Dump
EIS	Environmental Impact Statement
EISA	Energy Independence and Security Act
ENSO	El Nino Southern Oscillation
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERT	Emergency Response Team
ESH&Q	Environment, Safety, Health, and Quality
FEE	Front End Enclosure
FEH	Far Experimental Hall
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FTA	Federal Transit Administration
GeV	gigaelectron volt
GHG	greenhouse gas
gpd	gallons per day
HMBP	hazardous materials business plan
hp	horsepower
HXR	hard x-ray
I-280	Interstate 280
IPCC	Intergovernmental Panel on Climate Change
ISCORS	Interagency Steering Committee on Radiation Standards
ISEMS	Integrated Safety and Environmental Management System
JRBP	Jasper Ridge Biological Preserve
kVA	kilovolt amps
kW	kilowatt
L	liter
LBNL	Lawrence Berkeley National Laboratory
LCF	latent cancer fatality
LCLS	Linac Coherent Light Source

Ldn	day-night averaged sound level
Leq	equivalent continuous noise level
linac	linear accelerator
MCI	Maximum Credible Incident
MDR	Mileage Death Rate
MEI	maximally exposed individual
MMT/yr	million metric tons per year
mrem/year	millirems per year
$MTCO_2e$	million metric tons of carbon dioxide equivalent
NAAQS	National Ambient Air Quality Standards
NEH	Near Experimental Hall
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Act
NHPA	National Historic Preservation Act
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NZE	near-zero emission
ODH	oxygen deficiency hazard
OSHA	Occupational Safety and Health Administration
PAC	Protective Action Criteria
PCB	polychlorinated biphenyl
pCi	picoCuries
PEP	Positron-Electron Project
PHA	Preliminary Hazards Analysis
PM_{10}	particulate matter with a diameter of 10 microns or less
$PM_{2.5}$	particulate matter with a diameter of 2.5 microns or less
PMS	Perimeter Monitoring Station
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PPS	Personnel Protection System
PPV	Peak Particle Velocity

PULSE	Photon Ultrafast Laser Science and Engineering
PVTC	Portola Valley Training Center
RCRA	Resource Conservation and Recovery Act
RMA	Radioactive Material Area
RMS	root mean square
RPD	Radiation Protection Department
RPFO	RPD Field Operations Group
RWQCB	Regional Water Quality Control Board
SAAQS	State Ambient Air Quality Standards
SFBAAB	San Francisco Bay Area Air Basin
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SHPO	State Historic Preservation Office
SIMES	Stanford Institute for Material and Energy Sciences
SIP	State Implementation Plan
SLAC	SLAC National Accelerator Laboratory
SMC	San Mateo County
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SMOP	Synthetic Minor Operating Permit
SPCC	Spill Prevention, Control and Countermeasure
SPEAR	Stanford Positron Electron Asymmetric Ring
SSRL	Stanford Synchrotron Radiation Lightsource
SWPPP	Storm Water Pollution Prevention Plan
SXR	soft x-ray
TBD	To be determined
TDS	total dissolved solids
TED	total effective dose
TJNAF	Thomas Jefferson National Accelerator Facility
TPH	total petroleum hydrocarbons
TRC	Total Recordable Cases
UH	Undulator Hall
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VdB	velocity in decibels
VOC	volatile organic compound

WAPA	Western Area Power Administration
WEAP	Worker Environmental Awareness Program
WPT	western pond turtle
WSHP	Worker Safety and Health Program
XFEL	X-ray free electron laser

1.0 INTRODUCTION

1.1 SLAC Overview

The SLAC National Accelerator Laboratory (SLAC) is operated by Stanford University under contract to the U.S. Department of Energy (DOE). **Figure 1-1** depicts the regional location of SLAC on the San Francisco Peninsula. SLAC's research campus is located in an unincorporated portion of San Mateo County, California. SLAC was founded in 1962 for physics research and siting and operating a particle collider with scientific missions to include accelerator science and particle physics, and more recently photon science and astrophysics as well. SLAC is a multi-program national laboratory that uses electron and positron beams to explore frontier questions in accelerator research, particle physics, astrophysics, and the structure and function of matter.

From 2006 to 2009, SLAC constructed the Linac Coherent Light Source (LCLS), a free electron laser that delivers an extremely bright light source for detailed imaging. This Environmental Assessment (EA) addresses proposed upgrades to the LCLS experimental facilities, LCLS-II (Proposed Action).

SLAC was originally established in 1962 as the Stanford Linear Accelerator Center. SLAC's existing 2-mile-long linear accelerator (linac) was completed in 1966. SLAC then constructed several experimental facilities that use the beam produced by the linac. In 1972, SLAC commissioned the Stanford Positron Electron Asymmetric Ring (SPEAR) and began researching the nature of matter and antimatter. This led to the discovery of new types of particles such as the "charm quark," earning the site's scientists several Nobel prizes. The Stanford Synchrotron Radiation Lightsource (SSRL) was constructed in the 1970s and 1980s to conduct X-ray imaging experiments, which began in 1983. During the 1980s and 1990s, the construction of a series of facilities including the Positron-Electron Project (PEP), an upgrade of PEP (the PEP-II), and the B-Factory provided a second, larger accelerator ring capable of colliding particles at higher energies and more detailed studies of the properties of newly discovered particles. In 2009, the Stanford Linear Accelerator Center was renamed the SLAC National Accelerator Laboratory, though the acronym "SLAC" was retained. Today, Stanford University operates the laboratory under a contract with DOE. Stanford University also owns the land, which DOE uses under a long-term lease. SLAC has 161 buildings and structures, totaling nearly 1.9 million square feet, as well as site utilities, roadways, tunnels, and experimental facilities (**Figure 1-2**).

The largest facilities are the 2-mile-long klystron gallery (356,000 square feet) and the accelerator housing (115,000 square feet). Many of SLAC's facilities are designated as "user" facilities. User facilities are federally sponsored research facilities available for external use to advance scientific or technical knowledge. They are available to users for non-proprietary work on a no cost basis. Proposals are selected based on a merit review and include SLAC research as well as external proposals from universities, industries, foreign institutions, and other government laboratories. More than 3,000 students and scientists per year from across the U.S. and the world conduct experiments at SLAC. Some of the major experimental research programs operating now at SLAC include Stanford's Photon Ultrafast Laser Science and Engineering (PULSE) center; the Stanford Institute for Material and Energy Sciences (SIMES); and the Kavli Institute for Particle Astrophysics and Cosmology, Particle Physics, and Astrophysics.

1.2 Existing LCLS Facilities

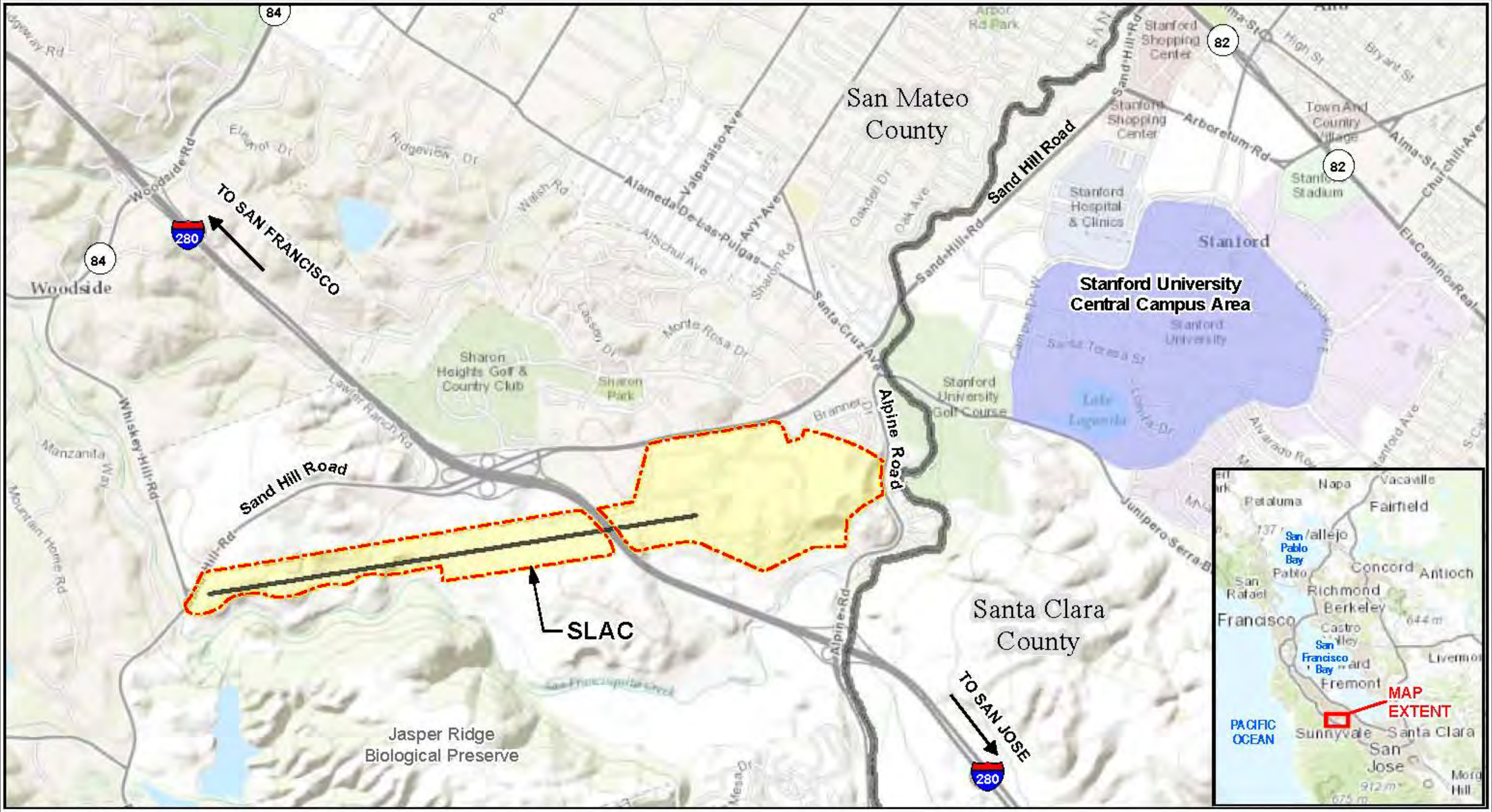
One of SLAC's major scientific facilities is the LCLS, the world's first hard X-ray free electron laser (XFEL). The brightness and other properties of the LCLS X-ray laser beams enable the simultaneous investigation of a material's electronic and structural properties on size (sub-nanometer) and time (femto-second) scales. LCLS investigations cover material sciences, catalytic sciences, structural molecular biology, and molecular environmental sciences.[1]

Construction of LCLS was completed between 2006 and 2009, and experiments began during the fall of 2009. LCLS uses SLAC's existing linac (**Figure 1-2**) to generate and accelerate the beam. However, LCLS uses only the last third (eastern 0.6 mile – Sectors 20 through 30) of the 2-mile-long, 30-sector linac, with an electron injector at Sector 20. The LCLS project included construction of a Beam Transport Hall (BTH), Undulator Hall (UH), Electron Beam Dump (EBD), Front End Enclosure (FEE), Near Experimental Hall (NEH), and Far Experimental Hall (FEH) (**Figure 1-3**). The LCLS experimental halls contain experimental stations with X-ray beam optics, diagnostic equipment, and control systems where LCLS users access the beam. NEH is partially buried and contains approximately 25,000 square feet of research facilities. The UH and FEH are completely underground and provide another 25,000 square feet of research facilities.

The commissioning of LCLS resulted in employment of approximately 60 additional permanent SLAC employees. In addition, up to 40 visiting researchers work at the LCLS at a given time. The LCLS predominantly supports only one experiment at a time, which typically requires ten researchers; the additional researchers are on site to prepare upcoming experiments and to close out completed experiments.

The potential environmental effects of the LCLS project were evaluated under the National Environmental Policy Act (NEPA) in an EA (DOE 2002a). After public review, DOE published a Finding of No Significant Impact (FONSI) (DOE 2003).

1 LCLS experiments have been used to investigate multi-photon and non-linear processes within atoms and molecules in the short wavelength regime, non-equilibrium or temporally evolving states of atoms and molecules, nanocrystals and nanostructures, imaging of viruses and cells, soft X-ray single-shot spectroscopy and imaging of chemical bonds, imaging of magnetic nanostructures, superconductivity and magnetoresistance, and hard X-ray single-shot coherent diffraction of disordered and crystalline systems.



Basemap: World_Topo_Map serviced by ESRI ArcGIS Online

LEGEND

- SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY
- STANFORD UNIVERSITY CENTRAL CAMPUS AREA
- LINEAR ACCELERATOR
- COUNTY BOUNDARY

N

0 3,000 Feet

Graphic Scale: 1" = 3000'

SLAC LCLS-II EA

REGIONAL LOCATION MAP

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FIGURE **1-1**

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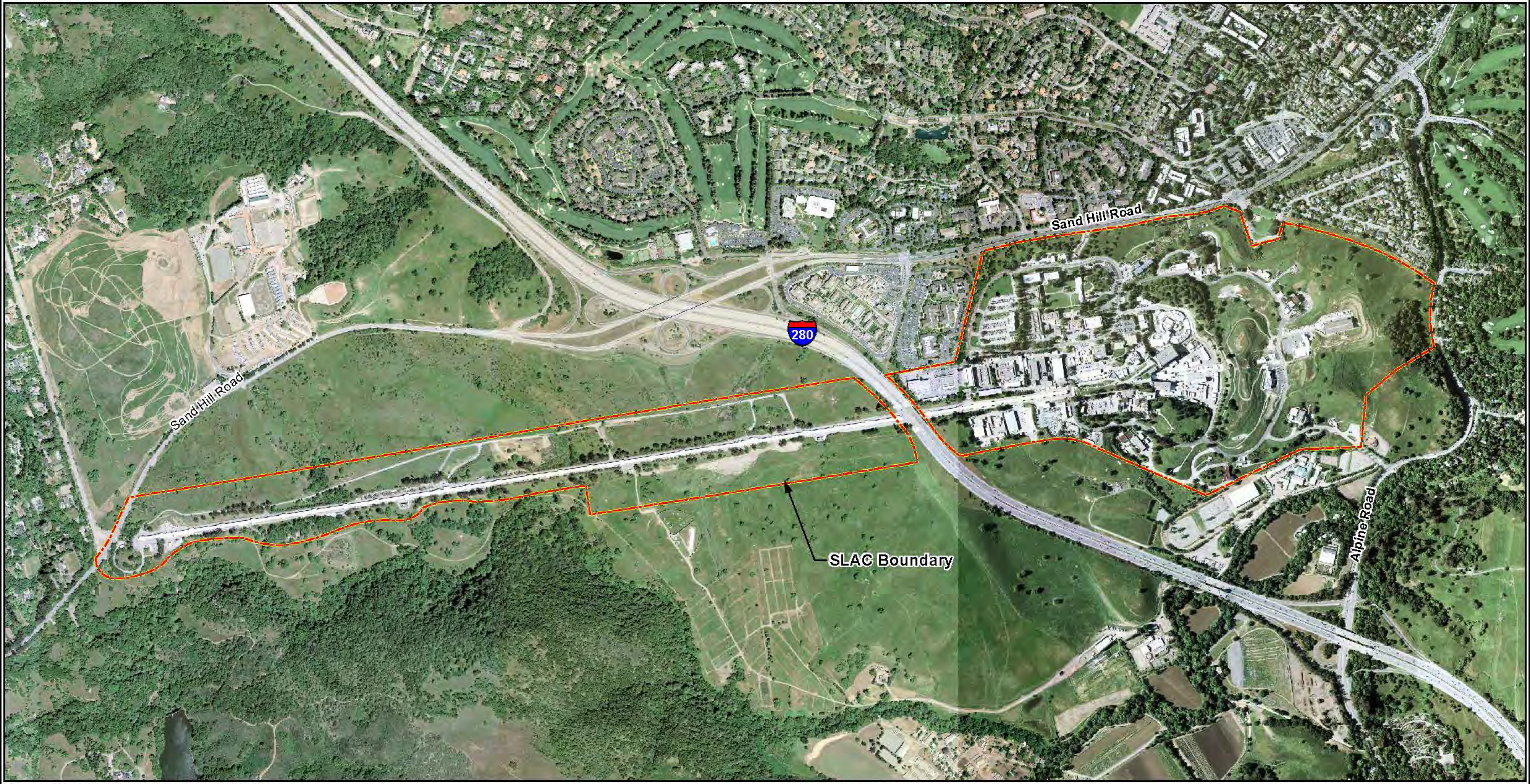


Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

N

0 1,000 Feet

Graphic Scale: 1" =1000'

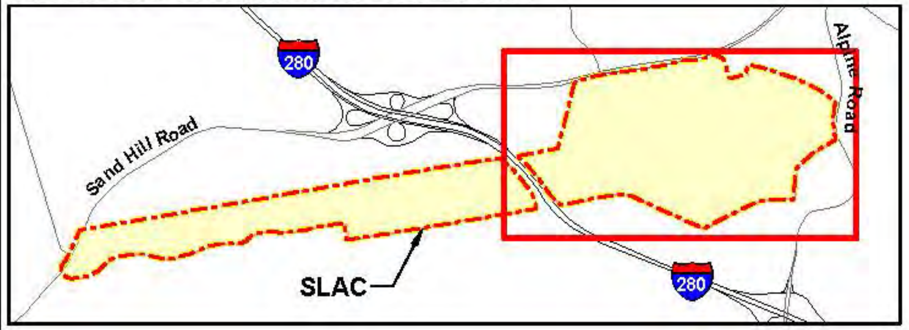
SLAC LCLS-II EA

EXISTING SLAC FACILITIES

ARCADIS

FIGURE 1-2

Basemap: City of San Francisco, photo dated on 04/2011.



LEGEND

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

EXISTING LCLS UNDERGROUND FACILITY

EXISTING LCLS ABOVEGROUND FACILITY

N

0 400 Feet

Graphic Scale: 1" =400'

SLAC LCLS-II EA

EXISTING LCLS FACILITIES

ARCADIS

FIGURE 1-3

1.3 Proposed Action Overview

The Proposed Action would be an upgrade to the existing LCLS to enhance its experimental capabilities and perform new types of experiments. These upgrades will require dismantling and removing existing equipment and utilities within Sectors 0 through 10 of the existing accelerator housing and klystron gallery and installing new superconducting accelerator equipment. It would also require upgrades to existing LCLS equipment and utilities including those contained in the BTH, UH, NEH, and FEH. One of the upgrades would be the installation of a second beamline, which would accommodate additional researchers and allow completion of more experiments.

To provide new capabilities, SLAC would construct two cryogenic plants to produce extremely cold liquid helium and circulate it through the superconducting accelerator equipment via new utility connections. The primary cryogenic plant would be located near Sector 4 of the existing klystron gallery and would consist of a steel-framed building to house compressors and control rooms. The plant's exterior would consist of piping, storage tanks for liquid helium and nitrogen (refrigerant), electrical transformers, and site access improvements. SLAC would also construct a smaller cryogenic plant adjacent to the primary plant or near Sectors 0 – 1 to provide additional production capacity and backup during maintenance shutdowns.

LCLS-II would have a planned operational lifetime of approximately 20 years, during which time SLAC staff would operate the new equipment. Operations would include maintenance, replacement of worn components, and deliveries of liquid helium and nitrogen, followed by eventual decommissioning and reuse or recycling of experimental components.

This EA evaluates the potential environmental effects of the Proposed Action, including dismantling and removing existing equipment, installing new equipment, operations, and eventual decommissioning. As required by NEPA, this EA also evaluates the no action alternative. DOE will use the EA to determine whether a FONSI is appropriate, or whether the Proposed Action warrants an Environmental Impact Statement (EIS). This EA complies with the NEPA, the Council on Environmental Quality (CEQ) Regulations Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508), DOE NEPA Implementing Procedures (10 CFR 1021), and DOE's NEPA Compliance Program (DOE Order 451.1B) (DOE 2012a).

1.4 Purpose and Need

DOE's Office of Science is the Nation's largest supporter of basic research in the physical sciences, which it pursues in partnership with national laboratories, universities, and other organizations with related missions. Basic research involves investigation and analysis focused on expanding our understanding of a subject, phenomenon, or a basic law of nature, potentially leading to commercial application of the research. One important research area within the physical sciences is the study of the structure and function of materials and chemicals at the scale of individual molecules and atoms. SLAC's LCLS provides important capabilities in materials science research.

The proposed LCLS-II would allow DOE to expand LCLS capabilities to extend the photon energy range, increase control over photon pulses, and enable two-color pump-probe experiments. The X-ray laser beams generated by LCLS-II would enable a new class of experiments: the simultaneous investigation of a material's electronic and structural properties.

SLAC had been planning to expand LCLS and originally proposed to build a new undulator tunnel and a new experimental hall with numerous additional experimental stations. Although a NEPA analysis was completed for this expansion, DOE has made a decision not to proceed with this project at this time. New research opportunities have arisen rapidly and, based on recommendations from DOE's Basic Energy Sciences Advisory Committee (BESAC) Subcommittee on Future X-ray Light Sources, DOE's Office of Science is now proposing to construct LCLS-II. Rather than simply expanding user access, LCLS-II would expand SLAC's current capability beyond what would have been the case in the original LCLS-II project mentioned above. The proposed LCLS-II would be a next-generation microscope that would use the most advanced technologies of both X-ray and laser science to provide scientists and engineers with advanced capabilities (high power, high time resolution, and high coherence).

The X-ray laser beams generated by the proposed LCLS-II would enable a new class of experiments: the simultaneous investigation of a material's electronic and structural properties, potentially leading to breakthrough discoveries across many areas of science including material sciences, catalytic sciences, structural molecular biology, and molecular environmental sciences. Two color pump-probe experiments would expand our understanding of the transient, excited states that lie at the heart of chemical and biological reactivity and function. In addition to these expanded capabilities, LCLS-II would accommodate more researchers. At present, LCLS supplies only one station with X-rays at a time. LCLS-II would substantially increase throughput or the number of experiments that can be completed in a given time period.

LCLS-II would build on the experimental results obtained from LCLS, and its added capabilities would help to drive new discoveries to advance our understanding of the fundamental mechanisms of chemical reactivity, allow us to tailor materials to transport and store energy more efficiently, and solve the nanoscale functionality of biological systems critical to advancement of medical science and pharmacology. LCLS-II would allow us to probe matter with near-atomic resolution that has not been possible using existing optical techniques. In addition to new capabilities, LCLS-II's superconducting linac would double the number of laser sources and greatly increase the number of experimental stations to accommodate more users. By adding capability and capacity, LCLS-II would be an important step toward maintaining LCLS as the world's premier X-ray laser facility.

The discoveries from LCLS-II would enhance our ability to understand processes at the most basic atomic level. LCLS-II could provide knowledge that would allow scientists to control chemical transformations at the molecular level. LCLS-II's extended photon energy range may reveal the molecular structures of complex biological systems and lead to the development of new materials with designs based on biological principles, or "bio-inspired" materials. Indeed, DOE, SLAC, and the scientific community envision that LCLS-II will help scientists and engineers attain a deeper understanding of the mechanisms that control nature and that this will help them design and tailor new materials and systems to solve technological challenges related to energy, information science, and medicine. These challenges relate to time – the dynamic nature of chemical processes; energy – how electrons influence material properties; and space – how the structure of complex molecules describes their function in living systems.

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2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

This section provides a detailed description of the Proposed Action, including equipment and installation, fabrication and installation of the project's cryogenic components, site improvements, operation, and eventual decommissioning. It describes the standard measures that SLAC would use to minimize environmental effects as well as the project's permitting requirements.

2.1.1 Equipment and Installation

Constructing LCLS-II would involve removing existing equipment and utilities, adding new equipment and utilities within existing buildings, and upgrading existing structures and equipment to allow installation of a second beamline within the existing UH. It would also involve installing two new cryogenic plants and related support infrastructure. The Proposed Action would include the following activities and components:

<u>Sectors 0 through 10</u>

- Dismantling and removal of existing equipment and utilities
- Replacement of the existing electron injector with a new high repetition rate injector
- Replacement of the existing linac and associated systems in the existing tunnel (Sectors 0 through 10) with a 4 gigaelectron volt (GeV) superconducting linac

<u>Sectors 4 and 0-1</u>

- Installation of a cryogenic plant (4 kilowatt [kW])needed for operation of the superconducting linac, in the general vicinity of Sector 4, and a second, smaller (1 kW) cryogenic plant at Sector 0-1 or adjacent to the larger plant at Sector 4

<u>East of Sector 11 and within the Existing LCLS</u>

- Modification and use of the existing beam transport line to bypass Sectors 11 through 30 to transport the beam to the Beam Switch Yard (BSY)
- Replacement of the existing LCLS undulator on the south side of the UH with an upgraded hard X-ray (HXR) undulator capable of receiving electrons from either the existing (normal-conducting or "warm") linac or the new 4 GeV superconducting linac
- Installation of a new soft X-ray (SXR) undulator source on the north side of the LCLS UH
- Modification of the existing beam dumps, X-ray optics, and SXR instruments to ensure compatibility with the new superconducting linac and X-ray sources

- Installation of new X-ray transport equipment, optics, and diagnostics for the new SXR source
- Modification of the existing HXR transport equipment and optics to enable use of the new high repetition rate X-ray source by existing HXR experiment stations

<u>Site Improvements</u>

- Relocation of an access road on the north side of the larger cryogenic plant
- Construction of soil berms around the new cryogenic plants
- Installation of electrical transformers

<u>Subsystem Design and Fabrication</u>

- Component design and fabrication at SLAC, Lawrence Berkeley National Laboratory (LBNL), Fermi National Accelerator Laboratory (Fermilab), Thomas Jefferson National Accelerator Facility (TJNAF), and Argonne National Laboratory (ANL)

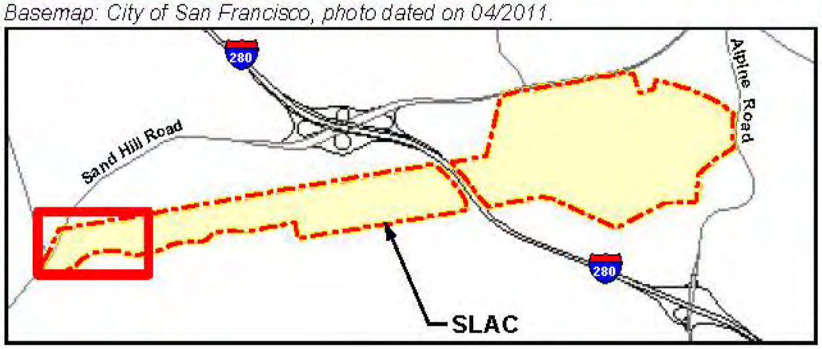
LCLS-II would use the existing accelerator tunnel and klystron gallery. The injector and superconducting linac would be installed in the first 0.6 mile (Sectors 0 through 10) of the existing accelerator housing after removal of the existing equipment. With the exception of the cryogenic plants and transformers, the new equipment and instruments would be located primarily within existing buildings. **Figure 2-1** depicts the layout of the proposed LCLS-II, including the cryogenic plants, injector, and superconducting linac. **Figure 1-3** depicts the locations of existing LCLS facilities to the east that would be modified as part of the proposed LCLS-II.

The following subsections describe LCLS-II equipment from west to east, beginning with the injector and proceeding east to the experimental halls.

2.1.1.1 Equipment Dismantling and Removal

The existing injector at Sector 0 would be reconfigured to prepare for installation of a new injector. Existing utilities in the accelerator housing (**Figure 2-2**), UH (**Figure 2-3**) and klystron gallery between Sectors 0 through 10 would also be reconfigured to meet the current building codes and federal requirements. This would require demolition, dismantling and removal of existing electrical equipment, hot and cool water system piping, air handling equipment, fire control equipment, and lighting.

Basemap: City of San Francisco, photo dated on 04/2011.



N

0 225 Feet

Graphic Scale: 1" = 225'

SLAC LCLS-II EA

PROPOSED ACTION LAYOUT

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FIGURE 2-1

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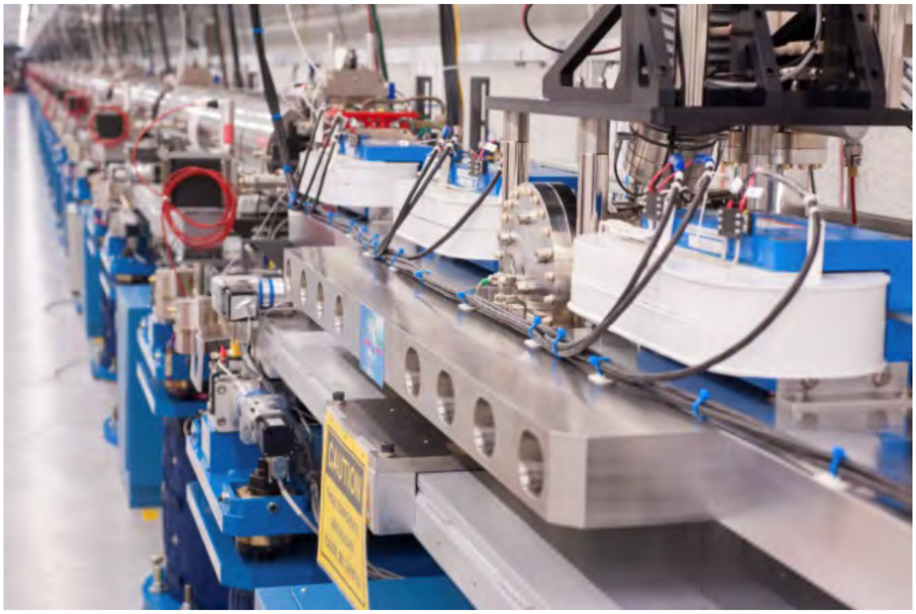
Figure 2-2 Existing Accelerator Housing and Linac

Figure 2-3 Existing Undulator Hall and Undulators



A decommissioning plan for the removal of the existing infrastructure within the accelerator housing and the klystron gallery would be prepared to ensure that all demolition activities comply with applicable laws, regulations, and procedures reflecting established DOE and SLAC policies. Decommissioning procedures would include detailed radiological monitoring and surveys, hazardous material and waste identification and characterization, decontamination, disconnection of operating systems, drainage of liquid-filled systems, and hazardous and radiological waste disposition. The plan would also include salvaging and recycling the materials for reuse at SLAC, packaging components for shipment to other DOE sites, transport/shipment to approved waste disposal sites, or long-term storage at SLAC. The dismantling and removal process would generate approximately 15,000 cubic yards (cy) of equipment and utilities for recycling and approximately 800 cy of radioactive waste (e.g., copper and aluminum components).

2.1.1.2 Injector

A new injector "gun" (electron source) with the required LCLS-II brightness and high repetition rate would be installed in the reconfigured injector area at Sector 0. The injector area would be supplied with new electrical power as well as mechanical systems, including cooling water, ventilation, and water collection systems.

2.1.1.3 Accelerator

SLAC's existing linear accelerator, the linac, increases the velocity of subatomic particles for use in physics experiments by subjecting the particles to electrical forces along the beamline. For LCLS-II, the linac between Sectors 0 and 10 would be replaced by a superconducting accelerator system to accelerate the electron beam from the injector to a final energy of 4.0 GeV. Superconducting accelerators use cryogens (in this case liquid helium) to create an extremely cold environment, which reduces electrical resistance along the beamline and allows faster particle velocities and enhanced experimental capabilities. The LCLS-II superconducting accelerator would consist of thirty-five 42-foot-long sections or cryogenic acceleration modules ("cryomodules") (**Figure 2-4**). The new accelerator would be installed on the north side of the existing accelerator housing. The cryomodules would be designed and fabricated at Fermilab, TJNAF, LBNL, and ANL (Section 2.1.2.1), and then transported to SLAC for assembly and installation.

2.1.1.4 Cryogenic Plant

LCLS-II would include installation of two cryogenic plants to generate cryogenic helium for use in the superconducting linac. The areas near Sectors 0-1 and 4 were selected for their proximity to the injector location, availability of utilities (e.g., water, power), and proximity to existing access roads. The proposed plant sites are located in topographical depressions to minimize views of the plants from surrounding areas. The smaller plant would provide additional capacity and backup during maintenance of the other plant. Each plant would be connected to the new cryogen distribution, cooling water, and electrical systems.

The cryogenic plants would include conventional steel-frame, corrugated metal buildings to contain compressors. The buildings would have sound attenuating features, such as sound-absorbing batting and other acoustical engineering features. The plants would convert compressed, ambient-temperature helium into an extremely cold liquid that would be maintained in cryogenic form using a refrigeration system. The tallest structures would be approximately 40 and 35 feet above the elevation of the foundations for the larger and smaller plants, respectively. The larger plant site would have a footprint of approximately 100 feet by 300 feet (30,000 square feet, 0.7 acre). The plant's steel-framed building would have approximately 10,000 square feet of internal space, and adjacent outdoor areas for utilities and storage tanks (**Figure 2-5**). The smaller plant would have a site footprint of 10,000 square feet and a similarly designed building with approximately 5,000 square feet of internal space. Other equipment would include refrigeration units (using liquid nitrogen as a refrigerant), fire control systems, ventilation systems, switchgear, and distribution piping. Storage tanks and a receiving dock for deliveries would be located on the south side of the building.

Figure 2-4 Typical Cryomodule (yellow) Portion of a Linear Accelerator

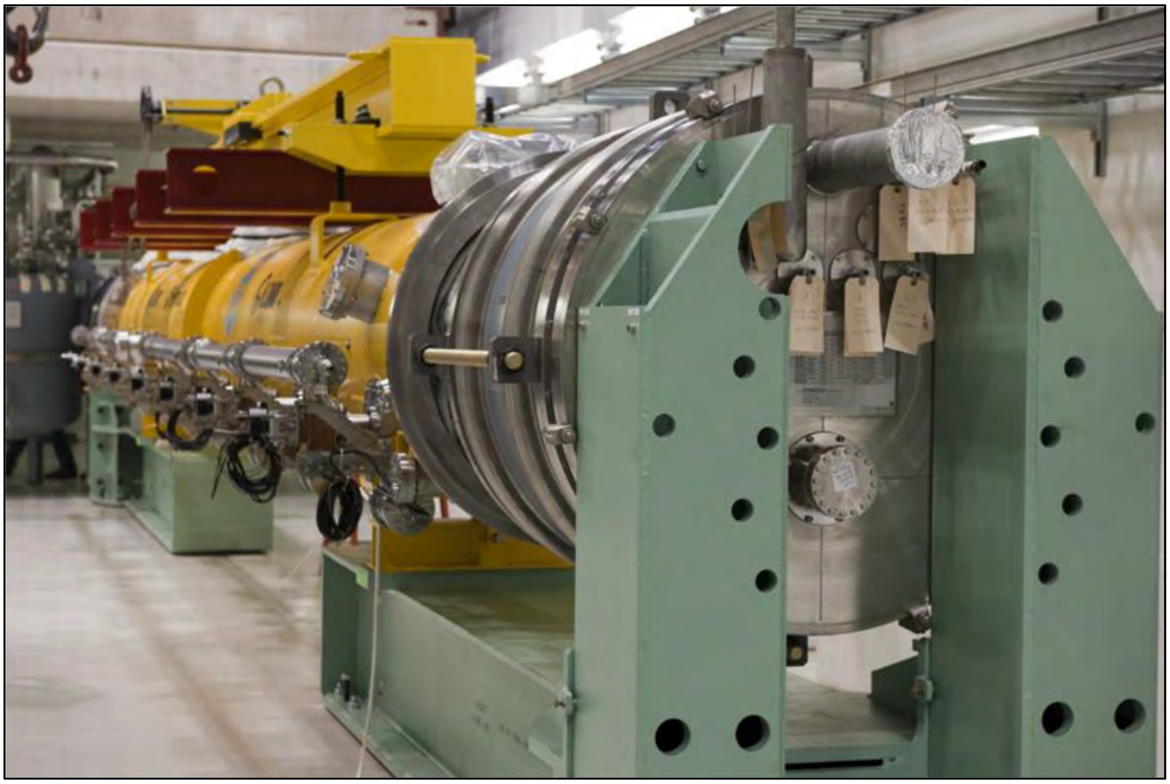


Figure 2-5 Typical Cryogenic Plant Equipment (Cold Box)

Source: Jefferson Lab

A cryogenic distribution system would circulate cryogenic helium through insulated pipelines to the cryomodules and then back to the cryogenic plants. This system would include distribution boxes, cryogen transfer lines, feed and end caps, and cryogenic bypasses to avoid warm linac beamline elements. Auxiliary systems would include warm helium gas-storage tanks, interconnecting piping, liquid nitrogen storage dewars, liquid helium storage dewars, a purifier system, an instrument air system, a cold box chilled water system, and associated cryogenic safety systems. The plant layouts would be refined during final design to optimize the layout and minimize construction and operation costs, provide ease of access, and minimize environmental impact.

The cryogenic plant compressors would require installation of two transformers (approximately 8 feet by 12 feet by 10 feet) (**Figure 2-6**) to convey electricity. The transformers would be located near the cryogenic plant sites and would be used to start the compressors and operate all cryogenic plant systems. The transformers would deliver approximately 10 and 2.6 megawatts (MW) of power to start up the larger and smaller plants, respectively. SLAC's current total power use is approximately 31 MW compared with the existing transmission system limit of 65 MW. Therefore, SLAC's power use with the addition of LCLS-II would be well within system limits.

Figure 2-6 Typical Cryogenic Plant Transformers

Dissipating the heat generated by the cryogenic plant compressors would require cooling water. The water would be piped through the distribution system to existing on-site cooling towers (**Figure 2-1**). SLAC's water system would replace water lost to evaporation in the cooling towers, adding approximately 55,000 gallons to SLAC's daily water use for the larger plant and approximately 19,500 gallons for the smaller plant, for a total of approximately 74,500 gallons per day. Water discharges to the sewer system would include the restrooms in the cryogenic plants and approximately 1,600 gallons per day for cooling tower blowdown. The additional usage of approximately 76,500 gallons of water per day (74,500 gallons of evaporation and approximately 2,000 gallons of additional wastewater including cooling tower blowdown and restrooms) would increase SLAC's daily water use of approximately 200,000 gallons by approximately 38 percent. SLAC is implementing its Site Sustainability Plan, which contains goals for reducing potable water consumption and has resulted in an overall 37 percent decline in water use at SLAC from 2007 to 2012 (SLAC 2013b, SLAC 2013c).

2.1.1.5 Beam Transport/Bypass

The beam transport segment, downstream of the injector, would be a combination of existing and new equipment. Between Sectors 10 and 30, a bypass line would transport the beam to the BSY, east of Sector 30. The area that would be bypassed is currently used by existing SLAC projects. At the end of the bypass line, the beam would enter a spreader that would transmit the beam to the existing LCLS UH where two new undulators, the SXR and the HXR, would be installed (next section).

2.1.1.6 X-ray Production and Delivery (Undulators)

The Proposed Action would include installation of new undulators, the SXR and HXR undulators, in the UH. The entirely new SXR undulator would be installed in the north side of the hall. The HXR undulator would be installed on the south side of the hall, replacing the existing LCLS undulator. The beam would be directed to either undulator. The SXR undulator would receive the beam from the superconducting linac. The HXR undulator would be able to receive the beam from either the existing "warm" linac or the new superconducting linac. The undulators would deliver X-rays to the NEH and FEH and would feed soft X-rays to End Station A or B.

2.1.1.7 Changes to Existing LCLS Facilities

Many of the existing LCLS facilities would require upgrades and changes including additional power, cooling, and other utility reconfigurations. Specific changes would include:

- BTH - additional concrete and/or iron radiation shielding and access restrictions to provide radiation protection from the increased beam power
- UH - installation of new undulators, replacement and reconfiguration of supporting utilities, and installation of front-end X-ray diagnostics and optics
- BSY – modifications to accommodate the new added beamline, beam dumps, and utilities, as well as removal of existing equipment
- FEE – structural and utility modifications to accommodate the new beamline and the new beamline optics
- EBD – installation of additional concrete and iron radiation shielding and a new cooling system
- NEH – installation of new experimental stations and detector and data acquisition equipment.
- FEH – upgrades of existing instruments in existing experimental areas.

Demolition and installation of new utilities and other equipment, as mentioned above, would be managed from SLAC's existing Research Yard (central SLAC), where the construction contractor would set up a staging area.

2.1.2 Cryogenic Component Fabrication and Installation

This section describes the fabrication and installation of the project's cryogenic components, including the cryogenic plants and the cryomodules.

2.1.2.1 Fabrication

SLAC would assign responsibility for the design and fabrication of major LCLS-II subsystems to other DOE laboratories including:

- LBNL - Design and fabrication of the LCLS-II undulators and provide the electron source (injector).
- Fermilab - Design and fabrication of half of the cryomodules as well as the helium distribution system.
- TJNAF – Fabrication of the other half of the cryomodules as well as design and procurement of construction of the cryogenic plants.
- ANL - Provide the undulator vacuum chambers.

The design and fabrication work at LBNL, Fermilab, TJNAF, and ANL would be conducted within existing offices and buildings at these sites. These activities would be contiguous with existing routine operations at these sites and would be completed by their respective existing staff. Engineers and technicians at these sites would use existing machine shops, furnaces, laboratories, equipment, clean rooms, and utilities to fabricate and test the undulators, helium distribution system, cryomodules, and vacuum chambers.

2.1.2.2 Cryogenic Plant Construction

Cryogenic plant construction would include laying foundations, erecting steel-frame buildings, and assembling and installing components for handling liquid helium, including compressors, tanks, and refrigeration units. Foundation construction for the plants would require excavation of approximately 15,000 to 30,000 cy of soil to create level construction sites and adjacent working areas. No drilling or blasting would be required. The excavated material would be used at locations on-site and adjacent to the cryogenic plants to construct soil berms that would obscure the plants from view and reduce the propagation of noise. The plant at Sector 4 would have an approximately 20-foot high berm, whereas the plant at Sector 0-1 would have a smaller berm. Disturbed areas would be planted and seeded with a native grass seed mix to restore vegetation.

The foundation excavation and construction of the cryogenic plants would be completed with conventional excavation and construction equipment such as loaders, excavators, hydraulic lifts, portable crane, compressors, and dump trucks. The foundation and utility trenches would be excavated, and temporary face supports consisting of temporary wooden shoring or soil nail walls would be used to protect the excavation.

Power for the early stages of construction would be provided by existing on-site power or temporary on-site diesel generators. Generators rated above 50 horsepower would be provided by subcontractors, as SLAC portable generators of this capacity are currently permitted for emergency use only. During later construction stages, power would be provided by existing sources and the new electrical transformers. If a power failure occurred during construction, emergency generators would be required to power essential equipment.

Components of the cryogenic plants would be delivered to SLAC on trucks. The refrigeration systems and cold boxes would be transported to SLAC on tractor-trailers or flatbed trailers. These trucks would enter SLAC at the Alpine Road gate or the main entrance on Sand Hill Road. SLAC would also allow occasional deliveries via the west gate at Sand Hill Road and Whiskey Hill Road in special circumstances. Trucking contractors would be required to comply with the SLAC Environment, Safety, Health, and Quality (ESH&Q) Manual (SLAC 2014), including requirements to prepare and implement a traffic control plan.

2.1.3 Other Site Improvements

Site improvements would include site preparation, staging areas, parking, stormwater drainage, and installation of other site utilities. Site preparation would include clearing and grubbing the cryogenic plant sites, installing fencing, and setting up safety perimeters. The construction contractor would establish staging areas directly adjacent (north) of Sectors 1 and 4. These areas would be used for construction trailers and offices, workshops, construction and worker vehicle parking, and storage of removed components and excavated material. All staging areas would be located within SLAC property.

The stormwater collection system would be designed to comply with Section 438 of EISA, as well as a stormwater Construction General Permit. Fire hydrants would be installed at appropriate spacing per National Fire Protection Association recommendations and requirements of the California Fire Code. Temporary utilities would be removed after construction was complete. Other utility improvements would include sidewalks, site sanitary sewer service, potable water service, and landscaping. Charging stations for government electric vehicles would be installed in the parking lots.

SLAC access gates off public roads would not require improvement. Construction crews would enter SLAC through the existing Alpine Road gate. Truck deliveries would enter SLAC through the Alpine Road gate or the main site entrance at Sand Hill Road. Trucks delivering materials for installation in Sectors 0 through 10 would drive west on the haul road and enter the underground accelerator housing through a vault and tunnel north of Sector 10 (**Figure 2-1**). Delivery trucks would also occasionally use the west gate at Sand Hill Road and Whiskey Hill Road. At the construction site, crews would drive on the Gallery Road, staging areas, paved areas at the west entrance to the accelerator housing, and the haul road to the north. All disturbed areas, including staging areas, utility trenches, and other disturbed areas, would be restored to preconstruction conditions, including regrading, repaving, and reseeding, as applicable.

2.1.4 Excavated Material Handling and Disposal

The proposed cryogenic plant foundations would require excavation of approximately 15,000 to 30,000 cy of soil. The soils that would be excavated for the cryogenic plant foundations have been subject to minimal disturbance and would not be likely to contain chemicals at concentrations that exceed future land use criteria. The soils excavated for foundations and utility installation would be tested according to SLAC's Excavation Clearance Program to confirm that there are no chemical impacts from past site activities and to identify disposal options. Suitable excavated soils would be used on the construction site to build soil berms around the cryogenic plants. Excess soils not used on the construction site would be relocated to areas within SLAC. Transporting excavated soil at the construction site or for on-site relocation would require approximately 2,150 truckloads of soil.

If chemicals were present in the soil at concentrations that exceed future land use criteria, they would require off-site disposal in a permitted industrial waste landfill. Covered trucks would transport the material to an off-site disposal facility. Travel distances would be less than 2 miles for on-site relocation of clean material, approximately 20 miles or more for off-site solid waste disposal, and approximately 50 miles to an industrial landfill (Altamont Landfill, Livermore, California). Trucks hauling soil off site would exit the site through the Alpine Gate and travel down Alpine Road to I-280. However, very little if any off-site disposal would be required because most of the excavated soils would be from areas that have been minimally disturbed by SLAC construction and operations.

2.1.5 Schedule and Work Force

Construction would begin in 2015 with dismantling and removal of existing equipment in the klystron gallery and accelerator housing. Design and fabrication of the cryogenics components fabricated at LBNL, Fermilab, and TJNAF would be completed between 2015 and 2017 and the completed components transported to SLAC. On-site construction would require a total of approximately 3 years (39 months). As currently planned, on-site activities would begin in 2015 and conclude in 2018. Later phases involving delivery of construction materials, equipment installation, modification of existing facilities, and construction of the cryogenic plants and support systems would occur primarily during 2017 and 2018. Because construction would require shutdown of SLAC accelerator facilities, SLAC would expedite construction to the extent practicable. Construction would be followed by a 2-year commissioning period before research operations would begin.

Construction would require an average work force of 20 with a peak of approximately 40 workers during concurrent installation of the superconducting linac components and the cryogenic plants. Construction would be completed during weekday shifts of 10 hours per day.

2.1.6 Operations and Maintenance

SLAC would operate and maintain the superconducting linac and cryogenic plants. The cryogenic plants would operate continuously with shutdowns at approximate 2- to 5-year intervals for maintenance. Prior to operations, the new buildings and equipment would be subject to safety analysis and operational readiness reviews as well as environmental reviews to ensure that environmental and operations permits were secured. SLAC staff would operate and maintain the associated electrical, cooling water, computer, security, leak detection, and liquid helium delivery systems. Startup would require 3 to 10 liquid helium deliveries, followed by 1 to 3 deliveries per year during operations. Similarly, the cryogenic system would require approximately four liquid nitrogen truck deliveries to fill the refrigeration systems, followed by approximately 3 to 4 deliveries per week for make-up volume. Liquid helium and nitrogen would be stored in insulated stainless steel tanks or dewars.

During accelerator operations, the new injector and linac would provide pulses of electrons to two new undulators in the existing UH. Operators would use magnets and mirrors to focus the beam with minimal radiological activation of components. The two undulators would generate photons in the spectral ranges required by researchers, who would monitor the beam diagnostics to record the resulting data. Researchers would be located at SLAC and may also remotely access, analyze, and interpret data.

SLAC would monitor and maintain system components, including replacement of irradiated or damaged components. Replacement and handling of irradiated components would be conducted by SLAC workers using short work shifts and shielding to minimize radiation exposure. SLAC operations staff would also maintain ventilation and cooling water systems and SLAC environmental, health and safety, radiological control, and industrial hygiene staff would provide work procedures and conduct monitoring (see Section 3.8, Health and Safety).

SLAC's power is generated and delivered by commercial power suppliers. SLAC also receives some power from the Bureau of Reclamation's Central Valley Project. Western Area Power Administration (WAPA) serves as purchasing agent for SLAC's power needs. LCLS-II would receive its power to generate the beam and to power the cryogenic plant compressors, refrigeration, and other systems through these same sources.

LCLS-II would have a planned operating period of approximately 20 years. Over the experiment's lifetime, LCLS-II would require approximately six staff to operate the injector system, cryogenic plants, and beam delivery systems. LCLS-II's additional beamline would support approximately 15 additional researchers.

2.1.6.1 Hazardous Materials Management

SLAC uses hazardous materials as authorized by the State of California (California Code – Section 25201.6) as part of its experiments, including fabricating and maintaining experimental devices. Examples of hazardous materials managed at SLAC include:

- Cryogens
- Flammable gases
- Compressed gases
- Acids and bases
- Solvents
- Oils and fuels
- Adhesives
- Paints and epoxies
- Metals
- Radioactive materials

The Proposed Action would comply with existing hazardous materials regulations, including Title III of the Superfund Amendments and Reauthorization Act of 1986 (also referred to as the Emergency Planning and Community Right-to-Know Act), the Occupational Safety and Health Act of 1970, and the Hazardous Materials Transportation Act. SLAC also implements the Toxic Substances Control Act, which is the federal statute that regulates polychlorinated biphenyls (PCBs) and asbestos-containing materials. Further, the Proposed Action would comply with state requirements, including preparing a hazardous materials business plan (HMBP) and preparing a spill control plan as required under the California Accidental Release Prevention Program (CalARP). DOE and SLAC would also comply with existing aboveground storage tank programs; pollution prevention and waste minimization programs; and hazardous materials and waste management regulations (e.g., Resource Conservation and Recovery Act [RCRA], Title 22 California Code of Regulations [CCR]).

2.1.6.2 Environmental Sustainability Practices

The Proposed Action would be consistent with DOE's policy on Waste Minimization and Pollution Prevention (DOE 1992). SLAC would evaluate chemical use and disposal to identify the potential to reduce the amount of chemicals requiring disposal as well as opportunities to employ specific best management practices (BMP) to prevent the release of chemicals to the environment.

SLAC has a comprehensive site-wide Storm Water Pollution Prevention Plan (SWPPP) (SLAC 2007a). Pollution prevention for the Proposed Action would begin before construction with a stormwater General Construction Permit and the development of a project-specific construction SWPPP for LCLS-II. During operations, the Proposed Action would involve implementing the existing site-wide operational SWPPP, including site-specific BMPs. The operational BMPs for the Proposed Action would focus on minimizing sediment and other constituents of potential concern in surface runoff. LCLS-II would also comply with Energy Independence and Security Act (EISA), Section 438 and the General Construction Permit requirements to manage potential hydrologic effects of added impermeable surfaces and increased runoff rates and volumes.

LCLS-II would also comply with other SLAC and federal requirements to reduce waste. SLAC's Site Sustainability Plan (SLAC 2013c) outlines specific sustainability goals. As a federal facility, SLAC is required to comply with Executive Order (EO) 13423, Strengthening Federal Environmental, Energy, and Transportation Management (Federal Register, Vol. 72, No. 17, January 26, 2007). Therefore, SLAC would design and operate LCLS-II in a manner consistent with the goals contained in this order, which include increased energy efficiency, reductions in toxic waste, and increased recycling and water conservation.

The Proposed Action would also be consistent with EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance (Federal Register, Vol. 74, No. 194, October 8, 2009). This EO expands on the energy reduction and environmental performance requirements identified in EO 13423. The goal of EO 13514 is "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas (GHG) emissions a priority for federal agencies." This EO specifically addresses agency GHG reduction targets, reductions in petroleum, potable water, watering of landscaping, solid waste, construction and demolition debris, and other targets.

2.1.7 Decommissioning

Decommissioning would not occur for decades into the future. A decommissioning plan would be prepared to ensure that the best available technology is used and that all closure activities were conducted in accordance with applicable laws and regulations, as reflected in established SLAC and DOE policies and procedures. This would include a detailed radiological survey to identify components with residual radioactivity. Such components would be stored in a secure area pending future reuse or final disposal. SLAC has well-developed controls for storage of radioactive materials and complies with DOE and SLAC requirements. These include, but are not limited to SLAC's ESH&Q Manual and Radiological Control Manual. Any radioactive materials would be stored on site within Radioactive Material Areas (RMAs) and monitored by radiation safety professionals to ensure worker and public safety and compliance with applicable requirements. Decommissioning procedures would include initial decontamination, disconnection of operating systems, drainage of liquid-filled systems including liquid helium and liquid nitrogen, physical and administrative controls to limit access, radiological and chemical characterization surveys, and surveillance and maintenance, as necessary. Other decommissioning procedures would likely include dismantling the cryogenic plants, storage of components for future use, packaging components according to U.S. Department of Transportation (DOT) specifications, and shipping them to approved disposal sites.

2.1.8 Avoidance and Minimization Measures

As part of the Proposed Action, SLAC would implement avoidance and minimization measures to reduce or eliminate potential minor adverse construction and operational impacts from this project. These air quality, biological and cultural resources, surface water and groundwater, traffic, health and safety, noise, and waste management measures are summarized below and described in detail in Section 3.

Air Quality

- Implement fugitive dust control measures in compliance with the SWPPP and Bay Area Air Quality Management District (BAAQMD) mandates.
- Minimize greenhouse gas (GHG) emissions in accordance with EOs and site-specific programs.

Biological Resources

- Maintain the required stormwater silt fence around construction areas for the additional purpose of preventing wildlife from entering the site should they occur.
- Restore disturbed areas to preconstruction conditions, including reseeding with a certified weed-free native seed mix.
- Apply SLAC's tree and shrub protection guidelines (SLAC 2013a), where applicable.

Cultural Resources

- Develop and implement an Inadvertent Discovery Plan.
- Train construction workers to avoid impacts on cultural resources and respond appropriately in the event of an unanticipated discovery.

Health and Safety

- Comply with all applicable federal and state regulations that pertain to worker safety and health programs for construction.
- Develop a Site-specific Safety Plan and Job Safety Analysis and require all workers to read and acknowledge the requirements.
- Hold safety "tailgate" meetings at the start of each workday to discuss potential hazards, required hazard controls and lessons learned from previous days.
- Comply with SLAC's approved radiological safety programs.
- Provide fire suppression equipment and shutdown devices to work crews, institute a no-smoking policy, and comply with hot work and other work permits to minimize fire risk.
- Implement emergency preparedness procedures in the event of fires (SLAC 2012).

Hydrology and Water Quality

- Install stormwater BMPs, according to the project-specific construction SWPPP, to minimize erosion and protect water quality in accordance with State Water Resources Control Board and Regional Water Quality Control Board regulations.
- Comply with EISA Section 438 requirements for managing stormwater runoff, including on-site stormwater retention, infiltration, and evapotranspiration
- Dispose of wastewater generated during construction in a manner compliant with site-wide discharge permits.

- Comply with spill prevention and control measures for generators and construction equipment.
- Add shielding and geomembrane to the existing EBD and other high beam loss points.

Noise and Vibration

- Avoid/minimize use of heavy equipment near residences outside of construction hours.
- Minimize noise impacts on residences through design measures including facilities layout and earthen berms.

Transportation

- Prepare a Traffic Control Plan to identify potential transportation routes and facilitate trucking of components and building materials to the construction site, including access from local roadways.
- Coordinate construction traffic from the Proposed Action with construction from other SLAC projects.

Visual Resources

- Reduce visual effects of the cryogenic plants by constructing the plants within topographical depressions, using excavated soil to create perimeter berms, and planting trees and shrubs on the berms.

Waste Management

- Provide for off-site disposal of any regulated waste generated during construction or operation, following federal, state, and local regulations, and DOE and SLAC requirements.

2.1.9 Permits and Approvals

Because the Proposed Action would not require placement of fill in wetlands or waterways or any waterway crossings, the Proposed Action may only need environmental permits and consultations from the following agencies:

- Regional Water Quality Control Board for a Construction General Permit for stormwater discharges;
- National Historic Preservation Act Section 106 consultation with the State Historic Preservation Office (SHPO) regarding potential impacts on historical and cultural resources; and
- BAAQMD permit to operate a stationary emergency standby generator, if required.

2.2 No Action

Under this alternative, LCLS-II would not be constructed. Throughout this EA, no action refers to both the Proposed Action as described above and the original LCLS-II capacity expansion, which DOE decided not to pursue. The no action alternative would not require import of workers and materials, excavation, or other operation of heavy construction equipment. Existing facilities at SLAC would continue to operate under current management practices. In the event that LCLS-II is not constructed, planned research would be constrained to the capabilities and capacity of the existing experiments and research institutions. However, no existing or planned experiment anywhere in the world can provide the research capabilities that would be provided by LCLS-II.

2.3 Alternatives Considered and Eliminated from Detailed Analysis

This section describes alternatives considered during conceptual design but rejected because they do not meet the purpose or mission need, or would be cost-prohibitive and therefore infeasible. The alternatives considered included constructing LCLS-II at a "green field" site at SLAC or at another DOE location.

2.3.1 Add Capacity to LCLS

As described in Section 1, SLAC had been planning to expand LCLS and originally planned to build a new undulator tunnel and a new experimental hall with numerous additional experimental stations. However, as new research opportunities have arisen, and based on BESAC recommendations, this option was rejected based on changing scientific need.

2.3.2 Build LCLS-II at a "Green Field" SLAC Location

Under this alternative, LCLS-II, including installation of a new linac, would be sited and constructed at a new location at SLAC. An alternative site would require substantial additional investigations and construction of a new accelerator housing and klystron gallery. This alternative would not be able to take advantage of existing facilities or LCLS equipment and infrastructure, and there would be increased environmental disturbance from construction of duplicate facilities. Further, construction of duplicate facilities would be cost-prohibitive and therefore infeasible. For these reasons, this alternative was not included in the detailed environmental evaluation.

2.3.3 Build LCLS-II at Another DOE Site

Under this alternative, LCLS-II would be constructed at another DOE facility. However, this would require construction of duplicate facilities that are already available at SLAC, which would be cost-prohibitive. Construction of LCLS-II at SLAC would reuse approximately $400 million in existing equipment and infrastructure and would maximize the $500 million already invested in LCLS. Thus, SLAC is clearly the most effective choice among alternative sites for LCLS-II based on cost and the relatively small incremental environmental consequences of siting the project adjacent to existing building. Therefore, siting the project at an alternate DOE property was not considered reasonable and was not evaluated in detail as an alternative in this EA.

3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter describes the existing physical, biological and socioeconomic features of the area and the potential environmental consequences of each alternative. Section 3.1 summarizes the regional setting including geography, facility history and land use. Section 3.2 describes the methodology used to conduct the assessment with a focus on the terms used to characterize environmental impacts. Section 3.3 summarizes the results of the environmental analysis for both the no action and Proposed Action alternatives. Sections 3.4 through 3.15 describe the affected environment and environmental consequences of the alternatives on the following resources:

- Air quality
- Biological resources
- Cultural resources
- Geology and soils
- Health and safety
- Hydrology and water quality
- Noise and vibration
- Socioeconomics and environmental justice
- Transportation
- Visual resources
- Waste management
- Cumulative effects

The Proposed Action construction and operation, including components fabricated at LBNL, Fermilab, TJNAF, and ANL, would occur entirely within the boundaries of lands leased by DOE for its national laboratories and primarily on land and within existing buildings devoted to DOE Office of Science research. Because DOE would lease or acquire additional land, there would be no changes in land use or disruption of existing land uses. Therefore, this EA summarizes existing land use conditions but does not address land use effects as a potential environmental consequence. Similarly, because neither construction nor operation would require construction of power generation facilities, generate substantial stormwater or wastewater, or require utility relocation or construction that would result in any interruption of off-site residential or commercial utility service, there would be no impacts on utilities and no further analysis is presented in this EA.

Section 3 provides an evaluation of potential environmental impacts from construction and operations at SLAC. However, LBNL, Fermilab, TJNAF, and ANL would only be involved in the construction phase of LCLS-II as the cryomodules and other components are fabricated and assembled. During operations, LCLS-II activities at these sites would cease. Therefore, for these site and resources, Section 3 addresses potential environmental impacts for construction only.

3.1 Regional Setting

SLAC is located on approximately 426 acres of Stanford University-owned land within unincorporated San Mateo County, California. SLAC is located in the foothills of the Santa Cruz Mountains, above the alluvial plain that borders the western margin of the San Francisco Bay. Construction of SLAC and the I-280 freeway has altered local topography, although the regional topographic aspect and drainage directions have not been changed (**Figure 1-1**). The maximum elevation within the SLAC site's boundaries is approximately 375 feet above mean sea level (AMSL). Jasper Ridge, located immediately southwest of the SLAC site's boundary, is the local topographic high at 600 feet AMSL. SLAC is located approximately 2 miles west of the main Stanford University campus.

Stanford University operates SLAC for DOE; the facility specializes in fundamental photon science and particle physics research. The original lease agreement was signed in 1962 between the Atomic Energy Commission (DOE's predecessor) and Stanford University for a period of 50 years. The lease was recently extended by approximately 30 years. The SLAC leasehold is part of the original land grant that established Stanford University; under the terms of the grant, the land cannot be sold and must be held in perpetuity by Stanford University's Trustees to support its educational mission. The current land use at SLAC is a combination of industrial and educational, and includes the Stanford Guest House, which provides accomodations for visiting researchers and others affiliated with or visiting Stanford University.

Construction of SLAC's particle accelerators began in 1962. Operations commenced in 1966 and have been continuous since that time. The dominant structure at SLAC is the 2-mile-long klystron gallery, which overlies the accelerator housing. These structures lie in an east-west orientation (**Figure 1-2**). I-280 crosses over the klystron gallery. Most of the facilities are concentrated in the eastern portion of SLAC (east of I-280) and include offices, research facilities, and support structures. The western area of the SLAC leasehold (west of I-280) supports the existing accelerator housing and klystron gallery (**Figure 1-2**). SLAC routinely updates its facilities, removes outdated and obsolete buildings, and improves its supporting infrastructure, such as parking and utilities.

Land use surrounding the eastern portion of SLAC is primarily medium to high density, with mixed residential, commercial and agricultural development. Sand Hill Road, a busy thoroughfare, borders SLAC to the north, with the high-density residential and commercial development of Sharon Heights to the north. Private homes (Stanford Hills) and grazing land exist along the eastern and southeastern boundaries. The area directly to the south and southeast supports agricultural land (Webb Ranch) and the Portola Valley Training Center (PVTC), a recreational equestrian facility. To the southwest is the 1,200-

acre Jasper Ridge Biological Preserve (JRBP), which is owned by Stanford University and maintained for research and conservation (Stanford University 2014).

3.2 Environmental Assessment Methodology

This section describes the methodology used to assess potential environmental impacts. Impacts are analyzed by evaluating the Proposed Action and no action alternatives, including the type and magnitude of the effect on each resource. Specifically, the magnitude or type and degree of impacts are analyzed by evaluating the following factors:

- Type - beneficial or adverse, direct or indirect
- Context - the geographic, biophysical, and social context in which the effects would occur, whether site-specific, local, regional, national, or global
- Duration and frequency - short-term or long-term
- Intensity - the severity of the impact, in whatever context(s) it occurs

Under NEPA, the intensity of effects is evaluated considering the following variables:

- Effects on public health and safety
- Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas
- The potential for controversy on environmental grounds
- Uncertainty about effects or unique risks
- The potential for establishing a precedent or representing a decision in principle that defines the parameters of a further action
- Cumulative impacts
- Potential adverse effects on "districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places," and the potential for "loss or destruction of significant scientific, cultural, or historical resources"
- Potential adverse effects on an endangered or threatened species or its habitat, or on a critical habitat; and
- Potential for violation of a Federal, state, or local law or requirement "imposed for the protection of the environment." (40 CFR 1508.27)

For the environmental impact analysis, the following descriptions were applied to characterize environmental impacts or effects (the terms “impact” and “effect” are used interchangeably):

- Beneficial impact – an improvement in the condition of the resource
- Adverse impact – a change that would be detrimental or detract from the condition of the resource
- Direct impact – an effect that would occur concurrently with the action

- Indirect impact – an effect that would occur later in time or at a different location, but would be reasonably foreseeable
- Short-term impact – an effect that would not be detectable within a short period because the resource would return to its original condition
- Long-term impact – a change in a resource that would persist or that would essentially be permanent
- No effect – the action would have no measurable detrimental or beneficial effect on the resource
- Minor effect – discernable effect with low severity
- Cumulative impacts - impacts that overlap in space and/or time with the impacts of other past, present, or reasonably foreseeable future actions

3.3 Summary of Impacts

The impact analysis presented in this section is intended to accommodate the full range of potential impacts from the Proposed Action and alternatives so that the range of impacts has been considered and minor changes in the project design would not require additional analysis and would be covered by this EA.

Table 3-1 summarizes the environmental impacts found for each resource evaluated in this section.

Table 3-1 Summary of Environmental Impacts by Resource

Resource Area	No Action	Proposed Action
Air quality	No effect.	Minor adverse impacts from construction and operation.
Biological resources: Wetlands	No effect.	No effect.
Vegetation	No effect.	Minor, local adverse impacts from construction of the cryogenic plants.
Wildlife	No effect.	Minor, short-term local impacts on common wildlife species from construction. No impact on special-status species.
Fisheries	No effect.	No effect.
Cultural resources	No effect.	Minor adverse impacts on historic structures. No impacts on known lithic scatter sites. Potential direct impacts on undiscovered archaeological and paleontological resources.
Geology and soils	No effect.	Minor, short-term impacts on soils from excavation. Minor long-term increased risk of landslides from steep slopes and earthquakes.
Health and safety	No effect.	Minor risk of health and safety impacts, radiological exposure, and accidents.

Table 3-1 Summary of Environmental Impacts by Resource

Resource Area	No Action	Proposed Action
Hydrology and water quality	No effect.	Minor, short-term impacts on surface water quality during construction. Minor operational impacts on stormwater quality.
Noise	No effect.	Minor noise impacts during construction would be minimized through daytime construction. Potential minor operational effects would be minimized through building layout, and planted earthen berms.
Socioeconomics and environmental justice	No effect.	Minor, short-term beneficial impacts from increased construction employment.
Transportation	No effect.	Minor, short-term impacts during construction.
Visual Resources		Minor visual impacts would be minimized by constructing earthen berms adjacent to the cryogenic plants and planting trees and shrubs on the berms.
Waste management	No effect.	Minor, short-term adverse impacts during construction. Minor impacts from hazardous and industrial waste generated during operation.
Cumulative effects	No effect.	Minor cumulative impacts on air quality, vegetation, paleontology, soils and geology, health and safety, flooding, water quality, groundwater, noise, transportation, and waste management.

3.4 Air Quality

This section addresses potential impacts on air quality from emissions of criteria pollutants during construction and operations. Therefore, the air quality analysis focuses on emissions from SLAC and California air quality. Emissions at the component fabrication sites would not increase above existing emissions. Because greenhouse gas emissions only have potential cumulative effects on global climate change, this issue is addressed in Section 3.15, Cumulative Effects.

3.4.1 Affected Environment

California is divided into air basins that are defined generally by their meteorological and topographical characteristics. The Proposed Action is located in San Mateo County, which is within the San Francisco Bay Area Air Basin (SFBAAB). The SFBAAB is characterized by complex terrain, consisting of coastal mountain ranges, inland valleys and bays, which distort wind flow patterns. The Pacific Coast Range is divided by the entrance to San Francisco Bay. Together with the Carquinez Strait to the east, this allows air to flow in and out of the SFBAAB and the Central Valley.

The climate is dominated by the strength and location of a semi-permanent, subtropical high-pressure cell. During the summer, the Pacific high-pressure cell is centered over the northeastern Pacific Ocean, resulting in stable meteorological conditions and a steady northwesterly wind flow. Upwelling of cold ocean water from below the surface because of the northwesterly flow produces a band of cold water off the coast. The cool and moisture-laden air approaching the coast from the Pacific Ocean is further cooled by the cold water band, resulting in condensation, fog and stratus clouds along the coast.

In the winter, the Pacific high-pressure cell weakens and shifts southward, resulting in wind flow offshore, the absence of upwelling and storms. Weak inversions coupled with moderate winds result in more dilution and dispersion and a lower potential for adverse effects. El Nino, or more precisely the El Nino Southern Oscillation (ENSO), is an ocean cycle that periodically produces heavy winter rains in California. During an El Nino event, wind and ocean currents flow eastward, so warm water collects off the west coast of North and South America. Strong El Nino conditions can produce heavier rainstorms, especially in northern California. In contrast, during a La Nina event, which sometimes alternates with El Nino, wind and water flow westward away from the coast and a pool of cooler water forms just offshore, producing drier winters. The ENSO is an integral aspect of the meteorology for the US Pacific Coast. This cycling between El Nino and La Nina occurs every 3-7 years, with widely varying amplitude.

Air quality management programs in California are the responsibility of the local air quality management district (AQMD), the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA). The local AQMD is the BAAQMD.

3.4.1.1 Criteria Pollutants

The ambient air quality in an area can be characterized in terms of whether it complies with National Ambient Air Quality Standards (NAAQS) and State Ambient Air Quality Standards (SAAQS), where applicable. The Clean Air Act (42 U.S.C. 7401 et seq.) requires the EPA to set national standards for emissions considered harmful to public health and the environment (criteria pollutants). Based on air monitoring data, the SFBAAB is currently classified by EPA as a non-attainment/marginal area for the 8-hour ozone standard. In addition, the SFBAAB was recently designated as non-attainment for the new federal fine particle (particulate matter with a diameter of 2.5 microns or less [$PM_{2.5}$]) standard. For all other federal standards, the SFBAAB is in attainment or unclassified. The SFBAAB is currently in non-attainment for both the 1-hour and 8-hour standards for ozone, particles with a diameter of 10 microns or less (PM_{10}), and $PM_{2.5}$ based on state standards. **Table 3-2** presents the NAAQS and SAAQS for each criteria pollutant and the current attainment designations for the SFBAAB.

Table 3-2 Air Quality Standards Attainment Status for the San Francisco Bay Area Air Basin

Parameter		State Standard		Federal Standard	
Ozone	1-Hour	0.90 ppm (180 µg/m^3)	Non-attainment	--	
	8-Hour	0.070 ppm	Non-attainment	0.075 ppm	Non-attainment
Carbon Monoxide	1-Hour	20 ppm (23 mg/m^3)	Attainment	35 ppm (40 mg/m^3)	Attainment
	8-Hour	9.0 ppm (10 mg/m^3)	Attainment	9 ppm (10 mg/m^3)	Attainment

Table 3-2 Air Quality Standards Attainment Status for the San Francisco Bay Area Air Basin

Parameter		State Standard		Federal Standard	
Nitrogen Dioxide	1-Hour	0.18 ppm	Attainment	0.100 ppm	Unclassified
	Annual Arithmetic Mean	0.030 ppm (57 μg/m^3)	Attainment	0.053 ppm (100 μg/m^3)	Attainment
Sulfur Dioxide	1-Hour	250 ppb (655 μg/m^3)	Attainment	75 ppb (196 μg/m^3)	Attainment
	24-Hour	0.04 ppm (105 μg/m^3)	Attainment	0.14 ppm (365 μg/m^3)	Attainment
	Annual Arithmetic Mean	--		0.030 ppm (80 μg/m^3)	Attainment
Particulate Matter (PM_{10})	24-Hour	50 μg/m^3	Non-attainment	150 μg/m^3	Unclassified
	Annual Arithmetic Mean	20 μg/m^3	Non-attainment	- -	
Particulate Matter – Fine ($PM_{2.5}$)	24-Hour	--		35 μg/m^3	Non-attainment
	Annual Arithmetic Mean	12 μg/m^3	Non-attainment	15 μg/m^3	Attainment
Lead	30 day Average	1.5 μg/m^3	Attainment	--	
	Rolling 3-Month Average	--		0.15 μg/m^3	Attainment
	Calendar Quarter	--		1.5 μg/m^3	Attainment

Notes:
-- no standard available
μg/m^3 = micrograms per cubic meter
ppb = parts per billion
ppm = parts per million

Sources: EPA 2013; CARB 2013a; BAAQMD 2014

3.4.1.2 Conformity

EPA requires each state to prepare and submit a State Implementation Plan (SIP) describing how the state will achieve the federal standards by specified dates, depending on the severity of the air quality within the state or air basin. EPA adopted the General Conformity Rule in November 1993 to implement the conformity provision of Title I, Section 176 (c)(1) of the Federal Clean Air Act. This provision requires that the federal government not engage, support or provide financial assistance to licensing, permitting or approving any activity not conforming to an approved SIP. The *de minimis* levels for conformity of each criteria pollutant in non-attainment along with SLAC's Synthetic Minor Operating Permit (SMOP) (BAAQMD 2013) limits are presented in **Table 3-3**.

Table 3-3 Applicable General Conformity to de Minimis Levels

Pollutant	de minimis Levels (Tons/Year)	SLAC's SMOP Limits (Tons/Year)
Ozone (NO_x)*	100	35
Ozone (VOC)*	100	35
PM_{10}/$PM_{2.5}$**	100	35

Notes:

* Ozone is a gas formed when volatile organic compounds (VOCs) and nitrogen oxides (NO_x) undergo photochemical reactions in the presence of sunlight. For this analysis, these two precursors were evaluated as surrogates for ozone. The *de minimis* values for non-attainment areas were used.

** No *de minimis* values have been established for $PM_{2.5}$. As a surrogate, the *de minimis* level for PM_{10} in a moderate non-attainment and maintenance area was used.

3.4.1.3 National Emission Standards for Hazardous Air Pollutants

As of January 2014, SLAC owns and maintains four cleaning units subject to 40 CFR 63, Subpart T "National Emission Standards for Halogenated Solvent Cleaning" which is part of the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. These units include a batch vapor degreaser using 1,1,1-trichloroethane, a near-zero emission (NZE) batch vapor degreaser using perchloroethylene, a batch vapor cleaning system using trichloroethylene, and a batch cold cleaner using Dynasolve 210 (consisting of primarily methylene chloride). As described in SLAC's annual NESHAP report for halogenated solvent cleaning (SLAC 2014a), all units were operated in accordance with the applicable NESHAP emissions limits, and there were no exceedances of regulatory limits.

As described in SLAC's Annual Site Environmental Report (SLAC 2013b), SLAC operations result in releases of radioactivity to air. The estimated annual radioactivity releases from SLAC to the ambient air are well below both the regulatory limits for the annual release of radionuclides (2,000 Curies per year [Ci/year]) per NESHAP and the maximum dose at the site boundary of 10 millirems per year (mrem/year) (40 CFR Part 61). Further information regarding the on- and off-site doses and risks from radionuclides in air and other media is presented in Section 3.8, Health and Safety.

3.4.2 Environmental Consequences

3.4.2.1 No Action

Under the no action alternative, the Proposed Action would not be constructed and no air quality impacts would occur. Therefore, the no action alternative would not result in impacts on air quality. Other facilities and experiments at SLAC, and other DOE sites involved in component fabrication, would continue to operate.

3.4.2.2 Proposed Action

Construction

The Proposed Action would emit criteria pollutants and greenhouse gases. Air quality impacts from criteria pollutant emissions would be intermittent and short term. Construction would generate emissions including those listed as non-attainment in the SFBAAB (VOCs, NO_x, PM_{10}, and $PM_{2.5}$). Construction would likely occur between 2015 and 2018 and involve construction activities including clearing and grubbing, excavation, installation of retaining walls, installation of subgrade utilities, preparation of foundation and pads, building construction, building finishing, and paving. Because any work that would occur in 2015 would be early preparatory work, such as removing equipment from existing buildings, the air quality analysis was conservative by combining those activities into the emissions analysis for 2016. Emissions were calculated using the CalEEMod Environmental Management Software. The CalEEMod model calculates both construction and operational source emissions using equipment emission factors (mass of emissions per unit time) from sources such as EPA, CARB, and site-specific information. CalEEMod also provides default values to quantify sources when site-specific information is not available.

Annual emissions calculated from CalEEMod were compared with general conformity *de minimis* levels and SLAC's SMOP limits for emissions of criteria pollutants (**Table 3-4**). Proposed Action construction emissions would not exceed general conformity *de minimis* levels for any of the evaluated pollutants. In addition, it would not result in overall SLAC emissions of VOC (12.8 tons/year), NO_x (19.5 tons/year), PM_{10} (less than 1 ton/year), or $PM_{2.5}$ (less than 1 ton/year) exceeding permit limits. Modeling methods and results are presented in Appendix A.

Table 3-4 Estimated Proposed Action Construction Emissions

Construction Year	Annual Emissions (tons per year)			
	VOCs	**NO_x**	**PM_{10}**	**$PM_{2.5}$**
2016	0.86	10.5	1.17	0.78
2017	0.45	5.76	0.97	0.60
2018	0.25	2.28	0.84	0.48
de minimis Levels	100	100	100	100
Overall SLAC Emissions*	12.8	19.5	<1	<1
SLAC's SMOP Limits	35	35	35	35
Exceed *de minimis* Levels or SMOP Limits?	No	No	No	No

Note:
* Overall SLAC emissions do not include emissions from the Proposed Action.

Further, fugitive dust control measures would be installed in compliance with the SWPPP, which would reduce PM_{10} and $PM_{2.5}$ emissions.

Fabrication of components at LBNL, Fermilab, TJNAF, and ANL would not result in new air emissions and would be continuous with ongoing operations at these facilities. The work would be conducted within existing buildings, laboratories, and machine shops that are routinely used to fabricate, clean, and test prototype equipment as well as manufacture components for use at DOE national laboratories and research facilities. Therefore, fabrication of components at these sites would result in little or no incremental increase in emissions beyond those already generated by those facilities and any environmental impacts would be negligible.

Operations

The Proposed Action would result in an increase in energy consumption, water, and vehicle trips. Operational emissions associated with the daily activities would result from increased vehicular trips to and from the site (i.e., various types of mobile vehicles). Increases in vehicular trips would result from an estimated additional six employees to operate the cryogenic plants and beam delivery systems. Energy consumption would include electricity for the injector, cryogenic plants, lighting, and equipment. The project would also consume water and natural gas for space heating. CalEEMod was used to estimate criteria pollutant emissions from mobile, area and energy sources during operations (**Table 3-5**).

Table 3-5 Estimated Proposed Action Operational Emissions

Emission Source	Annual Emissions (tons per year)			
	VOCs	**NO_x**	**PM_{10}**	**$PM_{2.5}$**
Area	0.305	0.000	0.000	0.000
Energy	0.004	0.034	0.003	0.003
Motor Vehicles	0.005	0.010	0.009	0.003
TOTAL	0.31	0.04	0.01	0.01
de minimis Levels	100	100	100	100
Overall SLAC Emissions*	12.8	19.5	<1	<1
SLAC's SMOP limits	35	35	35	35
Exceed *de minimis* Levels or SMOP Limits?	No	No	No	No

Note:
* Overall SLAC emissions do not include emissions from the Proposed Action.

Operation of LCLS-II would result in minimal incremental effects on air quality from hazardous air emissions. Operations would not increase halogenated cleaning solvent use. Operations would result in activation of air and water vapor adjacent the beam; however, consistent with existing accelerator operations, SLAC would retain this air for the maximum practicable duration to allow radioactive decay prior to release. Radionuclide emissions during operations at SLAC are minimal and LCLS-II would not increase hazardous air emissions substantially. SLAC would continue to implement NESHAP programs (40 CFR 61, Subpart H) to meet regulatory and DOE requirements.

Operational emissions from the Proposed Action would not exceed *de minimis* levels or SLAC's SMOP limits for VOCs, NO_x, PM_{10}, or $PM_{2.5}$ nor would the operational emissions substantially increase hazardous air emissions; therefore, air quality impacts would be minor.

3.5 Biological Resources

This section addresses potential impacts on biological resources including wetlands and aquatic habitat, vegetation, wildlife, and fisheries located near the Proposed Action. The evaluation addresses the areas directly affected by construction and operations including staging areas, access routes, and directly adjacent habitat. This section also addresses potential biological impacts at component fabrication sites, which would consist of existing buildings at DOE national laboratories and research facilities.

3.5.1 Affected Environment

SLAC is located on the western end of the Stanford University Campus. The majority of areas within the project area are developed and landscaped. However, areas to the north and south of SLAC, and areas surrounding the proposed cryogenic plants provide open space and natural habitats.

3.5.1.1 Wetlands and Aquatic Habitats

No wetlands or aquatic habitats occur directly within the Proposed Action footprint. However, San Francisquito Creek, Bear Creek, numerous unnamed tributaries, and other aquatic habitats (such as freshwater wetlands) are present in the area. The closest waterway to the project area is an unnamed, intermittent stream approximately 500 feet east of the larger cryogenic plant site at Sector 4. This stream functions as a drainage ditch, is directed under the klystron gallery via a corrugated metal pipe, and subsequently discharges to San Francisquito Creek. This ditch flows during storms but has no headwaters and therefore receives its flows by overland flow and direct precipitation during storms. It is dry during non-rainy periods and during the summer and fall. This feature has dense riparian vegetation and has a steep slope and cobble bed.

San Francisquito Creek occurs to the south of SLAC, approximately 800 feet from the cryogenic plant sites and Bear Creek is located 400 feet from the west end of the accelerator housing. The mainstem of San Francisquito Creek originates at the confluence of Bear Creek and Corte Madera Creek just below Searsville Lake in the Jasper Ridge Biological Preserve. Small emergent wetland areas occur to the north of the SLAC boundary along other unnamed tributaries of San Francisquito Creek approximately 1 mile east of the proposed cryogenic plant site at Sector 4. **Figure 3-1** depicts the location of San Francisquito Creek, Bear Creek, the drainage ditch, and the unnamed tributaries in the project area.

3.5.1.2 Vegetation

Vegetation communities found at SLAC include landscaped areas and non-native annual grasslands. The areas east of I-280 consist primarily of industrial areas associated with SLAC's existing experimental facilities and are either developed or landscaped. The area west of I-280 consists primarily of non-native annual grasslands. The grass species present within the non-native annual grasslands are those typically found within the adjacent JRBP (DOE 2002a). The grasslands are dominated by non-native, annual grasses and patches of scrub and tree species. Oak trees, including valley oak (*Quercus lobata*) and coast live oak (*Quercus agrifolia*), occur in a patchy distribution throughout the open space areas. Riparian vegetation occurs along San Francisquito Creek, Bear Creek, and their tributaries.

3.5.1.3 Wildlife

Wildlife use of the project area is likely limited to species that are highly adapted to the built environment and able to forage in the suburban/grassland interface. The landscaped areas support California ground squirrel (*Otospermophilus beecheyi*) and black-tailed jackrabbit (*Lepus californicus*), which likely forage in landscaped areas; black tailed deer (*Odocoileus hemionus columbianus*); striped skunk (*Mephitis mephitis*); and opossum (*Didelphis virginiana*). These areas around SLAC also support mountain lion or cougar (*Puma concolor*), which have been observed in the adjacent Jasper Ridge Biological Preserve. The dense riparian habitat found along San Francisquito Creek and the unnamed tributary provide suitable habitat for song birds such as black phoebe (*Sayornis nigricans*), song sparrow (*Melospiza melodia*), spotted towhee (*Pipilo maculatus*), and western scrub-jay (*Aphelocoma californica*). The large oaks provide suitable nesting and roosting habitat for raptors such as red tailed hawk (*Buteo jamaicensis*), Cooper's hawk (*Accipiter cooperii*), and red-shouldered hawk (B. *lineatus*).

Special status species with potential to occur within the project vicinity include California red-legged frog (CRLF), California tiger salamander, western pond turtle (WPT), and steelhead (O. *mykiss*). San Francisquito Creek provides suitable habitat for these species, and known occurrences are recorded in the California Natural Diversity Database (California Department of Fish and Wildlife [CDFW] 2014). Steelhead habitat occurs only in San Francisquito Creek and this species would not be affected by the Proposed Action. There is limited habitat for California tiger salamander north of San Francisquito Creek, with no recorded occurrences north of the creek or Lake Lagunita at the eastern end of the Stanford University campus (CDFW 2014). Mature oaks and snags may provide limited roosting areas for special-status bats that occur in the region, including long-legged myotis (*Myotis volans*), Yuma myotis (*Myotis yumanensis*), and long-eared myotis (*Myotis evotis*). Pallid bat (*Antrozous pallida)* occurs in the region but is a large bat that roosts in large groups in caves and rock outcroppings. Although unlikely, CRLF and WPT have the potential to occur on or near the project site and are described in further detail below.

CRLF (*Rana draytonii*) is a federal-listed threatened species and a California species of concern. U.S. Fish and Wildlife Service (USFWS) designated critical habitat for this species in 2010 (Federal Register 75: 12815, March 2010). CRLF are typically found in deep, cool pools or slow-moving streams with dense, emergent vegetation. Upland dispersal habitat is also preferred, and adult CRLF are known to migrate long distances between breeding habitats. The freshwater wetlands located along tributaries north of the SLAC boundary may provide suitable habitat for CRLF, and the adjacent non-native annual grassland habitat could provide potential dispersal and aestivation habitat for CRLF. However, no known occurrences have been documented in these areas (CDFW 2014). The closest known occurrences to the project site are approximately one mile north of SLAC at Lawler Ranch Road and in downstream reaches of San Francisquito Creek approximately 0.2 miles south of the klystron gallery (CDFW 2014).

WPT (*Actinemys marmorata*) is a California species of special concern. This aquatic species is found within freshwater streams and ponds throughout Northern California. This species can be found in many lakes, ponds, reservoirs, and slow-moving streams and rivers, which provide suitable basking habitat and shore areas for nesting. WPT are known to occur in San Francisquito Creek. The unnamed drainage that crosses under the klystron gallery near Sector 7 does not provide suitable habitat for WPT because it is ephemeral and has steep slopes. The unnamed tributaries and adjacent wetlands located approximately 5,000 feet to the east of the project site and north of Sector 20 and the SLAC boundary may provide suitable habitat for WPT, although dispersal of WPT to these features would be unlikely due to the physical barriers between known habitat and these locations. There are no documented occurrences of WPT in the aquatic features north of SLAC (CDFW 2014).

Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

- DRAINAGE DITCH (APPROXIMATE LOCATION)
- STREAM/CREEK
- SEARSVILLE RESERVOIR
- PROPOSED CRYOGENIC PLANT AREA
- SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

N

0 1,200 Feet

Graphic Scale: 1" = 1200'

SLAC LCLS-II EA

WATER RESOURCE LOCATIONS

ARCADIS

FIGURE 3-1

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3.5.1.4 Fisheries

San Francisquito Creek provides suitable habitat for common fish species such as roach (*Hesperoleucus symmetricus*), Sacramento sucker (*Catostomus occidentalis*), three-spined stickleback (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*), and steelhead.

3.5.1.5 Biological Resources at Component Fabrication Sites

Biological resources potentially affected by fabrication of LCLS-II components at LBNL, Fermilab, TJNAF, and ANL, would be those located directly adjacent to existing buildings and access roads within the industrial areas of these sites. These would consist primarily of grassy, landscaped areas and would not include wetlands, wildlife, streams, or other sensitive habitats.

3.5.2 Environmental Consequences

3.5.2.1 No Action

The no action alternative would not involve construction or operation of LCLS-II at SLAC; therefore, no impacts on biological resources would occur. Therefore, the no action alternative would not affect wetlands, vegetation, wildlife, or fisheries. SLAC would continue to operate existing experimental facilities, including LCLS. Similarly, LBNL, Fermilab, TJNAF, and ANL, would continue to operate their existing facilities.

3.5.2.2 Proposed Action

Construction

<u>Wetlands and Aquatic Habitat</u>

The Proposed Action would not directly or indirectly affect wetlands or other aquatic habitat. The cryogenic plants would be constructed within non-native grassland habitat. The plant at Sector 4 would be 500 feet from an unnamed ephemeral stream and approximately 5,000 feet from the two freshwater wetlands north of the SLAC boundary. A SWPPP would be developed for construction activities and would identify specific BMPs to prevent any indirect impacts on wetlands and aquatic habitat.

<u>Vegetation</u>

The Proposed Action would have both temporary and permanent effects on grasslands at SLAC. Construction of the cryogenic plants would have permanent effects on non-native grassland. Construction may result in removal of several young native oaks as well as other non-native trees; however, none of the larger oaks in adjacent grasslands would be removed, and temporary impacts on oaks near construction areas would be minimized per SLAC's Tree and Shrub Protection Guidelines (SLAC 2013a). This would require the construction contractor to install temporary fencing around trees that must be avoided during construction and by replanting if native trees are removed. The staging area for construction of the cryogenic plants would be located between Sectors 0 and 4 in between Gallery Road and the haul road

(**Figure 3-1**) in an area characterized by non-native grasses and trees. Disturbed areas would be restored to preconstruction conditions by reseeding with a certified weed-free, native seed mix.

<u>Wildlife</u>

The Proposed Action would not directly or indirectly affect federal- or state-listed species. No special status species have been observed within the SLAC boundary (CDFW 2014).

The Proposed Action is not located within CRLF critical habitat, designated in 2006 and revised in 2010 (75 FR 12816). Although unlikely, the species with the potential to occur near the project site are CRLF and WPT. The cryogenic plant at Sector 4 would be located approximately 500 feet west of an unnamed drainage. As observed during a February 2014 site visit, this drainage would not provide quality CRLF habitat, except under ideal conditions, because it is ephemeral and has steep side slopes. However, the intermittent tributaries approximately 1 mile to the east and adjacent wetlands in areas north of the SLAC boundary could provide potentially suitable habitat for CRLF. These areas are densely vegetated with cattails and other emergent vegetation. These features appeared to be mostly dry during the February 2014 site visit. However, there are no known occurrences of CRLF in these features according to the California Natural Diversity Database (CDFW 2014). Known CRLF occurrences at Lawler Ranch Road and in San Francisquito Creek are located at least 1 mile from the project boundary and are separated from the area by substantial physical obstacles to migration, including Sand Hill Road, Alpine Road, I-280, the Klystron Gallery, and other SLAC buildings and roadways.

Although there are no know occurrences of CRLF, and there are numerous physical barriers preventing their access to the project site, prior to the start of construction, SLAC would conduct site reconnaissance and install a silt fence to prevent erosion and sedimentation. The silt fence would be anchored to the ground with straw wattles and wooden stakes and therefore, would serve as an exclusion fence to prevent wildlife from entering the work area. A biologist would supervise installation of the fencing along the boundaries of the work areas. The fence would be monitored periodically during construction, and within 48 hours after rain, to ensure that it remains in good repair.

SLAC would also ensure that all workers would attend a Worker Environmental Awareness Program (WEAP) session. The WEAP would address the potential presence of endangered or threatened wildlife species, the species' sensitivity to human activities, the legal protection afforded to these species, the penalties for violating these legal protections, their responsibilities, and applicable protective measures.

WPT are known to occur in San Francisquito Creek. The unnamed ephemeral stream, located approximately 500 feet from the proposed cryogenic plant at Sector 4, does not provide preferred suitable habitat for WTP because of its steep slopes and ephemeral flow. San Francisquito Creek and Bear Creek are west and south of the project area and provide the closest suitable habitat for WPT. However, it would be unlikely that a dispersing turtle would reach the LCLS-II site because of the numerous physical barriers. The two freshwater wetlands, located approximately 5,000 feet east of the Sector 4 cryogenic plant construction area, may provide suitable habitat for WPT. However, given the distance from known habitat and the presence of physical barriers between the project area and the creek, and the absence of documented occurrences of WPT at SLAC (CDFW 2014), WPT are highly unlikely to occur within the project area and there would be no impacts on WPT from the Proposed Action.

The large oak trees located immediately beyond the project boundary provide limited wildlife habitat. Most of these oaks exist as single trees and are not oak woodlands or oak forests, which are stands of oaks of at least one hectare (approximately 2.5 acres) and in which oaks dominate the landscape (oak woodlands) or include oaks with at least 10 percent canopy cover (oak forest) (Gaman and Firman 2008; California Board of Forestry and Fire Protection. 2006). Species occurring in this area may include songbirds, deer, raptors, and bats. These trees may provide some potential nesting habitat for raptors, other birds, and, although dense oak stands would provide much higher quality habitat, cavities or deep cracks in bark of these isolated trees could provide temporary roosting sites for bats. Construction would result in a temporary increase in noise levels, lighting, and human activity, which could disturb wildlife near the construction site, potentially reducing their use of adjacent natural habitats. However, as described above, the areas adjacent to the klystron gallery and other buildings at the west end of SLAC project area is likely limited to species that are adapted to human activity. In addition, the larger isolated trees near the cryogenic plant construction sites would not be removed and construction would not result in direct effects. Sensitive species, such as birds and bats using these areas, would avoid the immediate area around the construction site. Furthermore, these effects would be temporary and limited to daytime construction hours.

To further limit impacts on birds, SLAC would to the extent practicable conduct the initial site preparation, excavation, and construction of soil berms between August 16 and January 31, which is outside of the breeding season. If these activities begin during the breeding season (February 1 through August 15), a biologist would conduct site reconnaissance to determine the presence of nesting birds, establish a buffer zone to minimize potential impacts if nesting birds are present, and work with the construction contractor to minimize construction noise in areas adjacent to occupied nests.

Similarly, SLAC would minimize impacts on bats to the extent practicable by conducting the initial site preparation, excavation, and construction of soil berms outside of seasonal periods of bat activity (approximately February 15 through April 15 and August 15 through October 30). Prior to construction, a biologist would conduct an assessment to determine the presence of roosting bats and would implement protective measures including establishing a buffer zone, working with the contractor to minimize construction noise.

Construction access, including to the cryogenic plant sites, would be via existing paved roadways and the east-west unpaved haul road (**Figure 2-1**). Therefore, no access roads would be constructed and construction would not interfere with wildlife movement corridors.

Fisheries

Construction of the Proposed Action would occur within 800 feet of San Francisquito Creek and primarily on the north side of the klystron gallery. However, the construction contractor would use stormwater runoff quantity and quality protection measures to eliminate potential impacts on fish in San Francisquito Creek. The contractor would be required to prepare and implement a SWPPP prior to construction. The SWPPP would identify specific stormwater BMPs to reduce the potential for water quality degradation during construction. With implementation of the project SWPPP, LCLS-II would not result in direct or indirect impacts on fish or other species in San Francisquito Creek.

Biological Resources at Component Fabrication Sites

Fabrication of LCLS-II components at LBNL, Fermilab, TJNAF, and ANL, would be conducted within existing buildings currently used to fabricate research equipment and would not require excavation, grading, or construction of new buildings, utilities, or access roads. Component fabrication would not require wetland or floodplain fill, removal of vegetation, disturbance of wildlife or their habitat, steam diversion, or new discharges to waterways. Therefore, any incremental effects from construction of LCLS-II components on biological resources at these locations would be negligible.

Operations

Wetlands and Aquatic Habitat

Operation of the Proposed Action would have no effect on wetlands or aquatic habitat. Operations would occur within the footprint of industrial facilities and would not affect wetlands or San Francisquito Creek, its tributaries, or the ephemeral stream. With the exception of the cryogenic plants, all LCLS-II equipment operations would occur within the footprint of existing buildings and would be served by the existing stormwater drainage system. The areas around the cryogenic plants, including the soil berm, would be required to comply with the stormwater General Construction Permit and EISA Section 438 as well as SLAC's existing industrial SWPPP (SLAC 2007a). The potential for accidental spills of oil would be addressed in the Spill Prevention, Control and Countermeasure (SPCC) Plan (SLAC 2013d). Because operation of the Proposed Action would not result in a direct or indirect discharge of stormwater, no effects on wetlands and aquatic habitats would occur.

Vegetation

LCLS-II operations would occur within developed areas and therefore would have no effect on grasslands or other vegetation.

Wildlife

Operation of equipment would occur indoors within existing buildings. Potential impacts on wildlife could occur as a result of vehicle collisions with SLAC vehicles, SLAC personnel vehicles, and delivery trucks. However, workers and trucks would be required to observe posted speed limits and other traffic and vehicular safety requirements of the SLAC ESH&Q Manual; therefore, wildlife collisions would be unlikely. The Proposed Action would not affect migration corridors because most operations would occur within existing buildings.

Operations would result in an increase in noise levels, lighting, and human activity, which could disturb wildlife in the area around the cryogenic plants, potentially reducing their use of adjacent natural habitats. However, wildlife in the area are acclimated to human activity and impacts from operations, such as operations and maintenance activity around the cryogenic plants, would be similar to existing activities at the western end of the accelerator housing and klystron gallery. Few numerical thresholds or criteria exist regarding potential impacts of noise on birds and other wildlife. Some jurisdictions (e.g., County of San Diego) have adopted a 60 decibel threshold for special-status bird species, based on a bird's ability to vocalize loud enough to ensure successful breeding (Bioacoustics Research Team 1997; AASHTO 2008). However, as described in detail in Section 3.8, Noise and Vibration, noise levels directly adjacent to the cryogenic plants (at a distance of 5 feet outside the cryogenic plant wall) would be approximately 61.5 to 64 decibels. Given the noise attenuation that would be provided by soil berms around the plants, only the area immediately adjacent to the plants would exceed 60 decibels. Because most of the area around the plant is treeless, noise impacts on birds and wildlife would be minor.

Fisheries

Operation of the Proposed Action would not affect steelhead populations in San Francisquito Creek, as operations would occur within the proposed new cryogenic plants and existing buildings. Any impacts on water quality or the volume of stormwater runoff would be addressed by the site-wide industrial SWPPP (see Section 3.9 of this EA).

3.6 Cultural Resources

This section addresses potential impacts on cultural resources at SLAC as well as at LBNL, Fermilab, TJNAF, and ANL. Cultural and historical resources include a broad range of objects, places, structures, and districts created or influenced by human use or occupation or recognized in past or current cultural practice. Examples include: single artifacts; habitation sites; resource collection areas; ritual or social observation locations; landforms of significance; trash dumps; roads, buildings and structures; and paleontological localities. Cultural and historical resources may include traditional resources, sacred sites, or traditional use areas that are important to a community's practices, beliefs, and cultural identity. Cultural resources may have archaeological, architectural, or traditional cultural significance. Architectural resources include standing buildings, bridges, dams, and other structures of historic significance.

The Proposed Action is subject to the National Historic Preservation Act (NHPA), Section 106, as amended. Section 106 requires that any federal or federally assisted project or any project requiring federal licensing or permitting consider the effect of the undertaking on historic properties listed in or eligible for the National Register of Historic Places (NRHP). NHPA/Section 106 procedures are addressed in 36 CFR 800.1, et seq. The NHPA also established the NRHP, the official list of the properties significant in terms of prehistory, history, architecture, or engineering. The NRHP is administered by the National Park Service, and properties listed in the NRHP may be privately or publicly owned. To meet the evaluation criteria for eligibility, a property must retain historic integrity and meet one of the following criteria:

- Criterion A: A property is associated with events that have made a significant contribution to the broad patterns of our history; or
- Criterion B: A property is associated with the lives of persons significant in our past; or
- Criterion C: A property embodies the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possesses high artistic values, or that represents a significant and distinguishable entity whose components may lack individual distinction; or
- Criterion D: A property has yielded, or may be likely to yield, information important in prehistory or history (36 CFR 60.4).

Resources less than 50 years old are not typically considered eligible for the NRHP; however, they may be eligible if they are of exceptional importance or if they have the potential to gain significance in the future per special NRHP considerations. Properties may be of local, state, or federal significance. Properties that are listed or eligible or that meet the NRHP evaluation criteria are historic properties according to the NHPA.

Section 106 of the NHPA requires a federal agency official to take into account the effects of a federal undertaking on historic properties, and afford the State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation (ACHP) an opportunity to comment (36 CFR Part 800). Section 106 requires an assessment of the potential effect of an undertaking on historic properties within the proposed project's Area of Potential Effect (APE). The APE is defined as "the geographic area(s) within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." Consultation with the SHPO, Indian tribes, and other consulting parties such as an applicant, the involved local governments, and the public also are a part of the Section 106 process. Major steps in the Section 106 process are the identification and evaluation of potentially affected historic properties, determination of potential effects of an undertaking on historic properties, determination of adverse effects, and resolution of any adverse effects.

3.6.1 Affected Environment

The affected environment for cultural resources is the footprint of the Proposed Action, including the cryogenic plant sites and staging areas. As SLAC recently reached its 50-year anniversary, and in compliance with the NHPA, Stanford University conducted a site-wide archaeological investigation

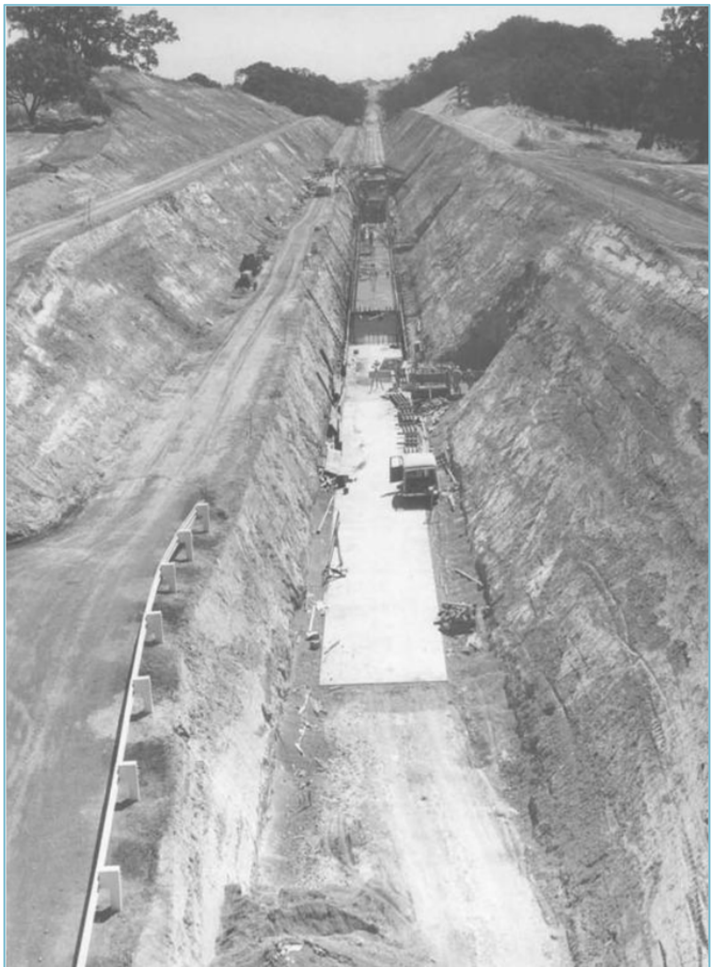
(Jones 2012). This survey included an assessment of archaeological and paleontological resources, consultation with the Muwekma Ohlone Tribe, and identification of historic structures and their contribution to scientific history: SLAC experimental facilities are associated with six Nobel Prizes—four in physics and two in chemistry.

Records for all known cultural resources in the affected environment are on file at Stanford University. Previous cultural resource studies identified lithic scatter sites and remnants of Camp Fremont tunnels (DOE 2002a; Jones 2012). Historic archaeological materials associated with the 19th century Martin North Ranch were recorded near San Francisquito Creek, south of the Proposed Action area and well outside the project footprint. Tunnels associated with Camp Fremont were identified during construction of SLAC in the 1960s. The tunnels were located in the main campus area approximately 2 miles east of the Proposed Action site. Previous studies also examined and documented SLAC historic structures, including the accelerator housing and klystron gallery. The original construction of the linear accelerator entailed considerable ground disturbance, affecting an area considerably wider than the accelerator housing (**Figure 3-2**) and left intact deposits only in undeveloped areas. Sites found during archaeological surveys of the western end of SLAC were outside the SLAC boundary along the banks of San Francisquito Creek to the south.

Previous paleontological studies identified vertebrate and invertebrate fossil resources, including six invertebrate fossil localities within 1 mile of SLAC. The most common invertebrate fossils in the area are marine fossils such as clams and snails. The most notable vertebrate fossil found in the area is a nearly complete specimen of *Paleoparadoxia*, which was discovered during SLAC excavations in 1964 (DOE 2002a). *Paleoparadoxia* is an herbivorous marine mammal of the extinct order Desmostylia, and the SLAC specimen represents the only complete post-cranial skeleton of *Paleoparadoxia* from North America. This specimen was found in the Miocene age Ladera Sandstone, whereas the Proposed Action would be constructed in the Eocene age Whiskey Hill Formation (see Section 3.5, Geology and Soils). Other vertebrate sites in the area include fossils of a seal-like mammal (*Allodesmus*) and other marine mammals. Younger (Pleistocene) fossil resources identified in the area include a large mastodon tusk found in the bank of San Francisquito Creek, a multi-taxon terrestrial fauna site found near the Stanford University Medical Center and other various isolated remains (Branner et al 1906). Because vertebrate fossils are less common than invertebrate fossils and taxa are often represented by very few or individual specimens, identifiable remains could add important information to the fossil record.

At the component fabrication sites, the affected environment would consist of existing buildings containing active offices, machine shops, laboratories and clean rooms with the equipment required to fabricate the cryomodules and other components of the LCLS-II superconducting linear accelerator.

Figure 3-2 View of Excavation for Accelerator Housing Looking East from Sector 0



Source: SLAC ER Photo Archive (Photo 51 M35-4) (July 26, 1963)

3.6.2 Environmental Consequences

3.6.2.1 No Action

The no action alternative would not affect historic properties or tribal interests. Current procedures for resource identification, evaluation, and management established by Stanford University as well as LBNL, Fermilab, TJNAF, and ANL, would remain in effect.

3.6.2.2 Proposed Action

Construction

To evaluate potential effects of the Proposed Action on archaeological resources, SLAC worked with the Stanford University archaeologist to complete reconnaissance surveys of the project area to identify sites with archeological resources. These reconnaissance surveys were conducted for the area of the proposed cryogenic plant sites and areas that would be affected by utility construction and construction staging areas. The areas adjacent to the accelerator housing were highly disturbed by previous excavation; therefore, the survey did not encompass these areas.

Prehistoric and historic properties discovered in the SLAC area during previous investigations were located outside of the footprint of the Proposed Action (Jones 2014). Construction would have no impacts on known resources, such as the lithic scatters and other sites adjacent to San Francisquito Creek. Undiscovered sites could be present; however, the area has a low potential for prehistoric village sites, cemeteries, or bedrock features. There are no Indian Trust Assets within or near the project footprint. Although impacts on undiscovered archaeological sites could occur, these types of resources would be unlikely to occur in close proximity to the accelerator housing because of previous construction disturbance. An Inadvertent Discovery Plan would be developed and implemented during construction. Construction workers would be trained to recognize and avoid impacts on cultural resources and to respond appropriately in the event of an unanticipated discovery.

In the event that human remains were discovered, a treatment plan would be required and would be developed with input from the principals involved. Discovery of human remains requires securing the find to protect it, redirection of project activity away from the find, and immediate notification of the County Coroner.

The Proposed Action would affect existing SLAC buildings older than 50 years, including at Sectors 0 through 10 of Building 001 (the Accelerator Housing) and Building 002 (the Klystron Gallery), which were constructed in 1964 and 1965, respectively (**Figure 3-3**). The Accelerator Housing was constructed of reinforced concrete, whereas the klystron gallery is constructed of corrugated metal cladding with steel doors. Because the proposed superconducting accelerator is consistent with designed use and would be constructed underground within the existing Accelerator Housing, and the Klystron Gallery would be used as-is to house new equipment, the Proposed Action would have no effects on these structures (Page and Turnbull 2014).

The Proposed Action area is not likely to expose or encounter remnant sections of the Camp Fremont training tunnels. These tunnels were constructed by Camp Fremont for training purposes during World War I and were abandoned in 1919. Remnant sections of those tunnels were encountered in the 1960s during SLAC construction; however, they do not occur in the project area nor would the Proposed Action affect archaeological materials associated with the 19th century Martin North Ranch, which is located south of SLAC.

DOE correspondence with the SHPO regarding the potential impacts of LCLS-II on historic structures and archaeological resources is presented in Appendix B.

Figure 3-3 Existing Structures in the Project Area (Building 001-Accelerator Housing [entrance shown at left] and Building 002: Klystron Gallery [right])

Invertebrate fossil resources could be encountered during excavations for the cryogenic plant foundations. Because invertebrate fossils would not add to the fossil record, this impact would be minor. Vertebrate fossil resources have moderate potential for discovery during excavation. Construction crews would be trained to redirect project activity away from any discoveries and to contact a qualified paleontologist to secure the site and determine a course of action.

Fabrication of LCLS-II components at LBNL, Fermilab, TJNAF, and ANL, would be conducted within existing buildings currently used to fabricate research equipment and would not require excavation or grading for new buildings or access roads that could disturb buried cultural or historical resources, or demolition or alternation of historic structures. Therefore, any incremental effects from fabrication of LCLS-II components on cultural resources at these locations would be negligible.

Operations

Once constructed, operations of the Proposed Action would involve access to and use of support facilities and buildings at SLAC. These activities would have no impact on archaeological, historical, or paleontological resources.

3.7 Geology and Soils

This section describes the existing geological and soils environment, including surface conditions and subsurface bedrock. It then describes potential environmental consequences, including excavation of soil and rock.

3.7.1 Affected Environment

3.7.1.1 Geology

SLAC is located in the foothills of the Santa Cruz Mountains, west of San Francisco Bay on the San Francisco Peninsula. The steep topography of the region has been created by active strike-slip and compressional tectonics. Bedrock underlying SLAC consists primarily of a thick sequence of marine sandstones, siltstones and shales that range in age from Eocene to Miocene (55 to 5 million years old). These sedimentary units include (from oldest to youngest) the Whiskey Hill Formation, Ladera Sandstone, and Monterey Formation.

SLAC geology has been extensively researched and documented since the 1950s, culminating in the publication of a SLAC-specific geological report (SLAC 2006a). Steeply dipping beds of the Whiskey Hill Formation are exposed at the western and east-central portions of SLAC. The Whiskey Hill Formation is between 3,000 to 4,000 feet thick near SLAC and is composed of poorly sorted, coarse-grained sandstone and interbedded claystones, siltstone, and glauconitic sandstone. The Whiskey Hill Formation also contains extensively deformed chaotic zones consisting of a mudstone matrix with mostly sandstone blocks (Pampeyan 1993, SLAC 2006a). The Ladera Sandstone is exposed in a broad syncline along the eastern portion of SLAC (Page 1993). The Ladera Sandstone consists of silty sandstone, which grades to sandy siltstone and lesser amounts of claystone, siltstone, and pebbly sandstone. The Ladera Sandstone has produced numerous fossils, including *Paleoparadoxia* (an herbivorous marine mammal), seal and whalebones, shark teeth, mollusks, fish scales, and foraminifera (single-celled organisms with shells) (SLAC 2006a). Prior to the original excavation, the hard, silty claystones of the Monterey Formation were exposed along the axis of the Central Syncline between Sectors 17.5 and 20.5. Stratigraphic thickness of the Monterey Formation where exposed along the Central Syncline is approximately 300 feet (SLAC 2006a).

Quaternary (less than 10,000 years old) alluvium, colluvium, landslide, and terrace deposits are also intermittently present at SLAC. These deposits reach a maximum thickness of 22 feet. Native fill derived from excavation of Miocene and Eocene sedimentary rocks is present along the entirety of the existing accelerator and beneath many of the other existing facilities. Non-native (i.e., not locally derived) fill material is present beneath the Sand Hill Road – I-280 interchange north of SLAC (SLAC 2006a).

Geologic Hazards

Most geologic hazards at SLAC are seismically induced and include ground shaking, fault rupture, ground deformation, slope instability, and liquefaction. In addition, mass wasting events, such as landslides, can also occur due to heavy precipitation.

Seismic Conditions

SLAC is located in a tectonically active area, consisting of numerous faults and fault-related geological features. The San Andreas Fault system is located approximately 1 mile west of SLAC. Although movement along the San Andreas Fault is dominantly strike-slip (dextral shear), the presence of Quaternary-age folds and reverse faults subparallel to the fault suggest that compression has occurred perpendicular to the fault (SLAC 2006a). In addition to the San Andreas Fault, the informally named “Test Lab Fault” is present at Sector 27.5. During the 1989 Loma Prieta earthquake, damage to the accelerator housing, Test Lab floor, and the Administrative and Engineering Building patio reportedly occurred along the mapped trace of the Test Lab Fault (SLAC 2006a).

The U.S. Geological Survey (USGS) 2007 Working Group on California Earthquake Probabilities estimated a 63 percent probability for a magnitude 6.7 or greater earthquake to occur in the San Francisco region between 2008 and 2038. By comparison, California’s 1989 Loma Prieta and 1994 Northridge earthquakes were magnitudes 6.9 and 6.7, respectively. The Hayward-Rodger Creek and San Andreas Faults are the most likely sources of an earthquake of magnitude 6.7 or greater, with lesser probabilities that such an event would occur along the Calaveras Fault, San Gregorio Fault, or others (USGS 2008).

Hazard Zones

Geologic hazards were identified by the San Mateo County Planning Department and State of California (CGS 2006; San Mateo County [SMC] 2011). Areas of potential earthquake-induced landslides and liquefaction are present along the existing linac. The proposed cryogenic plant sites are not within a landslide zone. Current landslide potential is greatest at the eastern end of SLAC and on the steep cut-slopes that were excavated for construction of the accelerator housing (i.e., between Sectors 17 and 22 and between 23 and 27). Liquefaction hazards are present along the length of San Francisquito Creek and the area south of the accelerator housing.

3.7.1.2 Soils

Soils at SLAC were described in the LCLS EA (DOE 2002a) based on U.S. Department of Agriculture (USDA) mapping from 1991 (USDA 1991). Designated soil groups at SLAC are defined by the USDA as:

- *Accelerator-Fagan Association and Accelerator-Fagan Urban Complex.* These are the main soils at SLAC and consist of clay-loam soils. They formed in material weathered from softer sandstone and siltstone at SLAC. Permeability is moderately low to low; available water capacity is moderately high to high.
- *Botella Loam and Botella-Urban Land Complex.* These are thicker and better-drained soils that formed from unconsolidated sediments, such as alluvial materials found at SLAC.
- *Urban Land Association*. These are areas where no soil exists or where more than 85 percent of the surface is covered by asphalt, concrete or buildings.

The affected geological and soils environment at LBNL, Fermilab, TJNAF, and ANL, would be limited to soils located directly adjacent to existing buildings containing machine shops and laboratories used in fabrication of components.

3.7.2 Environmental Consequences

3.7.2.1 No Action

The no action alternative would not involve excavation or grading for new buildings or utlities; therefore, no impacts on geological or soils resources would occur.

3.7.2.2 Proposed Action

Construction

During construction of the Proposed Action, impacts would be minimal and would include excavations in the Whiskey Hill Formation soils and bedrock. Excavation would occur in the bedrock’s weathered zone, where the bedrock is weak to friable. This weathered zone extends down to approximately 30 feet below ground surface (bgs) (SLAC 2006a). No existing points of geologic interest, such as quarries or natural bedrock exposures, would be disturbed by the Proposed Action. Potential impacts on paleontological resources are discussed in Section 3.6 of this EA. Construction of the Proposed Action would not be within any landslide zones or areas susceptible to liquefaction hazards.

Short-term impacts on soils would include increased risk of erosion due to vegetation removal caused by the use of heavy equipment, such as excavators. Soil slope destabilization due to steep bedrock dip and interbedded lithologies may create increased erosion and risk of sedimentation in San Francisquito Creek.

The construction contractor would implement a SWPPP during construction to control soil erosion. To minimize soil impacts, soil disturbance and grading would be minimized. Regrading would be completed during site restoration and stabilization, as necessary. Erosion control measures would be implemented and would include BMPs such as diverting runoff from exposed soil surfaces, revegetating disturbed areas, and other measures to collect and filter runoff over disturbed land surfaces (e.g., sediment/silt fences). Given the implementation of BMPs, excavation and grading would result in only minor, short-term adverse impacts on soils.

The Proposed Action would require the excavation of soil and removal of vegetation. These areas would be subject to increased likelihood of mass wasting (i.e., landslides) in the event of earthquakes or periods of intense precipitation. SLAC would incorporate applicable construction and building codes, including those applicable to geotechnical concerns.

Fabrication of LCLS-II components at LBNL, Fermilab, TJNAF, and ANL, would be conducted within existing buildings currently used to fabricate research equipment and would not require excavation or grading for new buildings or access roads that could disturb geological formations or soils or destabilize slopes. Therefore, any incremental effects from fabrication of LCLS-II components on geology or soils at these locations would be negligible.

Operation

Project facilities may be at risk of damage from seismic activity. Similar to the previously described damage resulting from the 1989 Loma Prieta earthquake, damage to SLAC facilities, including the accelerator housing along the Test Lab Fault may be repeated in the event of an earthquake of similar or greater magnitude. The probability of such an event occurring before 2038 is approximately 63 percent (USGS 2008). To minimize potential safety impacts for SLAC employees working at LCLS-II facilities, all new structures would be designed to conform to California Building Code 2013[2] requirements as well as SLAC Building and Site-Wide Design guidelines (SLAC 2011a), including seismic performance requirements, and would be constructed of metal with steel framing. The structures would be designed and constructed to resist seismic loads. In addition, SLAC has an Emergency Management Plan (SLAC 2012) that addresses risks to employees in buildings in the event of an earthquake or fire, including establishment of an emergency operations center, emergency communications procedures, and emergency medical and firefighting support. The plan requires training, drills and exercises, and evaluations. Local fire departments serving SLAC, as well as SLAC's Emergency Response Teams, would also assist with search and rescue operations. The soil berms around the cryogenic plants would be designed to conform to geotechnical design standards, with appropriate supports such as soil nail walls. Therefore, any impacts on worker safety during seismic events or other emergencies such as fires (wildlands or buildings) would

[2] Title 24, California Code of Regulations, "California Building Standards Code", Part 2, "California Building Code." California Building Standards Commission.

be minimized through employing current structural design criteria and implementation of SLAC's existing emergency procedures.

Operation of the Proposed Action would have no impact on soils. Ongoing grounds maintenance would be addressed by the existing site-wide SWPPP. Operations would not require excavation or grading. The Proposed Action would not result in any incremental impacts beyond those resulting from facility and grounds maintenance.

3.8 Health and Safety

This section provides an overview of the existing human health and safety environment and describes potential human health and safety impacts for workers and nearby residents during construction and operations. It addresses how these hazards and risks would be minimized by engineering controls, and existing safety and environmental health management programs at SLAC, as well as LBNL, Fermilab, TJNAF, and ANL. This section also describes the potential consequences of malevolent acts and accidents as required by DOE. The potential risk of traffic accidents is analyzed in Section 3.12 of this EA. Waste handling is addressed in Section 3.14.

3.8.1 Affected Environment

3.8.1.1 Occupational Safety

SLAC has a well-developed safety program to protect workers and the public from hazards associated with activities conducted at SLAC's facilities. SLAC has integrated safety into its management and work practices at all levels, including for construction contractors, by developing and implementing an Integrated Safety and Environmental Management System (ISEMS). The ISEMS applies the following five core functions:

- Define scope.
- Analyze hazards.
- Develop/implement hazard controls.
- Perform work within controls.
- Feedback and Improvement.

All DOE sites are required to establish a Worker Safety and Health Program (WSHP) in accordance with 10 CFR 851 to reduce or prevent the potential for injuries, illnesses, and accidental losses by providing workers with a safe and healthful workplace. The SLAC WSHP document (SLAC 2013e) was developed to comply with 10 CFR 851. The WSHP applies to all non-radiological safety and health issues associated with design, construction, operation, maintenance, decontamination and decommissioning, research and development, and restoration activities at SLAC's facilities. SLAC's Radiological Protection Program (SLAC 2010a) was developed to address radiological safety and health issues.

In addition to ongoing worker health and safety programs, SLAC has developed and implemented work planning and control processes to adequately identify and address hazards before projects are authorized. . These review processes (e.g., Experimental Project Review Process) involve input from subject matter experts and institutional safety officers (e.g., radiation, electrical). SLAC currently uses cryogens in several facilities and maintains inventories of liquid nitrogen, helium, hydrogen, and carbon dioxide. SLAC's engineering and facility designs comply with applicable codes and standards. In addition, independent peer review and internal evaluations are conducted by the SLAC Building Inspection Office. Hazards with environmental impacts beyond human health and safety are addressed in other sections of this EA (e.g., air quality, hazardous materials and waste management, geology for soil and groundwater issues, hydrology, and water quality).

Similar to other industrial settings, current activities at SLAC result in some occupation-related injuries. Workplace injuries and illnesses are tracked by the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), which requires employers to report recordable work-related injuries. The Bureau of Labor Statistics (BLS) maintains injury and illness statistics for the construction industry. Under OSHA regulations (29 CFR 1904), a work-related injury or illness is "recordable" if it results in any of the following: death; days away from work, restricted work, or transfer to another job; medical treatment beyond first aid; or loss of consciousness. Injuries or illnesses that require a hospital visit or prescription medication are tracked as Total Recordable Cases (TRCs). The rate is based on 100 employees working full-time for 1 year and is "normalized" for different size employers by taking the number of recordable cases divided by the hours worked and then multiplying the result by 200,000 (100 employees working 40 hours per week for 50 weeks). If an injury prevents an employee from performing any or all of his or her duties and must be assigned "light duty" or cannot work at all, the injury is classified as a Days Away, Restricted, or Transferred (DART) case. Days of restricted work activity and/or days away from work are counted using calendar days instead of workdays. DART cases are a subset of the TRCs, and the rate is calculated in a manner similar to that of the TRC Rate (number of DART Cases times 200,000 divided by work hours). SLAC's TRC and DART rates for 2013 were 1.4 (recordable cases per 200,000 hours worked) and 0.7 (DART cases per 200,000 hours worked), respectively.

The health and safety of SLAC employees, researchers, and nearby residents are also overseen by SLAC's Security and Emergency Management Department. The SLAC Fire Marshal's Office provides the oversight for fire protection and emergency response. The Menlo Park Fire Protection District, through an MOA provides fire protection and emergency response. SLAC's emergency management organization consists of the SLAC Emergency Response Team (ERT) and SLAC Site Security.

Occupational safety at LBNL, Fermilab, TJNAF, and ANL, would be addressed by existing health and safety programs at those sites, including procedures for machining of parts, laboratory operations, clean rooms, as well as site security and fire protection.

3.8.1.2 Radiation Safety

SLAC's experimental facilities produce ionizing radiation as part of routine operations. Worker and public radiation exposure from existing projects at SLAC is minimized by physical shielding and implementation of SLAC's Radiological Protection Program (SLAC 2010a), which requires exposure monitoring and engineering controls. The unit most commonly used to report dose is rem. For smaller doses, such as those that occur at SLAC, the unit millirem (mrem) is used frequently as well. The biological effects of radiation depend on radiation type and energy level, the portion of the body exposed, and the duration of exposure. SLAC employees work both inside and outside accelerator facilities. Dose limits for radiation workers are established by the U.S. DOE 10 CFR 835, "Occupational Radiation Protection" (DOE2011c). Although the limits vary depending on the affected part of the body, the annual dose limit for the whole body is 5,000 mrem (5 rem) (10 CFR 835.202). Radiological hazards are also addressed through SLAC's Radiation Protection Program (SLAC 2010a), which complies with DOE regulations for occupational radiation protection (10 CFR 835). SLAC Radiation Protection Department's (RPD's) Field Operations Group (RPFO) oversees radiological monitoring and control for workers. SLAC RPD's Dosimetry and Radiological Environmental Protection Group (DREP) provides dosimetry services for site workers and assessment and monitoring of impacts on the public and environment.

Radiation protection for the existing LCLS is provided by use of concrete shielding. SLAC's RPD includes the Radiation Physics Group, which provides expertise in shielding design for new experiments and facilities, and oversees the safe operation of beam lines and safety systems to protect workers, the public, and the environment. Radiation exposure at SLAC is minimized through engineering measures including shielding composed of thick concrete walls. Design criteria for radiation shielding at SLAC are based on controlling individual doses from external radiation sources to less than 1,000 mrem total effective dose per year and kept "as low as reasonably achievable" (ALARA) (SLAC 2014b). The existing concrete walls of the LCLS BTH are approximately 6 feet thick. The existing EBD is equipped with a specially designed radiation shielding maze. Other beam loss locations are equipped with local steel shields that conform to SLAC's Radiological Control Manual (SLAC 2013f) and Radiation Safety Systems Technical Basis Document (SLAC 2010b) guidelines and requirements.

For all SLAC project, SLAC's Radiological Protection Program monitors the small fraction of photons and neutrons that pass through the accelerator components and through the surrounding accelerator housing. This includes monitoring of direct radiation (i.e., skyshine) as well as radioactivity in air, soil, and groundwater to determine the potential radiation dose to the public and impacts on the environment. Radiation that escapes to the environment is minimized by facility design (i.e., underground construction, beam containment, shielding); however, substances exposed to photons and neutrons that escape the accelerator and strike soil or water may create activation products or radioactive isotopes of atoms present in soil (oxygen, nitrogen, carbon, beryllium) as well as water. The half-lives of most of these isotopes are measured in minutes; however, the half-life of beryllium (^{7}Be) is 53.6 days, and the half-life of hydrogen ^{3}H (tritium) is 12.3 years.

SLAC assesses and submits annual reports on airborne radioactivity as required by its policies and by state or federal regulations. SLAC uses EPA software (CAP88-PC) to estimate airborne dose based on conservative estimates of radioactive isotopes in air (e.g., Argon [^{41}Ar], Nitrogen [^{13}N], Oxygen [^{15}O], and Carbon [^{11}C]). EPA regulations (40 CFR 61, Subpart H) enacted under the Clean Air Act and DOE Order 458.1, "Radiation Protection of the Public and the Environment" require SLAC to demonstrate that airborne radionuclide emissions do not result in annual doses greater than 10 mrem (DOE Order 5400.5). In 2012, the maximum calculated off-site public dose was 1.63×10^{-3} mrem (0.00163 mrem) or 0.016 percent of the 10 mrem regulatory limit (SLAC 2013b).

SLAC also monitors radioactivity in industrial wastewater, stormwater, and groundwater. Federal (10 CFR 20.2003) and state (17 CCR 30253) regulations set limits on radioactivity in industrial wastewater. The limits are 5 Ci for tritium. In 2012, SLAC released 1.1×10^{-4} Ci (0.00011 Ci) of tritium or 0.002 applicable limit (SLAC 2013b). No radioactivity other than naturally occurring background was detected in stormwater or sediment samples (SLAC 2013b). Based on the results of groundwater monitoring of more than 100 groundwater wells under SLAC's groundwater Self-Monitoring Program, low levels of tritium were detected in one area adjacent to a former electron beam dump in localized areas of the site. For 2013, tritium values ranged from below SLAC detection limits (500 picoCuries per liter [pCi/L]) to a maximum quarterly average tritium value of 4,025 pCi/L (SLAC 2014c). However, this radioactivity (tritium) was below the federal and state drinking water standards, which are both 20,000 pCi/L (40 CFR 141.66 and 22 CCR 64443). In addition, groundwater is not used at SLAC as a source of drinking water because of insufficient quantity and naturally high concentrations of total dissolved solid (TDS); thus, no exposure pathway occurs.

Federal regulations and DOE orders require SLAC to demonstrate that the public does not receive an annual radiation dose of greater than 100 mrem. DOE standards limiting radiological doses to members of the public (not occupational workers) are addressed in 10 CFR 835, DOE Order 458.1 (DOE 2011a), and DOE-STD-1196-2100 (DOE 2011b). Public doses at SLAC are estimated by measuring site boundary radiation doses at more than 40 locations using sensitive photon and neutron environmental dosimeters. As in past years, the dose received by the public from SLAC operations is substantially below regulatory limits. In 2012, the maximum dose that could be received off-site (see discussion regarding maximally exposed individual [MEI] below) was 0.53 mrem (0.53 percent of the 100 mrem regulatory limit) (SLAC 2013b).

Worker (and public) exposures can also be evaluated in light of radiation doses from naturally occurring and man-made sources. The average member of the U.S. population receives a total dose of ionizing radiation of about 0.624 rem (624 mrem) per year (NCRP 2009) from sources such as terrestrial and cosmic radiation and from medical, commercial, and industrial activity. About half of the total annual average U.S. individual's radiation exposure comes from natural sources. The maximum public dose of 0.53 mrem form SLAC operations is well below background exposures.

Exposures to low levels of ionizing radiation may result in an increase in latent cancer fatalities (LCFs) in the exposed population. Because the primary health concern with radiation is latent cancers, DOE uses a dose-to-risk conversion factor to estimate potential radiation impacts. The number of radiation-induced LCFs is estimated by multiplying the dose (person-rem) by health risk conversion factors (DOE 2004). These factors relate the radiation dose to the potential number of expected LCFs based on comprehensive studies of people historically exposed to large doses of radiation, such as survivors of atomic weapon detonations during World War II. The factor most commonly used in recent assessments is 0.0006 LCF per person-rem of exposure for workers and for members of the public (Interagency Steering Committee on Radiation Standards [ISCORS] 2002). Based on a dose-to-risk conversion factor of 0.0006 fatal cancers per person-rem and the collective dose (0.19 person-rem in CY2012) for the population of 5 million within approximately 50 miles of SLAC, the estimated probability of an additional fatal cancer induced by SLAC radiation is 1×10^{-4} per year (about 1 in 10,000 or 500 in 5 million people). For comparison, an individual's natural lifetime risk of fatal cancer in the U.S. population is about 0.2 (two in 10 or 1.06 million in 5 million people) (American Cancer Society 2013).

Existing exposures of biological resources to ionizing radiation are below exposure standards. DOE risk assessment methods (DOE 2002b) state that exposure of plants and animals should not exceed 1 rad[3] per day for aquatic receptors and terrestrial plants and 0.1 rad (absorbed dose) per day for terrestrial animals (DOE 2002b). Monitoring conducted for 6 months in 2012 at 580 on-site locations found average doses of less than 0.0003 rad per day (SLAC 2013g). Because many of the monitoring locations were inside shielding facilities (i.e., concrete walls), SLAC found that any exposure of plants and animals outside the shielding would be below DOE standards.

Although there are well-established radiological protection programs at LBNL, Fermilab, TJNAF, and ANL, fabrication of LCLS-II components would not generate radiation, use radionuclides during fabrication, or generate radioactive waste.

3.8.2 Environmental Consequences

3.8.2.1 No Action

Implementation of the no action alternative would not result in new health and safety impacts on the public or site workers. SLAC's existing health and safety hazards, as well as those at LBNL, Fermilab, TJNAF, and ANL would continue to be managed in accordance with established programs, policies, and procedures.

[3] absorbed ionizing radiation dose equivalent to an energy absorption per unit mass of 0.01 joule per kilogram of irradiated material.

3.8.2.2 Proposed Action

Construction

Occupational Safety

SLAC completed a Preliminary Hazards Analysis (PHA) to identify the hazards that would be encountered in each phase of the project and to meet DOE safety requirements (DOE Order 420.2C, Safety of Accelerator Facilities). These hazards are generally well known at SLAC and across the DOE complex. SLAC employees and contractors may encounter hazards associated with construction activities, including excavation, heavy equipment, high voltage, traffic, dust, fumes, and noise. These hazards are addressed through existing programs, engineering and/or administrative controls, and use of appropriate personal protective equipment. All areas accessible to workers would be routinely monitored, and appropriate signs would be posted. These controls and protective measures would be designed to adhere to applicable health and safety standards, which would reduce the potential for injury.

During construction, workers would encounter hazards associated with removal of existing LCLS hardware (magnets and vacuum chambers) and the installation of new components (cryomodules, electrical distribution, and cooling systems). These activities would produce low quantities of hazardous and non-hazardous waste (e.g., mineral oil in electrical components). Potential health and safety hazards associated with LCLS-II construction activities include heavy equipment use and material handling. Hazardous materials used during these activities may include paints, epoxies, and oils. These hazards would be avoided or minimized by conducting task-specific hazard analyses, delineating and establishing project boundaries and barriers; implementing existing health and safety programs, procedures, and training; and conducting routine inspections. SLAC's ESH&Q Industrial Hygiene Group would identify related hazards as part of the hazard assessment process and would develop controls to ensure that workers are not exposed to dust, mists, or fumes at concentrations above permissible levels. These programs would be in place for all SLAC employees and other on-site workers, including subcontractors.

LCLS-II construction workers would primarily consist of employees of subcontractors selected by SLAC who meet stringent safety qualifications. SLAC's required procedures for subcontractor safety are contained in the SLAC ESH&Q Manual. SLAC would require contractors to develop and implement site-specific health and safety plans, including site-specific health and safety training and daily tailgate safety meetings.

Construction would require excavation of soil for the cryogenic plant foundations and utility trenches. To minimize exposure to excavation hazards during construction, SLAC's Excavation Clearance Program would require underground utility searches and SLAC staff would conduct sampling to identify chemical-impacted soil and address proper disposal of excavated soil and conformance with Task 14 of the San Francisco Bay Regional Water Quality Control Board Order (SFBRWQCB, 2009) that establishes site cleanup requirements.

The potential number of LCLS-II construction-related injuries and illnesses can be estimated based on the TRC and DART values presented above. With an average workforce of 20 over a period of 3 years of construction, and assuming each worker would be on the job 2,000 hours per year, the Proposed Action would result in an approximate 120,000 worker hours. Given SLAC's stringent health and safety programs and assuming enforcement of these requirements for subcontractor personnel, LCLS-II would result in less than one recordable injury during construction. Extrapolating from past TRC/DART data, LCLS-II would result in 0.84 recordable injuries and 0.4 DART cases.

As described above, SLAC's TRC and DART rates for calendar year 2013 were 1.4 and 0.7, respectively. By comparison, in 2011, for heavy construction in the U.S. as a whole, the total number of recordable cases of nonfatal occupational injuries/illnesses was 3.6 cases per 200,000 worker hours (OSHA 2011). The rate of fatal work injuries for U.S. workers in 2012 was 3.2 per 100,000 full-time workers, down from the 2011 rate of 3.5 per 100,000 (BLS 2013). Based on these comparatively higher rates, enforcement of SLAC's health and safety programs for sub-contractor personnel would minimize the risk of injuries and illnesses during LSLS-II construction.

Wildfire risk on the west side of the SLAC site, where the LCLS-II exterior construction work would occur, involves the potential for ignition of dried grass. For any exterior work during the wildfire season (typically beginning about April and continuing through about October), grass fire risk would be minimized by requiring that all grass within the construction site and within a minimum of 30 feet around the maximum anticipated boundary of the construction site be controlled. The grass would be cut to ground level as soon as it is dry. Contractors would be required to follow all construction fire safety precautions contained in OSHA, the California Fire Code, and the National Fire Protection Act (NFPA) 241, "Standard for Safeguarding Construction, Alteration and Demolition Operations." In addition, all ignition sources on the construction site would be controlled. Smoking would be limited to designated areas, and all hot work would be conducted in compliance with the SLAC hot work permit program. Exterior hot work would be prohibited on hot, dry, windy days, designated by the State of California as red flag days, which are very rare at SLAC. The LCLS-II area is considered a low risk site for wildfire under the guidelines of NFPA 1144, "Protection of Life and Property from Wildfire."

LBNL, Fermilab, TJNAF, and ANL, would assess potential hazards of fabrication and prepare hazard analyses under their respective programs for work in machine shops, laboratories and clean rooms. Such hazards may include heavy machinery, chemicals, furnaces, high voltage, dust, fumes, and noise. These hazards would be addressed through existing procedures, controls, and use of personal protective equipment. All areas accessible to workers would be routinely monitored and appropriate signs would be posted.

Radiological Safety

Workers entering the accelerator housing and klystron gallery would be exposed to irradiated beamline components as well as dust, flaking or peeling paint, and spilled cooling water. As workers dismantle and remove components, SLAC health physicists would minimize radiological exposures through monitoring and preventative measures such as dust control. In addition, during dismantling and removal activities, SLAC RP would support LCLS-II by conducting surveys and ensuring that activated material is surveyed, labeled, and moved to an appropriate on-site storage location or prepared for off-site disposal. Radiological wastes would be managed in compliance with DOE Order 435.1 (DOE 1999).

Accidents and Intentional Destructive Acts

Construction of the Proposed Action could potentially result in hazards identified as low risk based on the PHA, such as non-routine accidents, fires, hazardous materials releases, and natural disasters such as earthquakes. These types of events are addressed by the safety and response programs and plans currently in place at SLAC. With continued compliance with design guidelines and implementation of the existing SLAC safety programs, no major reasonably foreseeable accident scenario is likely to result from construction, such as a major fire or structural failure with severe consequences. Construction of the Proposed Action would not require the use or transport of large volumes of hazardous or radioactive materials; therefore, there would be minimal risk of intentional destructive acts associated with these types of materials.

The risks of radiation exposure would be minimal because irradiated components would be located within the accelerator housing and klystron gallery. Any intentional destructive act would be deterred by site security and would have little effect on surrounding residential areas because construction-related fuel and material storage would primarily occur away from nearby roads and neighborhoods. Therefore, intentional destructive acts during construction would carry a low but uncertain probability and limited consequences because of the isolated nature of the construction activity.

Given the safety and health protection programs currently in place at SLAC, including protection of workers and residents from construction hazards and exposure to chemicals and radiation, construction of the Proposed Action would result in a minor increase in the risk of adverse impacts on worker health and safety.

Operations

Occupational Safety

The Proposed Action would generate operational hazards similar to those associated with previous SLAC projects (e.g., LCLS) and routine operations. As described in the PHA, potential hazards for SLAC employees and other site workers would include fire, electric shock, hazardous materials exposure, seismic risks, and other environmental hazards. Hazardous materials generated during operations may include very small quantities of lead, beryllium, solvents, and oily waste. Electrical systems would produce high voltages. These risks are addressed in the ESH&Q Manual, which describes lockout and tagout procedures for electrical safety, emergency preparedness, construction safety measures, and accident reporting.

Operations would involve cryogenic hazards, as the cryogenic plants would create and use substantial volumes of liquid helium to cool the superconducting linac and uses liquid nitrogen as a refrigerant. Cryogen hazards would include the potential for oxygen-deficient atmospheres in the event of a leak from the cryogenic systems, particularly in indoor environments within the cryogenic plants, accelerator housing, and klystron gallery. Other hazards would include thermal hazards or cold “burns” from direct exposure, and pressure hazards from over-pressurized systems. Operation of the cryogenic plants would require the transport and handling of liquid helium for operation of the superconducting linac and liquid nitrogen for the refrigeration systems.

Cryogenic hazards and protective measures would be identified through the hazard analysis process as defined in SLAC’s ESH&Q Manual chapter titled *Cryogenic and Oxygen Deficiency Hazard Safety*. The primary hazard would be creation of an oxygen deficiency hazard (ODH). When a liquefied gas is released at room temperature and expands to 700 or 800 times its liquid volume, it can displace much or all of the air and result in rapid loss of consciousness and subsequent asphyxiation. Dense gases, such as nitrogen, can accumulate in an indoor environment, whereas lighter gases, such as helium, will rise and could potentially migrate to floors located above a spill. Prior to operations, SLAC would conduct risk assessments, classify LCLS-II work areas according to ODH, install monitors and signage as appropriate, and provide worker training. SLAC would also exercise stringent engineering controls to ensure proper design and maintenance of containers, insulation, piping, valves, pressure-relief devices, and interlocks.

Another operational hazard would be potential exposures to loud noises associated with the cryogenic plant compressors, refrigeration systems, and other equipment associated with cooling water, compressed air, and exhaust fans. SLAC industrial hygienists would work with operators to ensure that noise exposures are below OSHA noise thresholds and to implement noise monitoring, signage, and personal protective equipment (PPE) requirements as appropriate.

The potential number of LCLS-II injuries and illnesses during operations can be estimated based on the TRC and DART values presented above. Assuming six added staff would work for 20 years of operations at 2,000 hours per year, the Proposed Action would result in an approximate total of 240,000 worker hours. Based on SLAC’s TRC of 1.4 and DART of 0.7 for 2013, LCLS-II operations would result in approximately 1.6 recordable work-related injuries or illnesses and 0.8 DART cases.

Radiological Safety

As described above, SLAC has been conducting high-energy physics experiments since the 1960s. The existing linear accelerator housing and downstream LCLS facilities currently enclose an operating experimental beam. Therefore, any radiation risks from LCLS-II would result in incremental impacts beyond those already present as generated by the existing LCLS facilities. The paragraphs below describe potential exposures as well as the existing physical shielding, the new shielding that would be added for the Proposed Action, and the radiological safety programs in place at SLAC that minimize radiological safety impacts.

Worker Exposure - The primary radiation safety issue for workers would be the potential for exposure to beam radiation within the accelerator housing and the potential for radiation to penetrate the accelerator shielding during beam operation. The prompt radiation hazard would cease instantly when the beam is off; however, residual radiation would be present inside the shielded enclosure from activation of the accelerator and transport line components. An Access Control System (ACS), consisting of electrical interlocks and mechanical barriers, would protect SLAC employees and researchers from potential exposure to prompt radiation. This system would turn off the beam (or beams) if site workers inadvertently breached accelerator housing, or in the event of a security violation. Beam exposure would only occur if a series of interlock and other protective system failed.

Other worker exposure hazards within the accelerator housing would occur during maintenance, such as when workers handle irradiated beamline components. Beam operation could also result in exposure to non-ionizing radiation, including radio frequency and microwave radiation and magnetic fields and lasers. Direct exposure to laser radiation can adversely affect human skin or eyes if it exceeds certain levels. LCLS-II would also generate magnetic fields that could affect electronic devices (pacemakers), ferromagnetic implants (artificial joints), and other material (tools). To minimize radiation exposure, SLAC would incorporate the requirements specified in 10 CFR 835 and the accelerator-specific safety requirements as set by DOE Order 420.2C, Safety of Accelerator Facilities. Physical shielding, such as concrete walls, earthen berms, and steel or lead plating, would be the primary method to reduce radiation exposure and activation of environmental media (air, soil, and groundwater). SLAC uses thick concrete walls to contain radiation from the accelerators. For example, the existing concrete walls of the LCLS BTH are approximately 6 feet thick. This shielding would be augmented by up to 2 feet of additional concrete, and/or placement of local shielding on potential beam loss points. Relative to the existing LCLS operations, additional shielding would be added for LCLS-II; therefore, potential radiological exposures from LCLS-II operations would be similar to those associated with current SLAC operations. Other beam loss locations are equipped with local steel shields that conform to SLAC's Radiological Control Manual (SLAC 2013f) and Radiation Safety Systems Technical Basis Document (SLAC 2010b) guidelines and requirements. SLAC would use similar and expanded shielding for LCLS-II.

Another line of protection against radiation is the Beam Containment System (BCS), which would be designed to contain the LCLS-II electron beam in proper channels. Collimators and beam dumps would be designed to contain the beam and limit beam losses to certain locations that would be shielded to minimize radiological impacts on the public and environment. Furthermore, the EBD would be heavily shielded to reduce skyshine radiation, activation of the surrounding air, as well as the potential for residual activity in the soil. The potential for soil activation would be minimal and limited to a localized area immediately around the beam dump shielding. SLAC would evaluate potential activation of groundwater and would use shielding to ensure that impacts on soil would be ALARA and that effects on groundwater would be below detection limits.

DOE would reduce the potential for radiological exposure through implementation of existing management systems, work planning and control processes and compliance with regulatory requirements for radiological protection. SLAC's Radiation Protection Department includes the Radiation Physics Group, provides expertise in the design of radiation safety system (including shielding design) for new experiments and facilities, and oversees the safe operation of beam lines and safety systems to protect workers, the public, and the environment. The Radiation Safety System at SLAC is designed to ensure that worker and public radiation doses above background are ALARA and to prevent any person from receiving more radiation exposure than is permitted under federal regulations. The SLAC Radiological Control Manual specifies an administrative control level of 500 mrem total effective dose (TED) per year and a dose-management "ALARA Level" of a maximum of 360 mrem TED per year above natural background levels for radiological workers. The actual dose received by most SLAC personnel is well below these levels (DOE 2012b). This would continue for LCLS-II operations based on the radiation safety systems (including physical shielding) and existing radiological safety programs.

SLAC would shield the LCLS and LCLS-II electron beam enclosures to maintain the average dose rate at less than 0.5 mrem/h in accessible areas of the accelerator and research yard and less than 0.05 mrem/h for other areas of SLAC. Workers engaged in the Proposed Action would not be expected to incur harmful health effects from radiation exposures that they could potentially receive during normal operations. The effective dose for personnel working inside and around the experimental halls would not exceed 100 mrem per year. The maximum exposure to a radiological worker from the LCLS-II operations would be well below the SLAC administrative control level of 0.5 rem in 1 year and the SLAC dose-management "ALARA Level" of 360 mrem/year, and the average annual dose to an individual worker would not exceed 0.1 rem. For reference, between 2010 and 2013, the average dose (mrem/y per individual) to the limited SLAC workers (approximately 40) who have received doses from work was approximately 0.02 rem per year, much lower than the DOE dose limit of 5 rem for radiological workers. The number of radiation-induced fatal cancers in the potentially exposed SLAC population (conservatively assumed to be 50 individuals and that each worker would receive 0.1 rem per year) over an operating period of 30 years[4] is approximately 0.06 (using a cancer risk of 0.0004 per rem), with a 90 percent confidence interval ranging from 0.02 to 0.14. In comparison, the cumulative number of naturally occurring cancer deaths expected in the same population (50) would be about 10.

Public Exposure - Potential radiological exposures to the public and the environment include: 1) direct prompt radiation dose, 2) doses from the release of airborne radioisotopes, 3) activation or release of radioisotopes to groundwater, and 4) activated cooling water and stormwater. During LCLS-II operations, public exposures would be maintained ALARA by continued implementation of the existing LCLS radiological safety protocols as previously described. DOE Order 458.1 imposes an annual dose limit for

[4] LCLS-II would have a planned operational lifetime of 20 years. The risk assessment assumed 30 years of operation as a conservative assumption.

members of the public to the maximally exposed individual (MEI) of 100 mrem/year from all exposure pathways.

Skyshine radiation is caused by neutrons and photons that transmit through the accelerator housing roof, scatter off air molecules, and return to the ground. Skyshine may also be resulted from the klystrons in the klystron gallery. Shielding is the primary measure to reduce skyshine exposures. SLAC's shielding design guideline for skyshine radiation is 10 mrem/y to the MEI from all facilities and 5 mrem/y from any single facility. Because existing LCLS facilities are heavily shielded, the maximum dose to the MEI is approximately 0.53 mrem/y mainly from the klystrons. To reduce skyshine, LCLS-II would add shielding and relocate components to areas with lower beam losses. In addition, SLAC would continue to monitor skyshine using the dosimeters at the site boundary Perimeter Monitoring Stations (PMS).

The higher beam power of LCLS-II would result in a slightly higher increment of radioactive air that would be released through ventilation. The annual regulatory dose limit for the MEI from air exposure is 10 mrem/y, and a continuous air effluent monitoring system is required for release points that would exceed 0.1 mrem/y. SLAC used the EPA-approved code CAP88-PC to calculate the annual dose to the MEI and the collective dose to the population up to 80 km from SLAC. For CY2012, the maximum calculated off-site public dose from airborne radioactivity associated with SLAC was 1.63×10^{-3} mrem or 0.016 percent of the 10 mrem regulatory limit (SLAC 2013b). For 2012 LCLS operations, an annual dose to the MEI (located at the east end of the SLAC site boundary) was approximately 2×10^{-4} mrem/y, which is 50,000 times lower than the 10 mrem/y limit and 500 times lower than the 0.1 mrem/y threshold. Relative to the existing LCLS operations, additional shielding would be added for LCLS-II; therefore, SLAC expects that the maximum off-site public dose would be similar to current conditions.

For the higher beam power of LCLS-II, the Proposed Action would generate an additional increment of airborne radioisotopes. Release of airborne radioisotopes would be minimized by adding local shielding at high beam loss points, modifying the ventilation system to limit air exchanges during accelerator operation, and continuing ongoing air monitoring to ensure the 0.1 mrem/y threshold was met; therefore, the annual dose to the public MEI would be minimal.

LCLS-II would be designed to minimize wastewater and stormwater discharges. Potential wastewater discharges include LCW replacement and discharge as well as water originating within the accelerator housing. Wastewater is collected at sumps and pumped to holding tanks outside the accelerator housing. Storage, radiological monitoring and analysis, and discharge of wastewater into the sanitary sewer are managed to meet the discharge limits outlined in the Silicon Valley Clean Water (formerly South Bayside System Authority) wastewater permit.

Beam loss points have the potential to activate soil and groundwater. The main radioisotopes produced in soil are tritium ^{3}H (12.3-year half-life) and ^{22}Na (2.6-year half-life). For groundwater protection, ^{3}H is the main radionuclide of concern due to its high leachability (nearly 100 percent) from soil to groundwater.

Groundwater "may not be impacted, which in practical terms means that the groundwater cannot have detectable radioactivity" due to LCLS-II operation (SFBRWQCB 2009). This can be compared to the EPA-required detection limit of 1,000 pCi/L for ^{3}H in drinking water (EPA 1992). Therefore, because of the added beam power, and to minimize potential impacts on soil and groundwater at beam loss points, the main LCLS-II beam dumps would incorporate extensive additional shielding such that the potential activation for the water reaching the groundwater table below the dumps would be below detection limits. Furthermore, LCLS-II would install additional groundwater monitoring wells near high beam loss points such as the BSY and LCLS-II main dumps.

Although radiation risks at low doses are subject to large uncertainties, SLAC calculated the following conservative risk evaluation for LCLS-II operations. The uncertainties in risk estimates result in a 90 percent confidence interval for the lifetime risk for fatal cancer from $1.20x10^{-4}$ to $8.84x10^{-4}$ per rem, with an average risk for the U.S. population of $4x10^{-4}$ per rem (NCRP 2009). The risk estimates assume that the MEI for any single year would be exposed at the maximum dose rate for the entire 30 years of assumed LCLS-II operation, which is very unlikely.

Conservative estimates for 2012 operations were made to calculate radiation doses and associated risks to the MEI and to the surrounding population within 50 miles (approximately 5 million persons). The estimates are based on two radiation pathways: from direct radiation (or skyshine) and from the air pathway. The results of these estimates are shown in **Table 3-6**.

Table 3-6 SLAC Radiation Dose Estimates and Associated Risks Based on CY2012 Estimates

Pathway	MEI Dose (rem per year)	Population Dose (person-rem per year)	MEI Lifetime Risk for 30 years of Operation	Population Dose Lifetime Risk for 30 years of Operation
Direct	0.00053 (5.3E-04)	0.18 (1.8E-01)	6.4/1,000,000 (6.4E-06)	2200/1,000,000 (2.2E-03)
Air	0.0000016 (1.6E-06)	0.0086 (8.6E-03)	0.02/1,000,000 (2.0E-08)	100/1,000,000 (1.0E-04)
Total	**0.00053 (5.3E-04)**	**0.19 (1.9E-01)**	**6.4/1,000,000 (6.4E-06)**	**2300/1,000,000 (2.3E-03)**

Notes:
Dose values are presented as decimal values (e.g., 0.00053) and in scientific notation (e.g., 5.3E-04)
Risk values represent incremental cancer incidence per 1 million people (e.g., 6.4 per 1,000,000 or 6.4E-06 ($6.4x10^{-06}$)
Source: SLAC 2013f

Based on estimated doses for 2012 operations, the potential doses are well below the DOE and SLAC limits. The lifetime dose risk to the MEI from 30 years of LCLS-II operation would be approximately 6.4 in 1 million ($6.4x10^{-06}$). For comparison, the natural lifetime risk of fatal cancer in the U.S. population is about 0.2 (2 in 10). All of the risk values in the above table are significantly lower than this reference value by many orders of magnitude.

Additional risks to workers under potential accident scenarios are negligible because of deployment of robust and layered engineered and interlocked radiation safety systems for LCLS-II operations.

Since preparation of the LCLS-I EA, SLAC has monitored radiation doses to off-site receptors from all SLAC sources and published these data in the site's annual reports. Radioactivity in air, soil, groundwater and wastewater, and modeled doses based on constant presence on site results in only a minor human health risk beyond naturally occurring levels. The Proposed Action would create an additional and more intense source of radiation; however, given the design measures described above, off-site radiation exposure would remain much lower than the naturally occurring background levels.

<u>Accidents and Intentional Destructive Acts</u>

DOE NEPA guidance requires consideration of the potential impacts of "reasonably foreseeable accidents" (DOE 2002c). The term "reasonably foreseeable" refers to incidents with a probability in the range of one in a million to one in ten million (DOE 2002c). Accident analysis is also required to address the results of an intentional destructive or terrorist act (DOE 2006). The results of the accident impact analysis provides information to the decision process with regard to the possible (as opposed to the expected) impacts from choosing a given alternative or course of action.

Accident risk is based on two factors: probability of occurrence and magnitude of consequence. For NEPA considerations, the accident analysis focuses on the highest consequence accident. Accident types may include occasional accidents (probability of 1 in 100 to 1 in 10,000) such as trips and falls, remote accidents (probability of 1 in 10,000 to 1 in 1,000,000) such as a tank rupture, and improbable accidents (probability of less than 1 in 1,000,000) such as a plane crash. NEPA focuses on the highest consequence credible accident in terms of human or environmental impact, such as an accident involving multiple casualties or a release of a toxic chemical to a wetland or waterway requiring a rapid response.

For LCLS-II, the selected reasonably foreseeable accidents addressed in this EA include:

1. A beam accident resulting in highly irradiated and damaged equipment, and
2. A reasonable worst-case, outdoor cryogen spill resulting in a localized ODH.

<u>Beam Accident</u> - Improper control of the beam could cause substantial damage to components. Therefore, the beamline would be designed to minimize beam loss and component activation and damage. Operations staff would monitor a number of safety parameters before activating the beam. Reasonably foreseeable accidental beam loss would result in component heating and damage. However, under a maximum reasonably foreseeable accident, component temperatures would rise rapidly and would effectively destroy the component. This would result in several adverse consequences, including radiation exposure of workers involved in isolating and replacing the damaged component. Many of the components are very heavy, and handling them would result in additional risk of injury. Component replacement would require many hours of exposure to activated components. Facility operations would be affected because replacement of a damaged component would entail a facility shutdown. During this process, workers would move damaged components to temporary storage in a concrete-shielded cell until

they could be moved to a long-term storage facility. Potential health effects of radiation exposure would include latent cancers and related fatalities.

LCLS-II would be designed to avoid beam mis-direction and to limit radiation doses in areas near the shielding. Abnormal beam conditions would be analyzed and contemplated in the design of the project's radiation safety systems. For example, very detailed ray tracing would be used to design shielding and active monitoring systems that would shield and detect a beam that is mis-directed by incorrectly powered magnets. Similarly, shielding and monitors would protect against beams of excessive power.

SLAC would design LCLS-II such that the effective dose for the Maximum Credible Incident (MCI) would not exceed 25 rem/h, and such that the integrated effective dose would not exceed 3 rem. The MCI considers the unlikely scenario of failure of safety systems and is defined as the highest beam power that the accelerator can deliver to a point, assuming that all the BCS devices that limit beam power have failed.

Cryogen Spill - A cryogen accident scenario would involve an outdoor release of a substantial volume of cryogen, potentially affecting workers, visitors, and off-site receptors. This could involve a large spill during a liquid helium or liquid nitrogen delivery, or mechanical failure of a valve resulting in a release from a tank or pipeline.

As described in SLAC's ESH&Q Manual, liquid helium has a liquid-to-gas expansion ratio of 780 and is far lighter than air with a specific density of 0.14 (air has a density of 1). Cryogens are extremely cold and have very low boiling points; therefore, if released, they would quickly boil into a gas and displace oxygen. Liquid helium is colorless and odorless and thus has no warning properties. It can cause dizziness, loss of consciousness, and death. Liquid nitrogen has a liquid-to-gas expansion ratio of 780 and a specific density of 0.97. Because its density is similar to air, liquid nitrogen would not disperse as quickly as helium and would cause a more persistent ODH.

To evaluate potential impacts of an outdoor release, DOE used the Areal Locations of Hazardous Atmospheres (ALOHA) air dispersion model (EPA and National Atmospheric Administration 2007) to calculate the air concentrations of helium and nitrogen following a spill and size of the affected area. The resulting concentrations were compared with air concentration criteria from DOE's Protective Action Criteria (PAC) database (DOE 2012c). For liquid helium, the model assumed a reasonable worst-case release of 100 percent of the inventory of the cryogenic plant distribution system (4,200 gallons) within 2 minutes, potentially resulting from an explosion or earthquake. The modeling was based on reasonable worst-case weather conditions, with low wind speeds and very stable (low turbulence) dispersion conditions. Because liquid helium is not in the chemical library for ALOHA, the properties of liquid hydrogen were used as a surrogate. Similar to helium, hydrogen is much lighter than air, and has a cryogenic boiling point (-252.8 C). For liquid nitrogen, the modeled reasonable worst-case scenario was a spill at the delivery dock by a truck delivering refrigerant make-up volume through a 4-inch diameter hose and a spill rate of 120 gpm. Appendix C presents the ALOHA modeling assumptions and results.

The results of the dispersion modeling were compared to the PAC values for the MEI – a worker located approximately 16 feet from the accident.

- PAC-1 - the airborne concentration potentially resulting in discomfort, irritation, or certain asymptomatic, non-sensory effects that are not disabling and are transient and reversible.
- PAC-2 - the airborne concentration potentially resulting in irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape.
- PAC-3 - the airborne concentration potentially resulting in life-threatening adverse health effects or death.

The modeled spill of liquid helium would result in helium concentrations that would exceed the PAC-3 concentration (400,000 ppm) under worst-case meteorology conditions (F stability, wind speed of 3.3 feet per second). The PAC-3 concentration would be exceeded out to a distance of less than approximately 33 feet. The estimated maximum "puddle" diameter would be approximately 57 feet. The PAC-2 concentration, 250,000 ppm, would be exceeded to a distance of 36 feet, and the PAC-1 concentration (65,000 ppm) would be exceeded out to approximately 154 feet. Therefore, workers located within 36 feet of the spill could experience serious health effects. In addition, the extremely low temperature of the release could cause an ice patch and fog at the spill site.

Because nitrogen is denser than air, ALOHA predicts higher peak concentrations for liquid nitrogen, but the PAC levels are higher, and the potential risk would therefore be lower. The maximum estimated puddle diameter for this spill would be approximately 36 feet. The PAC-3 concentration for liquid nitrogen (869,000 ppm) would not be exceeded for the worst-case release scenario nor would the PAC-2 (832,000 ppm) or PAC-1 (796,000 ppm) levels. The highest estimated 1-minute average concentration was 698,000 ppm, at approximately 16 feet downwind of the release (directly above the pool of evaporating liquid). A nitrogen release could also result in an ice patch and fog at the spill site. **Table 3-7** presents the results of the cryogen spill accident analysis.

Table 3-7 Comparison of Cryogen Spill Concentrations with PAC* Values

Accident Scenario	Chemical (volume)	Release rate (gpm)	MEI Concentration: worst case meteorology	PAC-1 (ppm)	PAC-2 (ppm)	PAC-3 (ppm)
Piping release	Helium (4,200 gallons)	3,740	457,000 ppm	65,000	230,000	400,000
Valve failure during delivery	Nitrogen (16,000 gallons)	120	638,000 ppm	796,000	832,000	869,000

Note:
DOE PAC values for hydrogen were used to represent helium.

As described above for construction, DOE requires evaluation of potential impacts from intentional destructive, malevolent, or terrorist actions (DOE 2006). These types of events are addressed by the safety and response programs and plans currently in place at SLAC. Through continued compliance with design guidelines and implementation of the existing SLAC safety programs, no major reasonably foreseeable accident scenario is likely to result from operation of SLAC-II. Operation of the Proposed Action would not require the use or transport of large volumes of hazardous or radioactive materials; therefore, there would be minimal risk of intentional destructive acts associated with these types of materials. Any intentional destructive act would be deterred by site security, would be within the envelope of consequences addressed in the accident analysis and would have little effect on surrounding residential areas because material storage would primarily occur away from nearby roads and neighborhoods.

3.9 Hydrology and Water Quality

This section describes existing hydrologic and water quality conditions and evaluates potential environmental impacts from construction and operations on surface and groundwater hydrology and water quality at SLAC as well as at the fabrication activities at LBNL, Fermilab, TJNAF, and ANL.

3.9.1 Affected Environment

3.9.1.1 Surface Water

SLAC is located within the watershed of San Francisquito Creek, a perennial stream that flows from the foothills of the Santa Cruz Mountains eastward near the southern border of the SLAC site and eventually discharges into San Francisco Bay. San Francisquito Creek forms the boundary between San Mateo and Santa Clara Counties (**Figure 1-1**). The USGS has measured streamflow since 1930 at a gauging station on San Francisquito Creek, downstream of SLAC. The mean monthly stream flow varies from 20,643,361 gallons per day (gpd) in the wet months (October to May) to 387,790 gpd in the dry months (June to September) (SFBRWQCB 2009).

Stormwater from the existing SLAC facilities is discharged to San Francisquito Creek via a storm drain network. The eastern portion of SLAC, including the main campus, drains to two major surface-water channels. However, stormwater from the western portion of SLAC flows off-site through local drainage ditches (SFBRWQCB 2009). Undeveloped areas west of I-280 drain south through five stormwater channels to San Francisquito Creek. The western edge of SLAC drains west into Bear Creek, a tributary of San Francisquito Creek (**Figure 3-1**).

As described in the LCLS EA (DOE 2002a), no portion of the SLAC boundary is located in the 100-year floodplain. Therefore, the Floodplain Management Executive Order No. 11988 (42 F.R. 26951), which requires federal agencies to comply with flood protection standards, does not apply to the LCLS property. San Francisquito Creek is subject to flooding, primarily in areas downstream of SLAC. Most runoff from the developed areas east of I-280 is captured by a storm drain network. Runoff from the existing facilities drains to the southeast. SLAC has 25 separate discharge points, including tributaries of San Francisquito Creek that flow through culverts under the klystron gallery (**Figure 3-1**). Some of these drainages under the klystron gallery also collect groundwater seepage and may have low base flow levels, even in dry weather.

Water quality in San Francisquito Creek is typical of urban areas and the creek is on the 2006 Clean Water Act Section 303(d) list of water quality limited segments (California State Water Resources Control Board 2010) for the insecticide diazinon and sedimentation/siltation. New development must comply with the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP).

Surface water resources potentially affected by the Proposed Action at LBNL, Fermilab, TJNAF, and ANL include those directly adjacent to and downstream of fabrication facilities as well as those affected by stormwater and wastewater discharges.

3.9.1.2 Groundwater

SLAC is adjacent to the northern boundary of the Santa Clara Valley groundwater basin and straddles the western boundary of the San Mateo Plain groundwater basin. Based on topography, the regional groundwater flow direction is generally to the south and southeast toward San Francisquito Creek. However, groundwater flow directions and gradients across SLAC have been modified locally due to grading and previous construction as well as the subdrain system installed at the base of the accelerator housing approximately 35 to 40 bgs.

Groundwater resources potentially affected by the Proposed Action at LBNL, Fermilab, TJNAF, and ANL include those directly adjacent to and downstream of fabrication facilities as well as those potentially affected by spills.

3.9.2 Environmental Consequences

3.9.2.1 No Action

Under the no action alternative, there would be no impacts on surface water or groundwater because there would be no excavation, grading, or use of heavy equipment or chemicals. No impervious surfaces would be added and no additional stormwater or wastewater would be generated. The risk of inadvertent spills that could affect water quality would be minimized by continued implementation of existing spill prevention protocols.

3.9.2.2 Proposed Action

Surface Water

Construction

Construction of the Proposed Action, including potential on-site relocation of excess soils, would take place within approximately 800 feet of San Francisquito Creek, but mostly on the northern side of the klystron gallery. Construction, trenching, grading, and stockpiling activities would, if not properly addressed, result in bare soil that could be eroded by wind and rainfall and ultimately drain into San Francisquito Creek. The resulting sedimentation in San Francisquito Creek could degrade water quality, and channel siltation could affect hydraulic capacity and habitat quality. Discharge of stormwater into San Francisquito Creek is regulated under a general industrial stormwater discharge permit issued by the State Water Resources Control Board.

SLAC would obtain a General Permit for Discharges of Storm Water Associated with Construction Activity (Construction General Permit Order 2009-0009-DWQ). The permit requires the development and implementation of a construction SWPPP, which includes project-specific BMPs, a visual monitoring program, and a water quality monitoring program. Implementation of the SWPPP BMPs for management of disturbed soil and excavated material would minimize the potential for sediment to reach San Francisquito Creek, and the use of secondary containment and drip pans for temporary storage of chemicals and heavy and oil-filled equipment would contain inadvertent spills. In addition to state and local requirements, Section 438 of the EISA of 2007 requires that the final design, construction, and maintenance of projects with a footprint more than 5,000 square feet must restore the site's predevelopment hydrology and retain stormwater by one or more alternative methods, such as permeable pavements, landscaping, or sediment basins. Therefore, the Proposed Action would be designed and constructed in accordance with these requirements.

SLAC's wastewater discharges are regulated under Mandatory Wastewater Discharge Permit No. WB061216 issued by the Silicon Valley Clean Water (formerly South Bayside System Authority) and the West Bay Sanitary District. Given compliance with this discharge permit, operational discharges from the Proposed Action would result in no impacts.

At fabrication sites, impacts on surface water would be negligible. Fabrication activities would not require excavation or grading. No new buildings or other impervious surfaces would be added and no additional stormwater or wastewater would be generated. This activity would occur within existing buildings in machine shops and laboratories that are currently used for component fabrication, including use of cleaning and degreasing agents, acids, and caustic agents. These buildings are equipped with appropriate controls, including wastewater collection and treatment as well as operational stormwater BMPs. No new wastewater effluents would be generated. The risk of inadvertent spills during deliveries or transport would be minimized by continued implementation of existing spill prevention protocols, including for chemical use and storage.

Operations

Proposed Action operations would have minor effects on stormwater quality. Additional vehicles may contribute increases in oil and fuel use, as is the case in any parking lot or roadway; however, all parking areas at SLAC would be managed through BMPs as required by the SWPPP. Stormwater would continue to be sampled and analyzed as required by the SWPPP. The new impervious surfaces added with the

Proposed Action would not result in an increase in runoff volume that would result in flooding. Because much of the Proposed Action would be installed within existing facilities and would use existing disturbed or paved areas for staging, it would not add large impervious surfaces on site. The Proposed Action would comply with existing stormwater regulations and would allow percolation of stormwater in detention basins or similar BMPs. Therefore, the Proposed Action would have no impact on flooding.

Groundwater

Construction

Groundwater quality would not be affected by construction of the Proposed Action. Any impacts on groundwater flow would be temporary and localized. Potential impacts on groundwater quality would be addressed through implementation of pollution prevention BMPs as described above.

Operations

Groundwater quality would not be affected by operation of the Proposed Action. Use of chemicals during operation of the Proposed Action would be limited to small quantities, would occur primarily indoors, and would have only minor potential impacts on groundwater quality.

Proposed Action operations would have no impacts on groundwater hydrology. Bedrock groundwater from a thick sequence of marine sandstones is present beneath SLAC. However, recent alluvium does not occur in sufficient saturated thickness at SLAC to form an aquifer and the groundwater is not used as a water supply. Pursuant to San Mateo County well ordinances, the construction contractor would identify any groundwater wells in the project area and would implement a wellhead protection program as warranted for wells that provide drinking water.

Existing SLAC experiments have minor impacts on surrounding soils through formation of radionuclides that can potentially migrate to the groundwater. This risk is most prominent at the EBD, which is approximately 30 feet above the groundwater table. LCLS shielding was designed to address this risk. However, because LCLS-II would operate at higher powers, the shielding inside the EBD pits would be redesigned to increase the amount of iron shielding and to keep groundwater concentrations of radionuclides at below detection limits. SLAC would also install a geomembrane on the soil berm above the beam dump. This would keep percolating stormwater farther from the beam dumps. With these measures, the potential for migration of radionuclides from the soil around EBD to the groundwater would be is very low and concentration of radionuclides in groundwater from LCLS-II operations would be negligible and well below the detection limit.

3.10 Noise and Vibration

This section describes the existing ambient noise environment and potential noise and vibration effects of construction and operation of LCLS-II, including soil and excavation and transport during construction, fabrication of components at DOE national laboratories and research facilities, as well as operation of the cryogenic plants.

3.10.1 Affected Environment

The land use adjacent to SLAC near the Proposed Action includes intermixed residential, recreational (equestrian), agricultural, and undeveloped areas of Menlo Park and Woodside. The proposed cryogenic plants would be located in an isolated area near western end of the SLAC property. Ambient noise varies depending on the time of day, weather, and proximity to noise-attenuating features such as trees and topographical changes.

The existing ambient noise environment near the project site is affected by vehicle noise associated with Sand Hill Road, Whiskey Hill Road, and I-280. Other ambient noise sources include activities associated with the adjacent equestrian facilities and existing SLAC operations (**Figure 1-2**). Existing noise sources at SLAC include activities around the western end of the accelerator housing and klystron gallery. SLAC's main research areas are more than 1 mile to the east. The residences nearest to the construction area are located directly to the west in Woodside on Manzanita Way, approximately 2,000 feet from the larger cryogenic plant at Sector 4, 1,000 feet from the smaller plant, and approximately 400 feet from SLAC's west gate entrance at the corner of Sand Hill Road and Whiskey Hill Road. Other potential noise receptors exist on to the north and east of SLAC, such as on Campbell Lane in Stanford Hills.

In 2006, SLAC completed an ambient noise study (Charles M. Salter Associates, Inc. 2006) along SLAC's eastern boundary, including 24-hour ambient noise measurements in residential areas south of Sand Hill Road, along SLAC's northern boundary, at the southeastern corner of Campbell Lane and Branner Road, and at the southeastern corner of the SLAC property line (south of the intersection of Alpine Road, Sneckner Court, and Bishop Road). The resulting measurements are listed in **Table 3-8** and were below City of Menlo Park noise limits in areas to the north and east. Areas near Alpine Road at the southeast boundary were affected by ambient noise sources including automobile and truck traffic, which resulted in measured noise levels that exceeded the City of Menlo Park noise threshold limits.

Table 3-8 Existing Noise Levels at the Nearest Sensitive Receptors

Sensitive Receptor	City of Menlo Park Daytime/Nighttime Noise Limit (L_{eq}, dBA)	Monitored 24-hour Noise Level (L_{eq}, dBA)	Monitored Daytime Noise Level (L_{eq}, dBA)	Monitored Nighttime Noise Level (L_{eq}, dBA)
Northern Boundary	60/50	56.2	57.7	49.5
Eastern Boundary	60/50	54.2	55.7	47.7
Southeast Boundary (Alpine Road)	60/50	66.4	67.7	60.8

dBA = decibels A-scale
L_{eq} = equivalent continuous noise level
Source: Charles M. Salter Associates, Inc. 2006

Sand Hill Road west of I-280 is a two-lane road with ambient noise from automobile and truck traffic. To document current ambient noise levels in this area, which is near the proposed construction area at SLAC's western boundary and close to the nearest residential receptors, SLAC collected 2 weeks of ambient noise data. A noise meter was installed near the west gate entrance at the western end of SLAC to document ambient noise levels from Sand Hill Road and Whiskey Hill Road (**Figure 3-4**). The noise monitoring equipment operated continuously from April 3 through 16, 2014. **Table 3-9** provides a summary of these data.

Table 3-9 Existing Noise Levels – SLAC West Gate (2-week measurement)

Date	Daytime dBA L_{eq}	Nighttime dBA L_{eq}
4/3/2014	58.1	50.0
4/4/2014	58.4	50.6
4/5/2014	58.1	49.8
4/6/2014	57.2	49.2
4/7/2014	57.7	49.0
4/8/2014	57.3	49.1
4/9/2014	57.4	49.3
4/10/2014	57.2	47.7
4/11/2014	57.1	49.3
4/12/2014	56.5	48.4
4/13/2014	55.7	47.4
4/14/2014	56.4	48.5
4/15/2014	57.1	48.8
4/16/2014	57.1	49.3

The existing noise levels at this location ranged from 55.7 to 58.4 dBA L_{eq} during the day (7:00 a.m. to 10:00 p.m.) and from 47.7 to 50.6 dBA L_{eq} at night (10:00 p.m. to 7:00 a.m.). The higher daytime noise levels can be attributed to Sand Hill Road and Whiskey Hill Road traffic. To confirm the results for Sand Hill Road and to document ambient conditions in other receptor areas, SLAC collected individual daytime and nighttime short-term noise measurements at five off-site locations (**Figure 3-4**) on April 2 and 3, 2014. **Table 3-10** provides these results. These data confirm that existing community noise is present at SLAC's western boundary. Furthermore, there are relatively quiet conditions in the neighboring residential areas.

Table 3-10 Existing Measured Noise Levels

Receptor	Sample Location	Daytime 1-hour L_{eq} (dBA)	Nighttime 1-hour L_{eq} (dBA)
ST-1	SLAC Northern Haul Road	46.2	----
ST-2	SLAC Research Yard (Central SLAC)	58.6	----
ST-3	Manzanita Road, Woodside	57.3	42.8
ST-4	Manzanita Road, Woodside	54.9	41.8
ST-5	Sand Hill Road, Woodside	67.5	53.3
ST-6	Whiskey Hill Road, Woodside	61.7	43.8
ST-7	Alpine Road Across from SLAC Gate	63.2	----

As described in Section 2, construction would occur near the western end of the accelerator housing and klystron gallery, adjacent to the Town of Woodside. The Town of Woodside does not currently have a noise ordinance. Woodside Municipal Code limits construction to Monday through Friday (7:30 a.m. to 5:30 p.m.) and Saturday (8:00 a.m. to 1:00 p.m.). The town has set an objective of keeping ambient noise in residential areas at or below 55 dBA (day-night averaged sound level [L_{dn}]) in the daytime and 40 dBA (L_{dn}) at night.

Although Woodside established the objectives outlined above, Woodside's 2012 General Plan showed that ambient noise levels directly west of SLAC in the area of the nearest SLAC noise receptors are already above these published noise levels due to the substantial traffic and other noise sources along Sand Hill Road and Whiskey Hill Road. The Town of Woodside estimated noise levels along major roadways including Whiskey Hill Road based on estimated traffic noise levels for 2010 and projected traffic levels for 2030. Noise estimates (24-hour average [L_{dn}]) were calculated from traffic volumes, vehicle speeds, and the percentage of truck traffic using Federal Highway Administration (FHWA) procedures. This study found that Woodside residents along the l-280 corridor, Woodside Road, and other roads – including Whiskey Hill Road – are currently exposed to noise levels above the town's objectives. Estimated noise levels for Whiskey Hill Road were 63 Ldn for 2010 and 64 L_{dn} projected for 2030, with traffic levels (average daily trips [ADT]) of 3,000 and 4,100, respectively (Charles M. Salter Associates, Inc. 2010). The impact assessment presented below uses the direct noise measurements presented above to confirm that existing ambient noise levels exceed the Woodside objectives and mask noise from SLAC operations.

EPA (1974) published noise criteria for protection of public health and welfare using the L_{dn} metric. These guidelines, which provide standards intended to be generally applicable throughout the U.S., include an Ldn of 45 dBA indoors and 55 dBA outdoors for residential areas in a rural setting. **Table 3-11** summarizes the maximum noise level exposure guidelines for specified land uses.

Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

NOISE MONITORING LOCATION

N

0 1,000 Feet

Graphic Scale: 1" =1000'

SLAC LCLS-II EA

NOISE MONITORING LOCATIONS

ARCADIS

FIGURE 3-4

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Table 3-11 Summary of EPA Noise Guidelines

Effect	Noise Level	Land Use Area
Hearing loss	L_{eq}(24) = < 70 dB	All Areas
Outdoor activity interference and annoyance	L_{dn} = < 55 dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time, and other places in which quiet is a basis for use.
	L_{eq}(24) = < 55 dB	Outdoor areas where people spend limited amounts of time (e.g., school yards, playgrounds)
Indoor activity interference and annoyance	L_{dn} = < 45 dB	Indoor residential areas.
	L_{eq}(24) = < 45 dB	Other indoor areas with human activities (e.g., schools)

Source: EPA 1974

The City of Menlo Park Municipal Code contains limits for the generation of typical construction as well as operational noise on adjacent properties within the city. Section 8.06.030 includes criteria for maximum noise levels at residential property lines. The code limits construction hours to the hours of 8:00 a.m. through 6:00 p.m. Menlo Park code permits powered equipment used on a temporary, occasional, or infrequent basis within these hours provided it does not generate noise in excess of 85 dBA L_{eq} at 50 feet. SLAC would require that the construction contractor adhere to City of Menlo Park requirements when practicable. The City of Menlo Park limits the operational noise for both the daytime and nighttime periods. The daytime and nighttime noise threshold limits are summarized in **Table 3-12**.

Table 3-12 City of Menlo Park Municipal Code Sound Level Limits

Maximum Sound Level Measured from Residential Property (L_{eq}, dBA)	Time Period
60	Daytime Hours: 7:00am to 10:00pm
50	Nighttime Hours: 10:00pm to 7:00am

Source: City of Menlo Park 2010

The Federal Transit Administration (FTA) vibration guidelines state that a vibration level of 65 velocity in decibels (VdB) is the threshold of perceptibility for humans, and vibration that exceeds 80 VdB may cause annoying effects on humans. The threshold for structural damage is 90 VdB. **Table 3-13** summarizes FTA's construction vibration damage criteria.

Table 3-13 FTA Construction Damage Criteria

Building Category		PPV* (in/sec)	Approximate Lv**
I.	Reinforced concrete, steel, or timber (no plaster)	0.5	102
II.	Engineered concrete and masonry (no plaster)	0.3	98
III.	Non-engineered timber and masonry buildings	0.2	94
IV.	Buildings extremely susceptible to vibration damage	0.12	90

Notes:

* PPV = Peak Particle Velocity

** Root mean square (RMS) VdB re 1 micro-inch/second

At LBNL, Fermilab, TJNAF, and ANL, fabrication activities would occur within existing buildings in an industrial setting with substantial setbacks from residential areas or other sensitive noise receptors.

3.10.2 Environmental Consequences

This section evaluates the potential effects of LCLS-II construction and operational noise and vibration on the environment and is focused on direct effects on residential receptors adjacent to SLAC.

3.10.2.1 No Action

Under the no action alternative, there would be no dismantling, removal or installation of new equipment, no cryogenic plant construction, no operational noise, and no eventual decommissioning of equipment. DOE, SLAC, and partner national laboratories would continue to operate existing experimental facilities and construct approved projects and other infrastructure improvements. The no action alternative would not increase existing noise levels at site boundaries. Therefore, the no action alternative would have no impacts on adjacent residential receptors beyond existing conditions.

3.10.2.2 Proposed Action

Construction

Construction would require the use of heavy equipment including excavators, loaders, and haul trucks. The majority of the construction would be conducted during the daytime hours. To minimize nighttime noise impacts and comply to the extent practicable with local noise standards and objectives, the construction contractor would conduct the excavation required for the cryogenic plant foundations and the related site preparation and grading, as well as construction of utilities, during the day. The excavation would not require drilling or blasting. Construction would require trucking of removed equipment and building materials, staging, assembly of components, construction of the cryogenic plants, installation of the cryomodules, and trenching of utilities. Part of the work would be conducted at the west end of the accelerator housing and klystron gallery. Construction workers and trucks would use both the Alpine Gate and SLAC's main entrance on Sand Hill Road. Trucks would follow the haul road and enter the accelerator housing using a ramp, vault, and tunnel near Sector 10. Trucks would also occasionally use the west gate on Sand Hill Road near Whiskey Hill Road.

Construction noise levels for the Proposed Action were estimated using a predictive noise model (CadnaA - Computer Aided Noise Abatement) to determine potential noise impacts on residential receptors. Appendix D provides a description of the model and the input data. Noise values for construction equipment were derived from literature sources (e.g., Federal Highway Administration Construction Noise Handbook [FHWA 2009]). The loudest construction equipment typically emits noise levels between 73 and 85 dBA at 50 feet, with utilization factors of 20 to 40 percent (i.e., the percent of time the equipment would be used per day). Noise levels at any specific receptor would be dominated by the closest and loudest equipment. The types and numbers of equipment affecting any specific receptor location would vary over time.

The model accounted for a reasonable worst-case scenario of noise sources at both cryogenic plant sites; arrival of workers and trucks; equipment dismantling and removal; and installation of new equipment, including a portion of the cryomodules being installed at the west end of the linac. The model considered the effects of terrain, such as the ridge located just west of the Sector 4 cryogenic plant and the slope between the west end of the linac and receptors in Woodside to the west of Sand Hill Road. It also assumed no nighttime construction and no high noise/vibration-producing construction methods would be used, such as pile drivers or explosives.

Table 3-14 and **Figure 3-5** present modeled construction noise levels at adjacent residential receptors, including the nearest receptors on Manzanita Way in Woodside. The short-term ambient noise measurement locations (**Figure 3-5**) were used to represent adjacent residential receptor locations. According to the model, construction noise levels would range from approximately 49.1 dBA L_{eq} at the closest receptors west of Sand Hill Road to 12.5 dBA L_{eq} at receptors in Menlo Park to the north and east of the Research Yard. These values represent a reasonable worst-case analysis because they assume concurrent construction of the cryogenic plants and removal and installation of equipment and utilities. Noise levels would be slightly lower if activities were limited to the west end of the linac and substantially lower if activities were limited to the cryogenic plant sites. **Appendix D** describes the model, input data, assumptions including construction equipment, and model results.

Table 3-14 Modeled Construction Equipment Noise Levels at Receptor Locations

Sensitive Receptor	Receptor Location	Construction Noise Impacts (dBA L_{eq})				
		Excavation of Cryogenic Plant Foundation	Dismantling, Removal, and Installation of Equipment	Cryogenic Plant Construction	Truck use of west gate	Maximum Increase in Noise Levels (dB)
LT-1	Long-term Monitor Location	48.1	48.1	45.1	38.5	0.4
ST-1	SLAC Northern Haul Road	47.3	47.1	42.6	34.9	3.6
ST-2	SLAC Research Yard (Central SLAC)	31.4	44.3	26.9	24.3	0.2
ST-3	Manzanita Road, Woodside	41.8	41.8	39.4	23.9	0.1
ST-4	Manzanita Road, Woodside	44.1	44.1	41.5	27.7	0.3
ST-5	Sand Hill Road, Woodside	49.1	49.1	45.7	26.7	0.1
ST-6	Whiskey Hill Road, Woodside	42.3	42.3	40.5	29.8	0.0
ST-7	Alpine Road Across from SLAC Gate	42.9	41.3	38.1	38.1	0.0

The model results shown in **Table 3-14** and **Figure 3-5** represent the contribution of project noise only and do not account for existing community noise sources such as roadways, aircraft over flight, recreational, or residential/ commercial noise. As described above, traffic on Sand Hill Road and Alpine Road generates substantial ambient noise. Because the existing ambient noise levels at adjacent receptors range from 46.2 to 67.5 dBA Leq (**Table 3-9**), construction noise (**Table 3-13**) would result in small incremental noise increases. Daytime noise levels at receptor locations directly west of Sand Hill Road (locations ST-3, ST-4, and ST-5) would increase by approximately less than 1 dB. This level of noise increase would be imperceptible from day to day. As expected, the largest noise increases would occur within the SLAC boundary, such as along the haul road that would be used by haul trucks. Because of existing ambient sources, noise levels would not increase at locations adjacent to existing roadways (ST-6 and ST-7). Noise levels would diminish rapidly at distance because of attenuation by topography, trees, and buildings.

During construction, use of heavy equipment would generate ground-borne vibration. Potential sources of vibration would include excavators and dump trucks. According to the DOT FTA guidelines, a vibration level of 65 VdB[5] is the threshold of perceptibility for humans (FTA 1995), and levels exceeding 80 VdB during infrequent events could have a substantial effect. Based on the FTA-published construction equipment vibration levels (Appendix D), the types of equipment to be used, and the distances to the receptors, vibration levels would be approximately 52.6 VdB at nearest adjacent residential receptors. Therefore, vibration levels would be below perception and well below thresholds for annoyance and structural damage. Consequently, no vibration impacts would occur under the Proposed Action. Further information describing the vibration calculation methodology is presented in Appendix D.

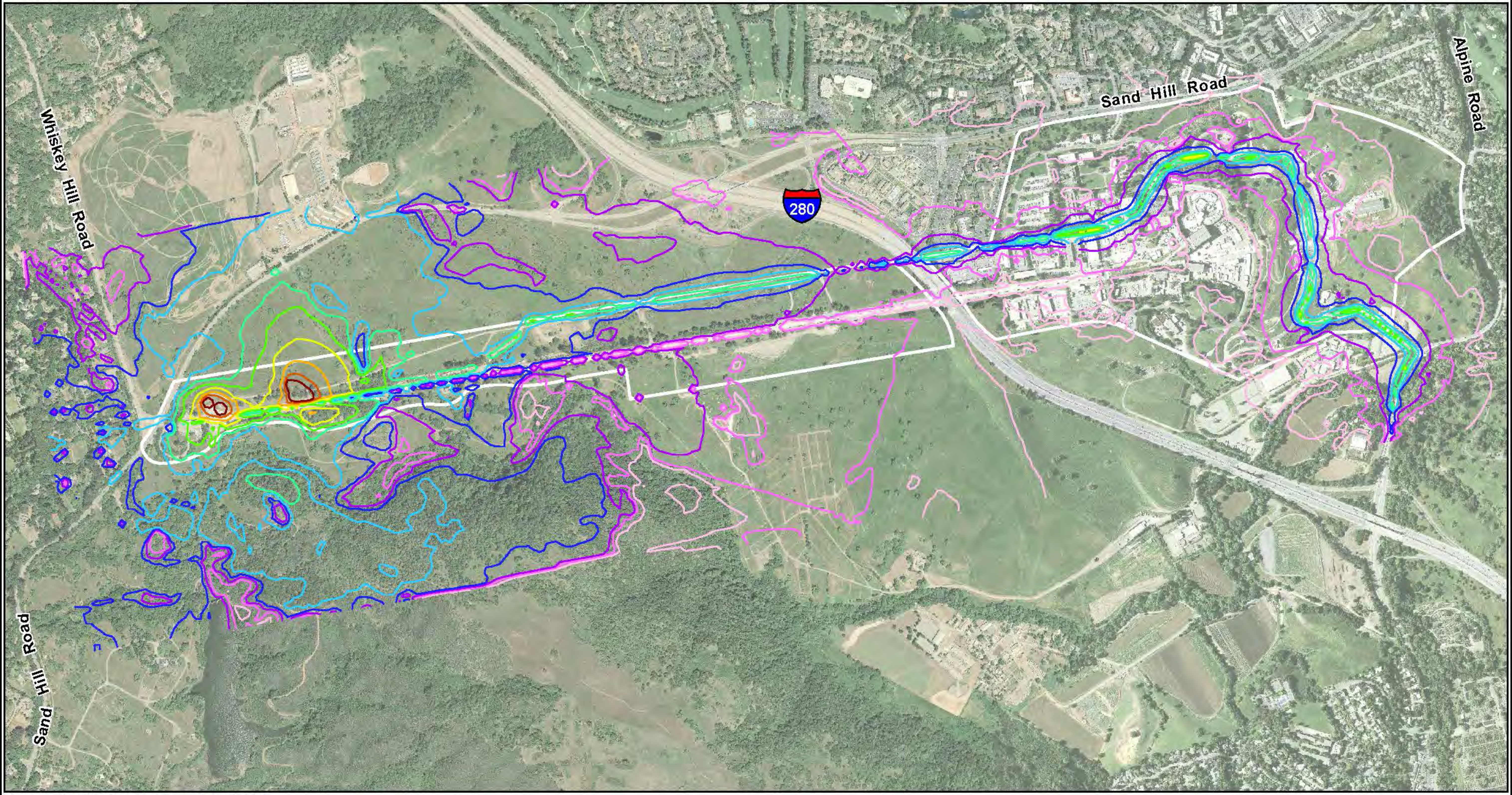
Fabrication of components at LBNL, Fermilab, TJNAF, and ANL would occur within existing buildings with active machine shops and laboratories in industrial areas set back from adjacent residential and commercial areas, and any impact on noise in those areas would be negligible.

Operations

During operations, the Proposed Action would increase the number of daily employees and users of the site from approximately 1,630 now to approximately 1,650 in the future. This increase would be inconsequential and is approximately equal to the fluctuation in the number of SLAC employees over 1 year (60 to 100 people) because of shutdowns, construction activities, and temporary labor. The projected increase, however, would result in an approximate less than 1.0 dBA increase in traffic-related noise levels along Alpine Road or Sand Hill Road near SLAC’s main entrance and would be below detection at the locations of sensitive receptors. Therefore, any operational effects from the Proposed Action on traffic noise would be minor.

Potential sources of long-term operational noise would include cryogenic plant components, specifically compressors, refrigeration units, and air handling and HVAC units. The cryogenic plant at Sector 4 would have five compressors –one at 2,500 hp, and four at 800 hp. The air handling and HVAC units would typically have a maximum noise level of 96 dBA power level (PWL) for a 12,000 cubic feet per minute (cfm) air handling unit and 78 dBA PWL for a commercial rooftop air conditioner (Carrier 1992). The plant would have from four to six emergency ventilation fans (20,000 cfm) mounted on the roof.

[5] VdB is a unit that denotes 20 times the logarithm of the ratio of the measured particle velocity to a reference particle velocity (usually 10^{-8} m/s).



Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

NOISE CONTOURS DECIBLE LEVELS

30	60
35	65
40	70
45	75
50	80
55	

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

N

0 1,000 Feet

Graphic Scale: 1" =1000'

SLAC LCLS-II EA

PROPOSED ACTION CONSTRUCTION NOISE CONTOURS

ARCADIS

FIGURE 3-5

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The Proposed Action would also include two new unit electrical transformers (**Figure 2-6**) and a 15 kilovolt (kV) outdoor medium-voltage SF6 switchgear. The main source of noise would be the transformers and cooling fans. The National Electrical Manufacturers Association standard describes sound levels for 2,000 kilovolt-amps (kVA) commercial transformers (e.g., vent-dry type) at a distance of 1 foot from the source as 66 dBA for self-cooled and 71 dBA for fan-cooled units (General Electric 1999).

In addition to these manufacturer data, data collected from DOE's cryogenic plant at TJNAF were used as model input. Because many aspects of the TJNAF plant would be replicated at SLAC, these noise data provide a good approximation of the noise that would be produced at SLAC. The data were collected in June of 2010 on the outside of the building. Noise levels at a distance of 5 feet outside the cryogenic plant wall ranged from 61.5 to 64 dBA Leq, and octave band data are shown in **Table 3-15**.

Table 3-15 Noise Data from Cryogenic Plant at TJNAF

Octave band (Hz)	Range
16	61.5 – 63.2
31.5	66.5
63	69.9 – 70.9
125	69.5 – 70.6
250	60.1 – 62.2
500	58.8 – 60.5
1,000	56.3 – 59.8
2,000	51.6
4,000	41.1
8,000	32.9 – 34.1
16,000	13.0 – 15.0

The noise values for the cryogenic plant components and the transformers were used to model noise impacts at receptor locations. The operational noise assessment assumed 24-hour operations and accounted for the 2,000-foot distance from the Sector 4 cryogenic plant to the receptors and the shorter distance from the smaller cryogenic plant. Model input data also included source elevations (building heights) and topography. Model input assumptions were similar to those used for the construction noise model (Appendix D) with one notable exception. As described in Section 2, the cryogenic plant design would include excavation to create flat foundations and using the soil to create berms around the plants to reduce noise propagation.

Table 3-17 and **Figure 3-6** present modeled operational noise levels (project only) for residential receptors. The calculated operational noise levels from LCLS-II at the nearest residential receptors would range from 13.0 dBA Leq to 44.5 dBA Leq. The project would result in an increase of less than 3 decibels to both the existing daytime and nighttime noise level at the nearest residential receptors. This increase would not result in a noticeable change at the nearest residential receptors. Nevertheless, to minimize operational noise levels, SLAC would evaluate options for reducing noise from the outdoor mechanical equipment located at the cryogenic plants and substation, including selecting quieter equipment during final design or adding enclosures or sound barriers.

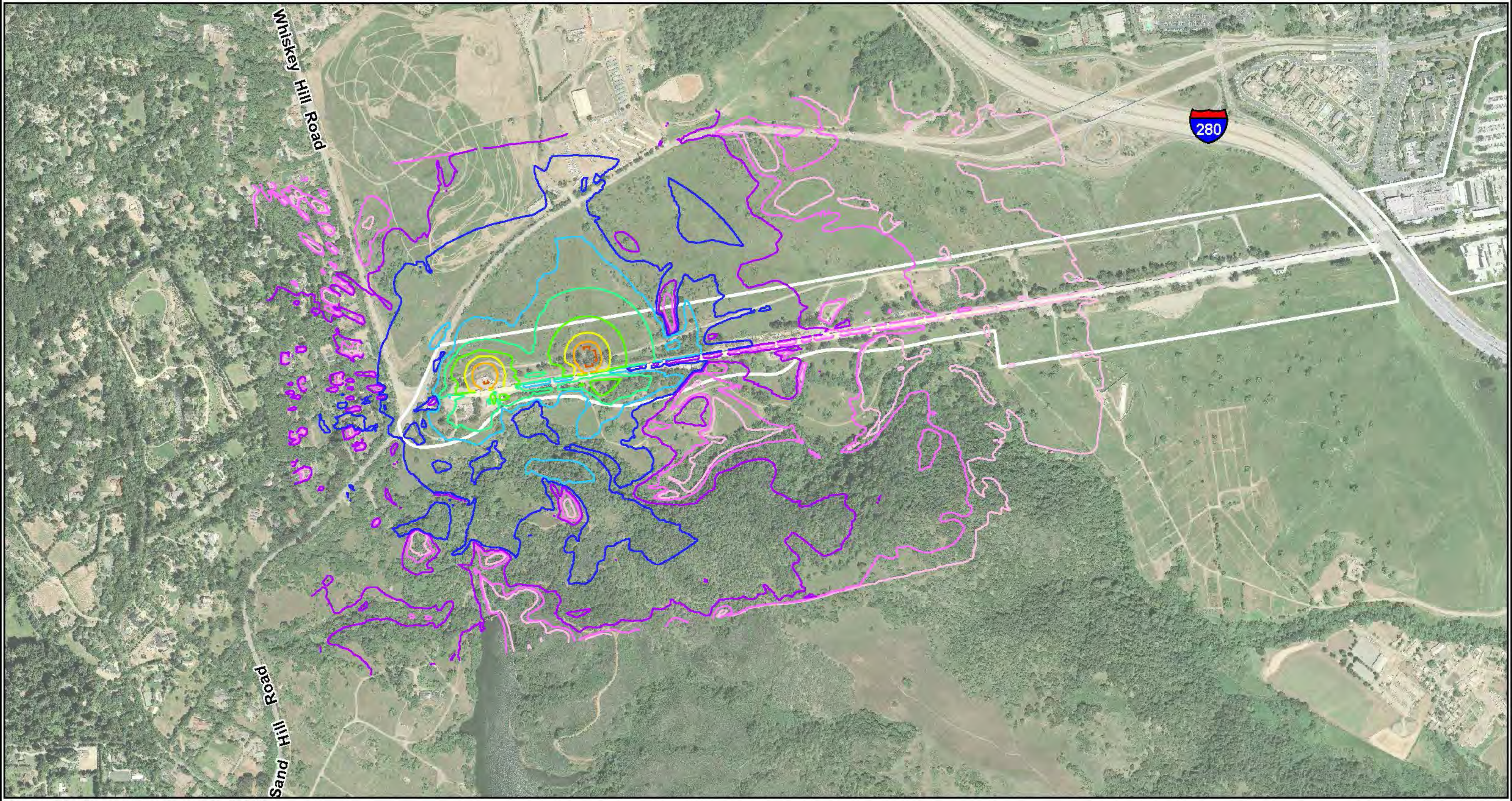
Table 3-16 Modeled Operational Noise Levels at Receptor Locations

Sensitive Receptor	Receptor Location	Operational Noise Impacts (dBA L_{eq})	Measured Ambient Noise Levels (dBA L_{eq})	Combined Noise Levels (dBA)	Noise Level Increase (dB)
LT-1	Long-term Monitor Location	46.7	49.0[1]	51.0	2.0
ST-1	SLAC Northern Haul Road	37.0	46.2[2]	46.7	0.5
ST-2	SLAC Research Yard (Central SLAC)	19.5	58.6[2]	58.6	0.0
ST-3	Manzanita Road, Woodside	37.4	42.8[1]	43.9	1.1
ST-4	Manzanita Road, Woodside	40.5	41.8[1]	44.2	2.4
ST-5	Sand Hill Road, Woodside	44.5	53.3[1]	53.8	0.5
ST-6	Whiskey Hill Road, Woodside	43.2	43.8[1]	46.5	2.7
ST-7	Alpine Road Across from SLAC Gate	13.0	63.2[2]	63.2	0.0

Notes:
1 Measured nighttime ambient noise level
2 Measured daytime ambient noise level

Vibration from the cryogenic plants would be inconsequential in off-site areas. The plants would be located approximately 200 feet away from the linac to minimize interference with the electron beam; however, the compressors would be inside the cryogenic plant buildings and designed to minimize vibration.

Overall, operational noise levels would be below local noise thresholds for both daytime and nighttime periods. Maintenance activities, such as visual inspections, vegetation mowing, and equipment parts replacement, would be part of the Proposed Action. Potential effects from these activities on noise levels may be detectable over short durations; however, given the distances to the nearest sensitive receptors, any potential increases in operational noise levels would be minor.



Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

NOISE CONTOURS DECIBLE LEVELS

30
35
40
45
50
55
60
65
70
75

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

N

0 800 Feet

Graphic Scale: 1" = 800'

SLAC LCLS-II EA

PROPOSED ACTION OPERATIONS NOISE CONTOURS

ARCADIS

FIGURE 3-6

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3.11 Socioeconomics and Environmental Justice

This section provides baseline data on population, ethnicity, employment, income, housing, and the local economy near SLAC and evaluates the potential socioeconomic and environmental justice impacts of the Proposed Action, including the potential for adverse human health or environmental impacts that could disproportionately affect a minority or low-income population. This section focuses on SLAC where construction and long-term operations would occur; however, it also addresses potential socioeconomic and environmental justice effects at LNBL, Fermilab, TJNAF, and ANL.

3.11.1 Affected Environment

The Proposed Action is located in unincorporated San Mateo County, California, adjacent to the communities of Woodside, Portola Valley, Menlo Park, Los Altos Hills, Palo Alto and Atherton. These communities and the Census Designated Places (CDPs) of Ladera, Stanford University and West Menlo Park comprise the area of study for the socioeconomics and environmental justice analysis.

3.11.1.1 Population, Race and Ethnicity

The population and ethnicity of residents within the area of study are shown below in **Table 3-17** (U.S. Census Bureau 2011). For comparison, this information is also provided for San Mateo and Santa Clara Counties, the State of California, and the United States as a whole. The population of the area of study is less diverse than that of the counties in which the communities and CDPs are found.

Table 3-17 Population and Ethnicity of Residents within the Area of Study

		Ethnicity (Percentage of Total Population)							
	Total Population	White	American Indian/ Alaska Native	Asian	Black or African American	Native Hawaiian or Other Pacific Islander	Some Other Race	Two or More Races	Hispanic
Atherton	6,914	80.5	0.1	13.2	1.1	0.7	1.4	3.1	3.9
Ladera CDP	1,426	89	0.1	6.9	0.2	0	0.4	3.5	2.3
Los Altos Hills	7,922	68.4	0.1	26.6	0.5	0.1	0.6	3.7	2.7
Menlo Park	32,026	70.2	0.5	9.9	4.8	1.4	8.7	4.5	18.4
Palo Alto	64,403	64.2	0.2	27.1	1.9	0.2	2.2	4.2	6.2
Portola Valley	4,353	91	0.1	5.6	0.3	0	0.7	2.4	4
Stanford	13,809	57.4	0.6	27.4	4.7	0.2	1.9	7.8	10.4
West Menlo Park CDP	3,659	81.5	0.1	11.4	0.8	0.1	1.4	4.8	5.5
Woodside	5,287	89.2	0.1	6.3	0.4	0.1	1.2	2.7	4.6
United States	**308,745,538**	**72.4**	**0.9**	**4.8**	**12.6**	**0.2**	**6.2**	**2.9**	**16.3**

Table 3-17 Population and Ethnicity of Residents within the Area of Study

	Total Population	Ethnicity (Percentage of Total Population)							
		White	American Indian/ Alaska Native	Asian	Black or African American	Native Hawaiian or Other Pacific Islander	Some Other Race	Two or More Races	Hispanic
California	**37,253,956**	**57.6**	**1**	**13**	**6.2**	**0.4**	**17**	**4.9**	**37.6**
San Mateo County	**718,451**	**53.4**	**0.5**	**24.8**	**2.8**	**1.4**	**11.8**	**5.3**	**25.4**
Santa Clara County	**1,781,642**	**47**	**0.7**	**32**	**2.6**	**0.4**	**12.4**	**4.9**	**26.9**

3.11.1.2 Minority Populations

There are 52 Census Tracts that are fully or partly within the communities and CDPs identified as constituting the area of interest. Of these, only four have a population where a minority group (or groups) accounts for more than 50 percent of the population of the tract: Tract 6117 (population 5,970; 1,130 Black or African American; 2,270 Other), which is located north of Highway 101 along the southern end of San Francisco Bay and more than 4 miles from the Proposed Action; Tract 6130 (population 10; 6 Black or African American), which is located within 1 mile of the site of the Proposed Action; Tract 5117 (population 106; 54 Asian), which is located in Los Altos Hills more than 5 miles from the site; and Tract 5093 (population 437; 159 Asian; 22 Black or African American; 33 Other), which is located more than 6 miles east of the site.

Of the 52 Census Tracts, two have populations that are majority Hispanic: 6117 and 6118. Both are located more than 4 miles from the site of the Proposed Action (U.S. Census Bureau 2011).

3.11.1.3 Income

The Census Bureau's 2008-2012 American Community Survey estimates the median household incomes of Santa Clara County and San Mateo County to be $90,747 and $87,751, respectively. By comparison, the median household income for the State of California as a whole was estimated to be $61,400. The median household and per capita incomes for the communities and CDPs contained in the area of study are shown in **Table 3-18** (U.S. Census Bureau 2010).

This data illustrates the considerable affluence of the two counties and the communities and CDPs within the area of study. The lower income levels in the Stanford CDP is attributable to the presence of the university and its student body (the average age for the CDP is 22.6, and 76.2 percent of the population is between the ages of 15 and 29).

Table 3-18 Median Household and Per Capita Incomes within the Area of Study

	Median Household Income, Dollars	Per Capita Income, Dollars
Atherton	228,393	135,838
Ladera CDP	161,711	94,291
Los Altos Hills	196,484	105,236
Menlo Park	113,774	67,072
Palo Alto	122,482	74,582
Portola Valley	166,384	145,563
Stanford CDP	55,299	32,151
West Menlo Park CDP	147,137	81,181
Woodside	212,649	122,060
California	**61,400**	**29,551**
San Mateo County	**87,751**	**45,458**
Santa Clara County	**90,747**	**41,041**

3.11.1.4 Housing

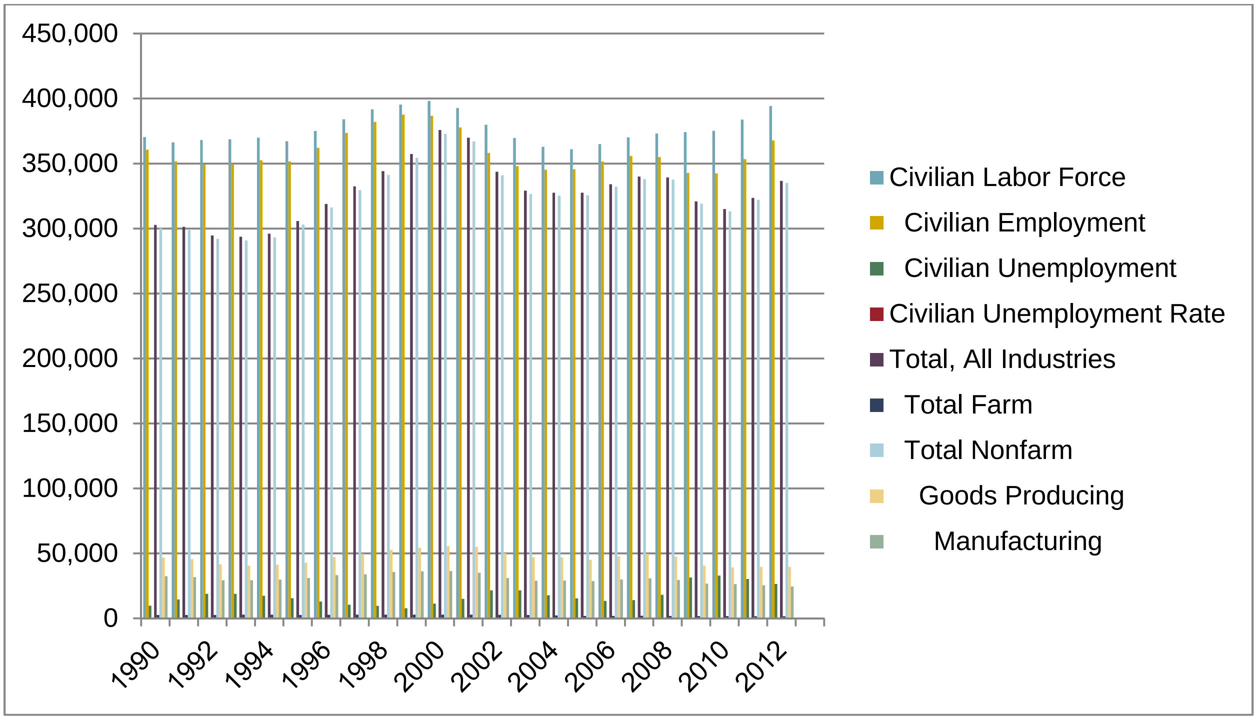
Reflecting the affluence of the area, home sales prices in the area of study are substantially higher than found across the state as a whole. In December 2013, the median sales price of a single-family house in California was approximately $438,040; in Santa Clara County, it was $768,000 and in San Mateo County, it was $1,000,000 (California Association of Realtors 2013).

3.11.1.5 Industrial Sectors

Santa Clara and San Mateo counties have the diversified economies typical of urban metropolitan areas. The percentages of workers employed in major industrial sectors are shown in **Figure 3-7**. Because the area is home to Silicon Valley, the manufacturing, professional, and business services sectors account for almost 40 percent of the workers in Santa Clara County.

SLAC employs approximately 1,630 staff, and hosts up to 1,000 visiting scientists and researchers each year. Other major employers in the area include Stanford University (approximately 8,300 employees), SRI International in Menlo Park, the U.S. Department of Interior in Menlo Park, Hewlett Packard in Menlo Park and the Veterans's Administration Medical Center in Palo Alto (State of California, Employment Development Department 2014a).

Figure 3-7 Workers Employed in Major Industrial Sectors



Source: California Employment Development Department 2014b

3.11.1.6 Low-Income Populations

While approximately 17 percent of California's population lives below the poverty line, in San Mateo and Santa Clara counties only 8.4 and 10.8 percent, respectively, of the population are living below the poverty line. There are no identified low-income populations within the area of study relevant to this socioeconomic analysis (U.S. Census Bureau 2014a).

Three secondary school districts serve the area of interest: Sequoia Union High School District, Palo Alto Unified School District and the Mountain View-Los Altos Unified School District. In 2012, the poverty rates for students attending these schools were 10.1, 4.2 and 6.7 percent, respectively. Six elementary school districts serve the area of interest: Redwood City, Woodside, Las Lomitas, Menlo Park City, Portola Valley and Palo Alto. The poverty rates for students attending these schools are 17.9, 4.7, 3.1, 3.8, 5.7 and 4.1 percent, respectively. For comparison, the state-wide poverty rate for those attending school is 22.4 percent. This indicates that fewer students attending schools in the area of interest live below the poverty line than statewide (U.S. Census Bureau 2014b).

3.11.2 Environmental Consequences

3.11.2.1 No Action

Selection of the no action alternative would result in no socioeconomic impacts in the area of study, no impact on the existing population or demographics of the area, no impacts on the housing market, and no environmental justice impacts.

3.11.2.2 Proposed Action

Socioeconomics

Construction

The Proposed Action would have negligible, if any, impact on the population or demographics of the area of study. Construction would be extremely unlikely to result in any in-migration that could adversely affect the population or demographics of the area of study. Construction of the Proposed Action would require a peak of approximately 40 workers per day. Employment in the construction industry (North American Industry Classification System) in San Mateo and Santa Clara Counties has fallen from 64,098 in 2007 to 49,006 in 2012; this shows an increase in the construction workforce from its low in the 2010-2011 period, but the data also shows that the current construction employment in the area lags the peak seen in 2007 (Bureau of Labor Statistics 2014). This suggests that construction employment needs could be met with local resources. Therefore, there would be no in-migration of workers to meet the construction labor demands of the Proposed Action, and no impacts on the population or demographics or to the local housing market.

The Proposed Action has a total estimated cost of approximately $895 million; of this amount, the work performed at SLAC (which includes, but is not limited to, construction costs) would account for approximately $350 million. Construction spending in California has fallen from approximately $65 billion in 2005 to a low of approximately $23 billion in 2009. Residential construction activity dropped from a high of approximately $47 billion in 2005 to a low of approximately $12 billion in 2009. Commercial construction experienced a smaller loss, dropping from a high of approximately $22.5 billion in 2007 to a low of approximately $10.9 billion in 2009 (CA Department of Finance 2014). Construction activity is currently growing, although construction spending is still at a level less than half of its peak. The Proposed Action would generate a small positive economic benefit to the construction industry and associated industries (e.g., transportation, warehousing). The greatest impacts would be realized in San Mateo and Santa Clara counties, with smaller impacts on other counties in the region. The size and duration of the Proposed Action’s construction cost and schedule are not sufficiently large to increase the costs for labor or materials in the region, and thus would not present the risk of negative economic impacts.

Construction of components at other DOE facilities would be completed by currently employed staff and would have no noticeable positive or negative economic impacts in those areas.

Operations

Operation of the Proposed Action would have no impacts on the population or demographics of the area of study. Because LCLS-II would create only approximately six additional positions at SLAC, operation of the Proposed Action would not result in substantial permanent in-migration of individuals to the area. Any indirect or induced economic effects generated from the earning and spending of new employees would be inconsequential. Similarly, there would be little or no impact on local housing markets. Operation of the Proposed Action may result in increased numbers of visitors to SLAC; the increased numbers of visiting researchers would have a small but near-negligible economic benefit resulting from hotel stays, dining, etc. The operation of the Proposed Action would represent a continuation of the research work currently conducted at SLAC, and thus would serve to preserve the economic benefits realized from maintenance of employment levels at SLAC.

Environmental Justice

Construction

As described above, no concentrations or large numbers of low-income populations have been identified within the area of study. The communities that make up the area of study have high per capita and median household incomes; fewer families in Santa Clara and San Mateo counties live in poverty when compared to the State of California and the United States and the poverty rate for students in the school districts that serve the area is lower than for the state as a whole.

Minority populations do not constitute a numerical majority in any of the communities or CDPs that comprise the area of study. Concentrations of non-white populations exist within some portions of the study area, notably Asians in Lost Altos Hills, Palo Alto, Stanford and West Menlo Park, and Hispanic populations in Menlo Park and Stanford. The concentrated Asian populations (those areas where Asians account for greater than 25 percent of the population) are located generally to the south and east of the site of the Proposed Action, at distances greater than approximately 2.5 miles. The concentrated Hispanic population in Menlo Park occurs in the northeastern portion of the city, north of Highway 101 and more than 4 miles from the site of the Proposed Action. The minority populations in the Stanford CDP are assumed to be students, and thus are presumed to have access to information and advice regarding environmental activities and associated risks that are addressed in DOE's Environmental Justice Strategy.

Construction would have only minor environmental impacts. These impacts would be minimized using the avoidance and minimization measures described in Section 2.1.8). These minor impacts would be borne uniformly by the population as a whole; thus, there would be no disproportionate effects from construction on minority or low-income populations. Similarly, fabrication activities at LBNL, Fermilab, TJNAF, and ANL would have negligible environmental effects that would be borne uniformly by those populations as a whole and there would be no disproportionate effects on minority or low-income populations.

Operations

There are no identified concentrations or large numbers of low-income populations or majority minority populations in any of the communities or CDPs in the area. Operation of the Proposed Action would have only minor environmental effects. Any potential impacts would be minimized by SLAC and would be borne uniformly by the population as a whole. Thus, there would be no disproportionate effects on minority or low-income populations.

3.12 Transportation

This section describes the existing transportation infrastructure and traffic volumes, project-related traffic, and potential effects on public roadways, including the potential for traffic delays and accidents, and potential strategies to minimize transportation impacts. While focused on SLAC, which would be affected by construction and long-term operations, this section also addresses impacts at the component fabrication sites.

3.12.1 Affected Environment

SLAC is bordered to the north and south by two main arteries - Sand Hill Road and Alpine Road. Primary access is from Sand Hill Road, a four-lane arterial that connects to a full interchange with I-280 to the west and the Stanford University campus and the cities of Palo Alto and Menlo Park to the east. There are several signalized intersections along Sand Hill Road near SLAC, most of which fall within the jurisdiction of the City of Menlo Park. There is one San Mateo County-controlled intersection (Sand Hill Road/Sharon Park Drive); the I-280 ramp intersections are maintained by the California Department of Transportation (Caltrans). Traffic counts conducted at the Sand Hill Gate recorded approximately 325 vehicles per hour on a weekday (CSG Consultants 2011). SLAC is not open to the public. The main gate at Sand Hill Road is staffed by security guards 24 hours per day.

The Alpine Road entrance accounts for much of the balance of site traffic. Alpine Road is a two-lane roadway that connects to a full-access interchange with I-280. To the east, Alpine Road connects to Santa Cruz Avenue/Junipero Serra Boulevard at a signalized intersection. Alpine Road falls within San Mateo County between I-280 and just west of Santa Cruz Avenue; the Alpine/Santa Cruz/Junipero Serra intersection is in City of Menlo Park. Alpine Road provides a secondary access to SLAC and at times is used by construction workers and trucks as well as for special and limited conditions, such as the delivery of construction materials. The Alpine Road entrance was used for site access during LCLS construction. The Alpine gate has an automated gate system that allows authorized staff to access the site.

The approximately 1.2-mile length of Alpine Road between I-280 and Junipero Serra Boulevard frequently backs up during the morning and evening commute period. Expanding the capacity of Alpine Road presents challenges because of the topography of the roadway and the proximity of residential neighborhoods. San Mateo County currently has no plans to widen the portion of Alpine Road near SLAC.

SLAC has a third entrance at its west end near the corner of Sand Hill Road (north of I-280) and Whiskey Hill Road. This entrance is used infrequently and only under special circumstances for construction on the accelerator components. This entrance leads to an access road with an uphill grade leading to the west end of the accelerator housing.

Traffic counts for area roadways are available for Sand Hill Road and Alpine Road in the vicinity of SLAC. The 2013 annual average daily traffic (AADT) on Alpine Road from I-280 to Piers Road was 18,941 (Houshmandi 2014). The AADT was 8,783 on Sand Hill Road west of I-280 between Whiskey Hill Road and Portola Road and 14,242 at Sand Hill Road east of I-280 between Sharon Park Drive and Santa Cruz Avenue (San Mateo County 2006).

The baseline traffic accident rate can be estimated using statistics published by the California Highway Patrol (CHP). During 2011, California had a total of 2,628 fatal traffic collisions and 159,115 traffic collisions with injuries (CHP 2014a). The California 2011 Mileage Death Rate (MDR) was 0.87, which represents the number of fatalities per 100 million miles traveled (CHP 2014a). California’s MDR was substantially lower than the national 1.14 MDR (OTS 2014). The 2011 injury rate was 0.005 per 100 million miles traveled. On-site accidents are minimized through mandatory training of SLAC employees and visiting workers.

Vehicles traveling on site roadways affect pedestrian movement within SLAC. Pedestrian pathways connect major parking areas with buildings. Outside SLAC’s Central Campus, there are fewer pedestrian pathways and pedestrians often share the road with vehicles. Increased vehicle use and speed have become a concern for pedestrians within the SLAC property.

The transportation environment at LBNL, Fermilab, TJNAF, and ANL would include the major arteries around those locations, including intersections at site entrances and on-site roadways and access points to existing buildings and laboratories that would be used during component fabrication.

3.12.2 Environmental Consequences

3.12.2.1 No Action

Under the no action alternative, there would be no construction or additional operational vehicular traffic. Therefore, this alternative would not affect traffic or circulation. SLAC, LBNL, Fermilab, TJNAF, and ANL would continue existing operations and approved construction projects.

3.12.2.2 Proposed Action

Construction

The Proposed Action would add construction-related vehicular traffic on local roads and on-site due to trips to and from the site by workers and trucks hauling and delivering building materials. While on-site construction activities would occur over three years beginning in early 2016, construction trips would peak in 2017 when most of the deliveries, assembly and installation work would occur. These activities would employ a peak of approximately 40 workers and would generate approximately 20 truck trips per day for a total of 60 additional round trips per day at the peak of construction. Trucks would use the Alpine Road entrance and the main gate; however, SLAC may occasionally direct larger trucks and heavy haul deliveries of cryogenic plant and accelerator components to the west gate at the west end of SLAC.

Points of origin for transport of construction-related materials and commuting workers would vary; however, the estimates in this section assume that workers would travel 50 miles per day round trip and that material for recycling would be trucked to San Jose. Several of the cryogenic components would be delivered by truck from Fermilab and ANL in Illinois and TJNAF in Virginia.

Construction traffic typically would occur outside the normal commute peak periods. Workers would arrive early at the site before the morning commute peak period, and leave before the start of the evening commute peak or after the evening commute period. In addition, SLAC would ensure that truck deliveries would not coincide with the commute peak traffic, particularly for heavy haul.

Figure 1-3 shows SLAC's main entrance at Sand Hill Road and the entrance at Alpine Road. **Figure 2-1** shows the west gate and access road at SLAC's west end (from Sand Hill Road west of I-280. Minor disruption of traffic may occur when the trucks and other construction-related vehicles turn left into the campus from Alpine Road or from Sand Hill Road. However, because the campus is not open to the public, the number of vehicles turning into SLAC would be limited. In some cases, construction vehicles would be staged and then escorted onto the campus. SLAC would establish procedures for inspecting and clearing vehicles through these gated entrances to prevent excessive queuing of construction vehicles and haul trucks.

Traffic Volume

During construction, traffic volumes would increase slightly on the public roadways near SLAC. Construction-related vehicular traffic on public roads would be comprised of commuting construction workers and trucks delivering construction materials and supplies. Construction-related traffic would occur over the 3-year construction period, but would be intermittent and would vary depending on the activities conducted.

Construction of the components would require a total of approximately 1,000 truck trips (round trips). These deliveries would involve an average of five truck trips per day over the three-year construction period; however, most truck deliveries would occur as dismantled equipment is removed and new utilities and electrical components arrive and would peak at approximately 20 trucks per day.

Daily commuting of the peak construction workforce of 40 together with 20 truck deliveries would result in an increase of approximately 60 vehicles per day on the surrounding roads. The increased volume of traffic on public roadways would be limited to the three-year active construction period. The additional project-related traffic would not result in traffic delays because there would a minimal increase in the number of vehicles traveling on public roadways. Traffic effects would be minimized by scheduling the arrival and departures of construction-related workers to avoid peak commute hours. Workers would arrive before 7 a.m., before the morning commute peak period, and leave at 3 p.m., before the start of the evening commute peak. The Proposed Action would not require closure of public roads but would require control measures for heavy haul, such as temporary traffic control using flaggers.

The Proposed Action would result in a minor increase in the AADT on public roadways near SLAC. Project vehicles would travel various routes, and no single road would experience all the worker and truck traffic. Therefore, the estimated percent traffic increases are very conservative because they assume that all 60 construction-related vehicles would travel the same route each day. No road would experience an AADT increase of greater than 0.5 percent and there would be little or no impact on public travel. Alpine Road is the most congested road in the area; however, LCLS-II would only increase the AADT by less than 0.5 percent.

The west gate would be used only occasionally and this analysis assumes that one truck would enter this gate per day. Given the AADT on Sand Hill Road east of I-280 is over 8,700, this would result in an increase in daily traffic of well below 0.01 percent.

To minimize traffic impacts, the construction contractor and SLAC would prepare a traffic management plan prior to the start of construction. Construction vehicles and workers would be required to enter SLAC via Alpine Road or the western entrance of Sand Hill Road in special circumstances. To minimize traffic delays resulting from vehicles turning left from either entrance, the traffic control plan would outline constraints on making left turns against oncoming traffic. The traffic control plan would establish project-specific traffic management measures such as arrival and departure times. Construction traffic typically would occur outside the normal commute peak periods. Heavy haul deliveries of construction materials and large components would arrive after 9 a.m. and depart after 7 p.m. With implementation of these measures, SLAC would minimize off-site construction traffic impacts.

<u>Traffic Accidents</u>

The Proposed Action would result in the potential for traffic accidents roughly proportional to the number of project-related vehicles miles. Although the rate of traffic accidents cannot be predicted definitively, the incremental increase can be estimated based on the historical rates.

Numerical estimates of potential accidents were calculated using the number of vehicle miles that would be driven during construction and applying the accident rates per vehicle mile from the California Highway Patrol statistics as previously described (CHP 2014a). The calculated result is an estimate of risk and does not imply that a particular number of accidents, injuries, or fatalities would actually happen.

To determine the number of vehicle miles associated with construction under the Proposed Action, a conservative average commute distance of 50 miles per round trip was used to estimate the distance traveled by workers driving to and from SLAC. This distance is based on a one-way distance of 25 miles between SLAC and San Francisco (and San Jose).

Under the Proposed Action, peak construction would result in 36,000 vehicle miles traveled. This estimate assumes one 25-mile roundtrip per day for 40 workers over the one-year peak construction period and 1,000 truck trips travelling one 35-mile roundtrip each. Based on CPH-published accident rates (CPH 2014b), the Proposed Action may potentially result in one (0.5) injury and zero (0.0) fatalities. These estimates are based on statewide statistics for both automobiles and trucks, and does not account for local factors such as traffic safety devices, weather conditions, police enforcement of safety regulations, or shared use of roads and parking areas with pedestrians and bicyclists. DOE and SLAC procedures to pre-qualify contractors with excellent safety records would predict even lower probability of occurrence of accidents than general traffic statistics indicated here.

Project-related trucks would adhere to SLAC's traffic safety policy. For construction, this policy requires signage and/or flashing lights, traffic cones, and flaggers to direct trucks where visibility is obstructed. Trucks would be required to adhere to on- and off-site speed limits. Traffic management would be incorporated into the construction contract.

Construction of the Proposed Action would not involve transport of substantial volumes of hazardous materials or any radioactive materials or wastes. Transported hazardous materials would include those required for construction such as lubricants and solvents. Risks from routine transport of small volumes of hazardous materials and waste are evaluated in Section 3.13, Waste Management.

Because construction-related traffic would use SLAC's construction entrances at Alpine Road entrance, which is used by only 10 percent of campus traffic, as well as the Sand Hill Road entrance at SLAC's west end, and because construction traffic would adhere to safety policies and would occur outside the normal peak commuting hours, the Proposed Action's construction traffic impacts would be minor.

Additional traffic generated by the Proposed Action at the component fabrication sites would be negligible as there would be no construction (e.g., excavation, building construction) at these sites. The fabrication work would be completed by existing staff, and truck deliveries of materials would be consistent with the existing frequency of deliveries. This is because the work would be completed at active machine shops, laboratories, and clean rooms at these locations. Because the work would be completed by existing staff, there would be no incremental increase in traffic volume or accidents and the impacts of the Proposed Action on transportation at these locations would be negligible.

Operations

Based on a conservative estimate of 1,630 employees and users with additional traffic due to visitors and vendors, approximately 6,750 (TJKM 2011) vehicles enter or exit SLAC daily at both the Sand Hill and Alpine Road entrances. Approximately 90 percent use the main entrance on Sand Hill Road. The Proposed Action would add approximately six permanent employees as well as the capacity to accommodate approximately 15 additional researchers. Currently, there are approximately 1,000 parking spaces at SLAC (TJKM 2011). The Proposed Action would add several parking spaces for the cryogenic plants and would not result in pressure on parking capacity in off-site areas or at Stanford University.

Traffic Volume

The Proposed Action would add approximately six new permanent positions and the new facilities would accommodate up to approximately 15 additional researchers. During operations, the 21 additional commuters would not result in a noticeable increase in traffic volume relative to current operations. Assuming this increase in personnel increases local traffic by an average of approximately 21 vehicles per day, the impact on nearby roads would be less than 0.5 percent, a negligible increase in traffic. Impacts on public travel would be minimal because the construction-related vehicles would result in a very slight increase in traffic volume relative to current conditions. This increase would be inconsequential and is approximately equal to the fluctuation in the number of SLAC employees throughout a year (60 to 100 people) because of shutdowns, construction activities and temporary labor. In addition, many users would reside in SLAC's guest facilities and would be less likely to use site entrance gates during peak traffic periods. Therefore, no adverse traffic or circulation impacts would occur as a result of project operations.

Traffic Accidents

Under the Proposed Action, operations would result in 1,950,000 vehicle miles traveled over the 20-year project life. Whereas construction workers may come from San Francisco or San Jose and suburbs, most of the operations staff would likely seek housing closer to SLAC; therefore, this estimate assumes one 25-mile round trip per day for 35 workers. Based on CHP-published accident rates (CHP 2014b), the total vehicle miles traveled for operations has the potential to result in one (1.0) injuries and zero (0.0) fatalities. The calculated result is an estimate of risk and does not imply that a particular number of accidents, injuries, or fatalities would actually happen.

3.13 Visual Resources

This section describes the visual setting of the project area and evaluates the potential visual impacts of the LCLS-II project, including the potential effects of off-site truck traffic and the cryogenic plants, as well as project features that would minimize effects, such as the soil berms and plantings to screen views.

3.13.1 Affected Environment

SLAC is located in San Mateo County in an area of mixed residential, agricultural, open space, and recreational land use. SLAC is located on approximately 426 acres of Stanford University-owned land located in the foothills of the Santa Cruz Mountains, above the alluvial plain that borders the western margin of the San Francisco Bay. The maximum elevation within the SLAC site's boundaries is approximately 375 feet AMSL. Jasper Ridge, located immediately southwest of the SLAC site's boundary, is the local topographic high at 600 feet AMSL. SLAC is located approximately 2 miles west of the main Stanford University campus. The predominant adjacent public roadways are Sand Hill Road, Alpine Road, and I-280. The characteristic landscape within and around SLAC is predominantly low-density residential in character.

SLAC's experimental facilities are largely screened from public view by the local topography. The area's rolling hills screen views of SLAC's central campus. The accelerator housing is visible from I-280 as it extends to the west of SLAC's main campus. These facilities are devoted to scientific research and have been present since SLAC was established in the 1960s.

The affected environment at LBNL, Fermilab, TJNAF, and ANL would consist of existing buildings in industrial settings at those locations.

3.13.2 Environmental Consequences

3.13.2.1 No Action

Under the no action alternative, LCLS-II would not be constructed or operated, and there would be no short- or long-term visual impacts. Existing SLAC facilities that can be seen from off-site, including the klystron gallery, would remain. Similarly, at off-site component fabrication locations, existing facilities would remain.

3.13.2.2 Proposed Action

Construction

Construction would be largely screened from public view. The cryogenic plant sites are not easily visible to motorists on the roadways surrounding SLAC as they are located in topographical depressions adjacent to the existing accelerator housing (**Figure 3-8**). Construction equipment would be visible as it enters SLAC at the Alpine Road or Sand Hill Road entrances; however, construction activities such as site preparation, grading, removing existing infrastructure, and assembly of components would only be visible from on-site. As the cryogenic plants are constructed, views would be obscured by the intervening landscape to the north and west. Construction of the tallest structures may be visible from the surrounding hills, but only from a distance of approximately one mile. Construction of the tallest structures may also be visible to motorists on I-280; however, views would be extremely brief traveling at highway speeds.

Figure 3-8 Cryogenic Plant Construction Site

Construction would require removal of several small oaks and non-native trees. Construction offices would be located out of public view adjacent to the existing accelerator housing. Construction would not occur at night, and therefore would not require overnight lighting other than security lighting.

Overall, construction would have minimal visual impacts, as views would be screened by the intervening landscape consisting of rolling hills, including the hill located directly to the west of the Sector 4 cryogenic plant. This hill as well as other existing features such as Sand Hill Road and adjacent trees would block views from residents to the west. Temporary views of construction of only the tallest structures would be briefly visible to passing motorists and could be distantly visible from residences in the surrounding hills.

Visual impacts at component fabrication sites would be negligible. This activity would occur within existing buildings and there would be no construction of new buildings, grading, or landscaping.

<u>Operations</u>

The visual effects of Proposed Action operations would include occasional deliveries, resulting in trucks on area roadways, including liquid nitrogen deliveries. Off-site views of the superconducting linac would be nonexistent, as most changes would occur within existing facilities, including the accelerator housing as well as the klystron gallery, which is visible from I-280. Other features, such as the transformers and utilities, would have low profiles or would be located underground and would not be visible.

Views of the cryogenic plants would be similar to those described above for construction and would only be visible briefly for passing motorists and from distant vantage points. **Figure 3-9** depicts a cryogenic plant similar to the ones proposed for SLAC. The tallest structures would be approximately 40 and 35 feet for the larger and smaller plants, respectively. The cryogenic plants may be partially visible from Sand Hill Road to the west of I-280; however, SLAC would screen the plants from public view by siting them in topographical depressions adjacent to the existing accelerator housing, using excavated soils to construct soil berms to limit visibility, and by planting trees and shrubs to obscure views. Views of the cryogenic plants would be blocked or obscured by the intervening landscape to the north and west. The tallest structures may be visible briefly for passing motorists on Sand Hill Road and from the surrounding hills, but only from a distance of approximately one mile. These same structures may also be visible to motorists on I-280; however, views would be extremely brief traveling at highway speeds.

SLAC would implement measures to minimize visual effects of the cryogenic plants. The plants' foundations would be below the elevation of the existing ground surface. Much of the required machinery would be indoors (**Figure 3-10**). In addition, SLAC would minimize views of the cryogenic plants by placing soil berms adjacent to the plants and preserving existing trees and other vegetation and through new plantings, as well as selecting colors consistent with other SLAC facilities. SLAC would develop a project-specific architectural style during final design to minimize visual effects.

Figure 3-9 Cryogenic Plant at Thomas Jefferson National Accelerator Facility

Figure 3-10 Cryogenic Plant Compressor Room

The cryogenic plants would be lit at night for safety and security. Each mounted light would be directed downward to illuminate the immediate area while minimizing the amount of light visible from off-site. This type of night lighting would minimize the night shine from the facilities. Night lighting would be visible from distant vantage points but would be minimal and consistent with the lighting present at adjacent existing SLAC buildings.

Overall, the visual impacts of LCLS-II would be limited and would be minimized by the plants' low profiles, preserving existing trees and other vegetation, planting new trees on ridge tops to obscure views, and designing the plants to reduce their visibility (e.g., layout, colors). The plants' appearance would be consistent with the existing, long-term presence of SLAC's experimental facilities and its associated buildings. Therefore, the Proposed Action would have minimal visual impacts.

3.14 Waste Management

This section describes existing waste generation and management and the potential environmental effects of the Proposed Action on waste management practices and facilities, including storage and disposal and hazardous and radioactive waste.

3.14.1 Affected Environment

3.14.1.1 Hazardous Materials

SLAC handles, stores, and uses hazardous materials as part of its experimental programs, including operation and maintenance of experiments, as well as construction, general operations, and maintenance. Examples of hazardous materials present at SLAC include radioactive materials and wastes, flammable gases, compressed gases, corrosives, organic solvents, oils and fuels, adhesives, paints and epoxies, and metals.

SLAC has established various hazardous materials programs and associated training to comply with regulatory requirements, including but not limited to:

- HMBPs/Emergency Response Plans
- Hazard Communication Program/Chemical Hygiene Plan
- Chemical Management System
- Aboveground Storage Tanks
- Spill Prevention Control and Countermeasure Plan
- CalARP
- California Fire Code Hazardous Materials Management Plan

All of the applicable hazardous materials programs and procedures are provided for SLAC employees and contractors in SLAC's ESH&Q Manual. The intent of these programs and procedures is to help ensure the safe handling of hazardous materials for the protection of SLAC workers, the surrounding community and public, and the environment.

The local implementing agency for hazardous materials regulation in California is primarily the Certified Unified Program Agency (CUPA). The CUPA responsible for providing regulatory oversight of hazardous materials and hazardous waste management at SLAC is the San Mateo County Health Services Agency, Environmental Health Division.

3.14.1.2 Waste Management

During its research operations, SLAC generates a variety of waste streams, including but not limited to mixed waste, hazardous waste, radioactive waste, universal waste, non-hazardous industrial waste, municipal solid waste and scrap metal.

Whenever practicable, SLAC actively practices the following pollution prevention hierarchy for managing its waste streams in accordance with established procedures in the ESH&Q Manual.

- Reduce waste and prevent pollution at the source through process changes, substitutions and/or work practices.

- Reduce waste and prevent pollution by reusing or recycling materials.
- Reduce waste and prevent pollution by using appropriate control technologies.
- After exhausting the previous three approaches, exercise proper disposal.

SLAC is classified as a large quantity hazardous waste generator and manages its mixed and hazardous waste in accordance with federal, state and local laws and regulations, which are implemented through the SLAC the ESH&Q Manual. Hazardous waste is generated from activities that include, but are not limited to, routine laboratory operations, facility operations and maintenance, and remediation, and/or cleanup/stabilization projects. However, SLAC has reduced the amount of hazardous waste generated by routine operations from 147 tons in 1993 to 16 tons at present (an 89 percent reduction) through waste minimization and pollution prevention. During 2012, SLAC also recycled 1,146 tons of municipal waste and disposed of 420 tons for a solid waste diversion rate of 73 percent (SLAC 2013b).

SLAC generates mixed and low-level radioactive wastes from routine and non-routine operation (i.e., repairs and special projects or experiments). The Radioactive Waste Management Group oversees the proper management and disposal of these waste streams for SLAC. All property exposed to radioactivity is surveyed before removal from SLAC. Any material with detectable radioactivity is retained for reuse on site or disposed of as radioactive and in accordance with applicable laws and regulations for other associated hazards. SLAC minimizes the volume of radioactively impacted wastes generated through education and training for the waste generators, operational planning, material surveys, segregation, reuse and volume reduction when applicable. The bulk of radioactively impacted wastes are generated from non-routine operations such as decommissioning.

In 2012, SLAC also reduced the inventory of materials no longer needed for experiments by removing 98 sealed radioactive sources and disposing of 539 cubic feet of low-level radioactive waste. These materials were shipped to appropriate permitted and licensed treatment and disposal facilities (SLAC 2013b).

The EPA has delegated authority to the state of California for implementing the federal RCRA program. In turn, the state has delegated its authority for certain aspects of hazardous waste program oversight to the local CUPA. The San Mateo County Health Services Agency, Environmental Health Division, serves as the CUPA with delegated authority to oversee SLAC’s hazardous waste management.

SLAC uses a site-specific computerized hazardous waste tracking system for cradle-to-grave management of its hazardous wastes. Hazardous waste containers are tracked from the time they are issued to the generator to their eventual disposal off site at permitted facilities.

Non-hazardous waste includes non-hazardous industrial waste and municipal solid waste. In addition to its hazardous waste management program, SLAC’s Waste Management Group manages regulated industrial waste resulting from SLAC’s laboratory operations and remediation operations that, while not classified as hazardous, does not meet the acceptance criteria of municipal or sanitary solid waste landfill.

Examples of industrial wastes include soils with low levels of petroleum hydrocarbons, PCBs or metals such that they qualify as non-hazardous but are not acceptable to municipal landfills. In California, industrial wastes are generally termed Class II waste because they are specifically required to be disposed of at permitted Class II landfills (these provide an intermediate level of protection to the environment between Class I hazardous waste landfills and Class III municipal solid waste landfills).

SLAC's Conventional Facilities Division operates a municipal solid waste program that collects a variety of recyclable materials, as well as regular dumpster refuse. SLAC's Property Control Department operates a salvage operation that sells metal and other industrial recyclables (construction materials, such as concrete, clean soils, asphalt and wood) and equipment for their cash value. Collection stations are strategically distributed around the site. Dumpsters for cardboard collection are also strategically placed around the site and a specific location is provided for waste wood and non-hazardous construction and demolition debris. Scrap metal and electronic waste is collected and construction materials from building demolition and rehabilitation projects are recycled. SLAC recycled over 100 tons of scrap metal from the decommissioning of SLAC's B-Factory detector (BaBar) and PEP II dismantling activities (SLAC 2013b).

SLAC's Excavation Clearance Program continues to support SLAC-wide projects to ensure proper disposal of excavated soil. An excavation permit form must be completed and submitted for activities that involve excavation or relocation of soil at SLAC. The program identifies potential hazards associated with excavation work at SLAC and ways to reduce worker exposure to these hazards. These hazards include underground utility lines, chemical and radiological hazards and ensuring proper management and disposal of excavated materials. Sampling results are reviewed to ensure conformance with SLAC's RWQCB Order (SFBRWQCB, 2009).

Fabrication work at LBNL, Fermilab, TJNAF, and ANL would be governed by existing plans and programs similar to those describe above for SLAC including for hazard communication, emergency response, spill prevention, and hazardous materials management.

3.14.2 Environmental Consequences

3.14.2.1 No Action

The no action alternative would not result in additional generation, transportation or disposal of mixed, hazardous, combined, or radioactive waste; therefore, no impacts would occur due to hazardous materials use and storage.

3.14.2.2 Proposed Action

Construction

LCLS-II would require soil excavation for cryogenic plant construction. The project would require a permit from SLAC's Excavation Clearance Program to ensure proper soil screening, waste characterization and disposal. The permitting process would identify and minimize potential hazards associated with excavation work at SLAC. Prior to construction, SLAC's Excavation Clearance Program would review past activities performed in the area and collect soil samples, as needed for analysis of organic (e.g., total petroleum hydrocarbons [TPH]) and inorganic (e.g., lead) chemicals. Based on the analytical results, the soils would be reused at the cryogenic plant sites to construct perimeter berms, relocated to another area at SLAC, or disposed of at a Class II landfill. Excavated materials would be stored and handled as outlined in the project-specific SWPPP.

During excavation and construction, generation of hazardous materials would be limited to fuels and lubricants for heavy equipment maintenance and fueling. Maintenance activities would occur in a designated area with appropriate means to prevent overflow or spills. Construction of LCLS-II may require limited use of hazardous materials, such as paints, epoxies, fuels and lubricants. Hazardous materials would be handled in accordance with established procedures. As described above, SLAC would minimize generation of solid waste by salvaging and recycling construction materials and removed instruments and utilities. Therefore, these potential adverse impacts would be short term and minor.

Any material removed from within the accelerator housing would be surveyed for residual radioactivity, labeled and held on site for disposal evaluation, in accordance with procedures established in the SLAC Radiation Safety Program (SLAC 2010a). Radioactive material with an identified future use may be stored indoors or on covered and properly controlled and maintained areas on site (SLAC 2014b). Newly generated radioactive waste may be stored for up to 18 months or longer with DOE approval in compliance with the SLAC Radioactive Waste Manual (SLAC 2006b), and mixed wastes must be disposed of within 90 days. Speculative accumulation is not consistent with DOE lifecycle planning requirements. SLAC would handle and dispose of all wastes in accordance with SLAC procedures.

Component assembly and installation may also produce hazardous wastes, such as used solvent from degreasing operations or spent cutting fluids. These wastes are managed and controlled routinely during operations at SLAC, in compliance with SLAC's existing policies and procedures for the management of hazardous materials and waste minimization.

Fabrication work at LBNL, Fermilab, TJNAF, and ANL would generate small quantities of solid and hazardous waste. Management of these wastes would be governed by existing plans and programs as described above including hazardous waste and solid waste management and disposal programs. Because these activities would be conducted at existing, active machine shops and laboratories, impacts on solid and hazardous waste management would be negligible.

Operations

During the operational phase of the LCLS-II, only minimal quantities of hazardous materials would be used. Examples include paints, epoxies, solvents, oils and lead in the form of shielding. Site- and project-specific procedures described above and in SLAC's ESH&Q Manual (Chapter 40, *Hazardous Materials*) would be implemented for the safe handling, storage and transport of these hazardous materials. SLAC would follow existing site-wide procedures for chemical storage, storage inspection and secondary containment. There would be little to no impact on hazardous materials handling, use or storage as a result of operation of LCLS-II.

3.15 Cumulative Effects

The cumulative impact analysis presented below is based on consideration of past, present and reasonably foreseeable future projects that could, based on their location or types of impacts, result in cumulative effects when considered together with the Proposed Action. Projects included in the cumulative effects analysis were identified based on review of recent environmental documents, contact with local planning departments and internet research.

Table 3-19 lists the recently completed past projects, projects currently under construction and future projects that would overlap with the construction and/or operation of the Proposed Action and could affect the same resources. It describes the projects, their locations, estimated construction schedules, access roadways and nearby waterways, and potential types of cumulative impacts that could occur in combination with those of the Proposed Action. For future projects, the analysis was based on estimated construction schedules. Where construction schedules were unavailable, it was assumed that construction periods would overlap with those of the Proposed Action. The projects identified are associated with SLAC, Stanford University, and projects being considered for approval by area municipalities. These projects involve residential construction, commercial developments, offices, research and development space, hospital facilities, electricity generation and transmission facilities, and wetland restoration.

For resources on which the Proposed Action would have no impacts, or in the case of negligible impacts from the Proposed Action’s component fabrication activities at distant sites and within existing buildings, cumulative impacts would not be relevant and no impact analysis is provided. Cumulative effects were not evaluated for wetlands, land use, recreation, socioeconomics or environmental justice because the Proposed Action would have no effects. For example, because the Proposed Action would have no impacts on recreation (e.g., parks, bicycle trails), there would be no cumulative recreation effects.

According to CEQ regulations for implementing NEPA (50 CFR § 1508.7), an action may cause cumulative impacts on the environment if its impacts overlap in space and/or time with the impacts of other past, present or reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place through time.

Sections 3.15.1 through 3.15.10 of this EA assess the potential cumulative effects of the Proposed Action together with other area projects. Cumulative effects were evaluated for air quality, biological resources, cultural resources, geology and soils, health and safety, hydrology and water quality, noise, traffic, visual resources, and waste management. CEQ regulations also require an assessment of cumulative impact of the no action alternative as a baseline for evaluation of cumulative impacts with the Proposed Action.

Under the no action alternative, SLAC would not construct LCLS-II, resulting in no contribution to cumulative effects on air quality, biological resources, cultural resources, geology and soils, health and safety, hydrology, water quality, noise, traffic, or waste management. Cumulative impacts from the no action alternative would be similar to baseline conditions. Ozone and other air pollutants would remain in non-attainment of air quality standards. Projects throughout the area would minimize impact on cultural resources by complying with local, state and federal laws, including consulting with SHPO in compliance with the NHPA, as applicable. Geology and soil impacts would be addressed by design measures and BMPs, as required, minimizing erosion. The no action alternative would limit the planned scientific and medical advances that would likely benefit human health. The projects listed in **Table 3-18**, including those at SLAC and Stanford University would have cumulative effects that would be minimized by existing flood control and water quality regulatory programs. These projects could have cumulative impacts if they occur at the same time in the same area. Other projects at SLAC and Stanford University, as well as local infrastructure projects, could contribute to traffic congestion on Alpine Road. In contrast, commutes to SLAC have declined as SLAC has reduced its workforce in recent years. In addition, other projects listed in **Table 3-19**, including demolition and modernization projects at SLAC, would generate solid and radioactive waste requiring management and reuse or disposal.

3.15.1 Air Quality

As described above, the EPA requires each state to prepare and submit an SIP describing how the state will achieve federal standards by the specified dates, depending on the severity of the air quality within the state or air basin. To determine whether the Proposed Action would conform or conflict with an approved SIP, the DOE completed a conformity review. The Proposed Action was below the *de minimis* levels for a conformity analysis as well as below SLAC's SMOP limits for each of the non-attainment criteria pollutants. Air quality impacts at the fabrication sites would occur in other states and would be negligible as well as separated geographically. Thus, the cumulative air quality impacts of the Proposed Action would be minor.

Unlike emissions of criteria air pollutants, which have local or regional impacts, GHG emissions can contribute to global warming or climate change. GHGs accumulating in the atmosphere contribute to warming of the atmosphere. The principal GHGs are carbon dioxide (CO_2), methane, nitrous oxide, and fluorinated compounds. These gases allow visible and ultraviolet light from the sun to pass through the atmosphere, but prevent heat from escaping back out into space. Global climate change has the potential to impact sea level, water supply, agricultural resources and natural wildlife habitats.

The Intergovernmental Panel on Climate Change (IPCC) stated that warming of the earth's climate is unequivocal and that most of the observed increase in globally averaged temperatures since the mid-20th century is likely due to the increase in GHG concentrations (IPCC 2013). Anthropogenic (human-generated) GHGs are primarily produced by stationary and mobile engines running on fossil fuels (e.g., coal, gasoline, diesel, natural gas).

Table 3-19 Projects Considered in Cumulative Impacts Analysis for the Proposed Action

Project	Project Description	Location	Construction Schedule	Major Access Roads	Nearby Waterways	Potential Cumulative Impact Issues
SLAC LCLS	Existing LCLS facilities	SLAC	2006-2009	Alpine Road, I-280	San Francisquito Creek	Cultural resources, health and safety, waste disposal
SLAC SSRL SPEAR3 Seismic Upgrades	Upgrade enclosure, office modernization and demolition of aging trailers	SLAC	2010-2011	Alpine Road, I-280	San Francisquito Creek	Air quality, water quality, noise, traffic
SLAC Facility Disassembly	Disassemble BaBar facility	SLAC	2011-Present	Alpine Road, I-280	San Francisquito Creek	Air quality, water quality, noise, traffic
SLAC Facilities Modernization	Infrastructure upgrades – substation, server farm, erosion control, cooling towers, electrical, piping, Alpine Road gate automation, athletic field	SLAC	2011-TBD	Alpine Road, I-280	San Francisquito Creek	Air quality, water quality, noise, traffic
SLAC Capital Improvements and Renovations	Science and User Support Bldg., Scientific Research Computing Facility, Photon Science Laboratory Bldgs., Arrillaga Recreation Center	SLAC	2013 - 2017	Alpine Road, I-280	San Francisquito Creek	Air quality, cultural resources, water quality, traffic
Stanford University Medical Center Renewal Project	Renovation and expansion of Hoover Pavilion, Stanford Hospital, Lucile Packard Children's Hospital, and the School of Medicine	Santa Clara Co.	2011-2020	Sand Hill Road and Alpine Road	San Francisquito Creek	Air quality, water quality, traffic
Stanford University	Capital Utilities Program – water, wastewater, grounds, transportation, parking, energy retrofits, and storm drain improvements.	Santa Clara Co.	2003 – TBD	Sand Hill Road and Alpine Road	San Francisquito Creek	Air quality, water quality, traffic
Stanford University	Bing Concert Hall, Bioengineering/ Chemical Engineering Building	Santa Clara Co.	2011 - 2014	Sand Hill Road and Alpine Road	San Francisquito Creek	Air quality, water quality, traffic
Stanford Outpatient Center Project	Renovation of four commercial buildings complete. Project amended to include 1,000,000 additional square feet.	Redwood City	2007 – TBD	US 101	Smith Slough, San Francisco Bay	Air quality, solid waste disposal, water quality

Table 3-19 Projects Considered in Cumulative Impacts Analysis for the Proposed Action

Project	Project Description	Location	Construction Schedule	Major Access Roads	Nearby Waterways	Potential Cumulative Impact Issues
Stanford University – Mayfield agreement	Soccer fields, 250 housing units in the Stanford Research Park, and relocation of 300,000 sq. ft. of R&D/office space.	Palo Alto	TBD	El Camino Real, California Avenue, Page Mill	San Francisquito Creek	Air quality, water quality, traffic
Stanford University (Arrillaga)	500 El Camino Real mixed-use development	Menlo Park	2014 -	El Camino Real, Santa Cruz	San Francisquito Creek	Air quality, water quality, traffic
Santa Clara County	Permanente Quarry Reclamation Plan Amendment	Santa Clara Co.	2014 - 2034	I-280	Permanente Creek	Air quality, traffic
San Mateo County	Pilarcitos Quarry and Water Resource Project	San Mateo Co.	2013-TBD	SR 92, I-280	Pacific Ocean	Air quality, traffic
City of Menlo Park	SRI Campus Modernization Project	San Mateo Co.	2014 - TBD	US 101, El Camino Real	San Francisquito Creek	Air quality, water quality, construction traffic
South Bay Salt Pond Restoration Project	Tidal wetland restoration project to convert 15,100 acres of commercial salt ponds to tidal marsh	Santa Clara Co., San Mateo Co.	2008-TBD	US 101	San Francisquito Creek, San Francisco Bay	Solid waste disposal
San Francisquito Creek Project	Flood protection measure in Palo Alto, East Palo Alto and Menlo Park	San Mateo Co., Santa Clara Co.	2014 - TBD	US 101	San Francisquito Creek	Air quality, construction traffic

Note:
TBD = to be determined

The EPA has published draft guidance intended to assist federal agencies in analyzing environmental effects of GHG emissions and climate change in NEPA documents (CEQ 2010). Federal agencies are advised to consider opportunities to reduce GHG emissions caused by proposed federal actions and adapt their actions to climate change impacts. The draft guidance suggests that actions with annual direct emissions greater than 25,000 metric tons of CO_2-equivalent warrant evaluation under NEPA.

The CalEEMod model was used to estimate GHG emissions from construction, including from heavy equipment (e.g., excavators, loaders), trucks and construction worker vehicles. **Table 3-20** summarizes GHG emissions from construction. GHG emissions from component fabrication activities at LBNL, Fermilab, TJNAF, and ANL would be negligible as there would be no heavy construction equipment, excavation, grading, building construction, or demolition at those locations and the work conducted in machine shops and laboratories at those locations would be short-term and intermittent. The table shows that annual emissions would be much less than the 25,000 metric ton standard articulated by CEQ. Therefore, GHG emissions from construction do not require further evaluation.

Table 3-20 Estimated Proposed Action Construction GHG Emissions

Construction Year	Annual Emissions (metric tons per year)
	CO_2e
2016	891
2017	455
2018	228
Threshold	25,000

Operation of the Proposed Action would generate GHG emissions from direct sources such as natural gas combustion and motor vehicles as well as indirect sources, such as from the energy used to treat water and wastewater, dispose of wastes, and generate the needed electricity. **Table 3-21** summarizes total estimated GHG emissions from Proposed Action operation. Direct emissions of 47 metric tons of carbon dioxide equivalent ($MTCO_2e$) would not exceed CEQ's 25,000 $MTCO_2e$ standard for further evaluation. **Table 3-21** also summarizes indirect GHG emissions from the Proposed Action, which are also below the CEQ standard. Overall, GHG impacts from operations would be minor.

Table 3-21 Estimated Proposed Action Operational GHG Emissions

Source	Annual Emissions (metric tons per year)	
	CO_2e	**CEQ Threshold**
Direct		
Natural Gas	38	
Motor Vehicles	9.2	
Total Direct	47	25,000
Indirect		
Electricity	17,324	
Water Use	3,034	
Waste Generation	0.35	
Total Indirect	20,358	N/A

In addition to LCLS-II, several other sources of emissions in the region (San Mateo County) will contribute to the overall regional emission inventory. **Table 3-22** compares the construction and operational emissions for the Proposed Action with the most recent data available for regional emissions, which include SLAC emissions. Regional criteria pollutant emissions included industrial and commercial stationary sources, on- and off-road mobile sources, as well as miscellaneous area sources for San Mateo County and were obtained from CARB's Almanac Emission Projection Data (CARB 2013). Regional direct and indirect GHG emissions including industrial, commercial, transportation, residential, forestry and agriculture activities in San Mateo were obtained from BAAQMD's Source Inventory of Bay Area Greenhouse Gas Emissions (BAAQMD 2010). As shown in **Table 3-22** the Proposed Action would result in emissions that would be a small percentage of the regional emissions, ranging from 0.009 to 0.2 percent. Therefore, the Proposed Action's contribution to regional air quality impacts would be minor.

Table 3-22 Proposed Action and Regional Emissions

Source	Annual Emissions				
	VOCs (tons/year)	NO_x (tons/year)	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	CO_2e (MMT/year)
Proposed Action – Construction*	0.86	10.5	1.17	0.78	0.0009
Proposed Action - Operation	0.31	0.04	0.01	0.01	0.02
Regional Emissions (San Mateo County**)	9,567	17,202	3,789	1,497	8.50
Percent of Proposed Action Emissions to Regional Emissions*	0.009%	0.06%	0.03%	0.05%	0.2%

Notes:
* Estimates for worst case year of construction
** Daily emissions converted to annual estimates assuming 365 days/year of emissions. Regional emissions from San Mateo County include SLAC.
MMT/yr = Million metric tons per year

3.15.2 Biological Resources

In conjunction with other projects, the Proposed Action would have a local, long-term, minor impact on vegetation. Other SLAC projects developments would affect grasslands, together with construction of the cryogenic plants. However, the grassland areas at SLAC are adjacent to existing industrial facilities. They do not provide suitable habitat for special-status species and none have been observed at SLAC. After the other SLAC projects are completed, any disturbed grassland areas would be restored to preconstruction conditions. Therefore, the Proposed Action would have only minor cumulative effects on grasslands when considered together with other projects.

3.15.3 Cultural and Historic Resources

The Proposed Action would involve excavation and could affect undiscovered cultural resources. Any unanticipated discoveries during LCLS-II or other SLAC construction would be addressed through consultation with a qualified archaeologist. Construction of the superconducting linac would involve minor changes to existing historic structures that would not be affected by other SLAC projects. Excavation of the cryogenic plant foundations and utility trenches could result in impacts on paleontological resources. Any fossil discoveries on SLAC or other major excavations on other projects would be addressed through consultation with a qualified paleontologist and, with minimization measures in place, only minor cumulative impacts would result.

3.15.4 Geology and Soils

Under the Proposed Action, short-term impacts on soils would occur, including increased risk of erosion due to vegetation removal, caused by the use of heavy equipment. These potential effects would be reduced through erosion control BMPs. Other SLAC projects would result in short-term impacts on geologic and soil resources from grading and road construction. These impacts would be reduced through BMPs and site restoration. Other projects would be subject to similar geologic and seismic engineering design and geotechnical measures as required by local and state building codes. Considered together with other area projects, the Proposed Action alternative would have minor cumulative effects on soils and geology.

3.15.5 Health and Safety

In conjunction with LCLS, the Proposed Action would have long-term minor impacts on worker health and safety by increasing the number of beams from one to two. However, these impacts would be managed by adding shielding as well as through SLAC’s existing health and safety programs and any cumulative effects would be minor. In addition, LCLS and the Proposed Action could have a cumulative beneficial effect on public health from the presumptive scientific breakthroughs related to energy and medicine.

3.15.6 Hydrology and Water Quality

Flooding along San Francisquito Creek has occurred historically. Development of previously open-space land commonly creates additional impervious surfaces and increased stormwater runoff. To address cumulative flooding impacts, local San Mateo and Santa Clara municipalities developed flood control programs requiring stormwater detention. Current and future urban development projects, including SLAC projects, are required to control stormwater runoff. In addition, area municipalities require flood control measures, including stormwater detention. Because the Proposed Action would be installed within existing facilities and cryogenic plant construction would comply with stormwater detention requirements including the stormwater management requirements of EISA Section 438, the Proposed Action would not increase the peak runoff rate. Therefore, any cumulative flooding impacts would be minor.

Similarly, past projects throughout the watershed have resulted in impaired water quality in San Francisquito Creek. San Francisquito Creek has been listed as impaired by sediments and an agricultural insecticide. Accordingly, Santa Clara Valley Urban Runoff Pollution Prevention Plan and SMCWPPP established National Pollutant Discharge Elimination System (NPDES) permit requirements to reduce pollution in runoff. In conjunction with other SLAC projects, and given implementation of the SWPPP and other BMPs constructed in the watershed, the Proposed Action would have only minor cumulative effects on water quality that would be monitored and addressed according to state and local stormwater regulations.

The Proposed Action would result in only minor, local groundwater impacts. Risks of contamination would be minimized through BMPs to prevent leaks and spills, and according to procedures presented in site-specific SWPPP and SPCC plans. Other projects, including SLAC renovations and Stanford University projects would use similar measures to minimize any impacts on groundwater through spills. Considered together with these projects, the Proposed Action would have only minor cumulative impacts on groundwater.

3.15.7 Noise

During construction, the Proposed Action would generate noise from excavators at the cryogenic plant sites, as well as on the site access roads, from vehicles transporting workers, equipment and materials to and from the site. The construction noise analysis demonstrated that noise from construction equipment would only marginally exceed existing ambient noise levels and construction noise impacts would be minor. The Proposed Action would also generate noise during operations, including from the cryogenic plant compressors and other equipment, as well as cryogen deliveries. Other projects at SLAC, including construction of research buildings and facility upgrades and operations, could result in noise impacts that would overlap with the construction and operation of the Proposed Action. However, other SLAC projects would be located approximately 2 miles or more from the cryogenic plant sites, which are the only LCLS-II components with potential offsite effects. Therefore, no cumulative impacts would result.

3.15.8 Traffic

The Proposed Action would result in short-term construction-related increases in traffic from worker commutes, demolition and waste removal activities, and from delivery of construction equipment and materials. However, most worker traffic and deliveries would occur at off-peak times. Other scheduled SLAC infrastructure upgrades would consist of minor upgrades and renovations. Construction would also overlap with other local projects (**Table 3-19**). Some construction and renovation would overlap with the Proposed Action, particularly the peak traffic period in 2017 and 2018. However, given the site circulation improvements, addition of the automated gate at the Alpine Road entrance, and timing of deliveries, the Proposed Action considered together with other projects including at SLAC, would result in only minor cumulative traffic impacts on Alpine Road. Other projects in the area would not have substantial traffic impacts on roads affected by construction. For example, the Stanford University Medical Center Renewal Project implements a number of traffic reduction measures including traffic adaptive signal technology, additional bicycle and pedestrian undercrossings, demand management and intersection improvements. In the long term, the other SLAC infrastructure upgrades identified in **Table**

3-19 would have no cumulative impacts because they would not overlap with the Proposed Action's operational traffic.

Other projects in the region would add truck trips on regional highways. Residential and commercial developments as well as mining projects could add truck traffic on I-280. However, these added truck trips would be inconsequential when considered together with the Proposed Action. These cumulative impacts would be minor considering the short-term construction at SLAC and the relatively small number of truck trips required for the Proposed Action.

Several large construction projects are planned in the region, including commercial, residential, and hospital construction (Table 3-19). However, these projects are located primarily in urban areas of San Mateo and Menlo Park along the U.S. 101 corridor and would only result in cumulative impacts with the Proposed Action if trucks from those projects used Sand Hill Road or Alpine Road. Because trucks and other traffic from other projects would be more likely to use U.S. 101, cumulative traffic impacts on local roads around SLAC would be minor.

3.15.9 Visual Resources

The Proposed Action would have only minor visual impacts as the construction site and cryogenic plants would be largely screened from public views by the intervening landscape. The changes related to the superconducting linac would be within existing facilities and the cryogenic plant sites would not be visible from adjacent roadways. Construction and subsequent operation of the tallest structures may be visible briefly to passing motorists on Sand Hill Road and from the surrounding hills, but only from a distance of approximately one mile. The only other project in the viewshed is SLAC's accelerator housing, which was constructed in 1963 and has been part of the landscape for decades. Therefore, the Proposed Action would have no cumulative visual impacts.

3.15.10 Waste Management

The Proposed Action would generate only a nominal amount of hazardous waste in the form of oily waste, but would generate substantial amounts of solid waste from dismantling and removal of equipment from the accelerator housing and klystron gallery. Although landfill capacity does not present a major constraint and regional landfills such as the Altamont Landfill have capacity through at least 2025 (CalRecycle 2014), the Proposed Action would comply with the SLAC Site Sustainability Plan (SLAC 2013c) to reduce solid waste disposal impacts on municipal and sanitary solid waste landfill capacity and operations. The Site Stability Plan includes a goal of recycling approximately 50 percent of non-hazardous construction and demolition debris. Through maximizing recycling and proper disposal of minor quantities of construction-generated hazardous waste, the Proposed Action would have a minor effect on waste management. Other projects would also produce solid waste, including excavated material and construction and demolition wastes. However, in compliance with state and local regulations and federal EOs, much of this material would be reused or recycled, reducing their effect on waste management. Considered together with these projects, the Proposed Action alternative would have a minor impact on waste management.

4.0 CONSULTATION AND COORDINATION

This section summarizes federal and state agency coordination in support of the Proposed Action. Section 4.1 lists the permits and approvals required for construction. Section 4.2 describes the required agency consultations. Documentation of correspondence with federal and state agencies is included in Appendix B.

4.1 Permits and Approvals

Environmental permits and approvals for the Proposed Action may be required from the following agencies:

- State Water Resources Control Board for a Construction General Permit for stormwater discharges;
- National Historic Preservation Act Section 106 consultation with the State Historic Preservation Officer;
- Bay Area Air Quality Management District for a permit to operate a stationary emergency standby generator, if installed.

The Proposed Action would be covered under the site-wide Synthetic Minor Operating Permit issued by the BAAQMD. DOE consulted with SHPO under Section 106 regarding potential impacts on cultural resources.

4.2 Agency Coordination

4.2.1 San Francisco Regional Water Quality Control Board

SLAC would obtain a Construction General Permit for stormwater discharges from the State Water Resources Control Board. The Regional Water Quality Control Board (RWQCB) provides oversight of implementation of the Construction General Permit. All associated documentation and monitoring results would be submitted to the RWQCB.

4.2.2 California State Historic Preservation Office

The Proposed Action would constitute an undertaking subject to Section 106 of the NHPA, as set forth in 36 CFR 800.16(y). Section 106 of the NHPA and its implementing regulations require federal agencies to consider the effects of undertakings on historic properties. An effect is defined as an "alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the National Register (36 CFR 800.16(i))." If an undertaking will affect a historic property, the nature of the effect must be assessed. DOE has consulted with the SHPO as well as the appropriate Indian Tribes/Nations and the Bureau of Indian Affairs regarding potential cultural resources impacts of the Proposed Action.

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5.0 LIST OF PREPARERS AND REVIEWERS

Table 5-1 lists the individuals responsible for preparing this EA. The EA was prepared for DOE and SLAC through a contract with ARCADIS.

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Conrad Mulligan	Socioeconomics and Environmental Justice
Jie Chen	Geographic Information Systems
Kathrine Cloutier	Traffic
Kathrine Cloutier	Waste Management

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APPENDIX A: AIR EMISSIONS ESTIMATES

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A.1 Emissions Calculations

Emissions were calculated using the CalEEMod Environmental Management Software.. The CalEEMod model provides a platform to calculate both construction and operational source emissions using equipment emission factors (mass of emissions per unit time) from sources such as EPA, CARB and site-specific information. CalEEMod also provides default values when site-specific information is not available.

Construction Emissions

Construction emissions have several different types of sources which contribute to emissions of pollutants including off-road equipment usage, on-road vehicle travel, fugitive dust, architectural coating, and paving off-gassing.

Off-Road Equipment Usage

For off-road equipment usage, CalEEMod calculates the exhaust emissions using the equation presented below:

$$\text{Emissions} = \Sigma\ EF_i \text{ x } Pop_i \text{ x } HP_i \text{ x Load Factor}_i \text{ x Activity}_i$$

Where:

EF = Emission factor in grams per horsepower-hour (g/bhp-hr)

Pop = Population (i.e., the number of pieces of equipment)

Hp = Equipment horsepower

Load = Load factor

Activity = Hours of operation

i = equipment type

On-Road Vehicle Travel

On-road vehicle exhaust, evaporative, and dust emissions from personal vehicles for worker and vendor commuting, and trucks for soil and material hauling are based on the vehicle miles traveled (VMT) along with vehicle emission factors as follows:

$$Emissions_{pollutant} = VMT * EF_{running,pollutant}$$

Where:

$Emissions_{pollutant}$ = emissions from vehicle running for each pollutant

VMT = vehicle miles traveled

$EF_{running,pollutant}$ = emission factor for running emissions

Fugitive Dust

CalEEMod calculates fugitive dust associated with the site preparation and grading phases from three major activities: haul road grading, earth bulldozing, and truck loading. The fugitive dust emissions from the grading phase are calculated using the methodology described in EPA AP-42[1] Section 11.9 for grading equipment and Section 13.2 for truck dumping or loading out. For demolition dust emissions, the methodology described in the report prepared for the EPA by Midwest Research Institute (MRI)[2].

Architectural Coatings and Asphalt Off-Gassing

CalEEMod calculates the VOC evaporative emissions from application of surface coatings using the following equation:

$$E = EF \times A \times F$$

Where:

E = emissions (lb VOC)

EF = emission factor (lb/sqft)

A = building surface area (sqft)

F = fraction of surface area.

CalEEMod estimates VOC off-gassing emissions associated with asphalt paving of parking lots using the following equation:

$$E = EF \times A$$

[1] EPA. 1995. AP 42, Compilation of Air Pollution Emission Factors, Fifth Edition. http://www.epa.gov/ttn/chief/ap42

[2] Midwest Research Institute. 1988. Gap Filling PM10 Emission Factors for Selected Open Area Dust Sources.

Where:

E = emissions (lb)

EF = emission factor (lb/acre). The default emission factor is 2.62 lb/acre.

A = area of the parking lot (acre)

Operational Mobile

CalEEMod calculates the emissions associated with on-road mobile vehicles visiting the project. The emissions associated with on-road mobile sources includes running and starting exhaust emissions, evaporative emissions, brake and tire wear, and fugitive dust from paved and unpaved roads.

The emissions from mobile sources were calculated with the trip rates, trip lengths and emission factors for running from EMFAC2007 as follows:

$$\text{Emissions}_{\text{pollutant}} = \text{VMT} * \text{EF}_{\text{running,pollutant}}$$

Where:

$\text{Emissions}_{\text{pollutant}}$ = emissions from vehicle running for each pollutant

VMT = vehicle miles traveled

$\text{EF}_{\text{running,pollutant}}$ = emission factor for running emissions

Area Sources

CalEEMod calculates area sources of air emissions located at the project site including consumer product use, architectural coatings, and landscape maintenance equipment.

Consumer Products

Consumer products evaluated include detergents; cleaning compounds; polishes; floor finishes; cosmetics; personal care products; home, lawn, and garden products; disinfectants; sanitizers; aerosol paints; and automotive specialty products. To calculate the VOC emissions from consumer product use, the following equation is used:

$$\text{Emissions} = \text{EF x BuildingArea}$$

Where:

Emissions = Emissions from consumer products

EF = pounds of VOC per building square foot per day

BuildingArea = Total square footage of all buildings.

Architectural Coatings

VOC off-gassing emissions result from evaporation of solvents contained in surface coatings such as in paints and primers. CalEEMod calculates the VOC evaporative emissions from application of surface coatings assuming an annual 10% reapplication rate.

Landscape Equipment

Landscape maintenance includes fuel combustion emissions from equipment such as lawn mowers, roto tillers, shredders/grinders, blowers, trimmers, chain saws, and hedge trimmers, as well as air compressors, generators, and pumps. Emissions are estimated as off-road equipment.

Energy

Energy use in buildings is divided into energy consumed by the built environment and energy consumed by uses that are independent of the construction of the building such as in plug-in appliances. In California, Title 24 governs energy consumed by the built environment, mechanical systems, and some types of fixed lighting. Non-building energy use, or "plug-in" energy use can be further subdivided by specific end-use (refrigeration, cooking, office equipment, etc.). CalEEMod calculates energy use by:

1. Calculating energy use from systems covered by Title 24 (HVAC system, water heating system, and the lighting system).
2. Calculating energy use from lighting.
3. Calculating energy use from office equipment, appliances, plug-ins, and other sources not covered by Title 24 or lighting.

Emissions from energy use are calculated by multiplying the energy use times the energy source specific emission factor. In general:

$$\text{Emissions} = \Sigma_i \,(\text{EF x Energy Intensity x Size})$$

Where:

Emissions = Emissions from energy use

EF = energy emission factor

Energy Intensity = energy intensity for a land use

Size = size of the building or Dwelling units

i = land use type

The proposed action would increase energy use by approximately 38,000 megawatt-hours per year.

Water

The amount of water used and wastewater generated by a project has indirect GHG emissions associated with it. The cryogenic plant would require approximately 3,600 gallons per minute of cooling tower water in addition to indoor water use. Emissions are a result of the energy used to supply, distribute, and treat the water and wastewater. In addition to the indirect GHG emissions associated with energy use, wastewater treatment can directly emit both methane and nitrous oxide.

Waste Generation

Municipal solid waste is the amount of material that is disposed of by land filling, recycling, or composting. CalEEMod calculates the indirect GHG emissions associated with waste that is disposed of at a landfill. The program quantifies the GHG emissions associated with the decomposition of the waste which generates methane based on the total amount of degradable organic carbon and also quantify the CO_2 emissions associated with the combustion of methane, if applicable.

Annual construction emissions calculated from CalEEMod are presented in Table A-1.

Table A-1 Estimated Proposed Action Construction Emissions

	Annual Emissions (tons per year)			
Construction Year	**VOCs**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**
2016	0.86	10.5	1.17	0.78
2017	0.45	5.76	0.97	0.60
2018	0.25	2.28	0.0.84	0.48

Operational emissions associated with the daily activities of the Proposed Action would result from increased vehicular trips to and from the site (i.e., various types of mobile vehicles). Increases in vehicular trips would result from an additional six employees to operate the cryogenic plant. Energy consumption would include electricity for the cryogenic plant, lighting and equipment and natural gas for water and space heating. CalEEMod was used to estimate criteria pollutant emissions from mobile, area and energy sources during operations (Table A-2).

Table A-2 Estimated Proposed Action Operational Emissions

Emission Source	Annual Emissions (tons per year)			
	VOCs	**NO_x**	**PM_{10}**	**$PM_{2.5}$**
Area	0.305	0.000	0.000	0.000
Energy	0.004	0.034	0.003	0.003
Motor Vehicles	0.005	0.010	0.009	0.003
TOTAL	0.09	0.04	0.03	0.00

Table A-3 summarizes GHG emissions from construction of the proposed action.

Table A-3 Estimated Proposed Action Construction GHG Emissions

Construction Year	Annual Emissions (metric tons per year)
	CO_2e
2016	891
2017	455
2018	228

Operation of the proposed action would generate GHG emissions from direct sources such as natural gas combustion and motor vehicles as well as indirect sources, such as water and wastewater use, waste generation, and electricity consumption. CalEEMod was used to estimate GHG emissions from proposed action operation (Table A-4).

Table A-4 Estimated Proposed Action Operational GHG Emissions

Source	Annual Emissions (metric tons per year)
	CO_2e
Direct	
Natural Gas	38
Motor Vehicles	9
Total Direct	47
Indirect	
Electricity	17,324
Water Use	3,034
Waste Generation	0.3
Total Indirect	20,358

LCLS II Cryoplant

San Mateo County, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
Research & Development	70.00	1000sqft	0.70	70,000.00	0

1.2 Other Project Characteristics

Urbanization Urban **Wind Speed (m/s)** 2.2 **Precipitation Freq (Days)** 70

Climate Zone 5 **Operational Year** 2018

Utility Company Statewide Average

CO2 Intensity (lb/MWhr) 1001.57 **CH4 Intensity (lb/MWhr)** 0.029 **N2O Intensity (lb/MWhr)** 0.006

2.0 Emissions Summary

2.1 Overall Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2016	0.8640	10.5289	5.6760	9.5900e-003	0.7495	0.4164	1.1659	0.3988	0.3857	0.7845	0.0000	886.0331	886.0331	0.2320	0.0000	890.9045
2017	0.4517	5.7605	2.9901	5.0000e-003	0.7646	0.2093	0.9738	0.4030	0.1925	0.5955	0.0000	452.6026	452.6026	0.1178	0.0000	455.0760
2018	0.2464	2.2790	1.4901	2.6000e-003	0.7560	0.0860	0.8420	0.4008	0.0791	0.4799	0.0000	227.2739	227.2739	0.0538	0.0000	228.4045
Total	**1.5621**	**18.5684**	**10.1562**	**0.0172**	**2.2701**	**0.7116**	**2.9817**	**1.2027**	**0.6573**	**1.8599**	**0.0000**	**1,565.9096**	**1,565.9096**	**0.4036**	**0.0000**	**1,574.3850**

2.2 Overall Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	0.3053	1.0000e-005	6.5000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	1.2500e-003	1.2500e-003	0.0000	0.0000	1.3200e-003
Energy	3.7700e-003	0.0343	0.0288	2.1000e-004		2.6100e-003	2.6100e-003		2.6100e-003	2.6100e-003	0.0000	17,319.1437	17,319.1437	0.5011	0.1042	17,361.9728
Mobile	5.1000e-003	0.0102	0.0529	1.2000e-004	9.3500e-003	1.4000e-004	9.4900e-003	2.5100e-003	1.3000e-004	2.6400e-003	0.0000	9.1437	9.1437	3.8000e-004	0.0000	9.1517
Waste						0.0000	0.0000		0.0000	0.0000	0.1543	0.0000	0.1543	9.1200e-003	0.0000	0.3457
Water						0.0000	0.0000		0.0000	0.0000	1.5599	3,020.4915	3,022.0514	0.2477	0.0219	3,034.0322
Total	**0.3141**	**0.0445**	**0.0824**	**3.3000e-004**	**9.3500e-003**	**2.7500e-003**	**0.0121**	**2.5100e-003**	**2.7400e-003**	**5.2500e-003**	**1.7142**	**20,348.7801**	**20,350.4943**	**0.7583**	**0.1261**	**20,405.5038**

3.0 Construction Detail

Construction Phase

Phase Number	Phase Name	Phase Type	Start Date	End Date	Num Days Week	Num Days	Phase Description
1	Demolition	Demolition	1/5/2016	3/7/2016	5	45	02
2	Clear and Grub	Site Preparation	1/5/2016	3/7/2016	5	45	01
3	Spoil Disposal	Site Preparation	1/5/2016	4/23/2018	5	600	12
4	Excavation	Trenching	1/26/2016	7/11/2016	5	120	03
5	Civil Improvements	Building Construction	5/1/2016	10/14/2016	5	120	04
6	Subgrade Utilities	Building Construction	10/1/2016	12/2/2016	5	45	05
7	Foundations & Pads	Site Preparation	11/3/2016	1/25/2017	5	60	06
8	Building	Building Construction	1/26/2017	4/18/2018	5	320	08
9	Building Finishes	Architectural Coating	3/19/2018	8/31/2018	5	120	09
10	Restoration	Site Preparation	8/1/2018	9/11/2018	5	30	10

11	Paving	Paving	8/1/2018	10/2/2018		5	45	11

Acres of Grading (Site Preparation Phase): 0

Acres of Grading (Grading Phase): 0

Acres of Paving: 0

Residential Indoor: 0; Residential Outdoor: 0; Non-Residential Indoor: 15,000; Non-Residential Outdoor: 5,000 (Architectural Coating –

OffRoad Equipment

Phase Name	Offroad Equipment Type	Amount	Usage Hours	Horse Power	Load Factor
Demolition	Concrete/Industrial Saws	0	8.00	81	0.73
Demolition	Excavators	1	8.00	140	0.38
Demolition	Rubber Tired Dozers	0	1.00	255	0.40
Demolition	Tractors/Loaders/Backhoes	0	6.00	97	0.37
Clear and Grub	Excavators	2	8.00	140	0.38
Clear and Grub	Graders	0	8.00	174	0.41
Clear and Grub	Rubber Tired Loaders	1	8.00	140	0.36
Clear and Grub	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Spoil Disposal	Graders	0	8.00	174	0.41
Spoil Disposal	Other Construction Equipment	1	8.00	232	0.42
Spoil Disposal	Rubber Tired Dozers	1	8.00	700	0.40
Spoil Disposal	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Excavation	Excavators	2	8.00	140	0.38
Excavation	Other Construction Equipment	1	8.00	232	0.42
Excavation	Rubber Tired Dozers	1	8.00	700	0.40
Excavation	Rubber Tired Loaders	1	8.00	140	0.36
Civil Improvements	Bore/Drill Rigs	1	8.00	116	0.50
Civil Improvements	Cranes	1	8.00	280	0.29
Civil Improvements	Forklifts	0	6.00	89	0.20
Civil Improvements	Other Construction Equipment	1	8.00	440	0.42
Civil Improvements	Pumps	1	8.00	170	0.74
Civil Improvements	Pumps	1	8.00	33	0.74

Civil Improvements	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Subgrade Utilities	Cranes	0	4.00	226	0.29
Subgrade Utilities	Excavators	2	8.00	140	0.38
Subgrade Utilities	Forklifts	0	6.00	89	0.20
Subgrade Utilities	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Foundations & Pads	Excavators	2	8.00	140	0.38
Foundations & Pads	Graders	0	8.00	174	0.41
Foundations & Pads	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Building	Cranes	1	8.00	280	0.29
Building	Forklifts	0	6.00	89	0.20
Building	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Building Finishes	Air Compressors	0	6.00	78	0.48
Building Finishes	Cranes	1	8.00	280	0.29
Restoration	Graders	0	8.00	174	0.41
Restoration	Other Construction Equipment	1	8.00	232	0.42
Restoration	Rubber Tired Loaders	1	8.00	140	0.36
Restoration	Tractors/Loaders/Backhoes	0	8.00	97	0.37
Paving	Cement and Mortar Mixers	0	6.00	9	0.56
Paving	Other Construction Equipment	1	8.00	232	0.42
Paving	Pavers	0	7.00	125	0.42
Paving	Rollers	0	7.00	80	0.38
Paving	Rubber Tired Loaders	1	8.00	140	0.36
Paving	Tractors/Loaders/Backhoes	0	7.00	97	0.37

Trips and VMT

Phase Name	Offroad Equipment Count	Worker Trip Number	Vendor Trip Number	Hauling Trip Number	Worker Trip Length	Vendor Trip Length	Hauling Trip Length	Worker Vehicle Class	Vendor Vehicle Class	Hauling Vehicle Class
Demolition	5	10.00	4.00	0.00	12.40	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Clear and Grub	5	5.00	3.00	0.00	12.40	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Spoil Disposal	4	10.00	3.00	2,150.00	12.40	7.30	3.20	LD_Mix	HDT_Mix	HHDT
Excavation	5	15.00	4.00	0.00	12.40	7.30	20.00	LD_Mix	HDT_Mix	HHDT

Civil Improvements	9	8.00	4.00	0.00	12.40	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Subgrade Utilities	7	3.00	4.00	90.00	12.40	7.30	25.00	LD_Mix	HDT_Mix	HHDT
Foundations & Pads	4	6.00	4.00	120.00	12.40	7.30	25.00	LD_Mix	HDT_Mix	HHDT
Building	5	30.00	4.00	350.00	12.40	7.30	25.00	LD_Mix	HDT_Mix	HHDT
Building Finishes	2	40.00	4.00	240.00	12.40	7.30	25.00	LD_Mix	HDT_Mix	HHDT
Restoration	4	3.00	3.00	0.00	12.40	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Paving	9	10.00	4.00	0.00	12.40	7.30	20.00	LD_Mix	HDT_Mix	HHDT

3.1 Mitigation Measures Construction

Water Exposed Area

Clean Paved Roads

3.2 Demolition - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	7.5500e-003	0.0862	0.0667	1.0000e-004		4.2400e-003	4.2400e-003		3.9000e-003	3.9000e-003	0.0000	9.7004	9.7004	2.9300e-003	0.0000	9.7618
Total	**7.5500e-003**	**0.0862**	**0.0667**	**1.0000e-004**		**4.2400e-003**	**4.2400e-003**		**3.9000e-003**	**3.9000e-003**	**0.0000**	**9.7004**	**9.7004**	**2.9300e-003**	**0.0000**	**9.7618**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	1.1800e-003	9.1200e-003	0.0156	2.0000e-005	5.7000e-004	1.3000e-004	7.0000e-004	1.6000e-004	1.2000e-004	2.8000e-004	0.0000	1.9039	1.9039	2.0000e-005	0.0000	1.9042
Worker	8.0000e-004	1.2500e-003	0.0119	2.0000e-005	2.0300e-003	2.0000e-005	2.0500e-003	5.4000e-004	2.0000e-005	5.6000e-004	0.0000	1.8340	1.8340	1.0000e-004	0.0000	1.8361

Total	**1.9800e-003**	**0.0104**	**0.0275**	**4.0000e-005**	**2.6000e-003**	**1.5000e-004**	**2.7500e-003**	**7.0000e-004**	**1.4000e-004**	**8.4000e-004**	**0.0000**	**3.7379**	**3.7379**	**1.2000e-004**	**0.0000**	**3.7403**

3.3 Clear and Grub - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					1.5500e-003	0.0000	1.5500e-003	1.7000e-004	0.0000	1.7000e-004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0264	0.2868	0.2046	3.0000e-004		0.0149	0.0149		0.0137	0.0137	0.0000	28.5658	28.5658	8.6200e-003	0.0000	28.7468
Total	**0.0264**	**0.2868**	**0.2046**	**3.0000e-004**	**1.5500e-003**	**0.0149**	**0.0164**	**1.7000e-004**	**0.0137**	**0.0139**	**0.0000**	**28.5658**	**28.5658**	**8.6200e-003**	**0.0000**	**28.7468**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	8.8000e-004	6.8400e-003	0.0117	2.0000e-005	4.3000e-004	1.0000e-004	5.3000e-004	1.2000e-004	9.0000e-005	2.1000e-004	0.0000	1.4279	1.4279	1.0000e-005	0.0000	1.4282
Worker	4.0000e-004	6.3000e-004	5.9500e-003	1.0000e-005	1.0200e-003	1.0000e-005	1.0200e-003	2.7000e-004	1.0000e-005	2.8000e-004	0.0000	0.9170	0.9170	5.0000e-005	0.0000	0.9180
Total	**1.2800e-003**	**7.4700e-003**	**0.0177**	**3.0000e-005**	**1.4500e-003**	**1.1000e-004**	**1.5500e-003**	**3.9000e-004**	**1.0000e-004**	**4.9000e-004**	**0.0000**	**2.3449**	**2.3449**	**6.0000e-005**	**0.0000**	**2.3462**

3.4 Spoil Disposal - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Fugitive Dust					0.7047	0.0000	0.7047	0.3873	0.0000	0.3873	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.3346	4.5842	1.7683	3.1200e-003		0.1661	0.1661		0.1528	0.1528	0.0000	294.2917	294.2917	0.0888	0.0000	296.1558
Total	**0.3346**	**4.5842**	**1.7683**	**3.1200e-003**	**0.7047**	**0.1661**	**0.8708**	**0.3873**	**0.1528**	**0.5401**	**0.0000**	**294.2917**	**294.2917**	**0.0888**	**0.0000**	**296.1558**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	6.5500e-003	0.0315	0.1047	6.0000e-005	2.4800e-003	3.0000e-004	2.7700e-003	6.4000e-004	2.7000e-004	9.2000e-004	0.0000	5.5407	5.5407	5.0000e-005	0.0000	5.5419
Vendor	5.0800e-003	0.0394	0.0674	9.0000e-005	2.4800e-003	5.6000e-004	3.0400e-003	7.1000e-004	5.2000e-004	1.2300e-003	0.0000	8.2186	8.2186	7.0000e-005	0.0000	8.2200
Worker	4.6300e-003	7.2100e-003	0.0685	1.4000e-004	0.0117	9.0000e-005	0.0118	3.1100e-003	9.0000e-005	3.2000e-003	0.0000	10.5554	10.5554	5.8000e-004	0.0000	10.5675
Total	**0.0163**	**0.0781**	**0.2407**	**2.9000e-004**	**0.0167**	**9.5000e-004**	**0.0176**	**4.4600e-003**	**8.8000e-004**	**5.3500e-003**	**0.0000**	**24.3147**	**24.3147**	**7.0000e-004**	**0.0000**	**24.3294**

3.4 Spoil Disposal - 2017

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.7047	0.0000	0.7047	0.3873	0.0000	0.3873	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.3376	4.6045	1.7767	3.1300e-003		0.1670	0.1670		0.1536	0.1536	0.0000	290.8307	290.8307	0.0891	0.0000	292.7020
Total	**0.3376**	**4.6045**	**1.7767**	**3.1300e-003**	**0.7047**	**0.1670**	**0.8717**	**0.3873**	**0.1536**	**0.5410**	**0.0000**	**290.8307**	**290.8307**	**0.0891**	**0.0000**	**292.7020**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	6.3300e-003	0.0290	0.1025	6.0000e-005	2.4800e-003	2.6000e-004	2.7400e-003	6.5000e-004	2.4000e-004	8.9000e-004	0.0000	5.4810	5.4810	5.0000e-005	0.0000	5.4821
Vendor	4.7800e-003	0.0355	0.0646	9.0000e-005	2.4900e-003	4.9000e-004	2.9800e-003	7.1000e-004	4.5000e-004	1.1600e-003	0.0000	8.1241	8.1241	6.0000e-005	0.0000	8.1254
Worker	4.1300e-003	6.5000e-003	0.0614	1.4000e-004	0.0118	9.0000e-005	0.0118	3.1300e-003	8.0000e-005	3.2100e-003	0.0000	10.2035	10.2035	5.3000e-004	0.0000	10.2147
Total	**0.0152**	**0.0710**	**0.2285**	**2.9000e-004**	**0.0167**	**8.4000e-004**	**0.0176**	**4.4900e-003**	**7.7000e-004**	**5.2600e-003**	**0.0000**	**23.8086**	**23.8086**	**6.4000e-004**	**0.0000**	**23.8222**

3.4 Spoil Disposal - 2018

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.7047	0.0000	0.7047	0.3873	0.0000	0.3873	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.1013	1.3453	0.5518	9.8000e-004		0.0496	0.0496		0.0456	0.0456	0.0000	89.1727	89.1727	0.0278	0.0000	89.7557
Total	**0.1013**	**1.3453**	**0.5518**	**9.8000e-004**	**0.7047**	**0.0496**	**0.7543**	**0.3873**	**0.0456**	**0.4330**	**0.0000**	**89.1727**	**89.1727**	**0.0278**	**0.0000**	**89.7557**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	1.8400e-003	8.3800e-003	0.0307	2.0000e-005	2.2600e-003	8.0000e-005	2.3400e-003	5.7000e-004	7.0000e-005	6.4000e-004	0.0000	1.6791	1.6791	2.0000e-005	0.0000	1.6795
Vendor	1.3900e-003	0.0101	0.0191	3.0000e-005	7.8000e-004	1.4000e-004	9.2000e-004	2.2000e-004	1.3000e-004	3.5000e-004	0.0000	2.4886	2.4886	2.0000e-005	0.0000	2.4890
Worker	1.1500e-003	1.8300e-003	0.0172	4.0000e-005	3.6600e-003	3.0000e-005	3.6900e-003	9.7000e-004	3.0000e-005	1.0000e-003	0.0000	3.0634	3.0634	1.5000e-004	0.0000	3.0666

Total	4.3800e-003	0.0203	0.0670	9.0000e-005	6.7000e-003	2.5000e-004	6.9500e-003	1.7600e-003	2.3000e-004	1.9900e-003	0.0000	7.2311	7.2311	1.9000e-004	0.0000	7.2351

3.5 Excavation - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.2254	2.8888	1.3648	2.2500e-003		0.1166	0.1166		0.1073	0.1073	0.0000	212.5269	212.5269	0.0641	0.0000	213.8732
Total	**0.2254**	**2.8888**	**1.3648**	**2.2500e-003**		**0.1166**	**0.1166**		**0.1073**	**0.1073**	**0.0000**	**212.5269**	**212.5269**	**0.0641**	**0.0000**	**213.8732**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	3.1400e-003	0.0243	0.0416	6.0000e-005	1.5300e-003	3.5000e-004	1.8800e-003	4.4000e-004	3.2000e-004	7.6000e-004	0.0000	5.0771	5.0771	4.0000e-005	0.0000	5.0780
Worker	3.2200e-003	5.0100e-003	0.0476	1.0000e-004	8.1300e-003	7.0000e-005	8.2000e-003	2.1600e-003	6.0000e-005	2.2200e-003	0.0000	7.3358	7.3358	4.0000e-004	0.0000	7.3442
Total	**6.3600e-003**	**0.0293**	**0.0893**	**1.6000e-004**	**9.6600e-003**	**4.2000e-004**	**0.0101**	**2.6000e-003**	**3.8000e-004**	**2.9800e-003**	**0.0000**	**12.4129**	**12.4129**	**4.4000e-004**	**0.0000**	**12.4222**

3.6 Civil Improvements - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Off-Road	0.2046	2.1466	1.4968	2.6500e-003		0.0956	0.0956		0.0905	0.0905	0.0000	239.2067	239.2067	0.0545	0.0000	240.3512
Total	**0.2046**	**2.1466**	**1.4968**	**2.6500e-003**		**0.0956**	**0.0956**		**0.0905**	**0.0905**	**0.0000**	**239.2067**	**239.2067**	**0.0545**	**0.0000**	**240.3512**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	3.1400e-003	0.0243	0.0416	6.0000e-005	1.5300e-003	3.5000e-004	1.8800e-003	4.4000e-004	3.2000e-004	7.6000e-004	0.0000	5.0771	5.0771	4.0000e-005	0.0000	5.0780
Worker	1.7200e-003	2.6700e-003	0.0254	5.0000e-005	4.3400e-003	3.0000e-005	4.3700e-003	1.1500e-003	3.0000e-005	1.1900e-003	0.0000	3.9124	3.9124	2.1000e-004	0.0000	3.9169
Total	**4.8600e-003**	**0.0270**	**0.0670**	**1.1000e-004**	**5.8700e-003**	**3.8000e-004**	**6.2500e-003**	**1.5900e-003**	**3.5000e-004**	**1.9500e-003**	**0.0000**	**8.9895**	**8.9895**	**2.5000e-004**	**0.0000**	**8.9949**

3.7 Subgrade Utilities - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0151	0.1723	0.1333	2.1000e-004		8.4800e-003	8.4800e-003		7.8000e-003	7.8000e-003	0.0000	19.4008	19.4008	5.8500e-003	0.0000	19.5237
Total	**0.0151**	**0.1723**	**0.1333**	**2.1000e-004**		**8.4800e-003**	**8.4800e-003**		**7.8000e-003**	**7.8000e-003**	**0.0000**	**19.4008**	**19.4008**	**5.8500e-003**	**0.0000**	**19.5237**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	1.3000e-003	0.0167	0.0178	4.0000e-005	9.4000e-004	2.1000e-004	1.1500e-003	2.6000e-004	1.9000e-004	4.5000e-004	0.0000	3.7114	3.7114	3.0000e-005	0.0000	3.7120
Vendor	1.1800e-003	9.1200e-003	0.0156	2.0000e-005	5.7000e-004	1.3000e-004	7.0000e-004	1.6000e-004	1.2000e-004	2.8000e-004	0.0000	1.9039	1.9039	2.0000e-005	0.0000	1.9042
Worker	2.4000e-004	3.8000e-004	3.5700e-003	1.0000e-005	6.1000e-004	0.0000	6.1000e-004	1.6000e-004	0.0000	1.7000e-004	0.0000	0.5502	0.5502	3.0000e-005	0.0000	0.5508
Total	**2.7200e-003**	**0.0262**	**0.0370**	**7.0000e-005**	**2.1200e-003**	**3.4000e-004**	**2.4600e-003**	**5.8000e-004**	**3.1000e-004**	**9.0000e-004**	**0.0000**	**6.1655**	**6.1655**	**8.0000e-005**	**0.0000**	**6.1670**

3.8 Foundations & Pads - 2016

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					2.0700e-003	0.0000	2.0700e-003	2.2000e-004	0.0000	2.2000e-004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0141	0.1608	0.1244	1.9000e-004		7.9100e-003	7.9100e-003		7.2800e-003	7.2800e-003	0.0000	18.1074	18.1074	5.4600e-003	0.0000	18.2221
Total	**0.0141**	**0.1608**	**0.1244**	**1.9000e-004**	**2.0700e-003**	**7.9100e-003**	**9.9800e-003**	**2.2000e-004**	**7.2800e-003**	**7.5000e-003**	**0.0000**	**18.1074**	**18.1074**	**5.4600e-003**	**0.0000**	**18.2221**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	1.2100e-003	0.0156	0.0166	4.0000e-005	1.1600e-003	1.9000e-004	1.3500e-003	3.1000e-004	1.8000e-004	4.9000e-004	0.0000	3.4640	3.4640	2.0000e-005	0.0000	3.4645
Vendor	1.1000e-003	8.5100e-003	0.0146	2.0000e-005	5.4000e-004	1.2000e-004	6.6000e-004	1.5000e-004	1.1000e-004	2.7000e-004	0.0000	1.7770	1.7770	1.0000e-005	0.0000	1.7773
Worker	4.5000e-004	7.0000e-004	6.6700e-003	1.0000e-005	1.1400e-003	1.0000e-005	1.1500e-003	3.0000e-004	1.0000e-005	3.1000e-004	0.0000	1.0270	1.0270	6.0000e-005	0.0000	1.0282

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Total	**2.7600e-003**	**0.0248**	**0.0379**	**7.0000e-005**	**2.8400e-003**	**3.2000e-004**	**3.1600e-003**	**7.6000e-004**	**3.0000e-004**	**1.0700e-003**	**0.0000**	**6.2680**	**6.2680**	**9.0000e-005**	**0.0000**	**6.2700**

3.8 Foundations & Pads - 2017

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					2.0700e-003	0.0000	2.0700e-003	2.2000e-004	0.0000	2.2000e-004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	5.6300e-003	0.0625	0.0532	8.0000e-005		3.0700e-003	3.0700e-003		2.8300e-003	2.8300e-003	0.0000	7.6382	7.6382	2.3400e-003	0.0000	7.6873
Total	**5.6300e-003**	**0.0625**	**0.0532**	**8.0000e-005**	**2.0700e-003**	**3.0700e-003**	**5.1400e-003**	**2.2000e-004**	**2.8300e-003**	**3.0500e-003**	**0.0000**	**7.6382**	**7.6382**	**2.3400e-003**	**0.0000**	**7.6873**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	5.0000e-004	6.0000e-003	6.8200e-003	2.0000e-005	1.0400e-003	7.0000e-005	1.1100e-003	2.7000e-004	7.0000e-005	3.3000e-004	0.0000	1.4632	1.4632	1.0000e-005	0.0000	1.4635
Vendor	4.4000e-004	3.2800e-003	5.9600e-003	1.0000e-005	2.3000e-004	5.0000e-005	2.8000e-004	7.0000e-005	4.0000e-005	1.1000e-004	0.0000	0.7499	0.7499	1.0000e-005	0.0000	0.7500
Worker	1.7000e-004	2.7000e-004	2.5500e-003	1.0000e-005	4.9000e-004	0.0000	4.9000e-004	1.3000e-004	0.0000	1.3000e-004	0.0000	0.4238	0.4238	2.0000e-005	0.0000	0.4243
Total	**1.1100e-003**	**9.5500e-003**	**0.0153**	**4.0000e-005**	**1.7600e-003**	**1.2000e-004**	**1.8800e-003**	**4.7000e-004**	**1.1000e-004**	**5.7000e-004**	**0.0000**	**2.6370**	**2.6370**	**4.0000e-005**	**0.0000**	**2.6378**

3.9 Building - 2017

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					

Category	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Off-Road	0.0711	0.9066	0.6147	8.4000e-004		0.0368	0.0368		0.0339	0.0339	0.0000	78.3561	78.3561	0.0240	0.0000	78.8603
Total	**0.0711**	**0.9066**	**0.6147**	**8.4000e-004**		**0.0368**	**0.0368**		**0.0339**	**0.0339**	**0.0000**	**78.3561**	**78.3561**	**0.0240**	**0.0000**	**78.8603**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	3.6400e-003	0.0441	0.0501	1.2000e-004	3.4300e-003	5.4000e-004	3.9700e-003	9.2000e-004	5.0000e-004	1.4200e-003	0.0000	10.7584	10.7584	8.0000e-005	0.0000	10.7600
Vendor	5.9300e-003	0.0441	0.0802	1.1000e-004	3.0900e-003	6.1000e-004	3.7000e-003	8.9000e-004	5.6000e-004	1.4400e-003	0.0000	10.0822	10.0822	8.0000e-005	0.0000	10.0839
Worker	0.0115	0.0182	0.1714	3.8000e-004	0.0328	2.5000e-004	0.0331	8.7300e-003	2.3000e-004	8.9600e-003	0.0000	28.4914	28.4914	1.4800e-003	0.0000	28.5225
Total	**0.0211**	**0.1064**	**0.3017**	**6.1000e-004**	**0.0393**	**1.4000e-003**	**0.0407**	**0.0105**	**1.2900e-003**	**0.0118**	**0.0000**	**49.3320**	**49.3320**	**1.6400e-003**	**0.0000**	**49.3664**

3.9 Building - 2018

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0207	0.2588	0.1780	2.7000e-004		0.0104	0.0104		9.6100e-003	9.6100e-003	0.0000	24.8728	24.8728	7.7400e-003	0.0000	25.0355
Total	**0.0207**	**0.2588**	**0.1780**	**2.7000e-004**		**0.0104**	**0.0104**		**9.6100e-003**	**9.6100e-003**	**0.0000**	**24.8728**	**24.8728**	**7.7400e-003**	**0.0000**	**25.0355**

Category	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
	tons/yr										MT/yr					
Hauling	1.1200e-003	0.0130	0.0155	4.0000e-005	2.9700e-003	1.7000e-004	3.1400e-003	7.6000e-004	1.6000e-004	9.1000e-004	0.0000	3.4111	3.4111	2.0000e-005	0.0000	3.4116
Vendor	1.7800e-003	0.0129	0.0246	4.0000e-005	1.0000e-003	1.8000e-004	1.1800e-003	2.9000e-004	1.7000e-004	4.5000e-004	0.0000	3.1952	3.1952	2.0000e-005	0.0000	3.1958
Worker	3.3100e-003	5.2800e-003	0.0495	1.2000e-004	0.0106	8.0000e-005	0.0107	2.8100e-003	7.0000e-005	2.8900e-003	0.0000	8.8497	8.8497	4.4000e-004	0.0000	8.8590
Total	**6.2100e-003**	**0.0312**	**0.0896**	**2.0000e-004**	**0.0145**	**4.3000e-004**	**0.0150**	**3.8600e-003**	**4.0000e-004**	**4.2500e-003**	**0.0000**	**15.4561**	**15.4561**	**4.8000e-004**	**0.0000**	**15.4664**

3.10 Building Finishes - 2018

Category	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
	tons/yr										MT/yr					
Archit. Coating	0.0521					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0318	0.3982	0.2739	4.2000e-004		0.0161	0.0161		0.0148	0.0148	0.0000	38.2659	38.2659	0.0119	0.0000	38.5161
Total	**0.0839**	**0.3982**	**0.2739**	**4.2000e-004**		**0.0161**	**0.0161**		**0.0148**	**0.0148**	**0.0000**	**38.2659**	**38.2659**	**0.0119**	**0.0000**	**38.5161**

Category	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
	tons/yr										MT/yr					
Hauling	3.1500e-003	0.0365	0.0436	1.1000e-004	2.5000e-003	4.9000e-004	2.9900e-003	6.9000e-004	4.5000e-004	1.1300e-003	0.0000	9.5961	9.5961	7.0000e-005	0.0000	9.5975
Vendor	2.7400e-003	0.0199	0.0378	6.0000e-005	1.5300e-003	2.8000e-004	1.8100e-003	4.4000e-004	2.6000e-004	7.0000e-004	0.0000	4.9158	4.9158	4.0000e-005	0.0000	4.9166
Worker	6.7900e-003	0.0108	0.1016	2.5000e-004	0.0217	1.6000e-004	0.0219	5.7700e-003	1.5000e-004	5.9200e-003	0.0000	18.1533	18.1533	9.0000e-004	0.0000	18.1723

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Total	**0.0127**	**0.0672**	**0.1830**	**4.2000e-004**	**0.0257**	**9.3000e-004**	**0.0267**	**6.9000e-003**	**8.6000e-004**	**7.7500e-003**	**0.0000**	**32.6651**	**32.6651**	**1.0100e-003**	**0.0000**	**32.6863**

3.11 Restoration - 2018

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					1.0300e-003	0.0000	1.0300e-003	1.1000e-004	0.0000	1.1000e-004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	5.9700e-003	0.0582	0.0456	6.0000e-005		3.2300e-003	3.2300e-003		2.9700e-003	2.9700e-003	0.0000	5.9211	5.9211	1.8400e-003	0.0000	5.9598
Total	**5.9700e-003**	**0.0582**	**0.0456**	**6.0000e-005**	**1.0300e-003**	**3.2300e-003**	**4.2600e-003**	**1.1000e-004**	**2.9700e-003**	**3.0800e-003**	**0.0000**	**5.9211**	**5.9211**	**1.8400e-003**	**0.0000**	**5.9598**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	5.1000e-004	3.7200e-003	7.0900e-003	1.0000e-005	2.9000e-004	5.0000e-005	3.4000e-004	8.0000e-005	5.0000e-005	1.3000e-004	0.0000	0.9217	0.9217	1.0000e-005	0.0000	0.9219
Worker	1.3000e-004	2.0000e-004	1.9100e-003	0.0000	4.1000e-004	0.0000	4.1000e-004	1.1000e-004	0.0000	1.1000e-004	0.0000	0.3404	0.3404	2.0000e-005	0.0000	0.3407
Total	**6.4000e-004**	**3.9200e-003**	**9.0000e-003**	**1.0000e-005**	**7.0000e-004**	**5.0000e-005**	**7.5000e-004**	**1.9000e-004**	**5.0000e-005**	**2.4000e-004**	**0.0000**	**1.2621**	**1.2621**	**3.0000e-005**	**0.0000**	**1.2626**

3.12 Paving - 2018

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					

Off-Road	8.9600e-003	0.0874	0.0685	1.0000e-004		4.8500e-003	4.8500e-003		4.4600e-003	4.4600e-003	0.0000	8.8817	8.8817	2.7600e-003	0.0000	8.9398
Paving	0.0000					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**8.9600e-003**	**0.0874**	**0.0685**	**1.0000e-004**		**4.8500e-003**	**4.8500e-003**		**4.4600e-003**	**4.4600e-003**	**0.0000**	**8.8817**	**8.8817**	**2.7600e-003**	**0.0000**	**8.9398**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	1.0300e-003	7.4500e-003	0.0142	2.0000e-005	5.7000e-004	1.0000e-004	6.8000e-004	1.6000e-004	1.0000e-004	2.6000e-004	0.0000	1.8434	1.8434	1.0000e-005	0.0000	1.8437
Worker	6.4000e-004	1.0200e-003	9.5300e-003	2.0000e-005	2.0300e-003	2.0000e-005	2.0500e-003	5.4000e-004	1.0000e-005	5.5000e-004	0.0000	1.7019	1.7019	8.0000e-005	0.0000	1.7037
Total	**1.6700e-003**	**8.4700e-003**	**0.0237**	**4.0000e-005**	**2.6000e-003**	**1.2000e-004**	**2.7300e-003**	**7.0000e-004**	**1.1000e-004**	**8.1000e-004**	**0.0000**	**3.5453**	**3.5453**	**9.0000e-005**	**0.0000**	**3.5474**

4.0 Operational Detail - Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Unmitigated	5.1000e-003	0.0102	0.0529	1.2000e-004	9.3500e-003	1.4000e-004	9.4900e-003	2.5100e-003	1.3000e-004	2.6400e-003	0.0000	9.1437	9.1437	3.8000e-004	0.0000	9.1517

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT

Research & Development	11.90	7.00	4.20	25,313	25,313
Total	11.90	7.00	4.20	25,313	25,313

4.3 Trip Type Information

	Miles			Trip %			Trip Purpose %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW	Primary	Diverted	Pass-by
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00	82	15	3

LDA	LDT1	LDT2	MDV	LHD1	LHD2	MHD	HHD	OBUS	UBUS	MCY	SBUS	MH
0.579415	0.062669	0.176431	0.113724	0.029579	0.004153	0.015740	0.004138	0.002638	0.003681	0.006622	0.000227	0.000983

5.0 Energy Detail

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Unmitigated						0.0000	0.0000		0.0000	0.0000	0.0000	17,281.7890	17,281.7890	0.5004	0.1035	17,324.3908
NaturalGas Unmitigated	3.7700e-003	0.0343	0.0288	2.1000e-004		2.6100e-003	2.6100e-003		2.6100e-003	2.6100e-003	0.0000	37.3547	37.3547	7.2000e-004	6.8000e-004	37.5820

5.2 Energy by Land Use - NaturalGas

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU/yr	tons/yr										MT/yr					
Research & Development	700000	3.7700e-003	0.0343	0.0288	2.1000e-004		2.6100e-003	2.6100e-003		2.6100e-003	2.6100e-003	0.0000	37.3547	37.3547	7.2000e-004	6.8000e-004	37.5820
Total		**3.7700e-003**	**0.0343**	**0.0288**	**2.1000e-004**		**2.6100e-003**	**2.6100e-003**		**2.6100e-003**	**2.6100e-003**	**0.0000**	**37.3547**	**37.3547**	**7.2000e-004**	**6.8000e-004**	**37.5820**

5.3 Energy by Land Use - Electricity

	Electricity Use	Total CO2	CH4	N2O	CO2e
Land Use	kWh/yr	MT/yr			
Research & Development	3.80401e+007	17,281.7890	0.5004	0.1035	17,324.3908
Total		**17,281.7890**	**0.5004**	**0.1035**	**17,324.3908**

6.0 Area Detail

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Unmitigated	0.3053	1.0000e-005	6.5000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	1.2500e-003	1.2500e-003	0.0000	0.0000	1.3200e-003

6.2 Area by SubCategory

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.0318					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Consumer Products	0.2734					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Landscaping	6.0000e-005	1.0000e-005	6.5000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	1.2500e-003	1.2500e-003	0.0000	0.0000	1.3200e-003
Total	**0.3053**	**1.0000e-005**	**6.5000e-004**	**0.0000**		**0.0000**	**0.0000**		**0.0000**	**0.0000**	**0.0000**	**1.2500e-003**	**1.2500e-003**	**0.0000**	**0.0000**	**1.3200e-003**

7.0 Water Detail

	Total CO2	CH4	N2O	CO2e
Category	MT/yr			
Unmitigated	3,022.051 4	0.2477	0.0219	3,034.034 7

7.2 Water by Land Use

	Indoor/Outdoor Use	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	MT/yr			
Research & Development	4.91694 / 1892	3,022.051 4	0.2477	0.0219	3,034.034 7

Total		3,022.0514	0.2477	0.0219	3,034.0347

8.0 Waste Detail

Category/Year

	Total CO2	CH4	N2O	CO2e
	MT/yr			
Unmitigated	0.1543	9.1200e-003	0.0000	0.3457

8.2 Waste by Land Use

	Waste Disposed	Total CO2	CH4	N2O	CO2e
Land Use	tons	MT/yr			
Research & Development	0.76	0.1543	9.1200e-003	0.0000	0.3457
Total		**0.1543**	**9.1200e-003**	**0.0000**	**0.3457**

APPENDIX B: CULTURAL RESOURCE AGENCY CORRESPONDENCE

U.S. DEPARTMENT OF ENERGY | Office of Science

SLAC Site Office
SLAC National Accelerator Laboratory
2575 Sand Hill Road, MS-8A
Menlo Park, CA 94025

March 31, 2014

Dr. Carol Roland-Nawi
State Historic Preservation Officer
Office of Historic Preservation
Department of Parks and Recreation
State of California
1725 23rd Street, Suite 100
Sacramento, CA 95816
Attention: Project Review Unit

Re: Section 106 Consultation for the Linac Coherent Light Source II (LCLS-II) Project, SLAC National Accelerator Laboratory, Menlo Park, CA, Reference: DOE_2013_1223_001

Dear Dr. Roland-Nawi:

The purpose of this letter is to provide formal notice of the Department of Energy's (DOE) determination that the proposed undertaking to construct and operate LCLS-II will result in no adverse effects to historic properties, and to seek your concurrence in this determination. DOE requests your review within 30 days, in accordance with 36 CFR 800.5(c).

The DOE has sent letters to five Native American tribal consultants, identified by the State of California Native American Heritage Commission, notifying them of the project and seeking their comment. The letters were sent to representatives of the Ohlone/Costanoan, Bay Miwok, Plains Miwok, and Patwin tribes.

In order to facilitate this Section 106 consultation, DOE has enclosed the Section 106 Technical Report that provides additional details regarding the proposed undertaking; delineates the area of potential effects (APE); identifies historic properties within the APE; and provides supporting documentation regarding DOE's determination whether adverse effects to those historic properties would result from the undertaking.

We look forward to continuing to work closely with you and your staff to fulfill our consultation requirements under the National Historic Preservation Act.

If you have any questions regarding the attached Section 106 Technical Report or any aspect of LCLS-II, please feel free to contact Mitzi Heard of my staff at (650) 926-5704.

Sincerely,

Paul Golan
Site Manager

Enclosures

cc:
Thomas McCulloch, ACHP

U.S. DEPARTMENT OF ENERGY | Office of Science

SLAC Site Office
SLAC National Accelerator Laboratory
2575 Sand Hill Road, MS-8A
Menlo Park, CA 94025

May 7, 2014

Dr. Carol Roland-Nawi
State Historic Preservation Officer
Office of Historic Preservation
Department of Parks and Recreation
State of California
1725 23rd Street, Suite 100
Sacramento, CA 95816

Subject: Section 106 Consultation for Proposed Expansion of Linac Coherent Light Source (LCLS-II) Facility, SLAC National Accelerator Laboratory, Menlo Park, CA

Dear Dr. Roland-Nawi:

Thank you for your April 30, 2014 concurrence that the Department of Energy's (DOE) Linac Coherent Light Source II (LCLS-II) project will not adversely affect historic properties at the SLAC National Accelerator Laboratory. DOE understands that consultation under Section 106 of the National Historic Preservation Act of 1966 is now complete. We base this understanding upon the following conclusion in your April 30 letter:

> I can, based on the information provided and my understanding of the undertaking's effects on [National Register of Historic Places] NRHP eligible properties, concur that this undertaking as proposed will not adversely affect historic properties pursuant to 36 CFR Part 800.5(b)....

You also have proposed that DOE agree to assume for the purposes of this undertaking that all properties at SLAC are NRHP eligible. However, there appears to be no practical effect of DOE's agreement or disagreement to this proposed condition. Accordingly, DOE declines to agree to the condition, but acknowledges that your office's concurrence should not be interpreted as constituting your agreement as to NRHP eligibility or ineligibility of any particular properties at SLAC.

DOE looks forward to continued consultation regarding the eligibility determinations identified in the Historic Resources Study for DOE's facilities at SLAC. We intend to provide a separate, follow up letter addressing the survey at a later date.

If you have any questions regarding the Section 106 consultation for this project, please feel free to contact Mitzi Heard at (650) 926-5704.

Sincerely,

Paul Golan
Site Manager

Cc: Tom McCulloch, ACHP
Hanley Lee, SSO
Hannibal Joma, SSO
Pat Burke, SSO
Jim Tarpinian, SLAC
Brian Sherin, SLAC
Helen Nuckolls, SLAC
Susan Witebsky, SLAC
Mike Hug, SLAC
Steve Porter, SLAC
Laura Jones, Stanford University
Ruth Todd, Page & Turnbull

STATE OF CALIFORNIA – THE NATURAL RESOURCES AGENCY EDMUND G. BROWN, JR., *Governor*

OFFICE OF HISTORIC PRESERVATION
DEPARTMENT OF PARKS AND RECREATION
1725 23rd Street, Suite 100
SACRAMENTO, CA 95816-7100
(916) 445-7000 Fax: (916) 445-7053
calshpo@parks.ca.gov
www.ohp.parks.ca.gov

April 30, 2014

Reply in Reference To: DOE_2013_1223_001

Paul Golan, Site Manager
Site Office
SLAC National Accelerator Laboratory
2575 Sand Hill Road, MS-8A
Menlo Park, CA 94025

Re: Section 106 Consultation for Proposed Expansion of Linac Coherent Light Source (LCLS-II) Facility, SLAC National Accelerator Laboratory, Menlo Park, CA

Dear Mr. Golan:

Thank you for continuing consultation regarding the Department of Energy's (DOE) efforts to comply with Section 106 the National Historic Preservation Act of 1966 (16 U.S.C. 470f) (NHPA), as amended, and its implementing regulations found at 36 CFR Part 800. The DOE is requesting my comments on a proposed undertaking identified as the Phase II of the Linac Coherent Light Source project at SLAC National Accelerator Laboratory. As noted in their comprehensive narrative project description, the following activities are among those being proposed by the DOE:

- Removal and replacement of equipment between Sectors 0 and 10 of Building 002 (Klystron Gallery);
- Installation of equipment within Building 001 (Accelerator Housing);
- Construction of an approximately 10,000 to 15,000 square foot steel framed cryogenics plant near Sector Four at the west end;
- Potential installation of an additional 1,000 square foot cryogenics plant;
- Subsurface piping installation between the cryogenic plant(s) and Building 002;
- Installation of concrete pads as required;
- Interior equipment upgrades as required in Buildings 001, 002, 009, 910, 920, 930 and 940.

After conducting a records search and pedestrian survey the DOE has determined that no recorded archeological sites are within areas of proposed ground disturbance and it is unlikely that subsurface resources will be encountered during project activities. Buildings 001 and 002 have been determined eligible for National Register of Historic Places (NRHP) inclusion through consensus with my office while my concurrence on the NRHP eligibility of the remaining subject buildings and any potential district(s) they may constitute has not been obtained. As these buildings require modification to support their existing purpose and function the DOE has determined that the proposed activities discussed in their 28 March 2014 letter will not adversely affect historic properties.

After reviewing the DOE's letter, I have the following comments regarding the DOE's continued historic property identification efforts:

1) Despite several attempts to do so, our agencies have been unable to reach NRHP eligibility consensus for the SLAC campus and the DOE's 17 December 2013 letter states "they cannot agree to delay consultation on LCLS-II" during ongoing NRHP evaluation efforts." Concurrence on property identification, evaluation and NRHP determinations is essential to project planning, historic property treatment, the development of sound mitigation strategies and importantly, successful Section 106 compliance. It bears repeating that should additional buildings and structures at SLAC be determined NRHP eligible, this status will not obstruct campus development but can help ensure that historic properties damaged, modified, removed or demolished during undertakings are properly documented to convey SLAC's historic significance.

2) The DOE's unwillingness to delay the LCLS-II undertaking prior to the completion of historic property identification efforts is inconsistent with the regulations as an assessment of adverse effects cannot be properly determined until property identification and evaluation efforts are complete. To that end, I recommend that pursuant to 36 CFR part 800.4(c)(2), the DOE obtain a formal determination of NRHP eligibility for the SLAC campus from the Secretary. Until this occurs I will be unable to review or provide comments on future DOE undertakings at SLAC.

I also offer the following comments regarding the currently proposed undertaking:

3) Pursuant to 36 CFR Part 800.4 (a)(1), I recommend the DOE revise their delineated area of potential effect to include the SLAC campus in its entirety.

4) Although SLAC and CA SHPO have consistently failed to agree on campus historic property evaluation efforts and methods, I can, based on the information provided and my understanding of the undertaking's effects on NRHP eligible properties, concur that this undertaking as proposed will not adversely affect historic properties pursuant to 36 CFR Part 800.5(b) on the condition that the DOE agree to assume NRHP eligibility of the entire SLAC campus for the purposes of this undertaking.

If you agree to the condition I have set forth regarding the proposed expansion of the Linac Coherent Light Source Facility (LCLS-II), please evidence your agreement by signing the signature block below and returning the letter to me as soon as possible. Alternatively, you may provide me with a separate letter concurring with the proposed determinations. Please be advised that under certain circumstances, such as an unanticipated discovery or a change in project description, you may have future responsibilities for this undertaking under 36 CFR Part 800. Thank you for seeking my comments. If you have any questions or concerns, please contact Ed Carroll of my staff at (916) 445-7006 / Ed.Carroll@parks.ca.gov.

Sincerely,

Carol Roland-Nawi, PhD

Carol Roland-Nawi, PhD
State Historic Preservation Officer

_______________________________________ Date_______________________

Paul Golan, Site Manager
SLAC National Accelerator Laboratory

CC:

Tom McCulloch, Program Analyst
Advisory Council on Historic Preservation
Old Post Office Building
1100 Pennsylvania Avenue, NW, Suite 803
Washington, DC 20004

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APPENDIX C: ALOHA MODELING RESULTS

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Time: June 4, 2014 0339 hours PDT (user specified)

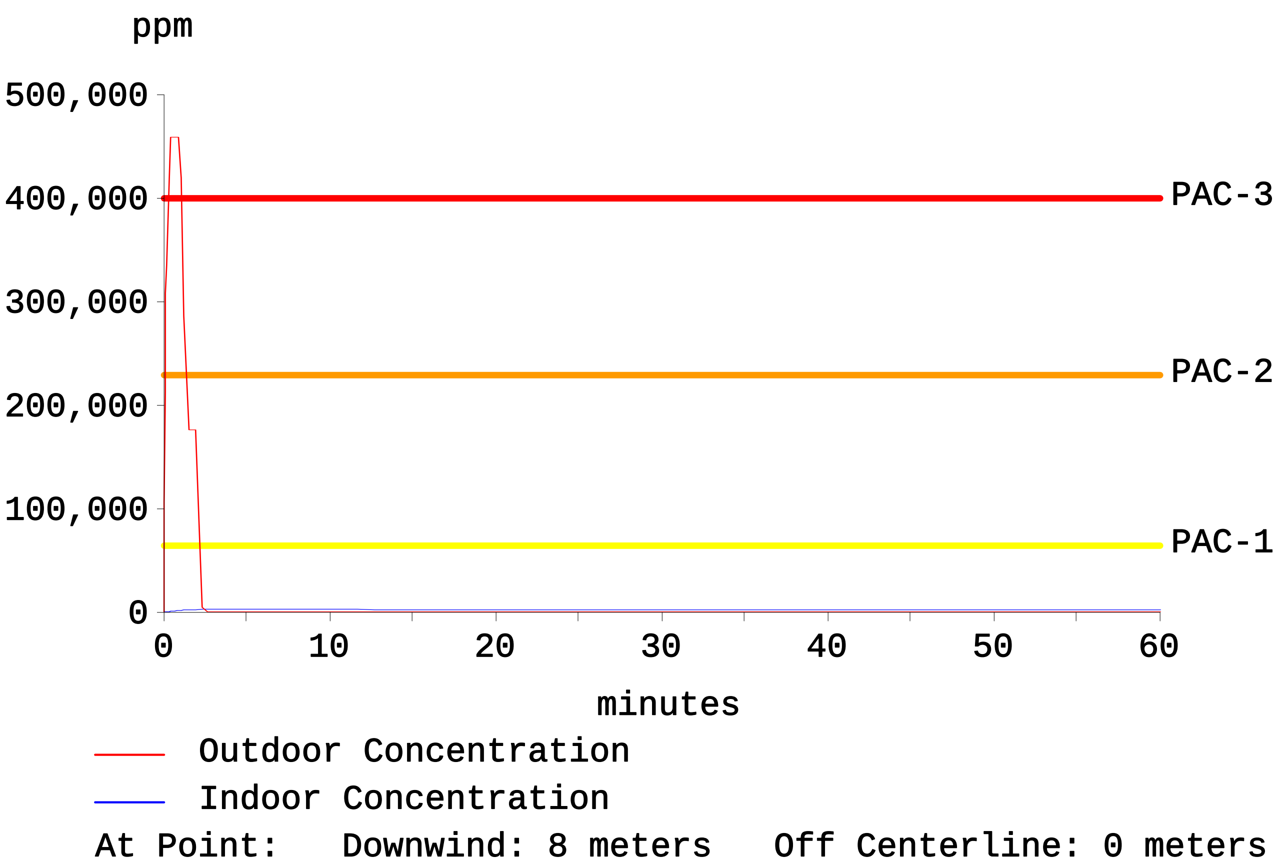
Chemical Name: HYDROGEN

Wind: 1 meters/second from N at 3 meters

THREAT ZONE:
Model Run: Heavy Gas
Red : less than 10 meters(10.9 yards) --- (400000 ppm = PAC-3)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Orange: 11 meters --- (230000 ppm = PAC-2)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 47 meters --- (65000 ppm = PAC-1)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Model Run: Heavy Gas
Red : less than 10 meters(10.9 yards) --- (400000 ppm = PAC-3)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Orange: 11 meters --- (230000 ppm = PAC-2)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 47 meters --- (65000 ppm = PAC-1)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

```
Time: June 4, 2014  0339 hours PDT (user specified)

Chemical Name: HYDROGEN

Building Air Exchanges Per Hour: 0.20 (unsheltered single storied)

THREAT AT POINT:
  Model Run: Heavy Gas
  Concentration Estimates at the point:
  Downwind: 8 meters                    Off Centerline: 0 meters
  Max Concentration:
     Outdoor: 457,000 ppm
     Indoor:  2,190 ppm
```



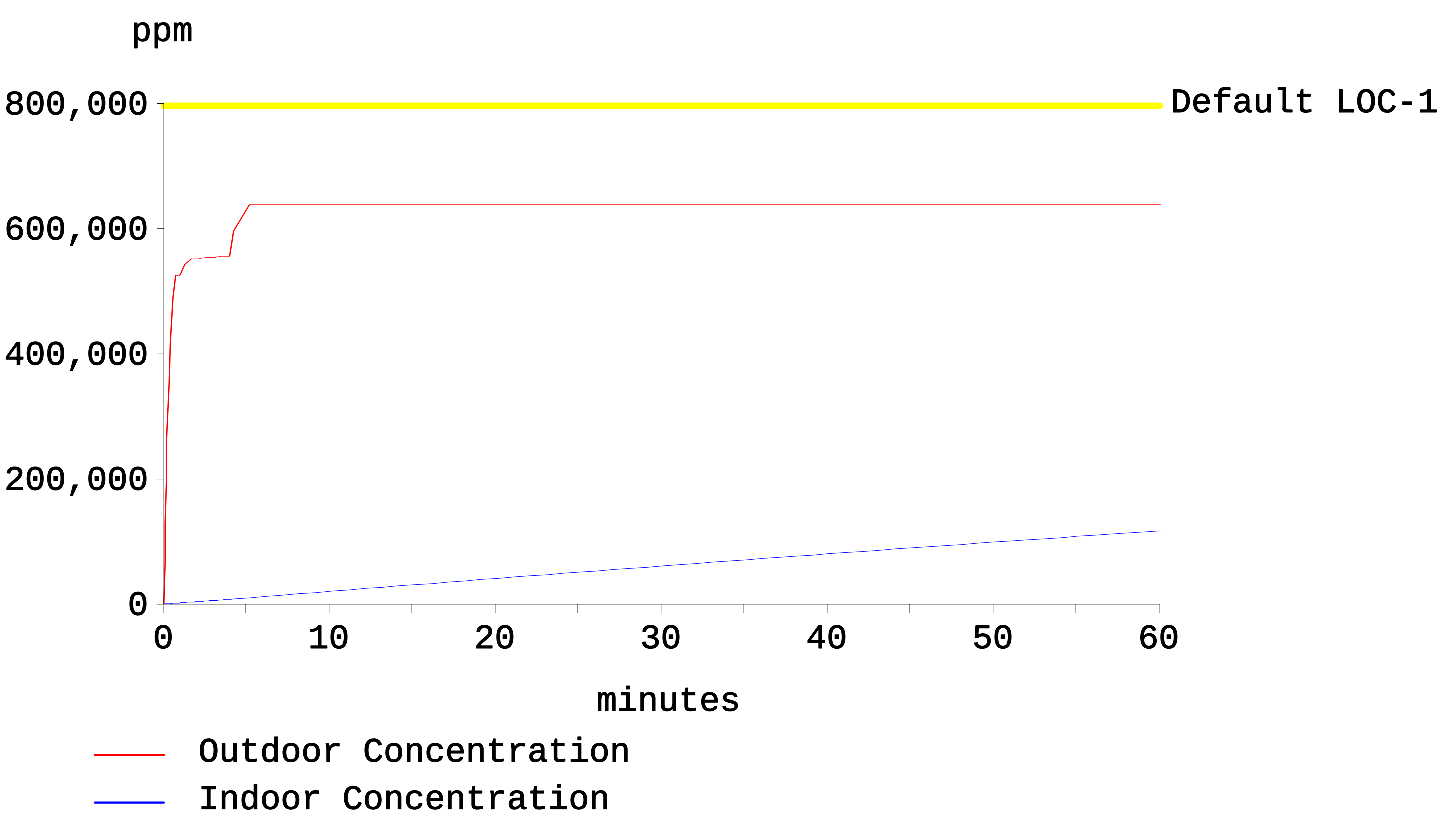
```
SITE DATA:
  Location: PALO ALTO, CALIFORNIA
  Building Air Exchanges Per Hour: 0.20 (unsheltered single storied)
  Time: June 4, 2014  0339 hours PDT (user specified)

CHEMICAL DATA:
  Chemical Name: HYDROGEN                Molecular Weight: 2.02 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 40000 ppm     UEL: 750000 ppm
  Ambient Boiling Point: -252.8° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1 meters/second from N at 3 meters
  Ground Roughness: 10 centimeters       Cloud Cover: 0 tenths
  Air Temperature: 20° C                 Stability Class: F
  No Inversion Height                    Relative Humidity: 50%

SOURCE STRENGTH:
  Leak from hole in horizontal cylindrical tank
  Flammable chemical escaping from tank (not burning)
  Tank Diameter: 6 feet                  Tank Length: 19.9 feet
  Tank Volume: 4200 gallons
  Tank contains liquid                   Internal Temperature: -254° C
  Chemical Mass in Tank: 1.26 tons       Tank is 100% full
  Circular Opening Diameter: 12 inches
  Opening is 0 feet from tank bottom
  Ground Type: Concrete
  Ground Temperature: equal to ambient
  Max Puddle Diameter: Unknown
  Release Duration: 2 minutes
  Max Average Sustained Release Rate: 1,020 kilograms/min
     (averaged over a minute or more)
  Total Amount Released: 1,143 kilograms
  Note: The chemical escaped as a liquid and formed an evaporating puddle.
  The puddle spread to a diameter of 17.5 meters.

THREAT ZONE:
  Model Run: Heavy Gas
  Red   : less than 10 meters(10.9 yards) --- (400000 ppm = PAC-3)
  Note: Threat zone was not drawn because effects of near-field patchiness
    make dispersion predictions less reliable for short distances.
  Orange: 11 meters --- (230000 ppm = PAC-2)
  Note: Threat zone was not drawn because effects of near-field patchiness
    make dispersion predictions less reliable for short distances.
  Yellow: 47 meters --- (65000 ppm = PAC-1)
  Note: Threat zone was not drawn because effects of near-field patchiness
    make dispersion predictions less reliable for short distances.

THREAT AT POINT:
  Concentration Estimates at the point:
  Downwind: 8 meters                     Off Centerline: 0 meters
  Max Concentration:
     Outdoor: 457,000 ppm
     Indoor:  2,190 ppm
```

Time: June 4, 2014 0339 hours PDT (user specified)

Chemical Name: NITROGEN

Building Air Exchanges Per Hour: 0.20 (unsheltered single storied)

THREAT AT POINT:
Model Run: Heavy Gas
Concentration Estimates at the point:
Downwind: 5 meters Off Centerline: 0 meters
Max Concentration:
Outdoor: 638,000 ppm
Indoor: 116,000 ppm



At Point: Downwind: 5 meters Off Centerline: 0 meters

```
SITE DATA:
  Location: PALO ALTO, CALIFORNIA
  Building Air Exchanges Per Hour: 0.20 (unsheltered single storied)
  Time: June 4, 2014  0339 hours PDT (user specified)

CHEMICAL DATA:
  Chemical Name: NITROGEN                Molecular Weight: 28.01 g/mol
  Default LOC-1: 796000 ppm   Default LOC-2: 832000 ppm   Default LOC-3: 869000
ppm
  PAC-1: 796000 ppm   PAC-2: 832000 ppm   PAC-3: 869000 ppm
  Ambient Boiling Point: -195.6° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1 meters/second from N at 3 meters
  Ground Roughness: 10 centimeters       Cloud Cover: 0 tenths
  Air Temperature: 20° C                 Stability Class: F
  No Inversion Height                    Relative Humidity: 50%

SOURCE STRENGTH:
  Leak from short pipe or valve in horizontal cylindrical tank
  Non-flammable chemical is escaping from tank
  Tank Diameter: 7.5 feet                Tank Length: 48.4 feet
  Tank Volume: 16000 gallons
  Tank contains liquid                   Internal Temperature: -200° C
  Chemical Mass in Tank: 56.4 tons       Tank is 100% full
  Circular Opening Diameter: 4 inches
  Opening is 0 inches from tank bottom
  Ground Type: Concrete
  Ground Temperature: equal to ambient
  Max Puddle Diameter: Unknown
  Release Duration: ALOHA limited the duration to 1 hour
  Max Average Sustained Release Rate: 386 kilograms/min
     (averaged over a minute or more)
  Total Amount Released: 22,906 kilograms
  Note: The chemical escaped as a liquid and formed an evaporating puddle.
  The puddle spread to a diameter of 10.9 meters.

THREAT ZONE:
  Model Run: Heavy Gas
  Red   : LOC was never exceeded --- (869000 ppm = Default LOC-3)
  Orange: LOC was never exceeded --- (832000 ppm = Default LOC-2)
  Yellow: LOC was never exceeded --- (796000 ppm = Default LOC-1)

THREAT AT POINT:
  Concentration Estimates at the point:
  Downwind: 5 meters                     Off Centerline: 0 meters
  Max Concentration:
     Outdoor: 638,000 ppm
     Indoor:  116,000 ppm
```

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APPENDIX D: CadnaA NOISE MODELING RESULTS

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Imagine the result

LCLS-II Noise Modeling Report

CadnaA Noise Model Results
Linac Coherent Light Source

May 16, 2014

SLAC National Accelerator Laboratory,
San Mateo County, California

Kevin Fowler
Acoustical Project Scientist

Michael Burrill
Senior Acoustical Scientist

LCLS-II Project

LCLS-II Noise Modeling Report

Prepared for:
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AZ001214.0031

Date:
May 16, 2014

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Tables

Figures

Attachment

1. Introduction and Summary

This technical noise modeling report provides backup for the noise modeling analysis completed for the examination of the potential noise impacts associated with the proposed LCLS-II Project at SLAC National Accelerator Laboratory (SLAC). The project site is located within San Mateo County in California. The nearest sensitive receptors are single-family residences located to the west along Manzanita Way in the City of Woodside.

The analysis addresses the Proposed Action, including construction of two cryogenic plants and installation of new equipment in the existing accelerator tunnel and klystron gallery. The EA presents a detailed description of the Proposed Action.

Noise is a physical disturbance in a medium, such as air, that can be detected by the human ear. Sound waves in air are caused by variations in pressure above and below the static value of atmospheric pressure. Sound is measured in units of decibels (dB) on a logarithmic scale. The “pitch” (high or low) of the sound is a description of frequency, which is measured in Hertz (Hz). Most common environmental sounds are composed of a composite of frequencies.

A normal human ear can usually detect sounds within frequencies from 20 Hz to about 20,000 Hz. However, humans are most sensitive to frequencies from 500 Hz to 4000Hz. Certain frequencies are given more “weight” during assessment because human hearing is not equally sensitive to all sound frequencies. The dBA scale corresponds to the sensitivity range for human hearing. Noise that can be heard by humans is measured in dBA. A noise level change of 3 dBA or less is barely perceptible to average human hearing. However, a 5 dBA change in noise level is clearly noticeable and a 10 dBA change in noise level would be perceived as a doubling (or halving) of noise loudness, while a 20 dBA change would be a dramatic change. Table 1 provides typical instantaneous noise levels of common activities in dBA.

Table 1 Typical Instantaneous Noise Levels of Common Activities in dBA

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
Jet Fly-over at 1,000 feet	100	--
Gas Lawn Mower at 3 feet	90	--
Diesel Truck at 50 feet, at 50 miles per hour (mph)	80	Food Blender at 3 feet Garbage Disposal at 3 feet
Noisy Urban Area, Daytime Gas Lawn Mower at 100 feet	70	Vacuum Cleaner at 10 feet
Commercial Area Heavy Traffic at 300 feet	60	Normal Speech at 3 feet
Quiet Urban Daytime	50	Large Business Office, Dishwasher in Next Room
Quiet Urban Nighttime	40	Theater, Large Conference Room (Background)
Quiet Suburban Nighttime	30	Library
Quiet Rural Nighttime	20	Bedroom at Night
	10	Broadcast/Recording Studio (background level)
Lowest Threshold of Human Hearing	0	Lowest Threshold of Human Hearing

-- No values available from Caltrans
Source: Caltrans Technical Noise Supplement, October 1998

Sound from a source spreads out as it travels away from the source, and the sound pressure level diminishes with distance in accordance with the “inverse square law.” Individual sound sources are considered “point sources” when the distance from the source is large compared to the size of the source, for example: transformer bank, construction equipment, and turbines. Sound from a point source radiates hemi-spherically, which yields a 6 dB sound level reduction for each doubling of the distance from the source. If the sound source is quite long in one dimension, the source is considered a “line source”, for example: roadways and railroads. Sound from a line source radiates cylindrically, which typically yields a 3 dB sound level reduction for each doubling of the distance from the source.

In addition to distance attenuation, the air absorbs a certain amount of sound energy, and atmospheric effects (wind, temperature, precipitation), and terrain/vegetation effects also influence the sound propagation and attenuation over large distances from the source.

An individual's sound exposure is valued based on a measurement of the noise that the individual experiences over a specified time interval. A sound level is a measurement of noise that occurs during a specified period of time. A continuous source of noise is rare for long periods of time and is typically not a characteristic of community noise. Community noise refers to outdoor noise and most commonly originates from transportation vehicles or stationary mechanical equipment. A community noise environment varies continuously over time depending on the contributing sources. Within a community, ambient noise levels gradually change throughout a typical day and the changes can be correlated to the increase and decrease of transportation noise or to the daytime/nighttime operation of stationary mechanical equipment. The variation in community noise throughout a day is also due to the addition of short-duration single-event noise sources, such as aircraft and sirens as well as natural sources (e.g., wind, birds, insects).

The metrics for evaluating the community noise environment are based on measurements of the noise exposure over a period of time in order to characterize and evaluate the cumulative noise impacts. These metrics are time-varying and are defined as statistical noise descriptors.

Construction activities could result in varying degrees of ground vibration, depending on the kind of equipment and operations involved, and the distances between the construction activities and the nearest sensitive receptors. The effects of ground-borne vibration generated by construction are typically imperceptible to an average human outside of the project site. However, high magnitude vibrations can damage nearby structures.

2. Methodology and Equipment

2.1 Methodology

2.1.1 Noise Model Software

Modeling of the proposed LCLS-II Project and surrounding community environment was accomplished using a noise model, CadnaA (Computer Aided Noise Abatement), developed by DataKustik for predicting noise impacts in a wide variety of conditions. All predicted noise impacts are based on the International Standards Organization (ISO) 9613 standard. The algorithm allows input of project information such as noise source data, sound barriers, intervening structures, ground absorption, and topography to create a detailed computer-aided drafting (CAD) output.

2.1.2 Long-term Noise Monitoring Measurement

To document existing noise conditions at SLAC's western boundary, a 2-week ambient noise monitoring measurement was conducted for the EA between Thursday, April 3 and Wednesday, April 16, 2014. The field noise monitor was programmed to log data every 30-minutes during the continuous 2-week time period. The microphone at the monitoring location was placed approximately 8 feet above the existing site grade. During the on-site ambient noise measurements, start and end times were recorded along with existing background noise sources to accurately account for the community noise environment (see Figure 1).

2.1.3 Short-term Noise Measurements

To further document the existing noise levels surrounding the project site and at identified residential receptor locations, a series of 30-minute equivalent sound level measurements (dBA Leq) was conducted as part of the EA during the daytime and nighttime hours of Wednesday, April 2 and Thursday, April 3, 2014. The microphones at all noise measurement locations were placed approximately 5 feet above ground level. These locations are shown in Figure 1.

2.2 Measurement Equipment

The following equipment was used to measure existing noise levels:

- Larson Davis Model 820 Sound Level Meter Environmental Monitor Kit
- Larson Davis Model 824 Sound Level Meter
- Larson Davis Model CA200 Microphone Calibrator
- Hand-held global positioning system (GPS) unit, microphone with windscreen, tripods

The sound level meters were field-calibrated prior to and following the noise measurement to ensure accuracy. All sound level measurements conducted and presented in this report, in accordance with the regulations, were made with sound meters that conform to the American National Standards Institute (ANSI) specification ANSI SI.4-1983 (R2006). All instruments are maintained with National Bureau of Standards traceable calibrations per the manufacturers' standards.

3. Existing Environmental Setting

3.1 Existing Noise Environment

The LCLS-II project would be located on Stanford University property. The land uses adjacent to SLAC near the Proposed Action include intermixed residential, recreational (equestrian), agricultural, and undeveloped areas within the City of Menlo Park and the City of Woodside. Residential communities are located generally to the north, west and east.

The existing ambient noise environment near the project site is primarily affected by vehicle noise associated with Sand Hill Road, Whiskey Hill Road, and I-280. Other ambient noise sources include the adjacent equestrian facilities and existing SLAC operations (see Figure 1). Existing noise sources at SLAC include activities around the western end of the accelerator housing and klystron gallery. SLAC's main research areas are more than 1 mile to the east. Ambient noise varies depending on the time of day, weather conditions, and proximity to noise-attenuating features such as trees and topographical changes.

3.1.1 Noise Receptors

Overall, the noise receptors in the area are single-family residences located directly to the west within the City of Woodside along Manzanita Way, approximately 2,000 feet from the proposed construction site of the cryogenic plant at Sector 4, 1,000 feet from the smaller cryogenic plant at Sector 0-1, and approximately 400 feet from SLAC's west gate entrance at the corner of Sand Hill Road and Whiskey Hill Road. Other potential noise receptors exist on to the north and east of SLAC, such as on Campbell Lane in Stanford Hills.

3.1.2 Prior Noise Study

In 2006, SLAC completed an ambient noise study (Charles M. Salter Associates, Inc. 2006) along SLAC's eastern boundary, including 24-hour ambient noise measurements in residential areas south of Sand Hill Road, along SLAC's northern boundary, at the southeastern corner of Campbell Lane and Branner Road, and at the southeastern corner of the SLAC property line (south of the intersection of Alpine Road, Sneckner Court, and Bishop Road). The resulting measurements are listed in Table 2 and were below City of Menlo Park noise limits in areas to the north and east. Areas near Alpine Road at the southeast boundary were affected by automobile and truck traffic, which resulted in noise levels that exceeded the City of Menlo Park noise threshold limits.

Table 2 Existing Noise Levels at the Nearest Sensitive Receptors

Sensitive Receptor	City of Menlo Park Daytime/Nighttime Noise Limit (L_{eq}, dBA)	Monitored 24-hour Noise Level (L_{eq}, dBA)	Monitored Daytime Noise Level (L_{eq}, dBA)	Monitored Nighttime Noise Level (L_{eq}, dBA)
Northern Boundary	60/50	56.2	57.7	49.5
Eastern Boundary	60/50	54.2	55.7	47.7
Southeast Boundary (Alpine Road)	60/50	66.4	67.7	60.8

Notes:
dBA = decibels A-scale
L_{eq} = equivalent continuous noise level
Source: Charles M. Salter Associates, Inc. 2006

3.1.3 Long-term Noise Monitoring Measurements

The current noise study for the EA included long-term noise measurements to define ambient noise levels. Sand Hill Road, west of I-280 is a busy two-lane road adjacent to the western SLAC property line that creates ambient noise from automobile and truck traffic. To document current ambient noise levels in this area, SLAC conducted a long-term measurement for a period of 2 weeks. A noise meter was installed near the west gate entrance near Sand Hill Road and Whiskey Hill Road (see Figure 1). The noise monitoring equipment operated continuously from April 3 through 16, 2014. Table 3 provides a summary of these data.

Table 3 Existing Noise Levels – SLAC West Gate (Long-Term Measurement)

Date	Daytime dBA L_{eq}	Nighttime dBA L_{eq}
4/3/2014	58.1	50.0
4/4/2014	58.4	50.6
4/5/2014	58.1	49.8
4/6/2014	57.2	49.2
4/7/2014	57.7	49.0
4/8/2014	57.3	49.1
4/9/2014	57.4	49.3
4/10/2014	57.2	47.7
4/11/2014	57.1	49.3
4/12/2014	56.5	48.4
4/13/2014	55.7	47.4
4/14/2014	56.4	48.5
4/15/2014	57.1	48.8
4/16/2014	57.1	49.3
Location GPS coordinate: 37.411796°N, 122.239926°W		

The noise monitoring data shows that existing noise levels at this location ranged from 55.7 to 58.4 dBA Leq during the day (7:00 a.m. to 10:00 p.m.) and from 47.7 to 50.6 dBA Leq at night (10:00 p.m. to 7:00 a.m.). The higher daytime noise levels can be attributed to Sand Hill Road and Whiskey Hill Road traffic.

3.1.4 Short-term Noise Level Measurements

To confirm the long-term noise measurement results for Sand Hill Road and to document ambient conditions in other receptor areas, SLAC collected individual daytime and nighttime short-term noise measurements at two on-site and five off-site locations (Figure 1) on April 2 and 3, 2014. Table 4 provides these results. These data confirm that existing community noise is present at SLAC's western boundary. Furthermore, there are relatively quiet conditions in the neighboring residential areas.

Table 4 Existing Measured Noise Levels (Short-Term Measurements)

Receptor	Sample Location	Daytime 1-hour L_{eq} (dBA)	Nighttime 1-hour L_{eq} (dBA)
ST-1	SLAC Northern Haul Road	46.2	----
ST-2	SLAC Research Yard (Central SLAC)	58.6	----
ST-3	Manzanita Road, Woodside	57.3	42.8
ST-4	Manzanita Road, Woodside	54.9	41.8
ST-5	Sand Hill Road, Woodside	67.5	53.3
ST-6	Whiskey Hill Road, Woodside	61.7	43.8
ST-7	Alpine Road Across from SLAC Gate	63.2	----

4. Noise Modeling

This section evaluates the potential effects of LCLS-II construction and operational noise and vibration on the environment and is focused on direct effects on residential receptors adjacent to SLAC.

4.1 Construction Noise

The Proposed Action would require dismantling and removing existing equipment and utilities within Sectors 0 through 10 of the existing linac tunnel and klystron gallery and installing new superconducting accelerator equipment. It would also require upgrades to existing LCLS facilities including the BTH, UH, NEH, and FEH. Part of the upgrades would allow installation of a second beamline.

As part of the Proposed Action, SLAC would construct two new cryogenic plants to produce extremely cold liquid helium that would be circulated through the superconducting accelerator equipment via new utility connections. The cryogenic plants would be located near Sector 0-1 and near Sector 4 of the existing klystron gallery and would consist of a steel-framed building to house compressors and control rooms. The plant exteriors would consist of piping, storage tanks for liquid helium and nitrogen (refrigerant), an electrical substation, and site access improvements.

Construction would require the use of heavy equipment including excavators, loaders, and haul trucks. The majority of the construction would be conducted during the daytime hours. To minimize nighttime noise impacts and comply to the extent practicable with local noise standards and objectives, the construction contractor would conduct the excavation required for the cryogenic plant foundations and the related site preparation and grading, as well as relocation of the haul road and construction of utilities, during the day. The excavation would not require drilling or blasting. Construction would also require trucking of removed equipment and building materials, staging, assembly of components, construction of the cryogenic plants, installation of the cryomodules, and trenching of utilities. Part of the work would be conducted at the west end of the accelerator housing and klystron gallery. Construction workers and trucks would use both the Alpine Gate and SLAC's main entrance on Sand Hill Road. Trucks would follow the haul road and enter the accelerator housing using a ramp, vault, and tunnel near Sector 10. Trucks would also occasionally use the west gate on Sand Hill Road near Whiskey Hill Road.

Table 5 identifies equipment type, quantity, utilization percentage, and noise level for each major type of construction equipment.

Table 5 LCLS-II Proposed Action Construction Equipment

Phase	Equipment Type	Equipment Quantity	Utilization Percentage	Noise Source Level at 50 feet (dBA)
Excavation of Cryogenic Plant Foundations	Compactor	1	20	80
	Dozer	1	40	85
	Drill Rig	1	20	84
	Excavator	2	40	85
	Haul Truck	9	40	84
	Loader	2	40	80
	Water Truck	1	20	84
	Delivery Trucks	9 per day	----	----

Table 5 LCLS-II Proposed Action Construction Equipment

Phase	Equipment Type	Equipment Quantity	Utilization Percentage	Noise Source Level at 50 feet (dBA)
Dismantling, Removal, and Installation of Equipment	Compactor	1	20	80
	Dozer	1	40	85
	Drill Rig	1	20	84
	Excavator	2	40	85
	Haul Truck	9	40	84
	Loader	2	40	80
	Water Truck	1	20	84
	Delivery Trucks	6 per day	----	----
Cryogenic Plant Construction	Compressor	2	40	80
	Concrete Truck	1	40	85
	Concrete Pump	1	20	82
	Crane	2	16	85
	Haul Truck	2	20	84
	Loader	2	40	80
	Shot Pump	1	50	77
	Delivery Trucks	3 per day	----	----
Truck use of west gate	Delivery Trucks	9 per day	----	----

Source: FHWA 2009

Noise values for construction equipment were derived from literature sources (e.g., Federal Highway Administration Construction Noise Handbook [FHWA 2009]). The loudest construction equipment typically emits noise levels between 77 and 85 dBA at 50 feet, with utilization factors of 16 to 40 percent (i.e., the percent of time the equipment would be used per day). Noise levels at any specific receptor would be dominated by the closest and loudest equipment. The types and numbers of equipment affecting any specific receptor location would vary over time.

The model accounted for a reasonable worst-case scenario of noise sources at both cryogenic plant sites; arrival of workers and trucks; equipment dismantling and removal; and installation of new equipment, including a portion of the cryomodules being installed at the west end of the linac. The model considered the effects of terrain, such as the ridge located just west of the proposed cryogenic plant at Sector 4, and the slope between the west end of the linac and receptors in Woodside to the west of Sand Hill Road. It also assumed no nighttime construction and no high noise/vibration-producing construction methods would be used, such as pile drivers or explosives.

Table 6 and Figure 2 present modeled construction noise levels at adjacent residential receptors, including the nearest receptors on Manzanita Way in Woodside. The short-term ambient noise measurement locations (Figure 1) were used to represent adjacent residential receptor locations. According to the model, construction noise levels would range from approximately 23.9 dBA L_{eq} to 49.1 dBA L_{eq} at the closest receptors west of Sand Hill Road and 38.1 dBA L_{eq} to 42.9 dBA L_{eq} at receptors in Menlo Park to the north and east of the Research Yard. These values represent a reasonable worst-case analysis because they assume concurrent construction of the cryogenic plants and removal and installation of equipment and utilities. Noise levels would be slightly lower if activities were limited to the west end of the linac and substantially lower if activities were limited to the cryogenic plant sites. Attachment 1 describes the input data, assumptions including construction equipment, and model results.

Table 6 Modeled Construction Equipment Noise Levels at Receptor Locations

		Construction Noise Impacts (dBA L_{eq})				
Sensitive Receptor	**Receptor Location**	**Excavation of Cryogenic Plant Foundations**	**Dismantling, Removal, and Installation of Equipment**	**Cryogenic Plant Construction**	**Truck use of West Gate**	**Maximum Increase in Noise Levels (dB)**
LT-1	Long-term Monitor Location	48.1	48.1	45.1	38.5	0.4
ST-1	SLAC Northern Haul Road	47.3	47.1	42.6	34.9	3.6
ST-2	SLAC Research Yard (Central SLAC)	31.4	44.3	26.9	24.3	0.2
ST-3	Manzanita Road, Woodside	41.8	41.8	39.4	23.9	0.1
ST-4	Manzanita Road, Woodside	44.1	44.1	41.5	27.7	0.3
ST-5	Sand Hill Road, Woodside	49.1	49.1	45.7	26.7	0.1
ST-6	Whiskey Hill Road, Woodside	42.3	42.3	40.5	29.8	0.0
ST-7	Alpine Road Across from SLAC Gate	42.9	41.3	38.1	38.1	0.0

The model results shown in Table 6 and Figure 2 represent the contribution of project noise only and do not account for existing community noise sources such as roadways, aircraft over flight, recreational, or residential/ commercial noise. As described above, traffic on Sand Hill Road and Alpine Road generates substantial daytime ambient traffic noise levels ranging from 63.2 dBA Leq to 67.5 dBA Leq (locations ST-5 and ST-

7 in Table 4). The calculated construction noise levels range from 23.9 dBA Leq to 49.1 dBA Leq at the noise receptor locations (Table 6) and result in small incremental noise increases during the daytime period. Daytime noise levels at receptor locations directly west of Sand Hill Road (locations ST-3, ST-4, and ST-5) would increase by approximately less than 1 dB. This level of noise increase would be imperceptible from day to day. As expected, the largest noise increases would occur within the SLAC boundary, such as along the haul road that would be used by haul trucks. Because of existing ambient sources, noise levels would not increase at locations adjacent to existing roadways (ST-6 and ST-7). Noise levels would diminish rapidly at distance because of attenuation by topography, trees, and buildings. In addition, construction would be completed during the day.

4.2 Operational Noise

During operations, the Proposed Action would increase the number of daily employees and users of the site from approximately 1,630 now to approximately 1,650 in the future. This increase would be inconsequential and is approximately equal to the fluctuation in the number of SLAC employees over 1 year (60 to 100 people) because of shutdowns, construction activities, and temporary labor. The projected increase, however, would result in an approximate less than 1.0 dBA increase in traffic-related noise levels along Alpine Road or Sand Hill Road near SLAC's main entrance and would be below detection at the locations of sensitive receptors. Therefore, any operational effects from the Proposed Action on traffic noise would be minor.

Potential sources of long-term operational noise would include cryogenic plant components, specifically compressors, refrigeration units, and air handling and HVAC units. The larger cryogenic plant would have five compressors – one at 2,500 hp, and four at 800 hp. The air handling and HVAC units would typically have a maximum noise level of 96 dBA power level (PWL) for a 12,000 cubic feet per minute (cfm) air handling unit and 78 dBA PWL for a commercial rooftop air conditioner (Carrier 1992). The plants would have from four to six emergency ventilation fans (20,000 cfm) mounted on the roof.

The Proposed Action would also include a new unit electrical substation and a 15 kilovolt (kV) outdoor medium-voltage SF6 switchgear. The main source of noise within the substation would be the transformer and cooling fans. The National Electrical Manufacturers Association standard describes sound levels for 2,000 kilovolt-amps (kVA) commercial transformers (e.g., vent-dry type) at a distance of 1 foot from the source as 66 dBA for self-cooled and 71 dBA for fan-cooled units (General Electric 1999).

Data collected from DOE's cryogenic plant at TJNAF were used as model input. Because many aspects of the TJNAF plant would be replicated at SLAC, these noise data (Table 7) provide a good approximation of the noise that would be produced at SLAC. The data were collected in June of 2010 on the outside of the building. Noise levels at a distance of 5 feet outside the cryogenic plant wall ranged from 61.5 to 64 dBA L_{eq}, and octave band data were as follows:

Table 7 Noise Data from Cryogenic Plant at TJNAF

Octave band (Hz)	Range (dBC)
16	61.5 – 63.2
31.5	66.5
63	69.9 – 70.9
125	69.5 – 70.6
250	60.1 – 62.2
500	58.8 – 60.5
1,000	56.3 – 59.8
2,000	51.6
4,000	41.1
8,000	32.9 – 34.1
16,000	13.0 – 15.0

Source: Owen 2010

The noise values for the TJNAF cryogenic plant components and the transformers were used to model noise impacts at SLAC receptor locations. The operational noise assessment assumed 24-hour operations and accounted for the distances from the cryogenic plants to the receptors. Model input data also included source elevations (building heights) and topography. Model input assumptions were similar to those used for the construction noise model with one notable exception. The cryogenic plant design would include excavation to create flat foundations and soil berms around the plants to reduce noise propagation.

Table 8 and Figure 3 present modeled operational noise levels (project only) for residential receptors. The calculated operational noise levels from LCLS-II at the nearest residential receptors range from 13.0 dBA Leq to 44.5 dBA Leq. The project would result in an increase of less than 3 decibels to both the existing daytime and nighttime noise levels at the nearest residential receptors. This increase would not result in a noticeable change at the nearest residential receptors.

Table 8 Modeled Operational Noise Levels at Receptor Locations

Sensitive Receptor	Receptor Location	Operational Noise Impacts (dBA L_{eq})	Measured Ambient Noise Levels (dBA L_{eq})	Combined Noise Levels (dBA)	Noise Level Increase (dB)
LT-1	Long-term Monitor Location	46.7	49.0[1]	51.0	2.0
ST-1	SLAC Northern Haul Road	37.0	46.2[2]	46.7	0.5
ST-2	SLAC Research Yard (Central SLAC)	19.5	58.6[2]	58.6	0.0
ST-3	Manzanita Road, Woodside	37.4	42.8[1]	43.9	1.1
ST-4	Manzanita Road, Woodside	40.5	41.8[1]	44.2	2.4
ST-5	Sand Hill Road, Woodside	44.5	53.3[1]	53.8	0.5
ST-6	Whiskey Hill Road, Woodside	43.2	43.8[1]	46.5	2.7
ST-7	Alpine Road Across from SLAC Gate	13.0	63.2[2]	63.2	0.0

Notes:
1 Measured nighttime ambient noise level
2 Measured daytime ambient noise level

5. Vibration

5.1 Construction Vibration

Proposed Action construction would include the use of heavy equipment that would generate ground-borne vibrations. Possible sources of vibration may include excavators, dump trucks, backhoes, and other heavy construction equipment.

The construction vibration calculations are based on the FTA published vibration levels provided in **Table 9**.

Table 9 Vibration Source Levels for Construction Equipment

Equipment	PPV* at 25 feet (in/sec)	Approximate L_v ** at 25 feet
Large Bulldozer	0.089	87
Caisson Drilling	0.089	87
Loaded Trucks	0.076	86
Jack Hammer	0.035	79
Small Bulldozer	0.003	58

Notes:
* Peak Particle Velocity
** RMS velocity in decibels (VdB) re 1 micro-inch/second

The construction of the project would result in vibration levels of approximately 30.9 VdB at the nearest residential receptor along Whiskey Hill Road. Therefore, vibration levels would be below perception and well below thresholds for annoyance and structural damage published by FTA and presented in the EA. Table 10 summarizes the calculated vibration levels at each receptor location.

Table 10 LCLS-II Proposed Action Construction Vibration Impacts

Sensitive Receptor	Receptor Location	Approximate Distance to Receptor (feet)	Calculated Vibration Level (VdB*)
LT-1	Long-term Monitor Location	1590	32.9
ST-1	SLAC Northern Haul Road	2400	27.5
ST-2	SLAC Research Yard (Central SLAC)	8000	11.8
ST-3	Manzanita Road, Woodside	2940	24.9
ST-4	Manzanita Road, Woodside	2400	27.5
ST-5	Sand Hill Road, Woodside	2460	27.2
ST-6	Whiskey Hill Road, Woodside	1850	30.9
ST-7	Alpine Road Across from SLAC Gate	12136	6.4

Notes:
* RMS velocity in decibels (VdB) re 1 micro-inch/second

5.2 Operational Vibration

Vibration from the cryogenic plants operations would be inconsequential to off-site areas due to the low level of vibrations produced. The compressors would be inside the cryogenic plant buildings and designed to minimize vibration.

6. References

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Figures

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CITY: Boulder, CO DIV/GROUP: IM/AIT DRAFTER: J. CHEN
Project (Project #): AZ001214
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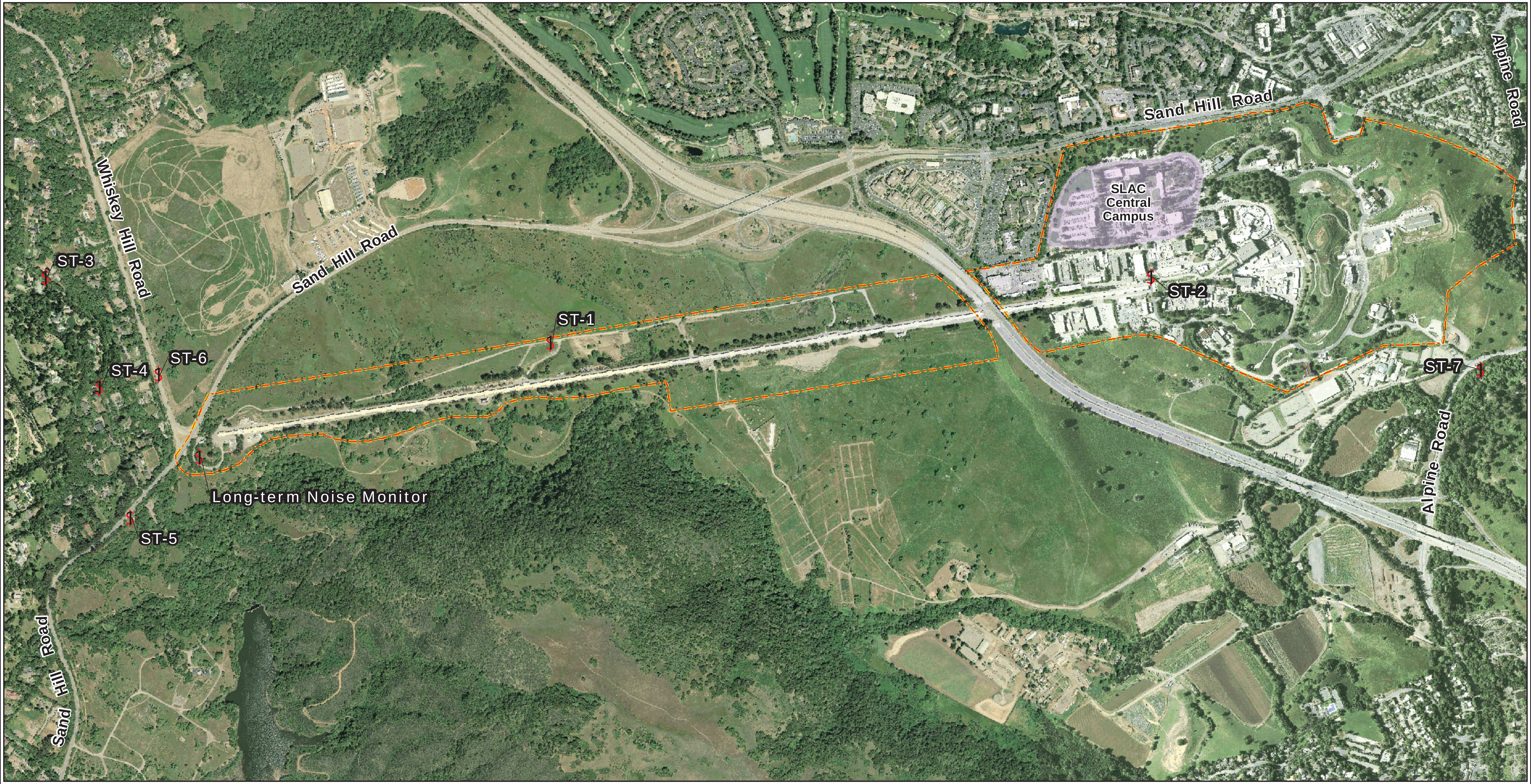


Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

NOISE MONITORING LOCATION

0 1,000 Feet

Graphic Scale: 1" =1000'

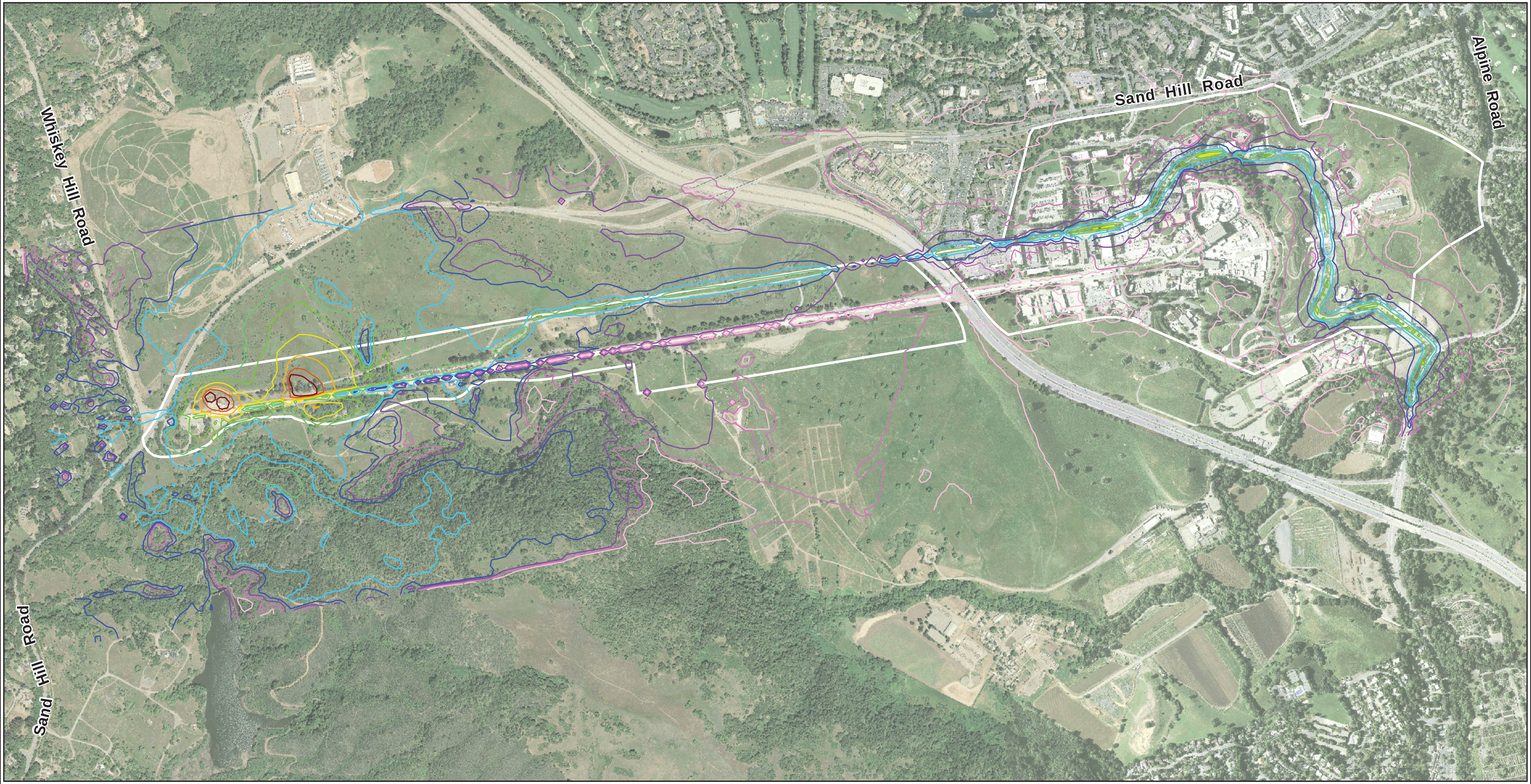
SLAC LCLS-II EA

NOISE MONITORING LOCATIONS

ARCADIS

FIGURE 1

CITY: Boulder, CO DIV/GROUP: IM/AIT DRAFTER: J. CHEN
Project (Project #): AZ001214
Document Path: C:\Users\jchen\Documents_PROJECTS\K\AZ001214_SLAC_LCLS_II_EA\GIS\ArcMaps\2014\Noise_Fig_3-3_Proposed Action Construction Noise Contour .mxd



Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

NOISE CONTOURS DECIBLE LEVELS

30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

0 — 1,000 Feet

Graphic Scale: 1" =1000'

SLAC LCLS-II EA

PROPOSED ACTION
CONSTRUCTION NOISE CONTOURS

ARCADIS

FIGURE
2

Basemap: City of San Francisco, photo dated on 04/2011.

LEGEND

NOISE CONTOURS DECIBLE LEVELS

30
35
40
45
50
55
60
65
70
75

SLAC NATIONAL ACCELERATOR LABORATORY BOUNDARY

0 1,000 Feet

Graphic Scale: 1" =1000'

SLAC LCLS-II EA

PROPOSED ACTION OPERATIONS NOISE CONTOURS

ARCADIS

FIGURE 3

Attachment 1

CadnaA Noise Model Data and Results

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Excavation of Cryogenic Plant Foundations

Point Sources

Name	Result. PWL	Lw / Li		Operating Time	Freq.	Height		Coordinates		
	Day	Type	Value	Day				X	Y	Z
	(dBA)			(min)	(Hz)	(m)		(m)	(m)	(m)
Excavator	119.7	Lw	excavator	240	1000	1.83	r	-2036.35	519.19	102.44
Dozer	119.7	Lw	dozer	240	1000	1.83	r	-2005.91	480.53	102.44
loader	114.7	Lw	loader	240	1000	1.83	r	-2032.65	482.12	102.44
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	471.27	102.34
compactor	114.7	Lw	compactor	120	1000	1.83	r	-2006.43	516.01	102.44
water truck	118.7	Lw	truck	120	1000	1.83	r	-2009.61	501.98	102.44
Drill Rig	119.7	Lw	drillrig	120	1000	1.83	r	-2023.11	502.51	102.44
Excavator	119.7	Lw	excavator	240	1000	1.83	r	-2314.87	507.18	103.96
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	475.34	103.9
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	477.34	103.92
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	479.34	103.93
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	481.34	103.95
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	483.34	103.96
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	473.27	102.24
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	475.27	102.14
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	477.27	102.01
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	479.27	101.98

Roadway Sources

Name	Lme	exact Count Data		Speed Limit
	Day	M	p (%)	Auto
	(dBA)	Day	Day	(km/h)
Haul Road	48.2	9	20	56

Receivers

Name	Level Lr		Height		Coordinates		
	Day	Noise Type			X	Y	Z
	(dBA)		(m)		(m)	(m)	(m)
LT-1	48.1	Total	1.52	r	-2498.07	404.25	95.29
ST-1	47.3	Total	1.52	r	-1294.62	602.48	100.61
ST-2	31.4	Total	1.52	r	871.15	495.61	91.46
ST-3	41.8	Total	1.52	r	-2793.04	963.41	94.51
ST-4	44.1	Total	1.52	r	-2738.34	662.95	92.14
ST-5	49.1	Total	1.52	r	-2723.76	237.51	101.39
ST-6	42.3	Total	1.52	r	-2558.8	711.2	96.37
ST-7	42.9	Total	1.52	r	1685.2	11.01	51.51

Dismantling, Removal, and Installation of Equipment

Point Sources

Name	Result. PWL	Lw / Li		Operating Time	Freq.	Height		Coordinates		
	Day	Type	Value	Day				X	Y	Z
	(dBA)			(min)	(Hz)	(m)		(m)	(m)	(m)
Excavator	119.7	Lw	excavator	240	1000	1.83	r	-2036.35	519.19	102.44
Dozer	119.7	Lw	dozer	240	1000	1.83	r	-2005.91	480.53	102.44
loader	114.7	Lw	loader	240	1000	1.83	r	-2032.65	482.12	102.44
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	471.27	102.34
compactor	114.7	Lw	compactor	120	1000	1.83	r	-2006.43	516.01	102.44
water truck	118.7	Lw	truck	120	1000	1.83	r	-2009.61	501.98	102.44
Drill Rig	119.7	Lw	drillrig	120	1000	1.83	r	-2023.11	502.51	102.44
Excavator	119.7	Lw	excavator	240	1000	1.83	r	-2314.87	507.18	103.96
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	475.34	103.9
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	477.34	103.92
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	479.34	103.93
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	481.34	103.95
loader	114.7	Lw	loader	240	1000	1.83	r	-2273.94	483.34	103.96
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	473.27	102.24
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	475.27	102.14
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	477.27	102.01
haul truck	118.7	Lw	truck	120	1000	1.83	r	-1987.11	479.27	101.98
Loader	114.7	Lw	loader	240	1000	1.83	r	1020.97	470.1	85.57

Roadway Sources

Name	Lme	exact Count Data		Speed Limit
	Day	M	p (%)	Auto
	(dBA)	Day	Day	(km/h)
Haul Road	46.5	6	20	56

Receivers

Name	Level Lr		Height		Coordinates		
	Day	Noise Type			X	Y	Z
	(dBA)		(m)		(m)	(m)	(m)
LT-1	48.1	Total	1.52	r	-2498.07	404.25	95.29
ST-1	47.1	Total	1.52	r	-1294.62	602.48	100.61
ST-2	44.3	Total	1.52	r	871.15	495.61	91.46
ST-3	41.8	Total	1.52	r	-2793.04	963.41	94.51
ST-4	44.1	Total	1.52	r	-2738.34	662.95	92.14
ST-5	49.1	Total	1.52	r	-2723.76	237.51	101.39
ST-6	42.3	Total	1.52	r	-2558.8	711.2	96.37
ST-7	41.3	Total	1.52	r	1685.2	11.01	51.51

Cryogenic Plant Construction

Point Sources										
	Result. PWL	Lw / Li		Operating Time	Freq.	Height		Coordinates		
	Day	Type	Value	Day				X	Y	Z
Name	(dBA)			(min)	(Hz)	(m)		(m)	(m)	(m)
compressor	114.7	Lw	compressor	240	1000	1.83	r	-2315.07	490.75	103.96
compresor	114.7	Lw	compressor	240	1000	1.83	r	-2035.5	518.29	102.44
loader	114.7	Lw	loader	240	1000	1.83	r	-2006.37	481.22	102.44
loader	114.7	Lw	loader	240	1000	1.83	r	-2280.12	482.81	103.83
shotpump	111.7	Lw	pump	300	1000	1.83	r	-2297.6	495.52	103.96
concretepump	116.7	Lw	concretepump	120	1000	1.83	r	-2032.32	484.4	102.44
concrete truck	116.7	Lw	concretetruck	240	1000	1.83	r	-2019.61	485.46	102.44
crane	101.2	Lw	crane	96	1000	1.83	r	-2024.91	508.76	102.44
crane	101.2	Lw	crane	96	1000	1.83	r	-2297.6	485.46	103.92
haul truck	118.7	Lw	truck	120	1000	1.83	r	-2262.65	476.46	103.96
haul track	118.7	Lw	truck	120	1000	1.83	r	-1989.43	479.11	102.12

Roadway Sources				
	Lme	exact Count Data		Speed Limit
	Day	M	p (%)	Auto
Name	(dBA)	Day	Day	(km/h)
Haul Road	43.4	3	20	56

Receivers							
Name	Level Lr		Height		Coordinates		
	Day	Noise Type			X	Y	Z
	(dBA)		(m)		(m)	(m)	(m)
LT-1	45.1	Total	1.52	r	-2498.07	404.25	95.29
ST-1	42.6	Total	1.52	r	-1294.62	602.48	100.61
ST-2	26.9	Total	1.52	r	871.15	495.61	91.46
ST-3	39.4	Total	1.52	r	-2793.04	963.41	94.51
ST-4	41.5	Total	1.52	r	-2738.34	662.95	92.14
ST-5	45.7	Total	1.52	r	-2723.76	237.51	101.39
ST-6	40.5	Total	1.52	r	-2558.8	711.2	96.37
ST-7	38.1	Total	1.52	r	1685.2	11.01	51.51

Truck Use of West Gate

Roadway Sources				
	Lme	exact Count Data		Speed Limit
	Day	M	p (%)	Auto
Name	(dBA)	Day	Day	(km/h)
Haul Road	43.4	3	20	56
West Access Gate	48.2	9	20	56

Receivers							
	Level Lr		Height		Coordinates		
	Day	Noise Type			X	Y	Z
Name	(dBA)		(m)		(m)	(m)	(m)
LT-1	38.5	Total	1.52	r	-2498.07	404.25	95.29
ST-1	34.9	Total	1.52	r	-1294.62	602.48	100.61
ST-2	24.3	Total	1.52	r	871.15	495.61	91.46
ST-3	23.9	Total	1.52	r	-2793.04	963.41	94.51
ST-4	27.7	Total	1.52	r	-2738.34	662.95	92.14
ST-5	26.7	Total	1.52	r	-2723.76	237.51	101.39
ST-6	29.8	Total	1.52	r	-2558.8	711.2	96.37
ST-7	38.1	Total	1.52	r	1685.2	11.01	51.51

Project Operations

Area Sources

Name	Result. PWL	Result. PWL''	Lw / Li		Freq.	Height
	Day	Day	Type	Value		
	(dBA)	(dBA)			(Hz)	(m)
main cryo plant	112.2	79.6	Lw''	cryoplant	1000	6.1
secondary cryo plant	110.9	79.6	Lw''	cryoplant	1000	6.1

Point Sources

Name	Result. PWL	Lw / Li		Operating Time	Freq.	Height		Coordinates		
	Day	Type	Value	Day				X	Y	Z
	(dBA)			(min)	(Hz)	(m)		(m)	(m)	(m)
Transformer	71.5	Lw	transformer		1000	2.13	r	-2038.23	469.47	102.74
Transformer	71.5	Lw	transformer		1000	2.13	r	-2031.97	469.47	102.74

Receivers

Name	Level Lr		Height		Coordinates		
	Day	Noise Type			X	Y	Z
	(dBA)		(m)		(m)	(m)	(m)
LT-1	46.7	Total	1.52	r	-2498.07	404.25	95.29
ST-1	37	Total	1.52	r	-1294.62	602.48	100.61
ST-2	19.5	Total	1.52	r	871.15	495.61	91.46
ST-3	37.4	Total	1.52	r	-2793.04	963.41	94.51
ST-4	40.5	Total	1.52	r	-2738.34	662.95	92.14
ST-5	44.5	Total	1.52	r	-2723.76	237.51	101.39
ST-6	43.2	Total	1.52	r	-2558.8	711.2	96.37
ST-7	13	Total	1.52	r	1685.2	11.01	51.51

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