DOE/EIS-0547

DRAFT SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR CONTINUED OPERATION OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY

VOLUME 2: APPENDICES A-I

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National Nuclear Security Administration

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RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy (DOE) / National Nuclear Security Administration (NNSA)

TITLE: *Draft Site-Wide Environmental Impact Statement for Continued Operation of the Lawrence Livermore National Laboratory* (LLNL SWEIS) (DOE/EIS-0547)

LOCATION: Livermore, California

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Abstract: The NNSA, a semi-autonomous agency within the DOE, is responsible for meeting the national security requirements established by the President and Congress to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile. The continued operation of the Lawrence Livermore National Laboratory (LLNL) is critical to NNSA's Stockpile Stewardship and Management Program, to prevent the spread and use of nuclear weapons worldwide, and to many other areas that may impact national security and global stability.

NNSA has prepared this SWEIS to analyze the potential environmental impacts of the reasonable alternatives for continuing LLNL operations for approximately the next 15 years. This LLNL SWEIS has been prepared in accordance with Section 102(2)(C) of NEPA (42 U.S.C. §§ 4321–4347, as amended), regulations promulgated by the Council on Environmental Quality (CEQ) (40 Code of Federal Regulations [CFR] Parts 1500–1508), DOE's NEPA implementing procedures (10 CFR Part 1021), and NNSA Policy (NAP) 451.1.

This SWEIS analyzes two alternatives: (1) No-Action Alternative and (2) Proposed Action. This SWEIS also analyzes the new hybrid work environment due to increase in telework at LLNL under both alternatives. Under the No-Action Alternative, NNSA would continue current facility operations throughout LLNL in support of assigned missions. The No-Action Alternative includes the construction of new facilities; modernization/upgrade/utility projects; and decontamination, decommissioning, and demolition (DD&D) of excess and aging facilities through 2022.

The Proposed Action includes the scope of the No-Action Alternative and an increase in current facility operations or enhanced operations that may require new or modified facilities and that are reasonably foreseeable over the next 15 years. Continued re-investment would allow LLNL to meet mission deliverables and sustain science, technology, and engineering excellence to respond to future national security challenges. Approximately 75 new projects, totaling approximately 3.3 million square feet, are proposed over the period 2023–2035. Of this, 61 projects, totaling approximately 2.9 million square feet, are proposed at the Livermore Site; 14 projects, totaling approximately 385,000 square feet, are proposed at Site 300. In addition, NNSA proposes 20 types of modernization/upgrade/utility projects each involving several facilities. Under the Proposed Action, NNSA would also DD&D about 150 facilities, totaling approximately 1,170,000 square feet. NNSA is proposing operational changes that would increase the tritium emissions limits in the National Ignition Facility (Building 581) and the Tritium Facility (Building 331), decrease the administrative limit for fuels-grade-equivalent plutonium in the Superblock (Building 332), increase the administrative limits for plutonium-239 at Building 235, and revise the National Ignition Facility radioactive materials administrative limits to be consistent with DOE's Facility Hazard Categorization Standard.

Following completion of this LLNL SWEIS, NNSA intends to decide how operations will be conducted at LLNL, including construction and operation of new facilities, modification/upgrade of existing facilities and utilities, modification of operations, and/or DD&D of excess and aging facilities. These decisions will be provided in the NNSA Record of Decision (ROD).

Public Comments: DOE issued a Notice of Intent (NOI) in the *Federal Register* (85 FR 47362) on August 5, 2020, announcing a 45-day SWEIS scoping period to receive input on the preparation of this Draft SWEIS. In response to comments, NNSA extended that comment period until October 21, 2020. Comments received during that scoping period have been considered in the preparation of this Draft SWEIS. Comments on this Draft SWEIS will be accepted following publication of the U.S. Environmental Protection Agency's Notice of Availability (NOA) in the *Federal Register* for a period of 60 days and will be considered in the preparation of the Final SWEIS. Any comments received after the comment period will be considered to the extent practicable. During the public comment period for this Draft SWEIS, NNSA will hold in-person and/or online public hearings. The dates and times of those public hearings will be announced on the DOE NEPA web page and the NNSA NEPA web page (https://www.energy.gov/nepa, https://www.energy.gov/nnsa/nnsa-nepa-reading-room), as well as in local newspapers, and in Federal Register Notices of Availability. All comments received during that public comment period will be considered by NNSA in preparing the Final SWEIS.

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ABBREVIATIONS AND ACRONYMS

°F	Fahrenheit
2005 LLNL SWEIS	2005 *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory*
3D	three dimensional
ABSL	Animal Biosafety Level
ACAM	Air Conformity Applicability Model
ACDEH	Alameda County Department of Environmental Health
ACE	Altamont Commuter Express
ACFD	Alameda County Fire Department
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing materials
ACRECC	Alameda County Regional Emergency Communications Center
ADT	average daily traffic (volume)
AI	Authorizing Individual
ALARA	as low as reasonably achievable
AME	Applied Materials and Engineering
AML	Advanced Manufacturing Laboratory
AO	Authorizing Organization
AQCR	Air Quality Control Regions
ARG	accident response group
ASC	Advanced Simulation and Computing
ASER	annual site environmental report
AVLIS	Atomic Vapor Laser Isotope Separation
BAAQMD	Bay Area Air Quality Management District
BART	Bay Area Rapid Transit
BeO	beryllium oxide
BEU	beyond extremely unlikely
BGEPA	*Bald and Golden Eagle Protection Act*
BLM	U.S. Bureau of Land Management
BLS	Bureau of Labor Statistics
BMP	Best Management Practice
Bq/L	Becquerel per liter
BSAT	Biological Select Agent and Toxin
BSL	Biosafety Level
C&D	construction and demolition
CAA	*Clean Air Act*
CAAQS	California Ambient Air Quality Standards
CAL FIRE	California Division of Forestry and Fire Protection
CAMS	Center for Accelerator Mass Spectroscopy
CARB	California Air Resources Board
CAS	Contractor Assurance System
CBRNE	Chemical, Biological, Radiological, Nuclear, and/or Explosive
CCR	*California Code of Regulations*
CDC	Centers for Disease Control and Prevention
CDFW	California Division of Fish and Wildlife

CDNL	C-weighted Day-Night Sound Level
CEQ	Council on Environmental Quality
CEQA	*California Environmental Quality Act*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CERT	Community Emergency Response Team
CESA	*California Endangered Species Act*
CF	Core functions
CFF	Contained Firing Facility
CFR	Code of Federal Regulations
CH-TRU	contact-handled transuranic
Ci	Curies
CMR	compliance monitoring report
CNDDB	California natural diversity database
CNPS	California Native Plant Survey
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COC	constituent of concern
COVID-19	Coronavirus disease 2019
CRD	comment response document
CSA	container storage area
CSU	Container Storage Unit
CSVRA	Carnegie State Vehicular Recreation Area
CTBT	Comprehensive Test Ban Treaty
CUPA	Certified Unified Program Agency
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	*Clean Water Act*
CWC	Chemical Weapons Convention Treaty
CX	Categorical Exclusions
DARHT	Dual Axis Radiographic Hydrodynamic Test
DART	Days Away with Restricted Time
dB	Decibel
dBA	A-weighted decibel
dBC	C-weighted decibel
dBP	peak sound level
DCS	Derived Concentration Technical Standards
DD&D	Decontamination, decommissioning, and demolition
DEHP	di(2-ethylhexyl)phthalate
DFEAT	Disposition and Forensic Analysis Team
DFO	DOE forensics operations
DHS	United States Department of Homeland Security
DNA	deoxyribonucleic acid
DNL	Day-night sound level
DoD	United States Department of Defense
DOE	United States Department of Energy

DOE-STD	U.S. Department of Energy Standard
DOF	California Department of Finance
DOL	Design optimization laboratory
DSA	Documented Safety Analysis
DTSC	Department of Toxic Substances Control
DU	depleted uranium
DWTF	Decontamination and Waste Treatment Facility
EA	Environmental Assessment
ECCA	Electronic Chemical Classification Application
ECFM	Exascale Complex Facility Modernization
ED	Emergency Director
EDD	California Employment Development Department
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EM	DOE Office of Environmental Management
EMDE	Energetic Materials Development Enclave
EMDO	Emergency Management Duty Officer
EMS	Environmental Management System
EO	Executive Order
EOC	Emergency Operations Center
EPA	California Environmental Protection Agency
EPHA	Emergency Planning Hazards Assessment
EPZ	Emergency Planning Zones
ERO	Emergency Response Organization
ES&H	environmental, safety, and health
ESA	*Endangered Species Act*
ESCRC	Experimental Synthesis/Chemistry Replacement Capability
ETF	Environmental Test Facility
EU	enriched uranium
EVA	Emergency Voice Alarm
EWSF	Explosives Waste Storage Facility
EWTF	Explosives Waste Treatment Facility
FAM	Functional Area Managers
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FFRDC	Federally Funded Research and Development Center
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FSC	Forensic Science Center
ft	feet
FXR	Flash x-ray
FY	Fiscal Year
G&A	General and Administrative
GAA	General Access Area
GAC	granulated activated carbon

gal	gallons
GBSD	Ground Based Strategic Deterrent
GCR	general conformity rules
GHG	greenhouse gas
GP	Guiding principles
GSA	General Service Area
GWP	Ground Water Project
HAP	Hazardous air pollutant
HazMat	Hazardous Material
HE	High Explosives
HEAF	High Explosives Applications Facility
HED	high energy density
HEMI	High Explosives Manufacturing Incubator
HEPA	high efficiency particulate air
HETEF	High Explosives Test and Evaluation Facilities
HEU	highly enriched uranium
HMX	Cyclotetramethylenetetranitramine
HPC	high performance computing
HPCIC	High Performance Computing Innovation Center
HSD	Health Services Department
HSU	hydrostratigraphic unit
HT	tritiated hydrogen gas
HTO	tritiated water
HVAC	heating, ventilation, and air conditioning
HVFS	High Vacuum Fluorination System
I	Interstate
IAEA	International Atomic Energy Agency’s
IBC	International Building Code
IC	Incident Commander
ICF	inertial confinement fusion
ICP	Incident Command Post
ICRP	International Commission on Radiological Protection
ICS	Incident Command System
IDA	intentional destructive acts
IHE	insensitive HE
IORB	Institutional Operations Review Board
IPaC	Information for Planning and Consultation
IPCC	Intergovernmental Panel on Climate Change
IS	Initial Study
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
ISS	Institutional Strategic Support
JASPER	Joint Actinide Shock Physics Experimental Research
JTOT	Joint Technical Operations Team
LANL	Los Alamos National Laboratory
LC	Livermore Computing

LCF	Latent cancer fatalities
LDRD	Laboratory Directed Research and Development
LEAF	Laser-Explosives Application Facility
LEDO	Laboratory Emergency Duty Officer
LEP	Life Extension Program
Leq	equivalent sound level
LFO	Livermore Field Office
LINAC	Linear Accelerator
LiOH	lithium hydride
LLESA	Livermore Laboratory Employee Services Association
LLNL or Laboratory	Lawrence Livermore National Laboratory
LLNL SWEIS	*Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory*
LLNS	Lawrence Livermore National Security, LLC
LLW	low-level radioactive waste
LOS	level of service
LPFD	Livermore-Pleasanton Fire Department
LRU	line-replaceable units
LSI	light science and industry
LTAB	Laser and Target Area Building
LVOC	Livermore Valley Open Campus
LWRP	Livermore Water Reclamation Plant
MAR	material at risk
MBTA	*Migratory Bird Treaty Act*
MCL	maximum contaminant level
MEI	Maximally Exposed Individual
MeV	million electron volt
MGD	million gallons per day
MLLW	mixed low-level radioactive waste
MMP	Mitigation and Monitoring Plan
MND	Mitigated Negative Declaration
MNL	Micro/Nano Laboratory
Mod	Modification program
MOU	Memorandum of Understanding
MRZ	Mineral Resource Zone
MW	megawatts
NAAQS	National Ambient Air Quality Standards
NAGPRA	*Native American Graves Protection and Repatriation Act of 1990*
NARAC	National Atmospheric Release Advice Center
National Register	National Register of Historic Places
NCA4	Fourth National Climate Assessment
NCDL	Non-destructive Characterization Laboratory
ND	Negative Declaration
NDE	nondestructive evaluation
NELA	nuclear explosive-like assembly
NEP	nuclear explosives packages

NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEST	nuclear emergency response team
NHPA	*National Historic Preservation Act*
NIF	National Ignition Facility
NIF&PS	National Ignition Facility and Photon Science Program
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NMED	New Mexico Environment Department
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NOI	Notice of Intent
Nox	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPR	Nuclear Posture Review
NPT	nuclear nonproliferation treaty
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NRIA	Nuclear/Radiological Incident Annex
NRMP	Natural Resources Management Plan
O&B	Operations and Business
O_3	ozone
OBU	Open Burn Unit
ODU	Open Detonation Unit
OGC	Office of General Council
OHSMS	Operational Health and Safety Management System
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAC	protective action criteria
Pb	lead
PBX	polymer-bonded explosive
PCBs	polychlorinated biphenyl
PCE	perchloroethylene (or perchloroethene); also called tetrachloroethylene or tetrachloroethene
pCi/L	picocuries per liter
PELs	permissible exposure limits
pg/m3	picograms per cubic meter
PGA	Peak Ground Acceleration
PI	Principal Investigator
PLS	Physical and Life Sciences
PMn	Particulate matter less than or equal to n microns in diameter
POTW	Publicly-Owned Treatment Works
PSD	Prevention of Significant Deterioration
Pu	plutonium
Pu-239	plutonium-239
PV	Photovoltaic

R&D	Research and Development
Rad-NESHAP	Radionuclide National Emission Standards for Hazardous Air Pollutants
RADTRAN	the Radioactive Material Transportation Risk Assessment
RAP	Radiological Assistance Program
RCRA	*Resource Conservation and Recovery Act*
RDT&E	research, development, test, and evaluation
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RG	Risk Group
RGD	radiation-generating device
RHWM	Radioactive and Hazardous Waste Management
RI	Responsible Individual
RIMS II	Regional Input-Output Modeling System
RISKIND	Risks and Consequences of Radioactive Material Transport
RMA	radioactive materials area
ROD	Record of Decision
ROI	Region of Influence
RSD	Requirement Source Documents
SA	Supplement Analysis
SAA	satellite accumulation area
SAER	Site Annual Environmental Report
SAG	Stakeholder Advisory Group
SAM	Subject Area Managers
SARA	*Superfund Amendments and Reauthorization Act*
SBD	Safety Basis Document
SBE	Safety-basis envelope
SHPO	State Historic Preservation Officer
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMRDC	Stockpile Materials R&D Center
SNL/CA	Sandia National Laboratories/California
SNL/NM	Sandia National Laboratories/New Mexico
SNM	special nuclear materials
SO	Security Organization
SOW	scope of work
Sox	sulphur oxides
SPCC	Spill Prevention Control and Countermeasures
SPEIS	Supplemental Programmatic Environmental Impact Statement
SPP	Strategic Partnership Projects
SRS	Savannah River Site
SSM PEIS	*Stockpile Stewardship and Management Programmatic Environmental Impact Statement*
SST	safe secure transport
STA	Safeguard Transporters
SWEIS	Site-wide Environmental Impact Statement
SWP	state water project
SWPPP	Stormwater Pollution Prevention Plan

TCE	trichloroethylene
TEDA	triethylenediamine
TEDE	Total Effective Dose Equivalents
TFD	Treatment Facility D
TFE	Treatment Facility E
TLVs	threshold limit values
TNM	Traffic Noise Model
TPS	Tritium Processing System
TRAGIS	Transportation Routing Analysis Geographic Information System
TRC	total recordable case
TRI	Toxics Release Inventory
TRU	Transuranic
TRUPACT-II	Transuranic Package Transporter Model 2
TSCA	*Toxic Substance Control Act*
TSD	Transportation Safety Basis Documents
TSDF	Treatment, Storage, and Disposal Facility
TSF	Terascale Simulation Facility
TWAs	time-weighted averages
U.S.C.	United States Code
UCMP	University of California Museum of Paleontology
UDEQ	Utah Department of Environmental Quality
UQ	Uncertainty quantification
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VOC	volatile organic compound
VRM	Visual Resource Management
WAA	waste accumulation area
WCD	work control documents
WCI	Weapons and Complex Integration
WDR	waste discharge requirement
WETRC	Weapons Environmental Testing Replacement Capability
WIPP	Waste Isolation Pilot Plant
WMU	Waste Management Unit
WMUA	Waste Management Unit Area
WP&C	Work Planning and Control
WP&C	Work Planning and Control
WSF	Waste Storage Facilities
WWTP	Wastewater Treatment Plant
XRF	X-Ray Fluorescence
YR	Year
Zone 7	Alameda County Flood and Water Conservation District, Zone 7

CONVERSION CHART

TO CONVERT FROM U.S. CUSTOMARY INTO METRIC			TO CONVERT FROM METRIC INTO U.S. CUSTOMARY		
If you know	**Multiply by**	**To get**	**If you know**	**Multiply by**	**To get**
			Length		
inches	2.540	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.03281	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.6214	miles
			Area		
square inches	6.452	square centimeters	square centimeters	0.1550	square inches
square feet	0.09290	square meters	square meters	10.76	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.4047	hectares	hectares	2.471	acres
square miles	2.590	square kilometers	square kilometers	0.3861	square miles
			Volume		
fluid ounces	29.57	milliliters	milliliters	0.03381	fluid ounces
gallons	3.785	liters	liters	0.2642	gallons
cubic feet	0.02832	cubic meters	cubic meters	35.31	cubic feet
cubic yards	0.7646	cubic meters	cubic meters	1.308	cubic yards
			Weight		
ounces	28.35	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.205	pounds
short tons	0.9072	metric tons	metric tons	1.102	short tons
			Temperature		
Fahrenheit (ºF)	subtract 32, then multiply by 5/9	Celsius (ºC)	Celsius (ºC)	multiply by 9/5, then add 32	Fahrenheit (ºF)
Kelvin (K)	subtract 273.15	Celsius (ºC)	Celsius (ºC)	add 273.15	Kelvin (K)

Note: 1 sievert = 100 rems

METRIC PREFIXES

Prefix	**Symbol**	**Multiplication factor**
exa-	E	1,000,000,000,000,000,000 = 10^{18}
peta-	P	1,000,000,000,000,000 = 10^{15}
tera-	T	1,000,000,000,000 = 10^{12}
giga-	G	1,000,000,000 = 10^{9}
mega-	M	1,000,000 = 10^{6}
kilo-	k	1,000 = 10^{3}
deca-	D	10 = 10^{1}
deci-	d	0.1 = 10^{-1}
centi-	c	0.01 = 10^{-2}
milli-	m	0.001 = 10^{-3}
micro-	µ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}

APPENDIX A

Facilities and Infrastructure

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LIST OF TABLES

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A FACILITIES AND INFRASTRUCTURE

A.1 KEY FACILITIES AT THE LIVERMORE SITE

A.1.1 Introduction

Appendix A characterizes the Lawrence Livermore National Laboratory (LLNL, Laboratory, or Lab) facilities and existing activities to facilitate the analysis of the alternatives in this *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory* (SWEIS). The purposes of this appendix are as follows:

- Present specific information on the existing facilities and select other facilities included within the No-Action Alternative (descriptions for these facilities are included in Chapter 3 and included in Table A-1 of this appendix), including size, function, activities conducted in those facilities, and the hazards and wastes associated with those activities.
- Provide information on the current administrative limits for hazardous and radiological materials for each facility, as appropriate.
- Describe the significant changes to the Laboratory infrastructure, programs, and capabilities that have occurred since the 2005 LLNL SWEIS.

A.1.2 Key Facilities

Table A-1 provides an overview of key facilities at the Livermore Site. The key facilities listed in the table are those that (1) are representative of those facilities that have potentially hazardous operations or material inventories; (2) are representative of typical industrial, shop, or computation facilities; or (3) have infrastructure and capabilities to provide support to the National Nuclear Security Administration (NNSA), U.S. Department of Energy (DOE), U.S. Department of Defense, and other operations that are unique to the complex. Many facilities associated with waste management, security, health services, and emergency response are also described.

Descriptions of these key facilities at the Livermore Site follow the table, with information on area, use, the principal types of hazards present, and wastes generated. Hazards are indicated as radiological, chemical, or other. Radiological hazards include low-level ionizing radiation and radiological emissions. Chemical hazards can be toxic, flammable, corrosive, poisonous, and/or carcinogenic. Other hazards include radiation-generating devices (RGDs), explosives, non-ionizing radiation, biological, storage and handling of compressed gas cylinders, and electrical hazards. Table A-2, which follows the descriptions of the key facilities, provides an overview of the remaining facilities at the Livermore Site. Additionally, Table A-9 shows hazard classification for all hazard types for each individual facility.

Table A-1. Key Facilities at the Livermore Site

Facility Number	Facility Name	Gross Square Feet	NNSA Capability	Lab/ Research	Office/ Service/ Support	Hazards		
						Chemical	Radiological	Other[a]
131	Weapons Engineering	287,192	Design and Certification	Yes	Yes	Yes	Yes	Yes
132N	Defense Programs Research Facility	204,146	Global Security	Yes	Yes	Yes	Yes	Yes
132S	Global Security Research Facility	172,104	Global Security	Yes	Yes	Yes	Yes	Yes
141	Engineering Tech Development	47,342	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
151 & 152	Analytical and Nuclear Chemistry Facility and Storage	96,030 (751)	Design and Certification	Yes	Yes	Yes	Yes	Yes
153	Microfabrication Laboratory	25,976	Non-Nuclear Components	Yes	Yes	Yes	Yes	Yes
154	Analytical and Radiochemistry Laboratory (part of B151 Complex)	9,138	Design and Certification	Yes		Yes	Yes	Yes
162 & 165	Crystal Growth and Optics/Development Labs	29,095	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
166	Development Lab	13,266	Plutonium	Yes		Yes	Yes	Yes
170	National Atmospheric Release Advisory Center	43,760	Strategic Partnership Projects		Yes			
174	Jupiter Laser Facility	19,437	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
190	Center for Accelerator Mass Spectrometry Lab Facility	10,252	Design and Certification	Yes		Yes	Yes	Yes
191	High Explosives Application Facility	121,031	High Explosives	Yes	Yes	Yes	Yes	Yes
194	Accelerator Tunnel Complex	41,544	Design and Certification	Yes	Yes	Yes	Yes	Yes
223	AME New Polymers Capability Facility *	13,200	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
225	Manufacturing Sciences Facility *	15,900	Tests and Experiments	Yes		Yes		Yes
231	Development and Assembly Eng.	131,454	Weapons Engineering	Yes	Yes	Yes	Yes	Yes
231V, OS232FA, 233GV	Vaults and Transportation	5,000 1,200 1,800	Weapons Engineering		Yes	Yes	Yes	Yes
235	Materials Science Division Offices and Labs	88,071	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
239	Radiography Facility	12,905	Plutonium	Yes		Yes	Haz Cat 3 Nuclear	Yes
253	HC Dept. Offices & Labs	30,932	Enabling Infrastructure	Yes	Yes	Yes	Yes	Yes
254	HC Bio Assay Lab	2,488	Enabling Infrastructure	Yes	Yes	Yes	Yes	Yes
255	HC SPD Labs and Offices	21,855	Enabling Infrastructure	Yes	Yes	Yes	Yes	Yes
262	Radiation Detector Development	10,815	Global Security	Yes		Yes	Yes	Yes
272	Materials Science Laboratory	10,124	Non-Nuclear Components	Yes		Yes	Yes	Yes
298	Target Development	47,987	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
310	Nondestructive Evaluation Building *	11,000	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
321A	Materials Fabrication Shop	59,515	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
321C	Materials Fabrication Shop	78,335	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
321G	Manufacturing Building *	13,000	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
322	Plating Shop	5,704	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
327	Radiography	19,101	Tests and Experiments	Yes	Yes	Yes	Yes	Yes

Facility Number	Facility Name	Gross Square Feet	NNSA Capability	Lab/ Research	Office/ Service/ Support	Hazards		
						Chemical	Radiological	Other[a]
331	Tritium Facility	30,484	Tritium	Yes	Yes	Yes	Haz Cat 3 Nuclear	Yes
332	Plutonium Facility	104,787	Plutonium	Yes	Yes	Yes	Haz Cat 2 Nuclear	Yes
334	Hardened Engineering Test Building	10,688	Plutonium	Yes		Yes	Haz Cat 2 Nuclear	Yes
335	Support Facility	11,988	Plutonium	Yes	Yes	Yes		Yes
341	Engineering Mechanical Testing	44,184	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
361 & 362	Bio Research Cornerstone Facility	68,889	Global Security	Yes	Yes	Yes	Yes	Yes
364	Bio Research Support Facility	9,372	Global Security	Yes	Yes	Yes	Yes	Yes
365	Biosafety Level 2 Laboratory	8,972	Strategic Partnership Projects	Yes		Yes		Yes
368	Biosafety Level 3 Laboratory	1,590	Strategic Partnership Projects	Yes		Yes	No	Yes
381	Target Fabrication and Offices	95,478	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
391	NIF Optics and Diagnostic Labs	197,842	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
392	Optics Laboratory Facility	8,413	Tests and Experiments	Yes		Yes	Yes	Yes
431	Beam Research Labs	54,790	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
432	NIF Target Fabrication Machining	33,575	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
453	Livermore Computing Facility	253,000	Simulations	Yes	Yes	Yes		Yes
490	NIF Engineering and Diagnostic Lab	216,789	Tests and Experiment	Yes	Yes	Yes	Yes	Yes
491	Development Lab	13,883	Tests and Experiment	Yes	Yes	Yes	Yes	Yes
511	Craft Shop	77,141	Tests and Experiment	Yes		Yes	Yes	Yes
581/582/681	NIF, Vacuum Systems Building, and Optics Assembly Building	700,907 2,927 46,818	Tests and Experiments	Yes	Yes	Yes	Yes	Yes
Area 612	RHWM Waste TSDF (B612, B614, B624, B624A/B, OS612A, Tent 6197B)	12,426	Plutonium		Yes	Yes	Yes	Yes
655	Advanced Manufacturing Laboratory	13,993	Strategic Partnership Projects	Yes		Yes		Yes
663	Health Services	24,786	Enabling Infrastructure		Yes	Yes		Yes
Area 625, 693 Yard, Area 696R	RHWM Radioactive Waste Storage Facilities	19,247 12,000 9,600	Plutonium			Yes	Haz Cat 2 Nuclear	Yes
695, 696S 697	RHWM Liquid Processing/Decontamination and Waste Treatment Facility	46,504 11,781 4,118	Plutonium	Yes	Yes	Yes	Yes	Yes

Haz Cat 2 Nuclear = Hazard Category 2 facility (as defined by DOE-STD-1027); Haz Cat 3 Nuclear = Hazard Category 3 facility— all radionuclides greater than Cat 3 thresholds but below Cat 2 thresholds; hazard analysis shows potential for only significant localized consequences (10 CFR Part 830); Other facilities marked as "Yes" in the Radiological column are considered to be Less than Haz. Cat 3 Nuclear; NIF = National Ignition Facility; RHWM = radioactive and hazardous waste management; TSDF = Treatment, Storage, and Disposal Facility;

a. Other hazards include biological materials, explosives, accelerators, x-ray machines, lasers, nuclear magnetic resonance, electrical, and collection and storage of compressed gas cylinders.

* Descriptions for these facilities are provided in Chapter 3. They are in various stages of design and construction (under the No-Action Alternative).

A.1.2.1 *Building 131*

Building 131, the Weapons Engineering Facility, is located in the southwest quadrant of the Livermore Site. The closest site boundary to Building 131 is East Avenue, which is approximately 385 meters away (note: East Avenue has restricted access extending through the Sandia National Laboratory/California site). The closest site boundary with unrestricted access is Vasco Road, which is approximately 442 meters from the facility (LLNL 2018a).

Building 131 is 285,241 square feet, and contains an office wing and high bay (LLNL 2019a). The facility is currently occupied by 500 individuals from the Engineering Directorate, including 15 resident workers in the high bay. The office wing and the high bay are considered separate segments for safety documentation purposes. The office wing originated as offices and laboratories that have since been converted into office space in multiple renovation projects (LLNL 2017a). The high bay is an industrial shop-type building for classified projects and consists of office space, classified storage, laboratory and laboratory space, a machine shop with limited inspection capabilities, a welding bench, a small spray-painting booth, electronic shops, and a large assortment of benches. There is also a glovebox used for work requiring low-moisture, inert atmospheres. The high bay is equipped with 20-ton cranes, an environmental test facility, low-humidity laboratories, laboratories equipped with high-efficiency particulate air (HEPA)-filtered hoods or gloveboxes for working with radioactive and hazardous materials, a conventional machine shop for working with nonhazardous and nonradioactive materials, and a materials management vault and other locations for storage of controlled items.

Building 131 provides engineering support for Laboratory-wide programmatic tasks. The type of engineering support can range from paperwork (design and evaluation of engineered systems) to hands-on fabrication, installation, and/or testing of parts and systems. The high bay provides work environments for experiments and operations in engineering evaluations, primarily in support of the Stockpile Stewardship and Management Program, although other programs are supported as well (LLNL 2017b, LLNL 2018a).

<u>Hazards Assessment</u>

The Building 131 office wing does not contain any shops or laboratories. The high bay is classified as a low-hazard facility for chemicals and radiological materials (LLNL 2017b). The hazards of concern in Building 131 are primarily toxicological in nature (LLNL 2018a).

Hazardous materials used in the high bay include hazardous and corrosive chemicals and gases, combustible and toxic metals and metal compounds, sealed radioactive sources, other radioactive materials, and small quantities of high explosives. Operations within the high bay involve lithium hydride, lithium deuteride, beryllium, natural thorium, and natural and depleted uranium, small quantities of high explosives as well as flammable and combustible liquids and combustible and toxic metals. Operations may also involve work with cryogens such as liquid nitrogen or liquid argon. The hazardous materials in the high bay that have been determined to be of greatest concern are lithium hydride, beryllium, and uranium (LLNL 2018a). There are administrative limits for the quantities of these materials (and others of less concern) in the facility (LLNL 2017lb).

The handling and storage of hazardous and radioactive materials is authorized in the *Building 131 High Bay Emergency Planning Hazards Assessment Report* (LLNL 2018a) and are controlled and monitored by a combination of computer-based inventory tracking systems. Quantities of hazardous materials in the immediate work area are limited to the minimum needed for each operation or experiment. The maximum quantity of uranium authorized in the high bay is 10,000 kilograms (30,000 kilograms under DOE-STD-1027-2018). The nominal total quantity present during the most recent inventory was 6,203 kilograms of depleted uranium only (LLNL 2018a).

Radiation sources are limited to the high bay area and include a few sealed sources and small neutron RGDs. Small antistatic devices containing sealed sources are also used in the toxic material fabrication laboratories. The health and safety technicians monitor radiation levels and check for radioactive and hazardous material surface contamination (LLNL 2018a).

Other potentially hazardous operations in the Building 131 high bay include the use of lasers and RGDs, such as x-ray-generating equipment. Lasers are used for general research activities, alignment work, measurements of component systems, and machining of toxic materials. RGDs are used for radiography and testing operations. X-ray sources are used to calibrate diagnostic systems and characterize materials, components, or assemblies. Safety controls, such as enclosing x-ray tubes in steel cabinets, using safety covers or guards on laser devices, and using interlocks and shielding devices for x-ray systems, are in place to minimize the potential of personnel exposure to x-rays and lasers (LLNL 2018a).

An emergency planning zone is a defined area that requires specific and detailed planning to protect people from the consequences of hazardous material releases. In the *Building 131 High Bay Emergency Planning Hazards Assessment Report* (LLNL 2018a), NNSA determined that the emergency planning zone for the Building 131 high bay is the area within a radius of about 200 meters around the facility. Because the closest site boundary with unrestricted access is approximately 442 meters from the facility, no offsite consequences from Building 131 hazards would be expected (LLNL 2018a).

Generated Wastes and Effluents

Hazardous wastes and nonhazardous wastes produced in Building 131 include alkaline and acid solutions; lab-packed and bulk-waste chemicals; lab-packed spent halogenated and nonhalogenated solvent solutions, both organic and inorganic; laser dyes; reactive salts; uncured epoxies; petroleum and mineral-based oils; empty containers; laboratory debris; such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; machine shop wastes; print shop wastes; and waste oil with trace gasoline, diesel, organics, and metals (LLNL 2017a).

Operations in the Building 131 high bay also generate small quantities of low-level radioactive waste (LLW) as well as explosives residues and debris contaminated with explosives. Hazardous and LLW are identified, labeled, and accumulated at satellite accumulation areas (SAAs) within the facility. This waste is transferred to the waste accumulation area (WAA) outside the facility for proper disposition when the waste exceeds the capacity or storage time limit (LLNL 2017a).

Hoods, gloveboxes, and enclosures used to control dispersible uncontained radioactive or hazardous particulates are ventilated to the outside environment through HEPA filters. Various other exhaust systems are used to intermittently ventilate the paint spray booth, welding hoods, bead blasters, vacuum pump exhausts, laser cavities, and inert gas flush systems directly to the outside of the building. No liquid hazardous or radioactive material is discharged into the sanitary sewer or storm drain systems. These liquid wastes are collected at the point of generation and managed through a radioactive and hazardous waste management (RHWM) facility (LLNL 2017a).

A.1.2.2 *Building 132N*

Building 132N, the Defense Programs Research Facility, is located in the southwest quadrant of the Livermore Site. This building contains approximately 204,146 (LLNL 2019a) gross square feet of office, laboratory, and storage facilities. Programs and research activities underway in the Building 132N laboratories include chemical analysis and synthesis, limit of detection studies, liquid abrasive cutting, emergency response technologies, laser and fiber optic diagnostics, and medical/biological studies in Biosafety Level (BSL)-2 laboratories. The facility also houses a comprehensive range of analytical facilities for work related to nonproliferation, counter-terrorism, and domestic law enforcement. There is also a high bay area with common industrial hazards and a machine shop (LLNL 2018b, LLNL 2019aa).

Hazards Assessment

Hazards associated with Building 132N operations include ionizing and non-ionizing radiation, lasers, electrical hazards (high voltage), hazardous and toxic materials, explosives, and risk group 1 and 2 (RG-1 and RG-2) biological materials.

RG-1 materials include live agents or materials commonly used in research, university, college, and hospital settings; RG-1 materials are not infectious to humans. RG-1 materials used in Building 132N include recombinant deoxyribonucleic acid (DNA) work. RG-2 materials include agents associated with human disease that are rarely serious and for which preventative or therapeutic interventions are often available. RG-2 materials used in Building 132N include infectious agents; tissues, including blood; or other items such as sewage, which may contain biologically hazardous agents and toxins produced by living organisms. Controls for these hazards are specified in work control documents and facility safety plans (LLNL 2018b).

Generated Wastes and Effluents

Wastes that contain biological materials are managed as biohazardous wastes as a best management practice. All biological waste is autoclaved (steam sterilized) in Building 361. The hazardous wastes generated include flammable solids and liquids, organics, biological (LLNL 2018b) wastes, radioactive wastes, corrosives, toxic metals, and laser dyes. A small amount of radioactive waste is generated in this facility. Waste materials are collected at SAAs and then moved to a designated WAA. The building also has a laboratory wastewater retention system that is used to collect and retain dilute nonhazardous and nonradioactive rinse-waters from laboratories until analysis determines they can be discharged to the sanitary sewer. Many of the laboratories are equipped with exhaust hoods (LLNL 2018b).

A.1.2.3 *Building 132S Complexx*

The Building 132S Complex, referred to as the Global Security Research Facility, is located in the southwest quadrant of the Livermore Site and contains Buildings 132S, 134, and 135. This 172,104-square-foot complex (LLNL 2019a) provides laboratory, office, shop, and storage facilities (LLNL 2019a). Primary activities include laboratory-scale research, medical technology research and development (R&D), light electronics fabrication, laser diagnostics and communications, spectroscopy, and radiation detector development (LLNL 2018b).

Operations in the Building 132S Complex include laser experiments, sensor development, spectroscopy, gamma ray imaging, medical physics/biophysics, materials research, pump and thruster motor development, and nucleic acid detection R&D. BSL-2 controls, as specified in the Centers for Disease Control and Prevention *BioSafety in Microbiological and Biomedical Laboratories* guidelines, are in effect at this facility (LLNL 2018b).

Hazards Assessment

Hazards associated with Building 132S Complex operations include ionizing and non-ionizing radiation, lasers, electrical hazards (high-voltage), hazardous and toxic materials, and RG-1 and RG-2 biological materials. Controls for these hazards are specified in both facility safety plans and work control documents (LLNL 2018b).

RG-1 materials include live agents or materials commonly used in research, university, college, and hospital settings; RG-1 materials are not infectious to humans. RG-1 materials used in Building 132S include DNA, culturing of non-pathogenic bacteria (for cloning), and recombinant protein work. RG-2 materials include agents associated with human disease that are rarely serious and for which preventative or therapeutic interventions are often available. RG-2 materials used in Building 132S include infectious agents and tissue-culture cell lines. Associated laboratory equipment includes incubators, freezers, syringes, and biological safety cabinets. Associated hazards include cuts or needle sticks from handling sharp objects, burns from handling hot objects or from ultraviolet light exposure, and laboratory-acquired infections from poor personal or housekeeping practices. Controls for these hazards are specified in work control documents and facility safety plans (LLNL 2018b).

Generated Wastes and Effluents

The types of waste produced by the medical physics and biophysics research include nonhazardous biological waste, biohazardous and contaminated sharp object (medical) waste, and chemical waste. Biohazardous waste includes waste generated from research with RG-1 and RG-2 agents. All biohazardous wastes are treated before disposal (LLNL 2018b).

Hazardous waste and nonhazardous waste produced in the Building 132S Complex include alkaline and acid solutions; lab-packed and bulk-waste chemicals; lab-packed spent halogenated and nonhalogenated solvent solutions, both organic and inorganic; laser dyes; radioactive waste; reactive salts; petroleum and mineral-based oils; empty containers; laboratory debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; machine shop wastes; and waste oil with trace amounts of gasoline, diesel, organics, and metals (LLNL 2018b).

A.1.2.4 *Building 141*

Building 141, Engineering Technology Development Facility, is located in the southwest quadrant of the Livermore Site. The facility has a total area of 47,342 gross square feet and consists of five bays containing office spaces, shops, and laboratories (LLNL 2019a). The facility houses a multi-user laboratory for basic chemistry, BSL-1 laboratory, electronics research, and development of systems and components. Laboratory work may also involve radiological materials. Building 141 also houses a machine shop for fabricating components for building program operations; high-voltage and radio frequency labs for testing and developing electro-optics, pulsed power, and dielectric operations and applications; x-ray-generating operations; and laser lab operations using Class 1 and 2 solid-state lasers (LLNL 2017c).

Hazard Assessment

Building 141 is classified as an LSI hazard facility. The hazards present in the facility are associated with flammable liquids; reactive, corrosive, carcinogenic, and pyrophoric materials; explosives, cryogens; high-voltage electrical systems; ionizing and non-ionizing radiation; toxic materials; lasers; and pulsed-power units (LLNL 2017c).

Numerous engineering and safety controls are in place. Laboratory practices involve minimizing the use and storage of chemicals as well as labeling and segregating materials kept on site. The hood and ventilation system consists of eight exhaust hoods. In the event of ventilation system failure, all work is stopped. Operations that require the use of high-voltage systems or those that produce ionizing radiation are equipped with interlock systems to safeguard personnel from electric shock or radiation hazards. Explosives inventories are maintained within LSI category limits (LLNL 2017c).

Generated Wastes and Effluents

Hazardous waste and nonhazardous waste is produced in Building 141, including alkaline and acid solutions; lab-packed and bulk-waste chemicals; lab-packed spent halogenated and nonhalogenated solvent solutions, both organic and inorganic; empty containers; laboratory debris, including contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; electronic manufacturing wastes; etching wastes; waste oil with trace amounts of gasoline, diesel, organics, and metals; discarded capacitors (potentially *Toxic Substance Control Act* [TSCA] wastes); and contaminated equipment, such as vacuum pumps and ignition tubes. No radioactive, mixed, or transuranic (TRU) waste is generated in the facility (LLNL 2017c).

A.1.2.5 *Building 151 Complex*

The Building 151 Complex, which consists of the Analytical and Nuclear Chemistry Facility (Building 151) and Storage (Building 152), the Analytical and Radiochemistry Laboratory (Building 154), and an office building (Building 155), are located in the southwest quadrant of the Livermore Site. The Building 151 Complex is within 600 yards of the fence bordering Vasco Road (LLNL 2019c). The laboratories in Building 151 have undergone a major multi-year (2017 through 2021) modernization effort that included the installation of new fume hoods, gloveboxes, casework, flooring, drainage, ductwork, sinks, cabinets, benches, and other general laboratory equipment to provide a safer and more efficient environment (LLNL 2016a). Key operations in Building 151 include a nuclear resonance facility that generates magnetic fields, a Type III radiological laboratory, and a glovebox laboratory that serves as a Type III workplace for handling dispersible radioactive materials (LLNL 2019d).

The complex has a total area of approximately 127,661 square feet (LLNL 2019a). Buildings 151 and 154 provide office, laboratory, and electronics shop facilities for laboratory operations in a broad range of chemical, radiochemical, and bio-chemistry and analytical research. Primary activities include research in radiochemical and chemical analysis, transport of radionuclides in geo-materials, preparation of radionuclides and analysis of environmental and waste samples, biological research and analysis, nanoscale synthesis and characterization, and clean room activities. Operations involving explosives with inventories that are a small fraction of the LSI limits are also conducted in Building 151. RGDs in Building 151 include scanning electron microscopes and x-ray equipment for material characterization purposes. Building 152 is used as a small staging and storage facility, which includes storage of corrosives and flammable liquids, storage of dry chemicals and noncorrosive, nonflammable liquids, and storage of radioactive materials. Building 154 contains biological and radiological laboratories and facilities for wet chemistry research, supported by offices and a mechanical equipment room. BSL-2 biological operations are not currently taking place within the B151 Complex, however, they may occur in the future with minor room modifications and approval of the Institutional Biosafety Committee. (LLNL 2019d).

<u>Hazards Assessment</u>

The primary hazards associated with the Building 151 Complex are biological, radiological (including RGDs and radionuclide hazards), and toxicological. Controls for these hazards are specified in work control documents and facility safety plans (LLNL 2019c, LLNL 2019d). Biological materials used in the Building 151 Complex include RG-2 infectious agents; tissues, including blood; or other items such as sewage and animals, which may contain biologically hazardous agents and the toxins produced by living organisms. Recombinant DNA work is also conducted in the facility (LLNL 2019c). All chemicals in Buildings 152 and 154 are maintained at inventories at or below inventories consistent with Light Science and Industry (LSI) definitions (LLNL 2021c).

The Building 151 Complex handles radiological materials in three primary categories: (1) sealed sources, (2) analytical samples, and (3) trace quantities in waste. The radiological inventory in each building in the Building 151 Complex is controlled to a facility limit less than the Hazard Category (HC)-3 limit.[1] Based on anticipated inventories, the radiological hazard categorization for each building in the complex is classified as "low" (LLNL 2019c). Low is defined as less than HC-3 limits. Based on the analyses of all potential hazards considered in *the Building 151 Complex Tier 3 Safety Basis Document* (LLNL 2019c), the Building 151 Complex does not represent a significant risk to adjacent facilities or the public.

[1] Under 10 CFR Part 830, DOE assigns hazard categories to nuclear and radiological facilities in accordance with the potential consequences of a radiological accident. The HC is based on the quantities of hazardous radiological materials, per DOE-STD-1027. An HC-3 nuclear facility would only have the potential for localized consequences.

Generated Wastes and Effluents

The hazardous wastes generated include corrosives, flammable organics, biological wastes, toxic metals, and radioactive and mixed wastes. Waste materials are collected at SAAs and then moved to a designated WAA. In the future, Building 151 could undergo minor modifications and be approved to conduct BSL-2 work. Wastes that contain RG-1 biological materials are managed as biohazardous wastes as a best management practice. All waste containing RG-2 biological materials must be autoclaved prior to disposal (LLNL 2019d).

A retention tank system is located on the north side of Building 151. This retention system is designed and managed to routinely accept nonhazardous and nonradioactive wastewater from the laboratory sinks in Buildings 151 and 154. Currently, this retention system consists of four 11,000-liter aboveground tanks with a secondary containment barrier surrounding the tanks. There are also two 15,000-liter underground storage tanks in standby mode. Wastewater is pH sampled, adjusted, and then released to the plant outfall or sent to an RHWM facility for further treatment (LLNL 2019c).

Wastewater potentially contaminated with radionuclides, metals, and acid discharged to sinks or floor drains in chemistry laboratories or shops is sent to the retention tank system. When full, the retention tanks are sampled. If the wastewater meets the sewer discharge criteria, it is released to the sanitary sewer. If it is unacceptable for release, it is sent to an RHWM facility for treatment, storage, and/or disposal (LLNL 2019c). Most laboratories are equipped with exhaust hoods that vent to the atmosphere, and some employ gloveboxes with HEPA filters for radiological work. The types of waste produced by the biological analysis and recombinant DNA research include nonhazardous biological waste, biohazardous and contaminated sharps (medical) waste, and chemical waste. Biohazardous waste includes waste generated from research with RG-1 agents not associated with disease in healthy human adults and RG-2 agents associated with human diseases that are rarely serious and for which preventative or therapeutic interventions are often available. All biological wastes are treated before disposal (LLNL 2019d).

Hazardous and nonhazardous wastes produced in the Building 151 Complex include alkaline and acid solutions such as lab-packed solutions; lab-packed and bulk-waste chemicals; lab-packed spent halogenated and nonhalogenated solutions, both organic and inorganic; empty containers; laboratory debris, including contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous and or radioactive constituents; cleaning solutions, including solvents; rinse-water; sludge/water; waste oil with trace gasoline, diesel, organics, and metals; asbestos; and contaminated equipment such as vacuum pumps and other equipment (LLNL 2019d).

A.1.2.6 *Building 153*

Building 153, the Micro- and Nano-Fabrication Laboratory, is located in the southwest quadrant of the Livermore Site. This 25,976-square-foot laboratory consists of laboratory working areas, dry laboratories, a clean room dressing area, and packaging and machine room areas (LLNL 2019a). The Micro- and Nano-Fabrication Laboratory is used for micro- and nano-fabricated optical, electrical, mechanical, and chemical devices. Additional capabilities include material characterization and device testing, microscopic inspection, packaging, and electrical and optical device testing. Building 153 also houses the Micro-Technology Center's multidisciplinary team, which applies advanced engineering, physics, chemistry, and biology to the development of micro- and nano-fabricated optical, electronics, mechanical, and chemical devices to support LLNL's missions in national security, global ecology, biosciences, and national industrial competitiveness (LLNL 2016b).

Hazards Assessment

Building 153 is classified as an LSI hazard facility. The principal hazards are associated with use of various lab-scale quantities of chemicals during the fabrication of silicon and gallium arsenide integrated circuits. Some of these chemicals include acids, bases, solvents, resins, phosphates, fluorides, iodides, and some toxic, pyrophoric, and reactive gases. Testing of microfluidic devices requires the use of small quantities of RG-1 or RG-2 biological agents. Wastes from this process are autoclaved (i.e., sterilized) prior to disposal. Additional hazards within the facility include common industrial hazards, carcinogens, lasers, radio frequency, and x-rays (LLNL 2016b).

Operations in Building 153 are controlled by work planning documentation and facility safety plans. Operations involving biological materials are controlled up to BSL-2. Hazardous materials operation may require the use of personal protective equipment. Quantities of hazardous materials in the work area are limited to the minimum needed for each activity (LLNL 2016b). The use of a hood is required if the operation could potentially release material into the workplace. Personnel safety is ensured by toxic materials storage and handling systems. Toxic gases are handled only in gas cabinets, and adequate ventilation and safety valves are provided for added protection (LLNL 2016b).

Safety controls are in place to minimize the potential of personnel exposure to x-rays and lasers. These include enclosing x-ray tubes in steel cabinets, placing safety covers and guards on laser devices, and having interlocks and shielding devices (LLNL 2016b).

Generated Wastes and Effluents

The operations in Building 153 generate hazardous, nonhazardous, and RG-1 and RG-2 biological wastes. Hazardous wastes and nonhazardous wastes are produced in the facility and include alkaline and acid solutions; lab-packed and bulk-waste chemicals; lab-packed spent halogenated and nonhalogenated solvent solutions, both organic and inorganic; laser dyes; petroleum- and mineral-based oils; empty containers; laboratory debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; machine shop wastes; and flammable liquids (LLNL 2016b).

Wastes that contain biological materials are managed as biohazardous wastes as a best management practice, which requires appropriate autoclaving before disposal. Building 153 has an 8,000-gallon capacity wastewater retention tank system, comprised of four 2,000-gallon retention tanks, that receives wastewater from the semiconductor operations. When full, the retention tanks are sampled. If the wastewater meets the sewer discharge criteria, it is released to the sanitary sewer. If it does not meet sewer discharge criteria, it is transferred to an RHWM facility for treatment, storage, and/or disposal (LLNL 2016b).

Some operations in Building 153 release small quantities of gases and organic vapors to the atmosphere. The gases from fume hoods feed into a 15-meter exhaust stack. Because the quantities of gases used are small, the release of gases under the worst-case condition will not exceed their respective Emergency Response Planning Guideline values (LLNL 2016b).

A.1.2.7 *Buildings 162 and 165*

Buildings 162 and 165 are located in the northwest quadrant of the Livermore Site. These buildings provide laboratory and office space for various activities related to lasers, optics/development, and crystal growth. The buildings and their operations are summarized below.

- Building 162 (19,042 square feet): Operations include the Non-Linear Optics Lab, Crystal Growth Facility, laser materials development, advanced solid state lasers, non-linear optical materials development, x-ray (LAUE) diffraction of crystals, and Inertial Fusion Energy Substrate Irradiation.

- Building 165 Complex (10,053 square feet): Operations support the NIF and Photon Science Directorate. The laboratory includes a high-bay, which is a production-capable facility for potassium dihydrogen phosphate crystals to be used in the NIF laser system. Cleanrooms are located on the east end of the building for laser and optics research laboratories. Laser and optics research is conducted in the cleanrooms (LLNL 2019s). Residual uranium is present in a localized apparatus from a previous experimental program. Building 165 is also used for research using a hypersonics wind tunnel. The Building 165 Annex (B 165A), is used to store and consolidate chemical wastes for the Radioactive and Hazardous Waste Management (RHWM) group.

Hazards Assessment

Hazards within these facilities are associated with high-voltages, x-ray radiation, laser beams, chemical reactions, and toxicity of materials including residual uranium compounds, pyrophoric metals, toxic gases, caustic chemicals, acid burns, and fire. Facility safety features are provided to reduce the hazards, providing multilevel protection against accident or injury to operational personnel (LLNL 2017d, 2017e). The hypersonics wind tunnel employs pressurized air storage up to 5,000 psi. Building 162 and the Building 165 Complex are classified as LSI facilities (LLNL 2019s).

Generated Wastes and Effluents

There are many different types of hazardous waste and LLW generated from this complex of buildings. The wastes include combinations of aluminum, arsenic, phosphorous, antimony, arsine, chlorides, and chlorine. Zinc and silicon may also be present in small amounts.

Wastes are generated from processes using aqueous solutions, acids, bases, halogen salts, gas scrubbers, and organic materials such as solvents and oils. Wastes from these processes are collected in designated containers in the SAAs (LLNL 2017d).

A.1.2.8 *Building 166*

Building 166 is a 13,229 square-foot facility with two storage trailers. Operations include the Pyrochemical Demonstration System, Atomic Vapor Laser Isotope Separation (AVLIS) laser demonstrator, and other nonnuclear equipment fabrications and demonstrations for the Superblock. The building is used for fabrication and testing using non-radioactive materials and various types of process equipment for radioactive material processing. These include items such as glove boxes, cryogenic operations, furnaces, and robotics. The facility contains a welding area in support of the fabrication effort (LLNL 2019a).

Hazards Assessment

Testing of equipment is performed in this building using LSI quantities of non-radioactive cerium and cryogenic operations (liquid nitrogen). Additional LSI quantities of miscellaneous chemicals (e.g. solvents, erbium oxide coating) may also be present. The machine shop and welding equipment present several standard industrial hazards (e.g., electrical, thermal, kinetic, pressure, height potential, and flooding sources). Programmatic inventory of hazardous chemicals is managed to maintain and comply with a facility safety basis envelope of LSI (LLNL 2019a).A portable X-Ray Fluorescence (XRF) unit may be utilized for in-situ analysis for a variety of environmental applications. This XRF unit uses a 30 microcuries (mCi) Am-241source to produce X-rays, and is not stored in the facility. This source is in a DOT Special Form housing, has a Certificate of Conformance maintained by the owner program, and is managed and maintained within the LLNL source control program. As such, it may be excluded from the Facility Radiological Inventory (LLNL 2019a).

Generated Wastes and Effluents

Hazardous and nonhazardous waste are generated in Building 166. These wastes are generated in small quantities and are typical of waste generated in experimental laboratories.

A.1.2.9 *Building 170*

Building 170, the National Atmospheric Release Advisory Center (NARAC), is located in the western portion of the Livermore Site, directly east of the Westgate Badge Office. The NARAC is 43,760 gross square feet and has occupied its current facility at Building 170 since 1996. Since its foundation as an operational center in 1979, NARAC has responded to hundreds of alerts, accidents, and disasters; supported thousands of exercises; and conducted numerous studies. As part of its emergency response mission, NARAC collaborates with and supports a wide range of organizations, including more than several hundred federal, state, and local agencies; emergency response teams; operations centers; and international organizations. In a typical year, the center fulfills 10,000 airborne-plume simulation requests for emergency preparedness, participates in 100 major emergency response exercises, and responds to 25 incidents. NARAC also maintains multiple websites for requesting and distributing plume predictions and sharing information during events (LLNL 2015).

Hazard Assessment

Building 170 is an office building with no hazardous materials or operations.

Generated Wastes and Effluent

Typical office building wastes are generated.

A.1.2.10 *Building 174 Complex*

Building 174, the Jupiter Laser Facility, is located in the northwest quadrant of the Livermore Site and contains 19,437 gross square feet. The Building 174 Complex includes Building 174 and its associated buildings, OS174 capacitor storage, 176, T1727, and the "MODS" storage units. The associated buildings primarily support the laser research conducted in Building 174. Building 174 houses numerous high-power lasers (LLNL 2019e).

Hazards Assessment

The hazards associated with Building 174 operations are principally from the use of hazardous and radioactive materials, including laser dyes; solvents; flammable liquids; and natural, depleted, or enriched uranium; cryogenic material; and beryllium. Personnel may be exposed to x-rays, high-power laser beams, high-voltages, heat and skin burns, eye injuries, and overpressure of vacuum chambers. Laser hazards are mitigated by door interlocks, laser enclosures, and appropriate eyewear. All chemicals and radioisotope inventories are below regulatory threshold levels, and the facility operates at the LSI level. The following controls are in place to ensure that facility operations do not exceed LSI classification:

- Programmatic inventory of hazardous chemicals is managed to comply with a facility safety-basis envelope (SBE) of LSI utilizing material thresholds. The LLNL ChemTrack system is used to monitor the inventory primary containers of hazardous chemicals, and to assign maximum facility inventory limits.

- Radiation generating device (RGD) operations are conducted in accordance with the Radiological Control Manual (MAN-2050, LLNL 2020n) to ensure that all RGDs operate below the level of an accelerator to ensure that all RGDs operate at a level that is exempted from DOE O 420.2C (LLNL 2019e).

Generated Wastes and Effluent

Building 174 generates wastes, including various hazardous and radioactive chemicals. Typical hazardous waste streams include spent solvents, waste oils, reactive metals, adhesives and epoxies, and regulated metals. Small amounts of radioactive and mixed waste may be generated from the use of radioactive targets. These wastes are generated in small quantities and are typical of waste generated in experimental laboratories. Waste generated at these facilities is temporarily stored at a WAA until transported to RHWM facilities for treatment, storage, and/or disposal (LLNL 2019e).

A.1.2.11 *Building 190*

Building 190, the Center for Accelerator Mass Spectroscopy (CAMS) facility, is located in the northwest corner of the Livermore Site. This 10,252-square-foot building houses a multi-user accelerator facility, the Multi-User Tandem Laboratory containing three accelerators ranging in size from 1.0 megavolts to 11 megavolts (LLNL 2018c, LLNL 2017cc). Facility operations include accelerator mass spectrometry and various ion beam analysis techniques for cosmogenic and radiogenic isotopes and a nuclear microprobe for materials characterization (LLNL 2018c).

Hazards Assessment

Hazards within the CAMS facility are typical of accelerator facilities and include ionizing radiation from ion sources, prompt radiation, and residual radiation induced in targets and shielding. Other hazards include high-voltage, magnetic fields, and asphyxiants. Administrative controls and mechanical and electronic safety devices are used to help mitigate these potential hazards. Administrative controls include monitoring for x-rays, radioactivity, and oxygen deficiency and requiring work control documentation and compliance with the facility safety plan for any new experimental project in the facility (LLNL 2018c).

Engineering controls associated with operations in the CAMS facility include safety interlocks to limit personnel access to certain areas during operation, radiation shielding, protective equipment or clothing, automatic systems to monitor and limit the production of radiation, and various methods of warning personnel of the operation of experiments with potential hazards. Access is controlled by the facilities coordinator and the hazards control technicians assigned to those facilities with a potential for contamination. The facility is classified as LSI for biological, chemical, industrial hazards, and low hazard for radiological and accelerator/RGD hazards (LLNL 2018c).

Generated Wastes and Effluents

Building 190 generates small quantities of biological, hazardous, radioactive, and mixed waste. Waste produced in the facility includes biological waste regulated at the BSL-1 level, lab-packed spent organic solvents; empty containers; laboratory debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, and wood and metal parts; and contaminated equipment. These wastes are collected in designated containers in the SAAs (LLNL 2018c).

A.1.2.12 *Building 191*

Building 191, the High Explosives Application Facility (HEAF), is located in the northwest quadrant of the Livermore Site. The building is 121,031 gross square feet and includes 13,000 square feet of office space. R&D activities at HEAF include studying intentional detonations, synthesizing and formulating materials, testing material properties and characterization, studying the physics of initiation, developing diagnostic methods and equipment, and conducting detonator surveillance (LLNL 2019a). The facility was built to perform explosives research and development ranging from laboratory synthesis and formulation of experimental explosives to detonation of materials of up to 10 kilograms net explosives weight of high explosives. This facility was constructed to provide LLNL with a centralized high-explosives research facility with modern diagnostic and testing equipment. Building 191 is currently LLNL's center for the study of chemical high explosives and their application to conventional explosive and nuclear device systems (LLNL 2020a).

Hazards Assessment

Hazardous materials in Building 191 are used in high-explosive synthesis and formulation, high-explosive properties characterization, assembly of explosives experiments, hand processing of explosives, combustion and detonation calorimetry, shock-loading experiments, detonation experiments, and various support shop operations. Operationally, intentional detonation experiments are limited 10 kilograms of high explosives. The facility is a moderate hazard facility for explosives and LSI for biological, chemical, and radiological materials. Hazard sources associated with HEAF operations include intentional detonation of high-explosives, high-voltage power; toxic, reactive, flammable, and corrosive materials; and ionizing and non-ionizing radiation. (LLNL 2017f, LLNL 2018d).

Hazardous chemicals include explosives, organic solvents, inorganic and organic acids and bases, inorganic salts, oxidizers, liquid fuels, thermites, reactive metals, compressed gases, and industrial products (e.g., adhesives, fillers, and cleaning materials). Hazardous chemicals may be irritating, toxic, corrosive, reactive, flammable, carcinogenic, and/or mutagenic. Health hazards include chemical burns to the skin, eye injuries, and exposures from inhalation. Other hazards include ingestion, or absorption of chemicals through the skin, and reproductive hazards. The physical hazards include flammability, reactivity, and corrosivity. Hazardous chemicals are used in most of the laboratories and shops, with the largest number and variety of chemicals in the explosives synthesis laboratories, Rooms 1311, 1313, and 1315, and the chemical storeroom, Room 1308 (LLNL 2018d).

The main radiological hazards are associated with Radiation Generating Devices (x-ray machines) and x-ray-computed tomography used to radiograph components and assemblies. These machines are heavily shielded with concrete or other shielding to minimize radiation exposure. The radionuclide inventories authorized at the HEAF consist of small sealed sources (check sources). The check sources are used for calibrating portable radiation survey instruments. The radiological material sum of ratios is less than 1/20th of the Hazard Category 3 limits; therefore, the radiological hazard classification of the HEAF is LSI (LLNL 2017f, LLNL 2019a).

Generated Wastes and Effluents

Activities at HEAF generate waste streams that may meet the criteria for nonhazardous, hazardous, radioactive, or mixed waste. The WAAs temporarily store wastes that exceed Office of Security and Safety Performance Assurance (SSA) requirements. Waste is stored in containers ranging from pint to 85-gallon drums. The wastes are managed by RHWM in the WAA until transferred to the appropriate RHWM facility or other permitted treatment, storage or disposal facility (LLNL 2017f).

A.1.2.13 *Building 194*

Building 194, the Accelerator Tunnel Complex Facility, is a 41,544-gross-square-foot facility located in the northwest quadrant of the Livermore Site (LLNL 2019a). Building 194 contains a complex of aboveground and underground facilities. The 100-million-electron-volt (MeV) electron-positron linear accelerator (LINAC), Mega-ray Test Station (MTS), Photonuclear Reactions for Isotopic Signature Measurements (PRISM), and Neutron Imaging (NI) accelerator systems are located underground for enhanced radiation shielding. PRISM accelerator operations include work with up to 10 grams of secondary high explosives. The aboveground buildings include a modulator building, an office, laboratory, machine shop, and storage facilities. An aboveground neutron silo and an associated time-of-flight experimental area are currently unused (LLNL 2018e).

Ongoing research programs in Building 194 include experiments in fundamental nuclear, atomic, solid-state, plasma, and particle physics; fundamental experiments in laser-electron interactions; applied research in materials science; and development of diagnostic and analytical techniques for industrial applications. Building 194 also houses various laser development and experimental activities and the electron beam ion trap experiment. Major equipment in the facility includes four particle accelerators and several high-power, short-pulse lasers (LLNL 2018e, LLNL 2019bb).

Hazards Assessment

The hazards associated with Building 194 include ionizing and non-ionizing radiation; air activation and generation of toxic gases; lasers; hazardous materials such as cryogenic gases, solvents, high explosives, and lead; vacuum; high-pressure gas; high voltage; and machine shop-associated hazards. Three types of radioactive materials are used in Building 194: sealed sources; plutonium samples, housed in a manner similar to a sealed source to prevent plutonium particles from being released; and items activated from accelerator operations. These building components and activated equipment are identified by surveying, are not considered contaminated areas, and are controlled accordingly (LLNL 2018e, LLNL 2019f).

Administrative controls and mechanical and electronic safety devices are used to help mitigate these potential hazards. Administrative controls include training personnel; maintaining lists of qualified operators; tracking all shipments of hazardous or radioactive materials to ensure that limits are not exceeded; conducting periodic or continuous monitoring for x-rays, radioactivity, or toxicity; and requiring work planning documentation and compliance with the site safety plan for any new experimental project. Hazardous materials used and stored in Building 194, including cryogens, are used and stored in accordance with institutional and programmatic controls for minimizing or reducing the potential for exposure, injury, or illness. Controls for the hazards are specified in facility safety plans (LLNL 2018e, LLNL 2019f).

Engineering controls associated with operations in Building 194 include safety interlocks to limit personnel access to certain areas during operation, radiation shielding, personal protective equipment or clothing, protective storage cabinets or filtered hoods, automatic systems to monitor and limit the release of toxic gases or the production of radiation, and various methods of warning personnel of the operation of experiments with potential hazards. Shielded areas previously used for accelerator and/or nuclear physics research are locked up. Access is controlled by the facilities coordinator and the hazards control technicians assigned to those facilities with a potential for contamination (LLNL 2018e, LLNL 2019f).

Generated Wastes and Effluents

Wastes generated in this facility include hazardous, radioactive, and small amounts of mixed waste. Hazardous waste streams may include solvents, oils, corrosive liquids, regulated metals, and other industrial waste such as epoxies and adhesives. Radioactive waste is generated from research activities using radioactive isotopes and the accelerator. Waste materials, both liquid and solid, are collected in containers at the SAAs (LLNL 2018e). It is also possible that equipment and parts may be radioactive due to their proximity to the accelerator.

Building 194 operations generate small amounts of gaseous effluents. These gaseous effluents include radioactive isotopes of oxygen and nitrogen with half-lives of 2 and 10 minutes, respectively, and dust particles. The air emissions are filtered through HEPA filters and discharged to the atmosphere from a 30-meter monitored stack (LLNL 2018e).

A.1.2.14 *Building 231*

Building 231, the Engineering Development and Assembly Facility, is located in the southwest quadrant of the Livermore Site and contains approximately 140,804 gross square feet. The facility consists of a single story, high bay, laboratories, a machine shop, and administrative offices in the mezzanine area. Primary operations conducted in Building 231 are shipping, receiving, and storage of controlled materials. These operations involve handling, lifting, loading, inspecting, weighing, measuring, surveying, swiping, packing, and re-packing. Related tasks include certifying nuclear explosive-like assembly (NELA)/non-fissile material (measuring/surveying) and handling radioactive/hazardous/mixed waste in satellite accumulation areas (LLNL 2021a). Operations within B231 are being transferred to other existing and replacement facilities at the Livermore Site.

A diverse range of R&D activities is conducted in the building as follows: (LLNL 2017bb)

- Mechanical testing of materials, components, and assemblies using common engineering materials, as well as beryllium alloys and oxides, lead, carbon nanotube materials and uranium alloys and other similar materials;
- Video/radio installation, testing and general maintenance throughout Livermore Site and Site 300;
- Radiological materials crosscut operations, including characterization and testing of natural and depleted uranium oxides, carbides, nitrides, and other uranium alloy metals and powders;
- Materials characterization of metals, ceramics, polymers, and composites, including material analysis and characterization using photography, optical microscopy, scanning electron microscopy, metallography, etc.
- Electronics shop, providing fabrication, repair, assembly and installation of components and assemblies;
- Polymers laboratory, including processes for bonding and casting operations of polymeric materials (liquid, solid, elastomeric, or foam);

- Polymer/powder characterization and testing laboratory performing applications on a variety of polymeric materials and additives;
- Vacuum processing laboratory, including deposition of a variety of thin-film materials onto substrates and parts, such as radioactive and non-radioactive materials, pyrophoric materials, explosives, and encapsulated beryllium parts; and
- Welding/brazing (joining) laboratory, involving welding and thermal processing of a variety of materials.

Hazards Assessment

The hazard classification for Building 231 is LSI for chemical, explosive, and industrial hazards; LSI for RGDs; and low hazard for radiological materials. Operations, which may involve hazardous materials, including beryllium and materials of special concern such as mercury, are allowed up to their respective hazard classifications through existing LLNL policies, procedures, and guidelines. A work control document is necessary to authorize work for these activities. The operations within Building 231 involve fabrication, material testing, chemical analysis, and other activities. These operations may use standard industrial equipment or specialized tools utilized in accordance with the ES&H Manual and specific requirements identified in the work control documents (LLNL 2018f).

Building 231 handles radioactive material in three primary forms: (1) sealed sources, (2) mainly solid form uranium and uranium alloys, and (3) low-level radioactive waste. Building 231 is a radiological facility and its inventory is controlled to less than the Hazard Category 3 limits of DOE-STD-1027 approved for use at LLNL, on a cumulative sum-of-the ratios basis for all isotopes. Hazardous chemical inventory is managed to maintain and comply with the LSI level. Storage and use of explosives inventories are controlled to ensure that the inventories would remain in the LSI hazard classification (LLNL 2018f).

Generated Wastes and Effluents

Activities performed in Building 231 generate waste streams that can meet the criteria for nonhazardous, hazardous, radioactive, or mixed waste. Waste is temporarily stored at the Building 231 WAA in containers ranging from 1-pint cans to 85-gallon drums. Incompatible waste streams are stored on separate containment pallets that guarantee the separation and prevent the mixing of incompatible wastes. Each waste container is managed by RHWM and conforms to RHWM packaging and inventory requirements. Hazardous and mixed wastes may be stored for 90 days or less, until transferred to the appropriate RHWM facility or other permitted treatment, storage or disposal facility (TSDF). The WAA is also used to store radioactive waste prior to being transferred to a TSDF. Through process knowledge, as well as monitoring chemical, explosive, and radiological materials received, facility management maintains the chemical and radiological inventories of Building 231 within the designated hazard classifications (i.e., LSI for chemicals LSI for explosives, and Low for radiological materials). Controls derived for the main operational areas in Building 231 are also applicable to the Building 231 WAA (i.e., inventory controls for Building 231 are inclusive of the inventory in the Building 231 WAA) (LLNL 2018f).

A.1.2.15 *Complex B231 Vault, Other Structure 232 Fenced Area and B233 Garage Vault*

Complex B231V, OS232FA and B233GV is the Vaults and Transportation Group's operational area. Building 231V Vault is a 5,000 square-foot concrete reinforced structure attached to the B231 Complex. Building 231 and Building 231V are considered separate segments for safety basis purposes due to several firewalls and open spaces. OS232FA, Fenced Area, is a 1,200 square-foot roof covered fenced area, and B233GV, Garage Vault, is an 1,800 square-foot structure containing an operational area with storage racks. These facilities are located in the southwest quadrant of the Livermore Site and are in a secured area greater than 1,000 meters from the southwest boundary and over 700 meters from the western boundary. Primary operations in this Complex are shipping, receiving, and storage of controlled materials. These operations involve handling, lifting, loading, weighing, measuring, surveying, swiping, packaging, and re-packing. Related tasks include certifying nuclear explosive-like assembly non-fissile material (measuring and surveying), and handling of radioactive/hazardous/mixed waste (LLNL 2021a).

<u>Hazards Assessment</u>

The hazards associated with this Complex include chemical, explosive, ionizing radiation (radioactive materials) and RGDs. Each segment of this complex is classified separately. They are each classified LSI for industrial, explosive and RGD hazards, and low hazard for radiological materials and chemical hazards. Controlled materials typically encountered in this complex consists of accountable nuclear materials, sealed sources, and other radioactive materials; mock explosives; and small quantities of explosives and precious metals. These materials may also include beryllium, lithium hydride/deuteride, and materials of special concern (e.g., lead) (LLNL 2021a). As part of the shipping/receiving function of the Complex, RGDs (up to Class IV) may be operated in the future in accordance with the requirements of MAN-2050 (LLNL 2020n, LLNL 2021a).

Legacy materials are stored in Building 233GV. Due to beryllium contamination, Building 233GV is not used for shipping/receiving purposes (LLNL 2021a).

<u>Generated Wastes and Effluents</u>

Because this facility is primarily used for shipping, storage and receiving purposes, it does not routinely generate significant quantities of wastes and effluents. To the extent that wastes and effluents are generated, the quantities would be *de minimus* and handled in accordance with LLNL's typical waste and effluent disposal practices.

A.1.2.16 *Building 235*

Building 235, the Materials Science Division Offices and Labs, is an 88,071-square-foot facility located in the southwest quadrant of the Livermore Site about 800 meters from the nearest site boundary. Building 235 consists of research laboratories and offices and provides facilities for chemical/metallurgical/biological laboratories, experiments and operations in materials development and engineering. The building houses a 4-MeV accelerator. All biological operations are restricted to those that have been authorized to be performed under BSL-2 conditions or less. Typical activities include x-ray spectroscopy, metallurgy, beryllium activities, electron microscopy, ceramics, surface science, electrochemical processes, chemical synthesis, and general wet chemistry, laser and fiber optics activities, and other specialized research projects (LLNL 2018g, LLNL 2018s). A project to provide needed maintenance, refurbishment, and seismic upgrades to Building 235 was begun in April 2018 to bring the facility into code compliance and reinforce the seismic design standards in place at that time (LLNL 2018g, LLNL 2018t).

Hazards Assessment

Building 235 is classified as a low hazard facility based on the inventory of radiological materials and the accelerator operations in Room 1251. Biological, chemical, explosive, industrial hazards, and operations involving RGDs other than the accelerator in Room 1251 are managed at the LSI level. Potential hazards in Building 235 include operations involving biological materials, chemicals, explosives, radiological materials, and RGDs. Biological operations are restricted to those that have been authorized to be performed under BSL-2 conditions or less. All biological work is reviewed via the work control process and the Institutional Bio-safety Committee (IBC) prior to starting work. Chemical inventories are tracked to ensure facility limits are maintained. Maximum facility inventory limit levels are set to LSI quantities. For all chemicals in Building 235, the administrative limit is set to 75 percent of the LSI limit. Explosives inventories are limited to a maximum of 3 grams in most individual rooms, with no more than 200 grams total in Building 235. Building 235 handles radiological materials in three forms: (1) sealed sources; (2) small quantity analytical samples; and (3) small quantities in LLW. The administrative limit for all radiological materials is set at 80 percent of the Category-3 limit of DOE-STD-1027-92. Under the proposed Action this limit would increase to less than DOE-STD-1027-2018 limits for Hazard Category 3 facility. Less-Than-Hazard-Category 3 facilities are classified in accordance with DOE-STD-1027 approved for use at LLNL. The RGD in Room 1251 is classified as an accelerator (LLNL 2018g, LLNL 2018s).

Generated Wastes and Effluents

Activities performed in Building 235 will generate waste streams that meet the criteria for nonhazardous, hazardous, radioactive, or mixed wastes. The hazardous and nonhazardous wastes that are produced in Building 235 include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; nonhalogenated solutions, both organic and inorganic; empty containers; laboratory debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous and radioactive constituents; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; discarded batteries; and contaminated equipment such as vacuum pumps, ignition tubes, and other equipment. Small amounts of both radioactive and mixed waste (e.g., laboratory chemical solutions and scintillation vials), are also generated (LLNL 2018s).

The types of waste produced by biological research include nonhazardous biological waste, biohazardous and contaminated sharps (medical) waste, and chemical waste. Wastes that contain RG-1 or RG-2 biological materials are managed as biohazardous wastes as a best management practice. Controls for these hazards are specified in safety basis documents and work control documents. Biohazardous waste includes waste generated from research with RG-1 and RG-2 agents. Building 235 also has a laboratory wastewater retention system used to collect and retain diluted nonhazardous and nonradioactive rinse-waters from laboratories until analysis determines the wastewater can be discharged to the sanitary sewer. Most laboratories are equipped with exhaust hoods that vent through HEPA filters to the atmosphere (LLNL 2018g, LLNL 2018s).

A1.2.17 *Building 239*

Building 239, Radiography Facility, is 12,905 square feet and contains nondestructive evaluation facilities. Building 239 was built in 1967 and is a reinforced concrete bunker-type structure (the majority of which is located below grade) designed to house two high-energy linear accelerators used for performing nondestructive testing and nondestructive evaluation (NDE) of nuclear components and hardware. Building 239 consists of two high bays for the high-energy linear accelerators (also called Linatrons or RGDs), ramp and loading areas, and a three-story area. The three-story portion of the building contains a computer lab and the mechanical equipment room on the upper level; a mezzanine (mid-level), which contains ventilation ducting; and the lower level, which contains the operations room (sometimes referred to as the control room) and film processing areas. A large portion of the structure is below grade, with the office area and high bays extending above grade. An earth embankment covers the west side of the building and more than half of both the north and south sides. The 3-foot-thick reinforced concrete roof over the high bay area is covered with a minimum of 3-foot-thick earth. Facility operations involving radiography are carried out in the basement of the building. Facility operations consist of material property evaluations and determination of composition, density, uniformity, and cell or particle size and of assembly structural integrity (LLNL 2016c, LLNL 2017dd).

<u>Hazards Assessment</u>

The range of hazards present in Building 239 include compressed gases, high-voltage electricity, reactive materials, explosives, hazardous and carcinogenic chemicals, including cleaning solvents, and ionizing and non-ionizing radiation. Fissile materials, in solid non-dispersible form are limited to Hazard Category 3 quantity limitations. These materials are not dispersed or changed in form in the facility, and they are not stored in the building. Plutonium is not allowed to be in the same area as explosives. Sealed sources are also used in the facility. Transitory TRU waste drums may be brought into the facility for radiography and held for a short time within the facility. The total quantity of material is maintained below Hazard Category 3 levels (LLNL 2016c, LLNL 2017dd, LLNL 2020o).

Chemical inventories typically consist of laboratory chemicals, cleaners, and oils. Lithium hydride and beryllium oxide are handled on a transitory basis but are always in an approved container and never handled uncontained in the building (LLNL 2016c, LLNL 2017dd).

<u>Generated Wastes and Effluents</u>

Only solid radioactive waste is generated in Building 239. Solid radioactive waste may result from handling items potentially contaminated with radioactive material, including smear tabs, gloves, and other nonhazardous materials that may have been exposed to a radioactively contaminated item. A small amount of lead waste is generated primarily from expended lead screens used in film radiography cassettes. Other hazardous waste consists primarily of rags and paper towels used to apply cleaning solvent to various pieces of hardware. No liquid radioactive waste is generated in the building. Liquid hazardous waste is generated during normal operation of the film-processing equipment. Liquid waste is accumulated and removed by RHWM (LLNL 2016c LLNL 2017dd).

A.1.2.18 *Building 253*

Building 253, the Radiation Protection and Worker Safety and Health Functional Areas and AS&I Labs Facility, is located in the central portion of the Livermore Site. This 30,932-square-foot facility is LLNL's primary analytical laboratory for hazards control samples (LLNL 2019a). The west wing of the building houses two laboratories, lab support areas, and offices to support dosimetry operations. In the main structure, the south corridor contains nine laboratories that support the whole-body counter and the analytical laboratory. The north corridor contains office space and meeting rooms. The main facilities within Building 253 are the Analytical Lab, Bioassay Lab, Radiological Measurement Lab, Whole Body Counter and Spectroscopy Labs, and Dosimetry. Building 253 provides office space and meeting rooms and houses wet chemistry and instrumentation labs for analyzing industrial hygiene and environmental samples, bioassay samples, and personal dosimetry. The Whole-Body Counter and Spectroscopy Labs provide low background counting labs for the in vivo analysis of radioactivity in the whole body and specific organs, and gamma and alpha spectroscopy services for the analysis of in vitro and special samples (LLNL 2018h).

Hazards Assessment

Hazards associated with Building 253 operations include toxic and corrosive chemicals, solvents, resins, and radiation associated with the small quantities of radionuclides contained in samples. Operations are performed under work control documents/a facility safety plan and a requirement for work planning documentation. Quantities of hazardous materials in the work area are limited to the minimum needed for each operation. The use of a hood is required if the operation could potentially release material into the workplace. Liquid nitrogen is used in the Spectroscopy Labs for detector cooling, in Dosimetry for reader operations, in ALAB for TOC analysis, purging ultrapure water and soil samples, and to pressurize samples prior to analysis. The hazard classification for Building 253 is LSI for biological, chemical, radiological materials and industrial hazards (LLNL 2018h).

Generated Wastes and Effluents

The waste stream generated at Building 253 contains both hazardous and nonhazardous wastes that include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; nonhalogenated solutions, both organic and inorganic; empty containers; laboratory debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous and radioactive constituents; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; discarded batteries; and contaminated equipment such as vacuum pumps, ignition tubes, and other equipment. Wastes that contain RG-1 or RG-2 biological materials are managed as biohazardous wastes as a best management practice. Small amounts of radioactive and mixed waste (e.g., laboratory chemical solutions, resins, and solvent wipe cleaning materials) are also generated. This material is collected in SAAs and then moved to the Radioactive and Hazardous

Waste Management (RHWM) facility. From there, the waste is transferred to the appropriate treatment/disposal facility by RHWM (LLNL 2018h).

A.1.2.19 *Building 254*

Building 254, the HC Bioassay Laboratory, is located in the central portion of the Livermore Site 800 meters from the nearest public fence line. This 2,488-square-foot facility is a wet chemistry laboratory that prepares urine and fecal samples for bioassay (LLNL 2019a, LLNL 2019g). Sample preparation operations include sample aliquoting, precipitation, ion exchange separation, and electrodeposition. The prepared samples are transferred to Building 253 for bioassay analyses (LLNL 2019g).

Hazards Assessment

Building 254 is Classified LSI for Biological, Chemical, Radiological Materials and Industrial hazards. Biological operations are restricted to those that have been authorized to be performed at BSL-2 levels or less. Hazards associated with Building 254 operations include the use of acids such as hydrochloric, nitric, and sulfuric; ammonium hydroxide; solvents; and ion exchange resins and potential exposure to the small quantities of radionuclides contained in bioassay samples. Operations are controlled by work planning documentation, when appropriate, and the facility safety plan. Quantities of hazardous materials in the work area are limited to the minimum needed for each operation. The use of a hood is required if the operation could potentially release material into the workplace (LLNL 2019g).

Generated Wastes and Effluents

The waste stream generated at Building 254 contains both hazardous and nonhazardous wastes that include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; resins; empty containers; laboratory debris such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous and radioactive constituents: waste oil with trace gasoline, diesel, organics, and metals; cleaning solutions including solvents; and contaminated equipment such as vacuum pumps, ignition tubes, and other equipment. Small amounts of radioactive and mixed waste (e.g., laboratory chemical solutions, resins, and solvent wipe cleaning materials) are also generated. Multiple waste streams are segregated and collected in various SAAs and then moved to a WAA at Building 253, where the wastes are segregated from other non-compatible waste streams (LLNL 2019g).

A.1.2.20 *Building 255*

Building 255, The ES&H Technical Services Division Labs and Offices Facility, is located in the central portion of the Livermore Site. This 21,855 square-foot facility is used for conducting experiments and operations with radioactive sources for the calibration and maintenance of radiological survey instruments, dosimeters, and experiments requiring material exposure to known source rates. It also houses office and lab space for the Industrial Hygiene Discipline, which tests HEPA filters, the Respirator Shop and Industrial Hygiene Instrumentation Section. Radiation dosimetry calibrations are conducted in the eastern portion of Building 255 using both sealed and unsealed sources and radiation-generating equipment. This part of the facility is equipped with shielded irradiation cells housing radiation sources, support laboratories, and offices. Radiation sources used for calibration generate beta, gamma, x-rays, neutrons, and tritium. Several sealed sources are stored in this portion of the building (LLNL 2019h).

The western portion of Building 255 houses offices, laboratories, and respirator services. Analytical chemistry, aerosol science, air cleaning performance, personal protective equipment performance, instrument development, and the industrial hygiene instrument laboratory activities are performed in this portion of the building. Respirator testing and cleaning are also performed in this area (LLNL 2019h).

Hazards Assessment

The hazards present at this facility include those associated with handling fissile material and intense x-ray and gamma-ray sources. The eastern portion of the Building 255 x-ray operations could produce an exposure rate of approximately 65,000 rem per hour, approximately 3 feet from the x-ray head. Sealed sources of radiation in this portion of the building could produce high radiation exposure from cobalt-60, californium-252, and cesium-137. The maximum rates of exposure from these sources are 8 rem per hour at approximately 3 feet from a gamma source such as cesium-137 or cobalt-60 and 5 rem per hour at approximately 3 feet from a neutron source such as californium-252 (LLNL 2019h).

Storage and use of the radioactive standards, including tritium, do not exceed 120 mCi each in the western portion of Building 255. The small amounts in use do not represent an external hazard from the x-ray and gamma radiation emitted from these materials. Similarly, the alpha and beta radiation from a majority of the isotopes do not represent a problem with internal deposition at these low levels. The estimated unshielded exposure rate from gamma radiation is not expected to exceed 1 millirem per hour at 0.4 inch while personnel are handling these materials (LLNL 2019h).

Maintenance and calibration gases, including carbon dioxide, carbon monoxide, hydrogen, methane, various refrigerants, and hydrogen sulfide, are used in the calibration of instruments in the eastern portion of Building 255. Carbon monoxide and hydrogen sulfide are toxic, and overexposure to these gases may result in serious health effects. Therefore, mixtures are held to five times or lower than the Occupational Safety and Health Administration permissible limit or threshold limit value of the toxic gas. A mercury vapor source is also present for calibrating mercury meters. Exposure to mercury may result in serious health effects. The laboratory ventilation system helps reduce risk to exposure of these materials (LLNL 2019h).

The rooms and storage cells in the eastern portion of the building that contain radioactive sources are equipped with safety interlocks and warning lights to prevent entry during operations. A remote area monitoring system provides a readout at the control console and initiates both an audible and a visual alarm if radiation is present in the cell and the cell door is open (LLNL 2019h).

There are no special access controls associated with the western portion of the building. Only authorized personnel are permitted access to these laboratories, which remain locked when not in use. The facility hazard classification is LSI for biological, chemical, explosive, RGD, industrial, and low for radiological materials hazards (LLNL 2019h).

Generated Wastes and Effluents

The waste stream generated at Building 255 contains both hazardous and nonhazardous wastes that include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; nonhalogenated solutions, both organic and inorganic; empty containers; laboratory debris such as contaminated paper; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; discarded batteries. This material is collected in SAAs and then moved to RHWM's OS169 WAA and segregated. From there, the waste is transferred to the appropriate treatment/disposal facility by RHWM (LLNL 2019h).

A.1.2.21 *Building 262*

The Building 262 Dome and attached Building 262 Building (the Radiation Detector Development Facility) is located in the northwest quadrant of the Livermore Site. This 10,815-gross-square-foot facility is fully utilized on both west and east sides as an applied-physics research and development laboratory. The Dome facility is used for the development and testing of radiation detectors. Current operations involve conducting neutron and gamma-ray detector development for passive and active interrogation applications. Additional experiments are performed in the fenced area outside the building and may involve RGDs and sealed sources. This facility can use and store allocated amounts of encapsulated special nuclear material (SNM). The facility is used to conduct training activities for emergency response organizations and testing and validation of commercial instruments.

The Building 262 Dome is divided into two equal compartments. The west dome was designed to be a containment structure with a 5-foot-thick high-density reinforced concrete wall which forms the half-moon shaped room. The east dome has a concrete footer that rises about 18 inches above ground level and is roughly 2-feet thick. Above this is a steel wall, which is about 5/8 inch thick. These two rooms are separated by a high-density concrete wall that is about 5-feet thick (LLNL 2019y).

Hazards Assessment

The hazards associated with Building 262 include operation and handling of RGDs, sealed sources, beryllium or materials of special concern (e.g., lead), and small quantities of hazardous materials involved in research activities. Hazardous materials used at this facility include solvents, pyrophoric materials (e.g., mock explosives), combustible and toxic metals, sealed radioactive sources, encapsulated SNM and other radioactive material in solid form. Sulfur hexafluoride (SF_6) is used in sealed neutron generator tubes. Although not anticipated, biological materials of non-select agents of Risk Group 2 with inventory control may be introduced into the facility. Building 262 is a radiological facility and its inventory is controlled to less than the Hazard Category 3 limits of DOE-STD-1027 approved for use at LLNL on a cumulative sum-of-the ratios basis for all isotopes. All other materials would be managed to maintain and comply with the LSI level. Explosive material beyond the *de minimus* level is not authorized (LLNL 2019y).

Generated Wastes and Effluents

The principal waste stream within Building 262 consists of lab trash (e.g., contaminated wipes and rags). Generation of radioactive waste is not expected, except for occasional disposal of sealed radioactive sources that have decayed to unusable levels. Waste is temporarily stored at Building 262 and managed by RHWM (LLNL 2019y).

A.1.2.22 *Building 272*

Building 272, the Material Science Laboratory, is a two-story, 10,124-square-foot facility located in the northwest quadrant of the Livermore Site (LLNL 2019a). The facility consists of office, laboratory, and shop space. The building contains several independent research laboratories that operate lasers and produce and assemble laser optics and equipment (LLNL 2019j).

Hazards Assessment

The primary hazards associated with Building 272 are those used to support laser operations and production and assembly of laser optics: solvents, lubricants, cleaners, compressed gases, and limited paint. Small quantities of beryllium are used in experiments. There currently is no radiological inventory in this building. The facility is classified as LSI for chemical, explosive, radiological materials, industrial, and RGD hazards. Additional research operations may be conducted in the building if they have approved work control documentation and the safety basis for the facility (LLNL 2019j).

Generated Wastes and Effluents

Small quantities of hazardous wastes are generated. The waste is transferred to the appropriate treatment/disposal facility by RHWM (LLNL 2019j).

A.1.2.23 *Building 298*

Building 298, the Target Development Facility, is located in the northwest quadrant of the Livermore Site. This 47,986-square-foot facility consists of various laboratories, a machine shop, and office areas (LLNL 2019a). The facility is used for R&D of inertial confinement fusion (ICF) targets; R&D and materials processing activities with lasers; and the development, fabrication, and characterization of laser optics. It supports the ICF and other NIF programs. Supporting activities involve developing and analyzing cryogenic deuterium-tritium fusion targets, producing fusion targets, and developing state-of-the-art optics associated with the NIF Program. Operations within the building include laser cutting; a 2,000-pound-per-square-inch pumping system; specialty gas equipment and gas mixing activities; sol-gel optical coating process R&D laboratory; capsules and organic materials development; cryogenic target studies; target development, fabrication, and characterization; excimer laser ablation of polystyrene; diffractive optics development labs; diffractive optics fabrication; cryogenic hohlraum development; and cryogenic target studies (LLNL 2013).

Hazards Assessment

Building 298 is classified as a radiological/general industrial facility. The building houses no biological and is LSI for industrial and chemical hazards. RGD inventory is maintained within LSI limits. Radiological inventory is maintained within the Low Hazard designation. This designation supports tritium use in fusion target development and testing (LLNL 2013, LLNL 2019ee).

The primary hazards within the building include the operation of chemical and physical laboratories, exposure to laser beams and x-rays, the use of vacuum and gas pressure systems, and leakage of cryogenic fluids. The facility is equipped with an automatic sprinkler system; access to lasers is controlled by warning signs, lights, signals, intercom systems, and door interlocks. The vacuum and pressure systems use engineering and operational safeguards, and the cryogenic fluid systems have been designed in accordance with LLNL safety standards (LLNL 2013, LLNL 2019ee).

Other operational and safety controls include radiation protection monitors, alarms, and controls; HEPA-filtered air flow hoods for depleted uranium and beryllium in the sputtering assembly area; and radiation shielding for RGDs. Primary radionuclides of concern are tritium and depleted uranium. Tritium is used as part of high vacuum systems that permit fusion target filling. These systems move the tritium between cryogenic cold traps and a test target (LLNL 2013, LLNL 2019ee).

Generated Wastes and Effluents

Wastes generated from this facility include hazardous wastes and LLW contaminated primarily with depleted uranium and tritium. Wastes are collected in designated containers in the SAAs. A retention tank system is located north of Building 298. The waste is transferred to the appropriate treatment/disposal facility. The system is designed and managed to routinely accept nonhazardous and nonradioactive wastewater that enters the system via specially designated sinks in the building (LLNL 2013).

A.1.2.24 *Building 321 Complex*

The Building 321 Complex, the Material Fabrication Shops, is 150,348 gross square feet and located in the south-central portion of the Livermore Site, approximately 640 meters from the closest site boundary. (LLNL 2019z, LLNL 2016d, LLNL2020b, LLNL 2016j, LLNL 2016e, LLNL 2016k, LLNL 2019cc). The Building 321 Complex consists of the following individual segments:

- Building 321A contains a large high-bay machine shop. There are numerous machine tools in this bay that vary in size from large computer numerical control mills and lathes to small conventional machines. Building 321A contains shops and offices, including the Optics Facility. The Heat Treat Facility and Spin/Press Forming Shop have large pieces of equipment used for their respective operations as well as furnaces heated by electric elements. Building 321A also includes an electronics circuit board fabrication process. An associated WAA, consisting of a 150-square-foot metal storage rack with two storage levels, is located south of Building 321A (LLNL 2019z).

- Building 321B is a single-story facility that contains electronics fabrication, assembly and machining operations, and offices. It is located between Building 321A and Building 321C but is not physically attached to either structure (aside from electrical conduit or water pipes) (LLNL 2016d).

- Building 321C has multiple high-bays, and contains offices, shops, and storage areas. The Special Materials Machining Facility (SMMF) Shop is equipped with Computer Numerical Control mills and lathes, electrical discharge machining, and additive manufacturing machine tools that use fine metal powders to build parts layer by layer. The Dimensional Inspection Shop provides an area to perform non-destructive inspection, measurement, assembly, and storage of parts. The water jet cutting machine uses high-pressure water and garnet to cut a variety of nontoxic materials including metals, ceramics, and plastics. A portable hand-held x-ray fluorescence machine is used for in-situ analysis and identification. Building 321C contains a vault, where classified hardware and accountable materials are stored (LLNL 2016e). Building 321C is expected to be vacated in 2024 as part of the Next Generation Life Extension Program R&D Component Fabrication Facility (LLNL 2020b).

- Building 321D is a concrete block-walled building that contains fabrication, assembly and machining operations (LLNL 2016j).

- Building 321E houses the main boiler chiller plant for the Building 321 Complex. It supplies chilled water and boiler water to 321A, B, and C and chilled water to Building 327 (LLNL 2016k).

- Building 321F is a storage shed for radiological materials used to support operations in 321C. 321F is considered part of the envelope of operations for 321C.

- Building 321G (described as part of the No-Action Alternative in Chapter 3) was constructed in 2020 in support of LLNL's growing national security programs. The 13,000-square-foot manufacturing building with an expanded vault-type room addresses the increased need for the combination of precision and classified manufacturing required by these multi-programmatic missions across the Laboratory. Building 321G is part of the envelope of operations for Building 321C (LLNL 2019cc).

Hazards Assessment

The primary hazards within the complex include chemicals, acids, rotating machinery, hazardous and radioactive material operations, high temperatures, cryogenic materials, pressure, lasers, high voltage, and x-rays (LLNL 2016d, LLNL 2016e).

In Building 321A, the Heat Treat Facility and Spin/Press Forming Shop are permitted to form and heat-treat fissionable materials such as uranium-238 (depleted uranium) and low-level radioactive material such as natural and depleted uranium and thorium. The Heat Treat Facility may also process toxic materials, such as beryllium. These areas are controlled, monitored, and routinely surveyed for airborne contaminants. Building 321A is authorized at the LSI level for chemical hazards, radiological materials, and industrial hazards (LLNL 2019z, LLNL 2016d, and LLNL 2016e).

The Building 321B segment is authorized at the LSI level for chemical and industrial hazards. Chemicals used are standard for the types of operations described above (LLNL 2016d).

In Building 321C, a variety of metals, hazardous, and radioactive materials are used, and may include compounds of uranium, thorium, cobalt, beryllium, and lithium hydride. Close capture ventilation at the machinery, vented through High Efficiency Particulate Air (HEPA) filters, protects against release of toxic and radioactive machining airborne dusts. The Building 321C radiological inventory is controlled to an overall facility limit less than Hazard Category 3 limits. Chemical, explosive, RGD, and industrial hazards are authorized at the LSI level (LLNL 2016e).

The Building 321D segment is authorized at the LSI level for chemical and industrial hazards. Chemicals used are standard for the types of operations described above (LLNL 2016j).

In 2012, the Lab began utilizing the existing radiography systems in Building 321C to provide useful, nondestructive, 3-D imaging and characterization of explosive samples. Storage and use of explosives are controlled to ensure that the facility limits are within the definitions of an LSI hazard classification (LLNL 2020b).

Generated Wastes and Effluents

The hazardous and nonhazardous wastes that are produced in the facility include alkaline and acid solutions, including lab-packed solutions; bulk and lab-packed waste chemicals; nonhalogenated solutions, organic and inorganic; empty containers; laboratory debris such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; wastewater; residues; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; discarded batteries; and contaminated equipment such as vacuum pumps, ignition tubes, and other equipment. Mixed wastes, such as coolants, laboratory debris, contaminated equipment, and metals, are also generated (LLNL 2016e).

Facilities within the Building 321 Complex are the sole-source facilities for waste entering the two Building 321C WAAs. Hazardous and mixed wastes may be stored at both WAAs for 90 days or less, until transferred to the appropriate RHWM facility or other permitted treatment, storage, or disposal facility. Radioactive wastes may also be stored at the WAAs. Waste types typically stored in the WAAs include laboratory wastes, trash, paper, and plastic; lab-packed waste chemicals; bulked waste chemicals, metals, and solvents; empty contaminated waste containers; coolant wash waters; rinse waters; sludge; metal chips, filings, and scrap; solvents; waste oil; and contaminated equipment and batteries. Waste may be stored in U.S. Department of Transportation-approved containers ranging from 5-gallon cans to 55-gallon drums. Each waste container present in the WAAs conforms to RHWM packaging and inventory storage requirements. Waste composition information is established through process and generator knowledge, as well as RHWM documentation and sampling. The WAA inventory is an extension of the facility's inventory and is considered to be inherently limited in quantity to a small fraction of the facility thresholds (LLNL 2016e).

A.1.2.25 *Building 322 Complex*

The Building 322 Complex is a plating shop with bead- and sandblasting equipment that provides protective and functional surface coatings on components using a variety of surface treatments, cleaning processes, and plating operations. The complex has associated bulk chemical storage and waste holding equipment with an evaporator to reduce waste volume and recycle process water. Building 322 is approximately 5,704 square feet and located in the south-central section of the Livermore Site. The facility occasionally cleans beryllium parts and parts that contain beryllium (LLNL 2017i).

Hazards Assessment

The Building 322 Complex is classified as LSI for chemical, radiological materials, and industrial hazards. The only radionuclide currently present consists of depleted uranium solid metal components. The cumulative amount of radioactive material in the facility is maintained at less than 1/20th of the Hazard Category 3 limit (DOE-STD-1027); therefore, the radiological hazard classification of the B322 Complex is LSI (LLNL 2017i).

Generated Wastes and Effluents

Minimal quantities of hazardous and nonhazardous wastes are generated during facility operations. The wastes are managed by RHWM and conform to RHWM packaging and inventory storage duration requirements (LLNL 2017i).

A.1.2.26 *Building 327*

Building 327, the Radiography Facility, is a 19,101-gross-square-foot facility located in the south-central portion of the Livermore Site and is over 800 meters from the western site boundary. The primary mission of this facility is to apply NDE methods to materials, components, and assemblies. The activities and operations include the receipt and handling of hazardous materials; maintenance and operation of RGDs, such as x-ray machines and sealed sources; film processing equipment; ultrasonic and acoustic test equipment; infrared imaging equipment; dye penetrant and magnetic particle equipment; eddy current equipment; visual inspection equipment; and various support equipment and systems. All biological operations are restricted to those that have been authorized to be performed under BSL-2 conditions or less (LLNL 2019k).

Hazards Assessment

Building 327 is classified as a low hazard radiological and explosive facility; LSI for Biological, Chemical, and Industrial hazards; and LSI for Radiation generators. The primary hazards within the building include common industrial hazards, hazardous and radioactive material operations, high temperatures, cryogenic materials, lasers, high voltage, and x-rays. Minor amounts of chemicals are kept in the building, including cleaning solvents and photographic chemicals. Lithium hydride is contained within components. Beryllium is handled in the facility but only as solids nondestructively examined (LLNL 2019k).

NDE is conducted on radioactive materials, solid (non-dispersible) uranium or thorium materials, biological clinical specimens, and samples of encapsulated or unencapsulated explosives in specific rooms. Use and handling of biological clinical samples are potentially hazardous. Work with these materials is conducted safely using proper procedures and facilities. The total quantity of fissionable material present in Building 327, including sealed sources, may not exceed specified limits and criteria (LLNL 2019k).

Generated Wastes and Effluents

The operations in Building 327 generate solid and liquid wastes (e.g., acid solutions and solvent contaminated debris) and solid LLW. The potential for generating mixed waste is small and is minimized by the proper segregation of hazardous and radioactive waste. Hazardous and mixed wastes generated in the workplace are collected in SAAs. Spent fixer and developer from film processing are disposed of pursuant to ES&H requirements. LLW is also collected in SAAs (LLNL 2019k).

The facility water retention tank system is located on the west side of the building and consists of a 5,000-gallon fiberglass in-ground tank designed and managed to accept nonhazardous waste from the ultrasonic tank. Retention tank wastewater is released to the sanitary sewer after characterization and when within release limits. Sinks and floor drains are connected to the sanitary sewer system and are intended for the discharge of nonhazardous waste only (LLNL 2019k).

A.1.2.27 *Building 331*

Building 331, the Tritium Facility, is part of the Superblock, a protected special access area located in the southwest quadrant of the Livermore Site. The Tritium Facility is located more than 800 meters from the Livermore Site boundary (LLNL 2018i). The 30,484-square-foot building contains laboratories, offices, and support areas. The access-controlled area of Building 331 consists of two connected wings (referred to as "Increment 1" and "Increment 2"). Increment 1 was constructed in 1958 and houses the actinide chemistry laboratories. Increment 2 was constructed in 1964 and houses the tritium area. Additions and upgrades continued into the late 1980s. Additional office areas and the Special Tritium Area Cold Shop were designed in 1986. Room 170 was built in 2007. A total of 18 laboratories were constructed of reinforced concrete. A machine shop/electronics shop and office areas are on the south and east side of the facility (LLNL 2018i).

Current operations performed in the facility include both tritium and non-tritium operations. Tritium operations include (LLNL 2018i):

- Tritium recovery from commercial and military illumination devices (e.g., grinder);
- Tritium analysis, separation, and purification;
- Filling NIF targets and other devices with tritium and diagnostics;
- Tritium target development and R&D;
- Tritium and actinide storage;
- Type B shipping container maintenance and certification; and
- Actinide analysis (e.g., high-sensitivity neutron instrument).

Most operations are performed inside the facility. Large shipping containers (e.g., transportainers) with radioactive materials are opened outside Increments 1 and 2. The Building 331 yard is typically used to store low-curie radioactive material (e.g., illumination devices), TRU waste containers, and nonradioactive equipment. Non-tritium operations involve the use of a high-sensitivity neutron instrument, computed tomography, and actinide chemistry operations (LLNL 2018i).

Hazards Assessment

Each increment in the Tritium Facility may be operated as a Hazard Category 3 nuclear facility based on an exemption from DOE-STD-1027. The hazard classification defines the required level of safety documentation and the DOE order(s) governing the safety analysis. The chemical hazard categorization was determined by comparing the chemical inventories with the reportable quantities in 40 CFR Part 302, Table 302.4; the threshold planning quantities in 40 CFR Part 355, Appendix A; and the threshold planning quantities in 29 CFR 1910.119. The facility's primary inventory consists of gram quantities of tritium. Sealed sources and other radioactive materials are kept in the facility. In addition, LLW and TRU waste in containers that are less than the Hazard Category 3 threshold values are occasionally present in the facility. In accordance with DOE-STD-1027 revisions approved for use at LLNL, the facility's inventory of tritium and non-tritium radionuclides in each increment is maintained such that the sum of the ratios of the quantity of each material to its corresponding Hazard Category 2 threshold is less than one. Tritium is limited to less than 35 grams for both increments combined. Radioactive materials in the facility are limited to less than the nuclear criticality quantities or, by the nature of the process involved, preclude the potential for a criticality. Thus, the facility's inventory limit of plutonium-239, uranium-233, and uranium-235 shall not exceed the criticality limits of 450 grams, 500 grams, and 700 grams, respectively, or the nature of the process shall preclude the potential for a criticality. These requirements ensure that the facility's categorization is maintained as Hazard Category 3. The increment fire barrier also reduces the probability of bringing together large quantities of materials from both increments under the evaluation-basis scenarios. Chemical inventories (e.g., chemicals, cleaners, oils) have been examined to determine the chemical hazard classification for the Tritium Facility. Most chemicals are present in small quantities.

Building 331 is divided physically and operationally into zones of relative potential hazard. All experimental laboratories and work with radioactive materials is limited to the radioactive materials area (RMA). The RMA is separated by double doors from the offices and shop area. Building 331 has an engineered ventilation system to protect workers and to control the release of radioactive material to the environment. Within the RMA, pressure gradients are maintained so that air always flows from clean areas toward areas of increasing contamination potential; i.e., from the RMA hall, to the lab, to the hood. The system is designed to quickly dilute and exhaust tritium through two 100-foot-high continuously monitored stacks (LLNL 2018i).

In addition to the engineered controls supplied to keep radioactive materials out of the worker's breathing zone, workers are further protected by using continuous air monitors that continually monitor the breathing zone air for tritium and other radioactive materials and sound an alarm to warn the workers if the activity exceeds a preset level. Gaseous effluents from the facility are also monitored in this fashion. To provide a lower limit of detection than is possible with the continuous air monitors, passive air sampling, which does not have alarming capability, is also conducted in work areas before gases are exhausted from the facility. The air monitoring equipment is electrically connected to the uninterruptible power supply and emergency power system. If power is lost, the uninterruptible power supply will provide power for the time it takes the standby diesel generator, shared with Building 334, to start and assume the load (LLNL 2018i).

Generated Wastes and Effluents

The hazardous and nonhazardous wastes that are produced in the facility include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; nonhalogenated organic solutions; empty containers; debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; cleaning solutions, including solvents; and waste oil with trace gasoline, diesel, organics, and metals. Radioactive and mixed wastes (e.g., laboratory debris, contaminated equipment, and metals, contaminated with tritium and other radioactive material) are also generated (LLNL 2018i).

Air potentially containing tritium at low concentrations is exhausted from the rooms and hoods, within the RMA and is discharged through two 100-foot-high continuously monitored stacks. Tritium is removed from glovebox atmospheres by tritium air scrubbing systems. Air discharged from the actinide chemistry laboratories may contain small quantities of organic vapor. These discharges are within permitted limits for the glovebox exhaust systems (LLNL 2018i).

A.1.2.28 *Building 332*

Building 332, the Plutonium Facility, is located inside of the Superblock. The Superblock is surrounded by an alarmed double security fence and an aerial-intrusion deterrent system. Four buildings (referred to as Increments 1 through 4) totaling 104,787 square feet comprise the Plutonium Facility, which was designed and constructed in discrete phases (LLNL 2017j, LLNL 2019dd).

Increment 1, which became operational in 1961, is the largest section of the facility and is two stories high. The first floor contains offices, an airlock, plutonium-handling laboratories, mechanical shops, a mechanical equipment room, change rooms, and LLNL's central storage vault. The second floor (loft) houses all glovebox exhaust and loft exhaust ventilation systems for Increment 1, including the exhaust fans, motors, and HEPA filters. The room and hood exhaust ventilation ducts for Increment 1 are routed through the loft and connected to the nearby (but separate) Plenum Exhaust Building. The Plenum Exhaust Building houses the dual plenum chambers, each of which consists of deluge water sprays, demisters, the final HEPA filtration stages, exhaust fans, and motors (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Increment 2 (Room 1256) is a small, nonradioactive material laboratory adjacent to Increment 1.

Increment 3, east of Increment 1, was completed in 1977 and consists of one ground-level floor and a basement. An airlock and corridor connect Increments 1 and 3. Two plutonium storage vaults and several plutonium-handling laboratories are located on the ground floor. On the eastern end of the corridor, another airlock connects with the security portal and change rooms adjacent to Building 335 (*see* Section A.1.2.30). The basement contains Increment 3 ventilation equipment, a storage tank for fire-suppression firewater, utilities, and support equipment for experiments conducted in Increment 3. The RMA consists of radioactive material-handling laboratories (rooms), the vaults in Increments 1 and 3, the corridors up to the airlocks leading to the clean support areas, and the basement. Fissionable material can be processed and stored only in the RMA (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Increment 4 (Room 1309) was added in 1977 to expand the Cold Machine Shop (Room 1305). A large, single-story office addition was completed in 1993. This addition consists of office space for facility residents, meeting rooms, an equipment room, and a workstation for protective force personnel (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

The mission of the Plutonium Facility is to support the nuclear weapons program through research in the physical, metallurgical, and chemical properties of plutonium, including aging, dismantlement, and disposition in support of stockpile stewardship, as well as fabrication, testing, and assembly of plutonium device parts in support of the LLNL's Nuclear Testing Program, and to serve as LLNL's central storage vault for SNM (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

The Plutonium Facility supports DOE programs as follows (LLNL 2017j, LLNL 2019dd, LLNL 2016l):

- Activities related to weapon dismantlement and plutonium disposition;
- Nuclear material part assembly and disassembly;
- Surveillance of parts from pits;
- Basic and applied research in the metallurgy and chemistry of plutonium and uranium isotopes, compounds and alloys, and certain actinide elements;
- Development and demonstration of pyrochemical processing methods;
- Material development—plutonium coatings and fabrication; and
- Stockpile stewardship.

Major work activities in Building 332 include basic and applied research in the metallurgy and chemistry of actinide elements, compounds, and alloys; pit part surveillance activities; development and demonstration of pyrochemical processing methods; development of plutonium coatings; fabrication of plutonium parts; nuclear material part assembly, disassembly, and reuse; and fabrication and assembly of subcritical experiment components. These main activities are supported by metallography, chemical, and x-ray analyses (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Operations similar to those that have historically and are currently being performed in Building 332 would continue. Facility initiatives to replace and upgrade Plutonium Facility operations include routine upgrades to the electrical system, replacement of continuous air monitors, and replacement of inert gas supply systems. Programmatic enhancements and initiatives in existing laboratories are routine activities in Building 332 and Superblock. These enhancements are part of the LLNL ongoing R&D mission in support of DOE's programmatic requirements and include replacement of the Recovery Laboratory, the e-beam welder, spectrometers, and the laser welding system; removal of older equipment; rebuilding the downdraft system; upgrading analytical chemistry capabilities; and replacing the material characterization laboratory, casting furnaces, machining equipment, and the isotope separation glovebox. LLNL has not performed plutonium isotope separation for many years and will be upgrading and replacing equipment to perform separation to recover non-weapons-grade isotopes for R&D activities (LLNL 2020d).

Hazards Assessment

Plutonium, uranium, and other radioactive materials and isotopes are stored, handled, and processed in Building 332. More than 750 different radionuclides are potentially present in Building 332. The facility has been classified as a Hazard Category 2 nuclear facility on the basis of radionuclide inventories in accordance with DOE-STD-1027 revisions approved for use at LLNL. The LLNL chemical hazard classification process identifies Building 332 as a moderate hazard for the presence of a small number of chemicals that exceed low-hazard thresholds (i.e., the reportable quantities listed in 40 CFR Part 302 and 40 CFR Part 355) (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

The 2005 SWEIS established an administrative limit of 1,400 kilograms and 500 kilograms for all isotopes of plutonium and enriched uranium, respectively, in the Superblock. In this SWEIS, NNSA is proposing to reduce that administrative limit to 300 kilograms of fuels-grade-equivalent plutonium; 200 kilograms of enriched uranium; and 1,000 kilograms of depleted uranium.

The primary potential hazard is exposure to airborne radioactive material. While the amount in inventory (as a result of the de-inventorying in 2012) is reduced, plutonium and enriched uranium remain the materials of primary concern. Plutonium and enriched uranium are fissile materials; quantities will be present and must be properly controlled to prevent assembly of a critical mass. Plutonium and enriched uranium are also reactive metals and alpha emitters. Fine powders, oxide, or metal involved in a fire have the potential for dispersal. Personnel handling dispersible forms are at risk for internal contamination and must be properly protected (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Most chemicals are present in small quantities and present no risk to workers, the public, or the environment. However, a few chemicals used by LLNL exceed the low-hazard thresholds that correspond to the reportable quantities listed in 40 CFR Part 302 and 40 CFR Part 355. The most notable instance is authorization for a chlorine gas cylinder stored outside of the building. The allowable chlorine inventory is less than 100 pounds. This represents a moderate-hazard classification compared to the threshold planning quantity given in 40 CFR Part 355 (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Other hazards in Building 332 include ionizing and non-ionizing radiation, x-ray, lasers, compressed gases, corrosives, asphyxiates, solvents, halogenated organics, hazardous and toxic materials (e.g., lead, beryllium, mercury), high-temperature equipment, hydrogen, combustible and flammable materials, vacuum chambers, and cryogenic liquids (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

The facility is divided physically and operationally into zones of relative potential hazard. Storage and work with radioactive materials is limited to the RMA. Handling the material in forms or enclosures that prevent its release to the worker's breathing zone controls exposure to airborne radioactive material within the facility. Handling the material in the RMA, that has an engineered ventilation system, controls release of radioactive material to the environment. Within the RMA, pressure gradients are maintained so that air always flows from clean areas toward areas of increasing contamination potential. In addition, entry into the radioactive materials area is through air locks that maintain the pressure gradient. All exhaust from the gloveboxes and laboratory areas is filtered through multiple stages of HEPA filters; this exhaust is continuously sampled and monitored for radioactive contamination prior to release from the facility. Processing in gloveboxes is usually done under an inert gas atmosphere (nitrogen or argon) since finely divided plutonium may spontaneously ignite in moist air. Any contamination within a glovebox is confined to its ventilation zone (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Two standby diesel generators provide emergency power for safety system structures and components. These generators can assume full load within minutes. Battery power is supplied to selected equipment to avoid interruption in supplied power. Battery power is provided, for example, to the fire alarm and criticality alarm systems (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

In addition to the engineered controls supplied to keep radioactive materials out of the worker's breathing zone, workers are further protected by the use of continuous air monitors that continuously monitor the breathing zone air for radioactivity and sound an alarm if the activity exceeds a preset level. Exhaust streams from facility rooms, hoods, and gloveboxes are also monitored in this fashion after passing through their final stage of HEPA filtration. To provide a lower limit of detection than is possible with the continuous air monitors, passive air sampling, which does not have alarming capability, is also conducted in work areas and before exhaust streams are discharged from the facility (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

The proposed modernizations/upgrades would be similar to ongoing activities in the building, and their potential ES&H impacts would be mitigated to minimal levels.

Generated Wastes and Effluents

There are five specific categories of waste that may be generated in Building 332: TRU waste; LLW; mixed waste; hazardous waste; and uncontaminated solid waste. For specific definitions of the waste types, see Section 4.13.1. Wastes in all of these categories are evaluated for radionuclide content before transportation to RHWM facilities (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Legacy and new TRU waste (such as glovebox waste and HEPA filters) is temporarily staged in containers in the facility, and the individual waste drums are scanned by a segmented gamma scanner to verify radionuclide and curie content. The drums are then sent to RHWM facilities. Plutonium-contaminated liquids are also generated by Building 332 operations and consist of cleaning or lubricating fluids and contaminated oil and aqueous solutions used in analytical and metallurgical operations. All plutonium-contaminated liquid wastes, typically in liter quantities, are either solidified prior to disposal as solid waste or retained in approved containers prior to pick up by RHWM for proper treatment, storage, and/or disposal (LLNL 2017j, LLNL 2019dd, LLNL 2016l).

Other Building 332 waste streams include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; halogenated and nonhalogenated organic solutions; empty containers; debris, such as contaminated paper and rags, protective clothing, glassware, plastic ware, tubing and fittings, wood and metal parts, and HEPA filters with hazardous constituents; wastewater; residues; asbestos; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; and contaminated equipment. Wastes generated in Building 332 are categorized as TRU waste, TRU mixed waste, LLW, low-level mixed waste, California combined waste, federal or California regulated hazardous waste, and nonradioactive/ nonhazardous waste. All waste produced in Building 332 is packaged in compliance with the RHWM WAC and is transferred to a designated WAA for temporary storage for up to 90 days until the wastes are taken for treatment, storage and disposal (LLNL 2019dd, LLNL 2017j).

A.1.2.29 *Building 334*

Building 334, the Hardened Engineering Test Building, is part of the Superblock, a protected area located in the southwest quadrant of the Livermore Site. Building 334, which has a total area of 10,688 gross square feet, is a Hazard Category 2 nuclear material facility and is used for three main activities (LLNL 2017k):

- Conducting intrinsic radiation measurements. Nonexplosive, plutonium-bearing assemblies are used in these experiments, using gamma and neutron generators in some cases, to determine the occupational radiation exposure to personnel during transportation, storage, and handling of nuclear components.
- Conducting physical testing of components to various combinations of vibration, acceleration, mechanical, and thermal shock. These tests simulate the harsh conditions to which the components may be subjected over their lifetime in storage, transportation, and use.
- Welding assemblies including non-radioactive and radioactive materials using an electron beam welder.
- Performing low-level radiography of specific components.

The building has two three-story high bays for performing tests, two control rooms, an entry and signal amplifier room, a mechanical equipment room, and supporting utilities. One test bay is used for low-level counting based on intrinsic radiation and radiography. The second test bay houses the physical test equipment and the electron beam welder. Each bay is equipped with a HEPA ventilation system. The separation of bays and the independent ventilation systems ensure that events in one bay do not affect the other (LLNL 2017k, LLNL 2016f, LLNL 2020e).

Work performed in Building 334 consists of thermal and mechanical testing, low-level x-ray radiography, welding, and intrinsic radiation measurements using a gamma or neutron generator on occasion. Work could involve items being brought into the facility that contain an array of potentially hazardous materials.

<u>Hazards Assessment</u>

The hazards for Building 334 are associated with reactive materials, cryogenic materials, heat sources, high-voltage electrical systems, compressed gases, radiation-generating devices, ionizing radiation, toxic materials, and industrial hazards due to sample testing techniques. These hazards are associated with thermal and mechanical shocks and radiation measurement activities (LLNL 2017k, LLNL 2016f, LLNL 2020e).

The release of radioactive material from Building 334 is prevented by multiple confinement barriers, including metal barriers around the radioactive source material in the intrinsic radiation bay and the engineering test bay (confinement) as well as walls and equipment enclosures (physical barriers) (LLNL 2017k, LLNL 2020e).

The Building 334 radionuclide inventory consists primarily of small radiological calibration and sealed test sources. The sealed sources are stored in heavily-shielded containers consisting of a polyethylene core surrounded by lead. Plutonium powders are precluded from the facility unless configured in a bolt can/conflate container less than or equal to 25 grams. When operations are ongoing in a bay, continuous air monitors are used to provide immediate warning if airborne radioactive contamination exists. If radiation levels exceed a preset level, continuous air monitors in each room sound an audible alarm to warn bay occupants and send a signal to the alarm panels in the control rooms (LLNL 2017k, LLNL 2020e).

A standby generator, shared with Building 331, provides power in the event of an outage. Standby power is provided for air monitoring systems, fire and security alarms, and lighting in the two bays (LLNL 2017k).

Generated Wastes and Effluents

This facility is used for measurement, welding, and testing only. No radioactive, hazardous, or mixed wastes are generated during normal operations in Building 334. There are no waste treatment systems in Building 334. The Building 332 WAA-A can be used for temporary storage of waste from Building 334. The Building 332 WAA-A is outside the scope of Building 334 and is managed separately (LLNL 2017k).

A.1.2.30 *Building 335 Complex*

Building 335, 335A, and 335B comprise the Building 335 Complex, which is located within the Superblock in the southwest quadrant of the Livermore Site. The Building 335 Complex was built in the 1980s and is 12,221 square feet. Building 335 is a reinforced concrete construction with a steel-braced frame. Both Buildings 335A and 335B were built in 1996 and are each 64 square foot wood storage sheds that contain emergency evacuation and communication supplies. The facility contains offices, laser welder power supply, the AVLIS laser system, and the AVLIS control system. AVLIS laser system operations involve mixing of laser dye solutions and the operation of various types of lasers, including tunable dye lasers with outputs of up to a few hundred watts, and solid-state lasers up to a few kilowatts. Laser light is transmitted via fiber optics and enclosed optical systems for use in the experimental areas in Building 332 (LLNL 2017l).

Hazards Assessment

The hazards associated with operations in the Building 335 Complex include exposure to high-power laser light, high voltage, toxic and flammable solutions of laser dye in solvent; electrical hazards; mutagenic dye concentrate handling; solvent handling; and laser beam hazards. Some of the operational and personnel controls include restricted access to lasers and safety door interlocks to interrupt the laser beam if doors are opened; eye protection requirement; installation of laser covers and beam tubes; shielded high-voltage locations with grounded enclosures; pumps and reservoirs containing flammable liquids placed on spill pans; dye solutions capped off or covered when not in use and stored in the designated cabinets; and lasers operated with strict operating controls (LLNL 2017l).

The Building 335 Complex contains radiation-detection equipment using argon and methane gases. In addition, the facility contains an area for calibrating and repairing leak-detection equipment using helium and a Class 4 laser welder. The operation of the laser welder is controlled by work control documents. While the laser is a Class 4 laser, the laser enclosure provides for a Class 1 laser operation. Interlock prevents exposure except during maintenance by authorized and qualified individuals. Buildings 335A and 335B are both used to store emergency evacuation and communication supplies. No radioactive, explosive, or biological hazards are allowed in the Building 335 Complex (LLNL 2017l).

Generated Wastes and Effluents

The wastes generated from operations in the Building 335 Complex include used dye powders or dye solutions, dye-contaminated solid objects, and dimethylsulfoxide wastes. The solid objects are sealed in polyethylene plastic bags and stored in sealed drums. The dye wastes are stored in containers located in the outside WAA. There is also a laser dye retention tank system in the complex. All wastes are handled by the RHWM for treatment, storage, and disposal (LLNL 2017l).

A.1.2.31 *Building 341*

Building 341, the Engineering Mechanical Testing Facility, is located in the southwest quadrant of the Livermore Site. This 44,184-square-foot, multi-story concrete building contains a variety of isolated, interlocked, and remotely controlled major experimental facilities for high-energy operations (LLNL 2019l).

A diverse range of R&D activities is conducted in the building, including characterizing the mechanical response of materials, components, and assemblies under various conditions of load, deformation, temperature, and environment. Services and capabilities include general test capabilities as well as high-rate and intermediate-rate testing using mechanical and servo-hydraulic test machines; compression, tension, shear, torsion, and bend tests to determine modulus; fracture and fatigue testing; and special tests and capabilities for hardness, surface energy measurements of liquids and solids, and density measurements (LLNL 2019l). Depleted uranium is used in Building 341 for a number of scientific applications.

Building 341 is currently classified as BSL-1 laboratory. LLNL is proposing to convert space in Building 341 to a BSL-2 facility. A BSL-2 laboratory is necessary as it is suitable for work involving agents of moderate potential hazard and contains biological safety cabinets or other physical containment equipment (LLNL 2019m).

Hazards Assessment

R&D activities will be conducted to study radioactive material chemistry and to study/characterize new and routine organic or inorganic chemicals on a laboratory-scale basis. Various acids, bases, organic, and other chemicals may be used in these studies. Use of RGDs and work with biological materials up to the BSL-2 level may also be conducted in Building 341 (LLNL 2019l). Conversion to a BSL-2 facility would require installation of additional safety equipment. Operations involving radioactive material are performed in areas designed to minimize both personnel exposure and the probability of releasing radioactivity into uncontrolled areas (LLNL 2019m).

Past operations have included work with explosives and biological materials and use of RGDs, radioactive materials, and sealed sources. Residual radiological material contamination may be found in legacy equipment from these past operations. Additionally, the catch tank and target chamber in Room 1009 used in past explosives operations may contain well dispersed small quantities of explosives residue. The LLNL explosives safety subject matter expert has concluded that the total explosives loading may be just a few grams and there is no credible explosives event with the explosives residue inside the catch tank and target chamber that presents a hazard to co-located workers or the public (LLNL 2019l).

Some of the operational and safety controls include warning light systems for hazardous operations, safety interlock systems for personnel entry, use of protective clothing and equipment, use of hazardous materials only in designated areas with equipment approved for the type of operation, remote operation of the high-speed rotor cameras, insulation and shielding of high-voltage systems, and high ventilation rates for enclosed spaces and vaults. Remote key-controlled firing, safety interlocks, and strict adherence to operational controls are required to prevent injuries and damage to property. The facility has a fire suppression system, and Room 1033 is equipped with underground trenches, berms, or other means of containing water from actuation of the fire suppression system or process liquid spills (LLNL 2019l).

Propellant and detonators are stored in approved storage areas only, in a non-propagating configuration. Detonator use is restricted to approved areas that are electrically interlocked and equipped with physical key lockouts. Advanced armor studies may also be conducted. Associated hazards could include explosion, shrapnel, x-ray exposure, high-voltage shock, smoke inhalation, and loose radioactive particles. Some of the controls include interlocked doors and equipment, remote operations, containment box ventilated through HEPA filters, air monitoring, x-ray safety boxes, and electrical isolation of explosives (LLNL 2019l).

Generated Wastes and Effluents

The proposed conversion to a BSL-2 facility would result in a temporary increase in non-routine solid and hazardous waste generation. All wastes would be characterized prior to disposal and would be managed and disposed of in accordance with LLNL procedures (LLNL 2019m).

A.1.2.32 *360 Complex*

The 360 Biological Research Complex (Buildings 361, 362, 364, 365, 366 and 368) is located in the center of the Livermore Site. The buildings in the complex are used in fulfilling most of the mission of the biological, biosecurity, and biotechnical projects at LLNL, which conducts basic and applied research in health and life sciences in support of national needs to understand causes and mechanisms of ill health, to develop biodefense capabilities for national and homeland security, and to improve disease prevention and lower health care costs. Activities in these facilities include general chemistry and biology research up to BSL-3. The Animal/BSL-2

(A/BSL-2) facilities (Buildings 361, 362, 364, 365 and 366) include work with biological agents up to Risk Group 2 (RG-2). The BSL-3 facility, Building 368, handles infectious microorganisms.

Building 368 is a biological research facility capable of providing ABSL-3/BSL-3 controls for pathogen research as defined in the Center for Disease Control and Prevention (CDC)/National Institutes of Health's (NIH) Biosafety in Microbiological and Biomedical Laboratories (BMBL). There are currently three laboratories in the facility. One of the laboratories can be operated as an ABSL-3 laboratory, which is suitable for performing experiments involving small animals (LLNL 2021c).

The 360 Block building sizes and operations are summarized as follows (LLNL 2016g, LLNL 2018j, LLNL 2018k, LLNL 2018u, LLNL 2011b, LLNL 2020p):

- Building 361 (68,889 square feet): Biological research
- Building 362 (3,766 square feet): Biological research
- Building 364 (9,372 square feet): Biological research
- Building 365 (8,972 square feet): Biological research
- Building 366 (2,631 square feet): Biological research
- Building 368 (1,590 square feet): Biological research

Hazards Assessment

The hazards associated with work in the 360 Block, minus Building 368, include radiological, chemical, beryllium, low level explosives, and biological. Radiological concerns include a cesium-137 irradiation facility at Building 364, and the use in various laboratories of primarily low-level carbon-14. Chemical hazards include the usual laboratory chemicals and a number of DEA controlled substances, pharmaceuticals, toxic and carcinogenic materials, such as chemotherapeutic agents, toluene and xylene. Biological work includes experiments with microorganisms and toxins up to RG-2 in buildings 361, 362, 364, 365 and 366 (LLNL 2016g, LLNL 2018j, LLNL 2018k, LLNL 2018u, LLNL 2011b, LLNL 2020p).

The BSL-3 facility (Building 368) handles RG-3 agents (i.e., agents associated with serious or lethal human disease that can be transmitted by aerosols and for which preventative or therapeutic interventions may be available). Facility operations are limited to agents and procedures whose combined risk assessment defines ABSL-3/BSL-3 level practices, procedures, and containment. This will include RG-2 and RG-3 indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation route of exposure. All biological work is reviewed via the work control process, the IBC, and the Institutional Animal Care and Use Committee, when appropriate, prior to starting work (LLNL 2021c). The facility does not contain radioactive materials, and hazardous chemical inventories are limited and kept to the minimum needed for current experiments (LLNL 2020p).

The design features of B368 preclude the potential for biological material storage and handling from presenting a significant risk to co-located workers and the public. The external barrier is designed to prevent aerosolized biological organisms and escaped rodents from exiting the building. As part of an external barrier to prevent aerosolized biological organisms from exiting building, the HVAC system utilizes HEPA filters where necessary. Rodent caging systems are to be seismically restrained using mechanically latching hardware (LLNL 2021c).

Generated Wastes and Effluents

The 360 Complex generates both LLW and hazardous waste. The LLW is mostly from carbon-14. The hazardous wastes include halogenated and nonhalogenated solvents, including lab-packed solutions; lab-packed waste chemicals; organics; disinfectants; corrosives; reactive salts; laser dyes; empty containers; and debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing, and fittings. Waste materials are collected at SAAs and then moved to a designated WAA (LLNL 2016g, LLNL 2018j, LLNL 2018k).

The types of waste produced by the biological research include nonhazardous biological waste, biohazardous in accordance with the California Medical waste act and biohazardous in accordance with the BMBL, and contaminated sharps (various classes of medical in accordance with the California Medical Waste Act) waste, and chemical waste. Biohazardous wastes include waste generated from research with RG-1 agents (i.e., agents not associated with disease in healthy human adults); RG-2 agents (i.e., agents associated with human disease that are not transmissible by aerosols, including hepatitis and human immune deficiency virus); and from research in the BSL-3 laboratory with RG-3 agents (i.e., agents associated with serious or lethal human disease that can be transmitted by aerosols and for which preventative or therapeutic interventions may be available). Medical waste and biohazardous sharp objects are sterilized prior to disposal as landfill waste (medical waste) or transferred to incineration offsite (biohazard sharps) (LLNL 2016g, LLNL 2018j, LLNL 2018k, LLNL 2017ee).

Hazardous packaged waste is bagged, labeled, and transferred to the WAA. Carcinogens are packaged and transferred directly to RHWM. Animal carcasses are double bagged and kept in freezers until they are disposed of in the tissue digester in B368 if nonhazardous/non-radiological, or picked up by RHWM for disposal as appropriate (LLNL 2016g, LLNL 2018j, LLNL 2018k).

The complex also has two laboratory wastewater retention systems that are used to collect and retain dilute nonhazardous, non-biohazardous, and nonradioactive liquids from laboratories until analysis determines they can be discharged to the sanitary sewer. The Building 364 water retention tanks receive animal cage rinse-water that may be contaminated with radioactive or hazardous materials. The Building 365 water retention tank collects water from sinks and floor drains from the seven laboratories in that building as well as from the tissue digester and laboratory sinks and floor drains in Building 368. The retention tank effluent from B365/B368 is sampled and neutralized before being discharged to the sanitary sewer (LLNL 2016g, LLNL 2018j, LLNL 2018k).

A.1.2.33 *Building 381*

Building 381, the Target Fabrication and Offices Facility, is located in the north-central section of the Livermore Site. This facility consists of a two-story, three-wing office area (63,886 square feet) and a 31,535-square-foot laboratory structure with a high bay, low bay, basement, and a mechanical equipment area. NIF Target fabrication and metrology is conducted on the main floor in a cleanroom environment. The labs in the B381 basement perform a broad range of multi-programmatic laser material testing using multiple high energy laser sources with custom pulse shaping and with wavelengths from the near-IR to the UV. Work in the labs includes optical material qualification, optical damage S&T, and laser-material interaction studies. These labs can support classified work.

Hazards Assessment

The primary hazards within the building include electrical, exposure to laser beams and x-rays, the use of vacuum and gas pressure systems, including cryogenic liquid nitrogen. The facility is equipped with an automatic sprinkler system. Class IV lasers are used in the basement area. Laser access is controlled by warning signs, lights, signals, intercom system, and door locks. Electrical equipment is designed with shielded cables and connectors and interlocked housing to prevent inadvertent electrical shock. Work control documents are followed for each experiment, and appropriate signs are posted on equipment and across doors (LLNL 2017m).

The facility's radionuclide inventory is derived from sealed sources and, for target construction, small tracer sources and milligram quantities of uranium. The radiological material sum of ratios is less than 1/20th of Hazard Category 3 lower threshold limit (DOE-STD-1027); therefore, the radiological hazard classification of the B381 is LSI. Based solely on building inventory quantities, only lead and mercury exceed the reportable quantities for classification as a general industry facility. The emergency response planning guidelines for lead or mercury would not be exceeded in the event of a spill or fire. Building 381 is classified as LSI (LLNL 2017m).

Generated Wastes and Effluents

Wastes generated from this facility include hazardous waste and LLW. Wastes are collected in designated containers in the SAAs (LLNL 2017m).

A.1.2.34 *Building 391*

Building 391, the NIF Optics and Diagnostic Laboratories Facility, is located in the north-central section of the Livermore Site. This 197,842-square-foot building provides laboratories, mechanical utility rooms, and office space for various R&D activities related to lasers. Historically, Building 391 contained the large laser projects (i.e., SHIVA [West end] and NOVA [East end]). It currently houses a variety of support activities for the NIF. A number of aboveground tanks are also associated with Building 391 operations. A water purification system is located adjacent to the northwest corner, and a standby power generator is located to the north of the facility on the western end. A 500-gallon, double-walled diesel tank supplies the generator (LLNL 2016h).

On the northeastern side of the building is a 28,000-gallon liquid nitrogen tank that supplies Building 391 and Building 381 with nitrogen liquids and gas. The tank can hold a maximum of approximately 86,000 kilograms. The tank is located below grade by the building at an inside-corner position with bollards in front, making vehicle impacts unlikely. The tank and associated piping are seismically mounted (LLNL 2016h).

Major research areas in the facility include beam control and laser diagnostics; laser peening technology; testing and development of cleaning, coating, and diagnostic techniques for large optics; development of fast-streak cameras; operation and testing of flash lamps; testing and assembly of amplifiers; fabrication of submicron-period diffraction gratings for x-rays; use of analytical x-rays; beryllium coating; and performance and reliability of the NIF power conditioning modules. Additionally, the Dense Plasma Focus (DPF) project is housed in the substructure formerly used by the NOVA Project (LLNL 2016h).

Hazards Assessment

The primary hazards in Building 391 include hazardous materials, exposure to laser beams and x-rays (RGDs), high voltage, explosion of components, cryogenic systems, and vacuum and pressure systems (LLNL 2019n).

Because of the many hazards present, Building 391 has several extensive operational and safety controls. These controls include an automatic sprinkler system; electrical equipment designed with shielded cables, connectors, and interlocked housings to prevent inadvertent electrical shock; access to lasers controlled by warning signs, lights, signals, and operational safeguards; and engineering and operational safeguards on the vacuum and pressure systems. Work control documents are followed for each experiment, and appropriate signs are posted on equipment and access doors (LLNL 2019n).

Building 391 is authorized to store and handle radioactive material in quantities that will maintain the facility radiological inventory within LSI hazard limits. Radiological material used in the facility to support programmatic operations includes sealed radioactive sources and potentially contaminated or activated equipment from the NIF. Additionally, neutrons emitted as part of the DPF Project have the potential to create localized material activation. Building 391 is classified as LSI (LLNL 2019n).

Generated Wastes and Effluents

Wastes generated from this facility that are identified as hazardous wastes are collected in designated containers in the SAAs (LLNL 2019n).

A.1.2.35 *Building 392*

Building 392, the Optics Laboratory Facility, is located in the north-central portion of the Livermore Site. This 8,413-square-foot facility supports the NIF Laser and Target Area Building (LTAB). The building is divided into three basic areas: a cleanroom for optics cleaning, coating, and vacuum testing of components; an interferometer laboratory; and a warehouse area, all of which support the NIF and Photon Science Directorate. Activities in Building 392 include a sol-gel coating process and photometer operations. A number of capacitors containing di(2-ethylhexyl)phthalate (DEHP) and ignitron switches containing mercury are stored in the Building 392 corporate yard (LLNL 2018l).

Hazards Assessment

Building 392 is classified as a general industry facility. The primary hazards in this facility include high-voltage electrical systems; lasers; compressed gases; hazardous materials, such as flammable liquids, hydrofluoric acid, ammonia, epoxies, and solvents; and industrial safety hazards. Safety documentation, such as integration work sheets, peer reviews, work control documents, and the facility safety plan, is used to help ensure personnel safety (LLNL 2018l).

The optics cleaning process uses a commercial product (Nanostrip 2X) that has a strong sulfuric acid component. It is introduced into the cleaning tank from small (typically 1-gallon) containers and is neutralized before release from the building via a 220-gallon sump tank. Optics coating is accomplished by use of an ethanol solution. The coating station is not currently used, but is maintained in working condition for possible restart. All other work uses typical laboratory solvents, cleaners, and lubricants in small amounts (LLNL 2018l).

A number of large ignitron switches, which have about 3.4 pounds of mercury sealed within each, are stored in the Building 392 corporate yard. In the past 45 years of LLNL operations using ignitrons, the large ignitrons have never failed or leaked. Capacitors that contain DEHP are also stored in the corporate yard. DEHP is considered to be a weak suspected carcinogen with low acute toxicity. Small amounts are contained in the welded, sealed case of each capacitor, with little possibility of leakage (LLNL 2018l).

Generated Wastes and Effluents

Small quantities of liquid and solid hazardous wastes are generated from this facility. Wastes are collected in designated containers in the SAAs (LLNL 2018l).

A.1.2.36 *Building 431*

Building 431, the Beam Research Facility, is a 54,790-square-foot, multi-use facility located in the southwest quadrant of the Livermore Site. It is a four-story structure, constructed of I-beam frames with a corrugated steel exterior. The north wall of the facility is constructed of concrete 5 feet to 7 feet-thick (a shielding wall from a legacy experiment). B431 operations consist of a variety of high voltage experiments, and up to class 4 laser experiments, high voltage switch component testing, Electro-Mechanical battery research, ILC flywheel, Flux Concentrator, NaI Assembly, Chrystal driven Neutron source, Radio frequency Quadrupole (RFQ) Experiments, Altos Photonics laser system installation, and Crooks Tube demonstration. These activities require the use of interlocks, high voltages, pulsed power supplies, chemicals, rotating mechanical equipment, vacuum systems, and ion pumps. Short duration experiments are planned with animal and human cells. The animal and human cells are brought over in sealed containers and the containers are not opened or stored in B431. Experiments with a few grams of explosives are also planned in B431 (LLNL 2020m).

Hazards Assessment

Building 431 is classified as LSI for biological, chemical, explosive, radiological materials, radiation generators, and industrial hazards. Specific hazards could include high-voltage/high-energy electrical systems; ionizing radiation; lasers; hazardous materials such as toxic gases, asphyxiants, solvents, explosives, and lead; magnetic fields; and industrial safety hazards. There are RGDs in the facility ranging from Class I to Class IV. Tritium is used as targets in some experiments. The cumulative amount of tritium in the facility is maintained at less than 1/20th of the Hazard Category 3 limit (DOE-STD-1027); therefore, the radiological hazard classification of the B431 is LSI. Applicable requirements in the Bloodborne Pathogens Standard (29 CFR 1910.1030) are observed. Building 431 also has a beryllium storage area (LLNL 2020m).

Generated Wastes and Effluents

The operations in Building 431 may generate small quantities of hazardous, nonhazardous, explosive, and radiological wastes. Biological waste is not anticipated since containers are sealed. Waste generated from experiments with explosives will be managed in accordance with ES&H characterization and disposal requirements. All waste is managed according to RHWM procedures (LLNL 2020m).

A.1.2.37 *Building 432*

Building 432 is a 34,000 square foot facility located in the south-central portion of the Livermore Site. It houses a machine shop, experimental research labs, offices, and storage space. Activities conducted in Building 432 include general machine shop activities; target development, assembly, metrology, and fabrication; UV epoxy curing; grinding and polishing of optics; laser cutting and milling; cutting, drilling and etching of sheet material, aero gels, and miscellaneous foams using a class 3B laser and a class 2 laser; research and development of new concepts and systems in micro and nano machining; advanced detector lab research and RF testing activities along with liquid uranium-233 source measurements; slumping polycarbonate plastic and glass into a metal and graphite molds; and additional operations involving minor amounts of standard solvents, (e.g. acetone and alcohols), adhesives and glues (LLNL 2020l).

Hazards Assessment

Building 432 is authorized at the LSI level for chemical, radiological materials, radiation generators, and industrial hazards. Operations include the use of welding equipment, power tools, lasers, compressed gases, RF testing equipment, sheet material, aero gels, foams, radiological materials (such as liquid U-233), standard solvents, adhesives and glues. There are also beryllium storage areas within the building. Controls for these hazards are specified in work control documents (LLNL 2020l).

Generated Wastes and Effluents

The operations in Building 432 may generate small quantities of hazardous, nonhazardous, radioactive, and mixed wastes, including laboratory debris (contaminated paper and rags, protective clothing, glassware, plastic ware, etc.), laser dyes, oils, empty containers, and waste chemicals. Wastes are managed by RHWM (LLNL 2020l).

A.1.2.38 *Building 453*

Building 453, The Livermore Computing (LC) Building is located in the central area of the Livermore Site. The 253,000-square-foot facility consists of computer rooms and a four-story office complex. The facility design accommodates parallel processing computer systems of increasing computational power within the same footprint and building space. As computer systems change, old equipment is removed and replaced with current, state-of-the-art equipment. The basic building structure, components, utilities, and exterior support facilities were designed to support the maximum planned computer loads and are upgraded when required for programmatic advancements. Building 453 is capable of housing the next generation of exascale computers and networks and the data and visualization capabilities necessary to perform the simulations essential to ensuring the safety and reliability of the U.S. nuclear stockpile. Using data from past test and surrogate experiments, computer scientists conduct 3-D simulations of nuclear weapon performance. Space is available for a weapons code development team to integrate experimental, physical, material, and computer sciences in support of stockpile stewardship requirements (LLNL 2017p).

As more advanced technology systems replace older systems, the exascale-class systems required additional power and cooling capacities than were originally available in Building 453. Therefore, the current power and cooling requirements for ongoing and future computational needs require upgrading (LLNL 2017q). To accommodate this, the Lab is building the Exascale Computing Facility Modernization (ECFM) Project. To implement the ECFM, NNSA is modifying Building 453 and increasing electrical power service to 85 megawatts by constructing a new electrical substation, and installing new cooling towers and cooling loop pumps to accommodate a total of 28,000 tons of cooling (LLNL 2020f). That project is scheduled to be completed by July 2022.

Hazards Assessment

Building 453 is a general industry facility. As such, the only hazardous materials present are industrial cleaning agents, equipment lubricating oils, and maintenance solvents and chemicals used for maintaining the cooling system, such as biocide, corrosion inhibitor, and chlorine. During construction of the ECFM project, hazards will include those associated with typical construction activities (LLNL 2017q).

Generated Wastes and Effluents

Building 453 consists of offices and computing facilities only. No radioactive, hazardous, or mixed wastes are generated during normal operations. Construction of the ECFM project would generate approximately 7,110 metric tons of nonhazardous solid waste, including asphalt, concrete, and soil. The solid waste would be characterized according to established LLNL procedures before disposal to the local landfill. During operations, the project would use approximately 1,500 gallons per year of corrosion inhibitor and biocide chemicals. These quantities would be similar to those used by the existing cooling tower. The ECFM project would also generate potentially hazardous wastes, such as empty water treatment chemical containers. These empty containers would be recycled by the vendor or disposed of according to existing LLNL waste management practices (LLNL 2017q).

A.1.2.39 *Building 490*

Building 490, the NIF Engineering and Diagnostic Lab Facility, is located in the north-central area of the Livermore Site. This 216,789-gross-square-foot facility houses NIF computer equipment (Integrated Computer Control System and communications, optics/laser laboratories, optics etching equipment, clean rooms for NIF equipment assembly, various other laboratories supporting NIF projects, and a graphics/communications center). NIF components are constructed, modified, and tested in the High Bay area. The laboratory emergency operations center occupies a 4,000-square-foot area in the center of the south side of the building (LLNL 2017r, LLNL 2020q). This will move to the new Emergency Operations Center as described in the No-Action Alternative.

Hazards Assessment

Other than standard industrial hazards, the chief hazards to personnel from ongoing operations are from optics etching chemicals, including hydrofluoric acids, RGDs, and laser light, which are present in LSI quantities and are managed accordingly. The building contains three fire areas and is fully sprinklered (LLNL 2017r, LLNL 2020q). Components that are activated or contain residual tritium contamination from NIF operations are handled in the Building 490 High Bay area. There is also legacy residual uranium contamination in the basement area of Building 490 from the former AVLIS Project. Building 490 is classified as LSI for all hazards.

Generated Wastes and Effluents

During operations, small quantities of solid and hazardous wastes, including acids and solvents, are produced. Some LLW is also generated and managed. All hazardous or other regulated wastes are collected in appropriate containers, labeled, and temporarily stored at a SAA prior to treatment or disposal by RHWM (LLNL 2017r, LLNL 2020q).

A.1.2.40 *Building 491*

Building 491, the Development Lab, is a 13,883-gross-square-foot facility located in the north-central area of the Livermore Site and is now associated with the NIF programmatic activities. The building was formerly used in the AVLIS project and removal of legacy equipment and contamination is ongoing to support new programmatic work. The new programmatic activities include the use of Class 4 lasers and LSI quantities of chemicals (LLNL 2019o).

Hazards Assessment

Building 491 is divided into a north and south side by an east-west wall. No programmatic activities are currently authorized in the south side pending completion of the ongoing removal of the residual uranium contamination. The north side of the building includes the use of Class 4 lasers. A 6,000-gallon liquid nitrogen-2 tank has been installed at the north-east corner of the facility. The hazards associated with this storage facility are associated with super cold compressed gases and liquids. Building 491 is classified as LSI (LLNL 2019o).

Generated Wastes and Emissions

Any wastes or emissions from continuing programmatic activities in Building 491 are *de minimus* (LLNL 2019o).

A.1.2.41 *Building 511*

Building 511, the Craft Shop, is located in the southeast quadrant of the Livermore Site. This 77,141-square-foot facility is used as a crafts shop for electrical and mechanical equipment assembly, disassembly, and repairs. It was originally constructed as an aircraft maintenance facility with a concrete foundation, an asphalt roof, wooden framing, and sheet-metal siding (LLNL 2020g).

This facility supports the Livermore Site field operations, including inspections of routine electrical equipment; repair and installation of electrical/communication vaults, manholes, and trenches; repair of refrigerant tubing; disassembly, repair, and maintenance of vacuum pumps; and visual inspections, maintenance, and electrical installations in manholes and underground vaults (LLNL 2020g).

Hazards Assessment

Hazards associated with operations in Building 511 include potentially flammable atmospheres, oxygen-deficient atmospheres, asbestos, or polychlorinated biphenyl oils; compressed gases; zinc or cadmium present as a plating material causing toxic fumes when exposed to flames; vacuum pumps that are contaminated with beryllium, mercury, radioactive materials, heavy metals, and toxic compounds; and electrical shock. Strict operational and safety controls are followed to avoid the many hazards associated with field operations. Some of the controls include proper ventilation of manholes and vaults during work activities; cleanup of asbestos and polychlorinated biphenyl oils performed under proper guidance from ES&H (LLNL 2020g).

Generated Wastes and Effluents

Specific waste streams produced in the facility include alkaline and acid solutions, including lab-packed solutions; lab-packed waste chemicals; nonhalogenated organic solutions; empty containers; debris such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with hazardous constituents; wastewater; residues; metals; asbestos; flammable liquids; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; discarded capacitors that are potentially TSCA wastes; and contaminated equipment. All contaminated wastes are handled by RHWM for proper treatment and disposal (LLNL 2020g).

A.1.2.42 *Buildings 581, 582, and 681*

The Building 581-582 National Ignition Facility (NIF) Complex is a stadium-size experimental facility used to create extreme temperatures and pressures by focusing up to 192 high-energy laser beams onto a small target. NIF experiments contribute to important advances toward achieving fusion ignition in the lab for the first time. NIF's extreme conditions cause hydrogen atoms to fuse and release energy in a controlled thermonuclear reaction. In an ignition experiment, as much or more energy is generated than the amount of energy delivered to the target. NIF also is a key element of the NNSA's science-based Stockpile Stewardship Program to maintain the reliability, security, and safety of the U.S. nuclear deterrent without full-scale testing. Additionally, the High Energy Density science program studies material behavior under extreme pressure at NIF, enabling researchers to conduct weapon physics experiments in a controlled laboratory environment once possible only with underground testing.

Building 581 is 700,907 square feet and houses the main operational functions of NIF's laser generation, laser delivery, and control systems. This includes two laser bays, two optical switchyards, capacitor bays, mechanical equipment areas, a control room, and the heavily shielded Target Bay, which houses the 10-meter diameter target chamber (TC). Directly adjacent to the south of the Target Bay is the Operational Support Building. Operations within Building 581 include storage of amplification energy in the capacitor bays; creation, amplification and conditioning of 192 high-energy laser beams; establishing and maintaining high-vacuum systems; operation of target diagnostic and shot timing systems; operation of target and diagnostic TC-entrant positioners; main laser and shot operations; health physics laboratory operations; and a variety of facility support functions (HVAC, fire suppression, power supply, etc.). Building 582, which is southeast of B581, consists of 2,927 gross square feet and houses TC vacuum roughing pumps and miscellaneous utilities. Building 681 is known as the Optics Assembly Building (OAB) and is directly adjacent to but physically segmented from the northern edge of Building 581. The OAB is used for refurbishment of NIF laser optics and support systems and for cleaning of NIF components that are designated to be used in a cleanroom environment (LLNL 2021d, LLNL 2018v).

Hazards Assessment

The NIF Complex is classified as low hazard less than Category 3 radiological facility as defined by the DOE hazard categorization standard (DOE-STD-1027). NIF must operate within the restrictive radiological inventory limits prescribed therein (LLNL 2021d). Less-than-Hazard Category 3 facilities are classified in accordance with DOE-STD-1027 revisions approved for use at LLNL. The primary controls for the radiation hazards are design features including radiation shielding, specific safety-basis administrative controls to limit fusion yield and use of safety interlock system to prevent personnel access. Inventory control processes are used to limit the accumulation of radioactive materials (LLNL 2018n).

Facility operations include integrated laser operations with up to 192 main laser beams, with a wide variety of target materials. Some targets may include radioactive material, such as tritium, uranium (various enrichments), thorium-232, tracer isotopes, and plutonium up to authorized limits (LLNL 2021d).

Chemical inventories are LSI, except that liquid argon and nitrogen are limited to low classification maximums. The NIF Complex is authorized to store and handle chemicals up to their specific LSI limits; however, argon and nitrogen limits are authorized commensurate with classification as a low-hazard chemical facility. All other hazards are within LSI limits. Liquid nitrogen and argon hazards are mitigated through containment (LLNL 2018n).

After 11 years of radiological/hazardous materials operations, NIF's engineered systems and formal operational protocols have demonstrated the ability to safely and effectively manage hazardous materials and conditions that are important to NIF's missions, including high-yield experiments and stockpile stewardship. (LLNL 2021d).

Generated Wastes and Effluents

Wastes generated from this facility include hazardous waste, LLW, and mixed waste, contaminated primarily with tritium. Wastes are collected in designated containers in the SAAs. This waste is handled and disposed of by RHWM (LLNL 2018n, LLNL 2018v).

A.1.2.43 *RHWM Radiological Facilities: Area 612, Buildings 695, 696S, and 697*

The RHWM Program manages and operates four separate low hazard non-nuclear radiological facilities: Area 612 (A612), Building 695 (B695), Building 696 Solid Waste Processing Area (B696S), and Building 697 (B697). These facilities are designed and operated for the management of radioactive and hazardous waste. Some of the buildings and areas within these facilities are included in the *Resource Conservation and Recovery Act* (RCRA)-equivalent Hazardous Waste Facility Permit, while some are designated and operated as Waste Accumulation Areas (WAA) for the short-term storage (less than 90 days) of hazardous waste. Other areas and buildings are neither permitted nor designated as WAAs. Configuration of RHWM facilities and permitted operations and quantities are described in the Hazardous Waste Facility Permit (99-NC-006; LLNL 2008).

Waste management operations include bulking, lab packing, repackaging/over packing, rainwater management, sampling, sample management, sample analysis, and discharge of waste waters that meet sanitary sewer limits. Waste treatment operations include container crushing, debris washing, evaporation, filtration, reactive processing, size reduction, and stabilization (LLNL 2019t).

Area 612 is located in the southeast quadrant of the LLNL Livermore Site, and includes a number of associated structures such as tank and container storage, and waste sampling and analysis support areas. Area 612 has both RCRA-permitted treatment and storage facility units and WAA 90-day units used for the temporary storage of hazardous, mixed and LLW. Waste is stored in containers ranging from 5-gal carboys to 600-gal portable tanks (LLNL 2017v).

Building 695 is located in the northeast corner of the Livermore Site and is part of the Decontamination and Waste Treatment Facility (DWTF) Complex. B695 is a RCRA-permitted treatment and storage facility, and includes storage and treatment units, reactive and liquid waste processing areas, and sampling and analysis areas. It includes hazardous waste, LLW, mixed waste, combined waste, and non-hazardous industrial waste (LLNL 2017w).

Building 696S is located in the northeast corner of the Livermore Site and is part of the DWTF Complex. B696S is a RCRA-permitted treatment and storage facility and includes a storage yard area to the west of B696S. B696S includes container storage areas, lab packing area, container crushing units, transportainer storage, rainwater management area, and other areas. Hazardous, radioactive, and mixed waste may be stored in B696S (LLNL 2017aa).

Building 697 is located in the northeast corner of the Livermore Site and is part of the DWTF Complex. B697 is a WAA used for the temporary storage of hazardous, radioactive, and mixed waste, and is outside of the DWTF fenced area. Hazardous and mixed waste can stay in the WAA no longer than 90 days; it must then be transported to either an onsite or off-site permitted TSDF. Waste is stored in containers ranging from 5-gal to 330-gal tanks (LLNL 2017x).

Hazard Assessment

LSI quantities of process chemicals present in these facilities are used for sampling and analytical operations, maintenance, decontamination, and vehicles/equipment. Some of these chemicals are flammable, carcinogenic, corrosive, toxic, or reactive. These facilities are classified as Low Hazard for the chemical hazard type.

The electrical industrial hazards are comprised of heaters, lights, receptacles, transformers and overhead transmission lines. The kinetic industrial hazards are comprised of the use of vehicles, forklifts, dollies, manlifts, pallet lifts, cranes, fans and roll-up-door motors. The potential pressure industrial hazards are comprised of gas cylinders, air compressors, fluid pumps, vacuum/pressure tankers and drum pressure buildup. The potential height industrial hazards are comprised of floor pits, elevated platforms, ladders and stacked waste drums and boxes (LLNL 2017v).

The total radiological inventory for each individual facility as described above is less than the Hazard Category 3 limits in DOE-STD-1027 approved for use at LLNL, on a cumulative sum-of-the-ratios basis for all isotopes. This basis includes materials contained in certified sealed sources or DOT Type B containers for which exclusion eligibility is no longer current (LLNL 2017v, LLNL 2017w, LLNL 2017x; LLNL 2017aa).

Generated Wastes and Effluents

Any wastes and effluents generated by waste management facilities are managed within the facilities, as appropriate.

A.1.2.44 *RHWM Waste Storage Facilities: Area 625, B696 Radioactive Waste Storage Area (B696R), and Building 693 and associated Yard Areas*

The Waste Storage Facilities (WSF) are managed and operated by the RHWM Program and includes Area 625, Building 693 and the Building 693 Yard Area, Building 696 Radioactive Waste Storage (B696R). These facilities are used to safely handle, store, and prepare for the shipment of hazardous waste, TRU waste, LLW, mixed waste, California combined waste, nonhazardous industrial waste, and medical waste generated at LLNL (LLNL 2020k). Configuration of RHWM facilities and permitted operations and quantities are described in the Hazardous Waste Facility Permit (99-NC-006; LLNL 2008).

Waste management activities at these facilities include receiving, moving, segregating, staging and storing containerized waste and items; inspecting, sampling and assaying (e.g. nondestructive assay, real-time radiography, headspace gas sampling) activities; bulking and transferring wastes; maintenance of containers and equipment; and other activities as outlined in the RCRA permit and safety basis documentation for the WSF (LLNL 2020k).

Area 625 is located in the southeast quadrant of the Livermore Site and includes container and tank storage units and associated yard areas. Containers used range in size from 5-gal carboys to

5,000 gal tanks, and include bags, drums, boxes, carboys, portable tanks, tank trucks, transportainers, and roll-off bins, and are selected for their compatibility with the contents. The DWTF portion of the WSF is located in the northeast quadrant of the Livermore Site, and includes B693, B696R, and associated yard and storage units. These areas are subdivided into container and portable tank storage units, roll-off bin storage units, and freezer storage unit.

Hazards Assessment

Area 625 and associated operations are classified as Nuclear Hazard Category 2 facilities. Building 693 and Building 696R and associated operations are also determined to be Nuclear Hazard Category 2 facilities. The radiological limits associated with the facility are maintained in compliance with the *Technical Safety Requirements (TSRs) for the Waste Storage Facilities* (LLNL 2019x).

Process chemicals present in the facilities are used for treatment, sampling and analytical operations, maintenance, decontamination, and vehicles/equipment. Process chemicals associated with hazardous waste activities are managed to maintain and comply with the facility *Documented Safety Analysis (DSA) for the Waste Storage Facilities* (LLNL 2019w).

The electrical industrial hazards are comprised of heaters, lights, power panels, transformers, and receptacles. The kinetic industrial hazards are comprised of the use of vehicles, forklifts, dollies, manlifts, pallet lifts, fans and roll-up-door motors. The potential pressure industrial hazards are comprised of air compressors, compressed gas cylinders, machinery hydraulic systems, steam boiler, and drum pressure buildup. The potential height industrial hazards are comprised of the mezzanine, floor pits, and stacked waste drums and boxes.

Generated Wastes and Effluents

Any wastes and effluents generated by waste management facilities are managed within the facilities or disposed of at a properly permitted offsite facility, as appropriate.

A.1.2.45 *Building 655*

Building 655, the Advanced Manufacturing Laboratory, is located in the southeast quadrant of the Livermore Site and supports the Strategic Partnerships Projects. It is sited in the Laboratory's Livermore Valley Open Campus. This 13,277-gross-square-foot facility is used for research, development, and collaboration on advanced manufacturing processes, including 3-D printing (LLNL 2019q).

Hazard Assessment

This facility houses multi-user laboratories for basic biological, chemistry, and material science research, and the development of advanced manufacturing technologies. Building 655 includes a wet lab and an instrument lab. Programmatic inventory of hazardous chemicals is managed to maintain and comply with a facility SBE of LSI. Biological work is authorized at the BSL-2 level including the bloodborne pathogens standard. Additive manufacturing may include the use of Class 4 lasers inside an interlocked enclosure. RGDs are authorized for use in this facility. LSI biological and chemical standards are applicable (LLNL 2019q).

Generated Wastes and Effluents

Wastes generated from this facility include hazardous, nonhazardous, and biological wastes that are handled and disposed of by RHWM (LLNL 2019q).

A.1.2.46 *Building 663*

The Building 663 Complex, Onsite Medical Services, is located on the east side of the Livermore Site. The complex consists of Building 663 and OS665. The Onsite Medical Services Complex is used for Occupational Health and Wellness Programs at LLNL. The complex houses the Health Services Department which is accredited by the Accreditation Association for Ambulatory Health Care and meets regulatory requirements and professional standards to assist in providing health care services (LLNL 2018p).

Building 663 is a medical clinic consisting of offices, treatment areas, a decontamination facility, conference rooms, lavatories, storage rooms, and a kitchen. The facility is protected by fire sprinklers and an alarm system that automatically signal the Alameda County fire dispatch center located onsite. Building 663 has an emergency generator, located outside south of the building, that allows for limited operations to continue in the event of an emergency. OS665 is an outdoor, medical triage area consisting of a wide through driveway for emergency vehicles, two 1,000 square foot storage buildings constructed of metal with stucco siding, and two outdoor showers located on the north side the facility (LLNL 2018p).

Health Services Department (HSD) performs patient care activities that are commonly performed by the medical industry and are provided by licensed and/or certified medical personnel. Patient care activities include, but are not limited to, medical examinations and services (e.g., immunizations, lab tests, phlebotomy, point of service testing (cholestech), diagnostic radiography, and emergency (including decontaminating of patients) care (LLNL 2018p).

Hazard Assessment

The Building 663 biological operations are restricted to conform to the Bloodborne Pathogens Standard (OSHA 29 CFR 1910.1030). All biological work is reviewed via the work control process and the medical staff. Medical x-ray units utilize an authorized RGD for diagnostic purposes and complies with safety requirements specified by the Food and Drug Administration.

Chemical hazards are authorized in the facility. No chemicals exceed LSI classification (LLNL 2018p).

Generated Wastes and Effluents

Patient care may generate medical waste. Types of medical waste generated may include biohazardous, pathology, pharmaceutical, sharps, trace chemotherapeutic and trauma scene. LLNL disposes of medical/biohazardous waste at approved disposal sites, currently the Clean Harbors Environmental Services, Inc. facility in Aragonite, Utah (LLNL 2019u, LLNL 2019v).

Biological operations are restricted to conform to the Bloodborne Pathogens Standard (OSHA 29 CFR 1910.1030). All biological work is reviewed via the work control process and the medical staff. Medical waste is regulated by the California Department of Public Health and, at the Livermore Site, the program is also regulated by the ACDEH (LLNL 2020j). LLNL is registered with ACDEH as a generator of medical wastes and is required to renew those registrations on an annual basis.

Table A-2. All Other Facilities at the Livermore Site

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
OS041S	Security Kiosk	60			Yes		
041	WCI Livermore Computing Facility	25,555	Yes		Yes	Yes	
071	Westgate Badge Office	4,166	Yes				
OS071N	Security Kiosk	132			Yes		
110	Storage	153				Yes	
111	Design Physics Offices	112,418	Yes			Yes	
112	Computer Center	45,512	Yes				
113	Global Security Offices	44,427	Yes	Yes			
OS113E	Security Kiosk	34			Yes		
115	Computer Center	17,150	Yes				
116	LEP Project Offices	7,781	Yes				
117	LLNL National Security Computing Center	11,370	Yes				
118	Teleconference Facility	1,505			Yes		
121	Physical and Life Sciences Offices	90,759	Yes				
122	Laboratory Infrastructure Office	962	Yes				
OS122S	Guard Kiosk	225			Yes		
123	Auditorium	7,767			Yes		
125	West Cafeteria	12,513	Yes			Yes	
133	B132S Complex Central Plant	5,631				Yes	
134	Global Security Storage	1,284					
142	International Security Research Facility Annex	20,306					
155	Nuclear and Radiochemistry Offices	21,742	Yes				
161	High Energy Density Labs	6,105		Yes		Yes	
164	Machine Shop	207			Yes		
OS169	RHWM Facility	2,000			Yes	Yes	
170A	Global Security Storage	800				Yes	
175	MARS E-Beam Facility	16,656	Shutdown				
176	Jupiter Laser Storage Facility	3,973				Yes	
179	HED and X-Ray Optic Calibration Lab	2,720			Yes		
181	Engineering Fabrication	13,532	Yes	Yes	Yes		
182	O Program	2,027	Standby				
193A	ES&H Service Monitoring Station	151			Yes		
195	ES&H Shop	400			Yes		
196	ES&H Service Monitoring Station	1,053		Yes			
196A	ES&H Storage	112				Yes	

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
197	Center for Accelerator Mass Spec Lab	10,716		Yes	Yes	Yes	
198	Physical & Life Sciences Machine Shop	959			Yes		
211	Nuclear and Geosciences Offices	14,121	Yes				
212	Accelerator Facility	3,770	Shutdown				
214	Assurance Review Office	4,837	Shutdown				
216	Cyber Security	18,976	Yes		Yes		
217	WCI Offices	17,914	Yes				
218	Institutional Cooler	17,956	Yes				
219	UC Relations/PLS Office	18,429	Yes				
224	AME Office	22,000	Yes				
231A	Bead Blasting—Receiving	110			Yes		
233	Materials Management	4,933	Yes		Yes		
234	Materials Management Offices (Part of Building 231 Complex)	5,261	Yes				
OS235N	Security Kiosk	32			Yes		
241	Pluto Project Testing & Fabrication Facility	53,935	Shutdown				
243	Energy and Environment Lab	20,000	Standby				
251	Heavy Element Facility	31,128	Shutdown				
252	Shipping and Receiving Shed	192				Yes	
256	Telephone Switching Node	5,937	Yes		Yes		
261	Z Division/NAI	52,656	Shutdown				
263	Telephone Filter Facility	77	Shutdown				
264	Physics Offices	2,817	Yes				
271	Security Protective Force	18,874					
274	Security Administration	21,436	Yes		Yes	Yes	
275	Armory	2,880					
276	Security Fitness Training Center	8,487					
280	Livermore Pool Type Reactor – Shutdown	5,478					
280A	Butler Shed	80	Shutdown				
281	Energy and Environment Lab – Shutdown	18,505					
282	Analytical and Quantum Science Facility	2,160		Yes	Yes		
284	Greenhouse Research Facility	1,800					
292	Rotating Target Neutron Source – Shutdown	20,811	Yes	Yes			
293	CAMS Storage - Standby	800				Yes	
294	CAMS Facility	1,086		Yes			
297	Paper Disposal	1,086			Yes		
297A	Document Destruction	335			Yes		
311	DOE Offices (LFO)	40,951	Yes			Yes	

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
312	IMF Managed Facility – Standby	11,482	Yes		Yes		
312A	UNCLE Credit Union Shutdown	107			Yes		
313	Regional Dispatch Center	4,352			Yes		
314	Barracks Office	13,237	Yes				
315	WCI Office Facility	18,133	Yes				
316	Engineering Cooler	14,091	Yes			Yes	
OS316N	Security Kiosk	49			Yes		
317	Networking Group Facility	1,426			Yes		
318	Locker Room	6,112					Yes
319	Quantum Science Offices	18,048	Yes				
322A	Plating Shop Annex	340			Yes		
323	Emergency Services/Fire Station #1	18,761			Yes		
324	Emergency Services/Alarms	10,181			Yes		
329	Lasers Weld Shop	5,150					
335A	Emergency Response Facility	64				Yes	
335B	Emergency Response Facility	64				Yes	
336	South Security Portal	792			Yes		
337	NW Security Portal	792			Yes		
OS338	Guard Tower	417					Yes
343	Explosives and High Pressure Testing Facility	27,368	Shutdown				
345	Chemistry & Materials Sciences – Shutdown	9,467	Yes	Yes	Yes		
367	Biology and Biotech Research – Standby	629	Standby				
373	Global Security Warehouse	1,768				Yes	
376	Machine Shop	1,575	Shutdown				
378	Marshall Island Project Laboratory	3,840	Yes	Yes			
379	Marshall Island Project Counting Facility	1,500		Yes			
382	Technical Support	303			Yes		
383	Machine Shop	6,715	Yes		Yes		
392S	Redwood Room/Conference Center	1,081					
404	O&B Battery Shop/Warehouse	6,460	Yes		Yes	Yes	
405	O&B Facility	8,636	Yes		Yes	Yes	
406	O&B – Shutdown	449		Yes		Yes	
411	Main Warehouse and Distribution	71,625	Yes		Yes	Yes	
415	Employee Resources	19,297	Yes			Yes	
OS415W	Guard Kiosk	154					Yes
418	Paint Shop	12,167	Yes		Yes		
423	Machine Shop and Beam Research Lab	7,791	Yes	Yes	Yes		
433	Institutional Fabrication Shop	5,793				Yes	

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
435	Fusion Research – Shutdown	57,723					
436	PLS Shipping/Receiving/ Storage	9,745			Yes	Yes	
438	ERD Office & Field Operations	16,262	Yes	Yes	Yes		
439	WCI Livermore Computing	12,055	Yes	Yes	Yes	Yes	
442	WCI Facility	4,170	Yes	Yes	Yes		
443	WCI Facility	8,954	Yes		Yes	Yes	
445	WCI Facility	5,100		Yes		Yes	
446	Bioreactor Facility – Shutdown	1,743					
451	WCI Livermore Computing	51,398	Yes		Yes		
452	WCI Livermore Computing	492				Yes	
471	Central Cafeteria	16,086					
473	AIS Storage	205				Yes	
481	NIF Directorate Office	61,303	Yes			Yes	
482	NIF Directorate Office	108,013	Yes				
492	Laser Dye Pump Facility - Standby	9,550		Yes	Yes		
493	NIF Warehouse	19,100	Yes			Yes	
494	NIF Warehouse	29,960	Yes			Yes	
OS495	NIF CWAA	1,800				Yes	
501	DUS Yard	200	Yes				
509	Sheet Metal Shop Storage	256				Yes	
510	UPS Battery Bank	144			Yes		
512	Crafts Supply	8,128	Yes			Yes	
512S	Construction Office - Shutdown	2,590	Yes				
514A	Institutional Storage	2,530				Yes	
515	Crafts & Training	8,588	Yes		Yes	Yes	
516	Crafts Facility/Machine Shop	6,496	Yes				
517	Offices	6,090	Yes		Yes		
517A	Custodial Laundry Room	474			Yes		
518A	O&B Storage	204				Yes	
519	O&B Heavy Equipment Shop	9,788			Yes		
519A	Heavy Equipment Storage	594				Yes	
520	O&B LPM Pesticide Storage	400				Yes	
522	Restroom Facility	515					Yes
523	Weld/Carpentry Work Shed	4,064			Yes		
525	Electrician Shop Area	1,632			Yes		
531	Liv-IT Office	12,381					
532	Service Building	198	Shutdown				
533	O&B Storage	320				Yes	
543	O&B/CFO Offices	78,269	Yes		Yes	Yes	
551E	O&B Offices	40,881	Yes		Yes		
551W	BUS/NCOP/TID/SCM	65,817	Yes		Yes		
571	NIF Directorate Office	41,407	Yes				
583	NIF Directorate Office	21,793	Yes				
591	NIF Maintenance Equipment Building	3,207				Yes	
597	ERD Corp. Yard	300	Yes		Yes		

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
597A	ERD Restroom and Shower	99					Yes
610	Truck Inspection Station	4,281					
611	Auto Fleet Maintenance/Admin	15,018	Yes		Yes		
615	DUS Office – Standby	3,525	Yes				
616	Donation, Util. & Salvage - Shutdown	2,273	Yes				
619	Donation, Util. & Sales	2,038			Yes	Yes	
622	O&B Corp Yard	1,033			Yes	Yes	
624	Offices	240	Yes				
642	LVOC Office	28,800	Yes				
643	LVOC Office Building Conference Annex	2,975	Yes				
651	Visitor's Center	2,382					Yes
OS651N	Guard Kiosk	93					Yes
653	ES&H Sampling Staging	96			Yes		
652	Public Affairs Office	208	Yes			Yes	
654	WCI Livermore Computing	15,894	Yes	Yes	Yes		
661	Hertz Hall	19,855	Yes	Yes			
667	Hertz Hall Offices	1,400	yes				
671	NIF Directorate Office	41,476	Yes				
OS682	NIF Central Plant	8,820					Yes
OS683	NIF Cooling Towers	2,000					Yes
684	NIF Chemical Storage	310				Yes	
691	RHWM Office	18,437	Yes		Yes		
694	Offices	10,590	Yes				
1277	Weapons Infrastructure Office	4,117	Yes				
1280	Engineering	5,760	Yes				
1601	Physics & Advanced Technology	2,199	Shutdown				
1602	Physics & Advanced Technology	2,160	Shutdown				
1632	F&I Deployed Teams Offices	4,297	Yes				
1677	Engineering Offices	28,576	Yes				
1680	DO Office	5,690	Yes				
1713	Restroom Trailer	411					Yes
1714	Shower Trailer	292					Yes
1726	Physics & Advanced Technology	2,160	Yes				
1727	Jupiter Technical Support	1,884	Yes		Yes		
1730	Jupiter Visitor's	2,100	Yes		Yes		
1735	Jupiter Offices	3,279	Yes				
1739	Atmospheric, Earth & Energy Sci Offices	5,646	Yes				
1802	Restroom Facility	411	Yes				
1826	Physics and Advanced Technology	3,632	Shutdown				
1878	Offices	6,292	Yes				
1879	Laboratory Training Center	11,118	Yes				
1885	WCI Offices	7,406	Yes				

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
1886	HEAF Support	3,643	Yes		Yes		
1887	HEAF Support	5,089	Yes		Yes		
1888	Center for Accelerator Mass Spec Offices & Shop Facility	11,520	Yes		Yes		
1889	Laboratory Training Center	17,380	Yes				
1925	Physical and Life Sciences Offices – EBIT	2,236	Yes				
1927	Chemistry	2,160	Shutdown				
2420	Office Trailer 9-Plex		Y				
2552	DO Office – Shutdown	2,100	Yes				
2554	Bio-Assay Offices -Shutdown	741	Yes				
2580	Secure Communication Center	4,296	Yes				
2599	Storage Tent	841				Yes	
2632	Security	2,817	Shutdown				
2679	Training Center	12,310	Yes				
2684	Offices	5,284	Yes				
2685	Cain - Shutdown	4,320	Yes				
2687	Alarms - Shutdown	2,100	Yes		Yes		
2726	Offices	2,098	Yes				
2727	Locks and Keys	5,090	Yes				
2728	Physics & Advanced Technology	2,160	Shutdown				
2775	Security	9,875	Yes				
2806	Physics and Advanced Technology	223	Shutdown				
3180	Director's Office Annex Shutdown	4,371	Yes				
3203	Plating Shop Support	649					
3204	Plating Shop Support	649			Yes		
3340	Offices	2,160	Yes				
3427	Offices	6,365	Yes				
3526	Human Reliability Program	2,120	Yes				
3527	DOE Offices	9,792	Yes				
3555	Human Reliability Program	518		Yes			
3577	Offices/Computer Space	4,290	Yes				
3649	Biotech & Bioengineering Office	4,800	Yes				
3724	NIF Directorate Offices	19,810	Yes				
3725	ES&H/PLS Offices	19,867	Yes				
3726	Director's Office	19,824	Yes				
3777	Bring IT Service Center	4,300	Yes		Yes		
3925	Redwood Room/Conference/ Classroom	1,081			Yes		
3982	NIF Technician Trailer	1,800	Yes		Yes		
4113	Paint Shop Storage	183				Yes	
4199	Staging Tent	4,942				Yes	
4297	Engineering Tent	5,253				Yes	
4298	NIF Storage Tent	4,141				Yes	
4299	Beam Research Tent	5,253				Yes	
4399	Storage Tent	2,400				Yes	
4406	Control Room – Shutdown	1,560	Yes				

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
4475	Energy & Environment Offices – Shutdown	4,176	Yes		Yes		
4525	WCI Livermore Computing	5,736	Yes				
4576	WCI Livermore Computing	854	Yes		Yes		Yes
4675	Employee Resources	11,142			Yes		
4725	IMF-Managed Facility	9,389	Yes				
4726	Science & Technology/ Computations	9,384	Yes		Yes		
4727	O&B TID Library	9,951	Yes				
4728	Liv-It/Computations	6,762	Yes		Yes		
4729	O&B LivIT	10,018			Yes		Yes
4926	C&MS Offices – Shutdown	1,641	Yes				
4997	NIF Storage Tent	5,304				Yes	
4997A	NIF Storage Tent	3,865				Yes	
4998	NIF Storage Tent	4,968				Yes	
4998A	NIF Storage Tent	1,800				Yes	
4999	NIF Storage Tent	4,968				Yes	
5105	Labor Only Construction	627	Yes				
5125	PE Construction Office	2,912	Shutdown				
5198	GS Storage	2,214				Yes	
5207	O&B Facility	320	Shutdown				
5225	O&B Offices	1,939	Shutdown				
5226	O&B Offices	2,548	Yes		Yes		
5299	ACS Labor Only Tent	2,858				Yes	
5477	IMF Managed Office Facility	6,693	Yes				
5626	Audit & Oversight	4,356	Yes				
5627	Legal Services	8,470	Yes				
5675	Staff Relations	4,277	Yes				
5998	NIF Tent	3,090					
5999	ERD Storage Tent	810				Yes	
6127	RHWM Offices	1,575	Yes				
6178	Change House	1,040	Yes		Yes		
6179	RHWM Office	3,898	Yes			Yes	
6197	RHWM Storage Tent	5,148				Yes	
6197B	RHWM Storage Tent	4,662				Yes	
6198	RHWM Storage Tent	3,368				Yes	
6199	Donation, Utilization & Sales	9,892			Yes	Yes	
6199A	Donation, Utilization & Sales	9,854			Yes	Yes	
6199B	Donation, Utilization & Sales	5,345			Yes	Yes	
6199D	Donation, Utilization & Sales	2,625			Yes	Yes	
6205	Heavy Equipment Yard	404	Yes				
6206	Industrial Electronics Storage	688					
6298	ACS Labor Only Tent	2,352					
6299	Electric Utility Tent	1,500					
6299A	Electric Utility Tent	1,500					
6299B	Electric Utility Tent	1,500					
6301	O&B Riggers Storage	732					
6325	Offices	4,320	Yes				
6425	UNCLE Credit Union	2,152					
6475	LVOC Offices	809					
6501	Public Affair's Office	908	Yes				

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
6525	Visitor's Center Auditorium	971					Yes
6526	Public Affair's Office	2,757	Yes				
6527	High Perf Computing Innovation Center	2,115	Yes				
6575	Public Affair's Office	1,460	Yes				
6675	Hertz Hall Offices	2,880	Yes				
6925	Nuclear Ops Office	5,873	Yes				
6926	Nuclear Ops Office	2,160	Yes				
6928	Nuclear Ops Office	1,912	Yes				
6929	IMF Managed Facility	4,867					
6930	IMF Managed Facility	5,995					
6951	RHWM Service Building	1,440	Yes		Yes		

AIS = Automated Information System; AME = Applied Materials and Engineering; CAMS = Center for Accelerator Mass Spectroscopy; DO = Directors Office; DUS = Donation, Utility, Salvage; DWTF = Decontamination and Waste Treatment Facility; EE = Electronics Engineering; ERD = Environmental Restoration Division; HEAF = High Explosives Application Facility; HED = High Explosives Development Center; ES&H = Environmental, Safety, and Health; LEP = Life Extension Program; LLNL = Lawrence Livermore National Laboratory; LVOC = Livermore Valley Open Campus; MARS = Military Affiliate Radio System; MMED = Manufacturing and Materials Engineering Division; NDE = nondestructive evaluation; NIF = National Ignition Facility; RHWM = Radioactive and Hazardous Waste Management; UC = University of California; UNCLE = University of California Radiation Laboratory at Livermore (now LLNL); UPS = Uninterruptible Power Supply; WAA = Waste Accumulation Area; WCI = Weapons and Complex Integration.

A.2 EXISTING FACILITIES AT SITE 300

A.2.1 Introduction

Site 300 occupies approximately 7,000 acres, approximately 11 square miles, in Alameda and San Joaquin counties. Site 300 is 15 miles southeast of Livermore, and 6 miles southwest of downtown Tracy, California. Site 300 was established in 1955 as a remote explosives testing ground for the theoretical weapons developed at LLNL. Site 300 facilities offer approximately 381,000 gross square feet of operational space, with 4 percent in temporary facilities.

Activities at Site 300 include (LLNL 2020h):

- Test firing of explosives that allows sophisticated diagnostic recovery of high explosives test data;
- Dynamic and thermal testing of explosives;
- Explosives formulation, processing, machining, radiography, and assembly;
- Non-explosives experimentation;
- Testing of weapons components;
- Explosives waste treatment;
- State-of-the-art destructive and nondestructive materials and weapons design;
- Diagnosis of the chemical reactions involved in explosives detonations;
- Compatibility and reaction studies of explosives;
- Storage of explosives; and
- Transportation of explosives.

Site 300 includes two remote test areas (thermal and dynamic test areas), a chemistry area, an HE Process Area, the Small Firearms Training Facility, and a general service area.

The Site 300 facilities consist of multiple complexes throughout the site. Each complex contains multiple segmented structures (i.e., buildings, magazines, or areas) which are independent from all other facilities/complexes at Site 300. Segmented structures do not share air handling, mechanical, electrical, fire protection system, or alarm system utilities with any other facility/complex at Site 300 in any manner whereby an event in one structure could impact the others. This demonstrates independence of these systems for facility segmentation purposes.

A.2.2 Existing Facilities

Table A-3 provides an overview of the Site 300 key facilities that the Laboratory uses to accomplish its missions. The selected key facilities at Site 300 are described in Sections A.2.2.1 through A.3.2.18, covering information on location, square footage, operations, and hazard assessment. Hazards may be radiological, chemical, or other. Radiological hazards include low-level ionizing radiation and radiological emissions. Chemical hazards include chemicals that may be toxic, flammable, corrosive, poisonous, and/or carcinogenic. Other hazards include RGDs, high explosives, non-ionizing radiation, biological agents, compressed gas cylinders, and electrical equipment. The sections also include brief summaries on generated wastes and effluents for each facility. Table A-5, which follows the description of the key facilities, provides an overview of the remaining facilities at Site 300.

A.2.2.1 *Building 801 Complex*

Building 801 is a Complex of buildings consisting of Building 801A, Building 801B and 801D. Building 801A, the Contained Firing Facility, is approximately 46,848 gross square feet. Building 801A is part of the explosives test facilities and is in the northeast quadrant of the site, called the east firing area. It is a concrete, steel-reinforced firing chamber that contains blast effects. Performing test explosions in the firing chamber dramatically reduces particle emissions and minimizes the generation of hazardous waste, noise, and blast pressure from those tests that were previously conducted outdoors. The bullnose of the Flash X-Ray accelerator and the roof of the underground optics room project into the firing chamber. On the chamber walls and floor are optical portholes and fittings for fiber optics, electronic signal cables, electricity and gas. Interlocked isolation valves in the chamber protect its ventilation system, which is separate from the systems of the bunker areas that are occupied during testing. Ventilation (including a scrubber and HEPA filters), washdown water, and water collection systems are installed to remove the hazardous and radiological materials that are dispersed inside the chamber during an experiment (LLNL 2018q).

Table A-3. Overview of Key Buildings and Facilities at Site 300

Facility Number	Facility Name	Gross Square Feet	NNSA Capability	Lab/ Research	Office Service/ Support	Hazards		
						Chemical	Radiological	Other[a]
801A/B/C	Contained Firing Facility	46,848	Design and Certification	Yes	Yes	Yes	Yes	Yes
805	Inert Machining/Explosives Waste	6,830	High Explosives	Yes	Yes	Yes	Yes	Yes
806A/B	HE Machining	7,505	High Explosives	Yes	Yes	Yes	Yes	Yes
807	HE Machining	1,575	High Explosives	Yes	Yes	Yes	Yes	Yes
809A/B/C	HE Pressing and Oven Facility	3,794	High Explosives	Yes	Yes	Yes	Yes	Yes
810A/B/C	HE Assembly and Storage	5,200	Design and Certification	Yes	Yes	Yes	Yes	Yes
816, M2-5	Explosives Waste Storage Facility	1,223	High Explosives		Yes	Yes	Yes	Yes
817A/B/C/E/ F/G/H	HE Pressing and Oven Facility	3,102	High Explosives	Yes	Yes	Yes	Yes	Yes
823A/B	LINAC Radiography	2,748	Design and Certification	Yes	Yes	Yes	Yes	Yes
825	Chemistry	1,547	High Explosives	Yes	Yes	Yes	Yes	Yes
826	Chemistry	1,547	High Explosives	Yes	Yes	Yes	Yes	Yes
827A/B/C/D/ E	Chemistry Control and Process Facility	18,709	High Explosives	Yes	Yes	Yes	Yes	Yes
832A/C/E, OSM832B/D	Storage Facilities	2,456	High Explosives		Yes	Yes	Yes (A, E)	Yes
834A/B/C/D/ E/F/H/M	Thermal Test Facilities HE Storage	11,199	Enabling Infrastructure, Tests and Experiments	Yes	Yes	Yes	Yes	Yes
834L	HE Additive Manufacturing	1,000	High Explosives	Yes	Yes	Yes	Yes	Yes
836A/B/C/D	Dynamic Test Facility	13,023	Tests and Experiments	Yes	Yes	Yes	Yes (B, C, D)	Yes
845A/B	Explosives Waste Treatment Facility	722	High Explosives		Yes	Yes	Yes	Yes
850	Firing Facility	5,095	Enabling Infrastructure	Yes	Yes	Yes		Yes
851A	Outdoor Firing Facility	13,176	Design and Certification	Yes	Yes	Yes	Yes	Yes
855A/B/C	HE Machining	1,700	High Explosives	Yes	Yes	Yes	Yes	Yes

HE = high explosives; LINAC = Linear Accelerator; EWSF = Explosives Waste Storage Facility; EWTF = Explosives Waste Treatment Facility.

880. Other hazards include biological materials, explosives, accelerators, x-ray machines, lasers, nuclear magnetic resonance, electrical, and collection and storage of compressed gas cylinders.

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The Contained Firing Facility is one of two facilities in the NNSA complex that integrates advanced diagnostics (e.g., multiplex Photonic Doppler Velocimeter, optical ranging, and high-speed cameras) with high power radiographic sources to image imploding weapons. The other facility is the Los Alamos National Laboratory's DARHT facility. Building 801A is designed to obtain explosives test data through the use of the flash x-ray accelerator, and accelerate charged particles and generate x-rays, a high-speed camera, and a laser-doppler interferometry operation. This equipment measures the velocity of explosively driven surfaces. Other electronic and mechanical systems capable of diagnosing various aspects of the high-explosives tests are housed in Building 801 Complex facilities.

The Contained Fire Facility's accelerator is approaching 40 years old. The addition of modern radiographic tools would complement its unique features and allow the facility to continue to fulfill its mission for the next 30 years. Modern radiographic sources and detector provide weapon designers with significant flexibility to accommodate new and unpredictable military requirements (including new weapon designs) as well as advancements in detectors and imagers. This flexibility extends to doses, number of pulses, inter-pulse timing, pulse width, resolution, and even the type of radiography (e.g., flash neutron versus x-ray). LLNL is currently advancing the technologies needed to make arbitrarily timed n-pulse accelerators a reality and is actively pursuing flash neutron radiography technologies (LLNL 2020i).

Hazards Assessment

The Building 801 Complex is bounded by a fence whose nearest point to the firing chamber for explosives experiments is 400 feet. The nearest site boundary is 4,200 feet from the firing chamber, toward the north (LLNL 2018q).

The common hazards at this firing complex are associated with the handling and firing of explosives, high-voltage electricity, toxic and radioactive materials, high levels of ionizing radiation, lasers, cranes and machine tools, and high-pressure systems. Personnel could be exposed to x-rays from the flash x-ray accelerator or non-ionizing radiation from high-power lasers. The high-speed rotor cameras are controlled to avoid exceeding design speeds to ensure their structural integrity is maintained.

The hazards in the photo-processing operations are various laboratory reagents; photo-chemicals; and chemicals in spent developers, fixers, and rinse-waters. When film is processed, the developers and fixers are automatically replenished and waste is captured in separate barrels.

Formal work control documents have been prepared for the facility as a whole and are supplemented for individual tests. Procedures are reviewed by the Hazards Control Department. All explosives are handled, transported, and test fired following these procedures. All work with radioactive materials and toxic materials conforms to established health and safety guidelines.

In the explosive firing facilities, personnel safety is enhanced by positive key control of the various aspects of the operation, including enabling the firing console. Personnel access is prohibited from areas of x-ray flux by fences, barriers, and interlocked access doors and gates. The interferometer room is also interlocked. Equipment is electrically isolated from the shot assembly until personnel are under cover. A muster or positive accounting is used for control of personnel access to the test area.

Personnel are not allowed to enter the firing chamber after a shot until specific conditions are met, including waiting for a specified period of time in case of malfunction or misfire. Re-entry into the firing chamber is allowed after the chamber ventilation has purged hazardous atmospheres. Personnel use personal protective equipment that is appropriate to the exposure potential of the hazardous materials in the chamber.

Generated Wastes and Effluents

The containment chamber is equipped with a portable, manually operated water washdown system that uses an articulating nozzle. This system washes detonation residue that may contain radioactive materials, such as depleted uranium, or hazardous contaminants, such as beryllium, from the firing chamber walls and floor. A manually operated hose and a high-pressure washer are also used, when necessary, to complete the cleanup process. The washdown water from the chamber is diverted to a 20,000-gallon holding tank, filtered, and reused. However, if it becomes necessary to dispose of the washdown water stored in the holding tank, the water would be sampled and transferred to the Livermore Site for discharge to the sanitary sewer if parameters are within acceptable limits. If not, the water would be transferred to an RHWM facility for appropriate disposal. Other wastewater, including photographic wastewater and water generated from a protective clothing washing process, would be handled in a similar manner that could include transferring the water to the Site 300 Class II surface impoundments.

Tritium has contaminated the firing chambers in the past and will be a contaminant in the future. The hazardous wastes generated from the photo-processing operations, the flash x-ray, and the interferometry operations include solvents, lubricating fluids, dielectric fluids, and photographic wastes. These nonradioactive wastes are temporarily stored in the workplace WAA and transferred to an RHWM facility for treatment and/or disposal.

A.2.2.2 *Building 805*

Building 805, the Inert Machining and Explosives Waste Facility, is a 6,830-square-foot facility in the southeast quadrant of Site 300, known as the HE Process Area. Building 805 is used for explosives waste packaging, inspection and non-explosives machining. Building 805 is constructed of reinforced concrete (LLNL 2018q). Building 805 is used for machining metal and nonmetal parts (e.g., stainless steel, brass, plastic) and mock explosives. The packaging or repackaging of explosives waste is also performed at this facility prior to storage at the Explosives Waste Storage Facility (EWSF) or shipment to the Explosives Waste Treatment Facility (EWTF) for treatment.

Hazards Assessment

The major hazard associated with packaging and repackaging waste explosives is the possibility of detonation of the explosives by mishandling. The hazards associated with the machining process involve rotating equipment and toxic chemicals in the explosives waste and mock explosives. Building 805 meets the requirements from its DOE-approved Explosives Siting Document (latest revision). It is independent from all other facilities/complexes at Site 300. It does not share air handling, mechanical, electrical, fire protection system, or alarm system utilities with any other facility/complex at Site 300 in any manner whereby an event in one structure could impact the others. This demonstrates independence of these systems for facility segmentation purposes (LLNL 2018q).

Generated Wastes and Effluents

Wastes generated during the machining of mock explosives consist of dust. The nonhazardous dust is collected in a permitted dust collector and disposed of in the general trash.

A.2.2.3 *Building 806 Complex*

Buildings 806-A and 806-B form a 7,505-square-foot complex for contact and remote machining, disassembly, and inspection of explosives, explosive assemblies, and inert materials. Explosives are also temporarily stored at the complex. The Building 806 Complex is located in the HE Process Area in the southeast quadrant of Site 300 (LLNL 2018q).

Hazards Assessment

The major hazard associated with this complex is the detonation of explosives during the machining process. Risks also include those associated with the operation of the machinery and chemicals used in the machining process. Machining is performed both with an operator present and remotely from a control room. During remote operations, all operations personnel are alerted, fences are secured with warning lights and alarm systems, and the limited personnel present are restricted to the control room.

Generated Wastes and Effluents

The explosives machining operations in the Building 806 Complex (as well as explosives machining operations in Buildings 807 and 855, and explosives pressing operations in Buildings 809 and 817) utilize water that comes in contact with explosives. Because that water can collect particulate explosives, the water is collected and directed through filter systems in which the particulate explosives are collected, removed from the water, and drained to a retention tank. (LLNL 2017y).

Wastes contaminated with high explosives are generated in the Building 806 Complex. The water used during the machining process is passed through two filter bags, and the trapped explosives waste is placed in plastic-lined containers for storage and treatment at the EWTF. Scrap explosive pieces are wrapped, boxed, and labeled for treatment at the EWTF and storage at the EWSF.

A.2.2.4 *Building 807*

Building 807, the HE Machining Facility, is part of the Site 300 HE Process Area. Building 807 is used for activities similar to those of the Building 806 Complex. This 1,575-square-foot facility, however, is also used to machine and inspect explosives parts and to decontaminate potentially contaminated equipment. There are explosives service vaults in Building 807 and explosives parts are also temporarily stored at the facility (LLNL 2018q).

Hazards Assessment

The major hazard associated with this facility is the detonation of the explosives during the machining process. Risks also include those from the rotation of the machinery and chemicals used in the machining process. Machining is performed both with an operator present and remotely from a control room. During remote operations, all operations personnel are alerted, fences are secured with warning lights and alarm systems, and the limited personnel present are restricted to the control room (LLNL 2018q).

Generated Wastes and Effluents

Building 807 generates wastes contaminated with high explosives. Wastes are managed in the same manner as discussed above for the Building 806 Complex.

A.2.2.5 *Building 809 Complex*

The Building 809 Complex, HE Pressing and Oven Facility, is located in the HE Process Area and is used for preparing and isostatic pressing of bulk explosives and mock explosives. This 3,794-square-foot complex consists of Buildings 809A, 809B, 809C, and Magazine M10 for the storage of explosives. Building 809A contains an Autoclave 25-inch isostatic press, control room, and office space; Building 809B contains support utilities; and Building 809C contains the oven facility used for heating and annealing explosives (LLNL 2017y).

Hazards Assessment

The major hazard associated with machining explosives is the possibility of ignition from the forces involved. There are also hazards associated with high temperatures and pressures and the toxic nature of the chemicals in the explosives that present the risk of injury to personnel. Rotating equipment also presents the risk of injury to personnel. Heating and pressing of explosives are conducted remotely, under controlled temperature conditions.

Work control documents are enforced in the Building 809 Complex to ensure personnel safety. During remote operations, all personnel and the process security post operator are alerted, the gate to the area is locked, warning lights and alarm systems are activated, and the limited personnel present are restricted to the control room (LLNL 2018q).

Generated Wastes and Effluents

The Building 809 Complex generates high explosives-contaminated wastes. Explosives waste is placed in plastic-lined containers for treatment at the EWTF and storage at the EWSF.

A.2.2.6 *Building 810 Complex*

The 5,200-square-foot Building 810 Complex, HE Assembly and Storage Facility, is also located in the HE Process Area, and consists of Buildings 810A, 810B, and 810C. Buildings 810A and 810B consists of three bays and one bay, respectively, for preparing explosives charges in various configurations that include assemblies containing metal parts, as well as uranium powder, explosives, and detonators for hydrodynamic studies and other explosives operations. Building 810C is used for radiological storage (LLNL 2018q).

In 2016, the Lab proposed a change in inventory or operations beyond that authorized in existing safety-basis documents to allow up to 1 kilogram of terbium oxide to be comingled with explosives in Buildings 810 and 823 (Note: 1 kilogram is less than 1/300th of the LSI threshold for terbium oxide) (LLNL 2016i). The test components may also include beryllium, lithium, tritium, thorium, or depleted uranium.

Hazards Assessment

The major hazard associated with this complex is the detonation of the explosives by dropping or mishandling. The number of personnel is limited in these buildings (LLNL 2016i).

Generated Wastes and Effluents

The Building 810 Complex generates high explosives-contaminated wastes. Explosives waste is placed in plastic-lined containers for treatment at the EWTF and storage at the EWSF.

A.2.2.7 *Building 816, Explosive Waste Storage Facility*

The EWSF is also located in the HE Process Area and is comprised of five storage magazines (M816, M2, M3, M4 and M5) that are permitted by the California Department of Toxic Substances Control for the one-year storage of explosives hazardous waste until treatment at EWTF or off-site treatment. The storage of other hazardous, radioactive or mixed waste materials is prohibited in the EWSF (LLNL 2018q, LLNL 2017z).

Hazards Assessment

The major hazard associated with storing waste explosives at the EWSF is the possibility of detonation of the explosives through mishandling.

Generated Wastes and Effluents

The facility is used as a storage facility and does not generate any wastes.

A.2.2.8 *Building 817 Complex*

The Building 817 Complex, the High Explosives Pressing and Oven Complex Facility, is also located in the HE Process Area. The Building 817 complex is utilized for preparing and isostatic pressing of bulk explosives and mock explosives. This 3,102-square-foot complex houses laboratories, mechanical equipment areas, a control room, and storage space for the preparation and isostatic pressing of bulk explosives and mock high explosives. Building 817A is a control room and office; Building 817B is the explosives pressing facility, which includes a small shaker table and two isostatic presses; M817C is an explosives storage magazine; Building 817E is an inactive storage building; Building 817F contains the oven facility used for heating and annealing explosives; Building 817G is the boiler room; and Building 817H is for storage of mock explosives, pressing bags, and general chemicals (LLNL 2018q, LLNL 2017y).

Hazards Assessment

The major hazard at this complex is an inadvertent explosion as the result of the handling, heating, and pressing of explosives. There is also the risk of injury to personnel associated with high temperatures and pressures or the toxic chemicals in the explosives. To help minimize these risks, the heating and pressing of explosives are conducted remotely, under controlled temperature conditions. During remote operations, all personnel are alerted, the fenced area is locked, and warning lights and alarm systems are activated. Operating personnel are limited in number and restricted to the control room during remote operations. Explosives are permitted only in approved and posted areas, and an insulated cart is used to transfer hot material from the oven and pressing operations. The work areas are frequently washed, and equipment, tools, fixtures, and other parts that may have become contaminated are decontaminated. Safety protocol and procedural documentation are used to ensure personnel safety.

Generated Wastes and Effluents

The Building 817 Complex generates high explosives-contaminated wastes. Explosives waste is placed in plastic-lined containers for treatment at the EWTF and storage at the EWSF.

A.2.2.9 *Building 823 Complex*

The Building 823 Complex ("LINAC Radiography") is used for radiographing controlled materials. The activities include receipt and handling of explosives, maintenance and operations of RGDs, maintenance and operation of film-processing equipment, and operation of the various support equipment and other support systems (LLNL 2017y). The Building 823 Complex is a 2,748-square-foot facility in the southeast quadrant of Site 300 and consists of two buildings. Building 823A contains office space, a darkroom with a radiographic film processor, and control panels for three real-time imaging systems housed in Building 823B. These units include three x-ray machines: a transportable 9-MeV, a 2-MeV, and a 120,000-electron-volt. Building 823B contains staging and real-time imaging systems. This complex provides the means for radiographic inspection of pressed explosives parts and weapon test components. After x-ray film has been exposed in Building 823B, it is processed through the automatic film processor in Building 823A. The authorized materials in this facility include explosives, natural and depleted uranium, and beryllium in metallic form. Fissile materials currently are not allowed at Site 300 except with documented approval by Site 300 management.

Building 823B has an earthen berm on two sides that provides radiation shielding for the office/control building located east of the berm. The Varian 9-MeV LINAC is used in Building 823B to beam into the open space directly to the west.

Hazards Assessment

The potential hazards in the Building 823 Complex arise primarily from the levels of radiation associated with the generated x-ray beam; the high voltages associated with the power supplies; and the handling of test units containing explosive, radioactive, or toxic materials. Explosives in powder form are not permitted at this facility, and explosives are not permitted at the facility when fissile materials are present. The number of personnel is limited to five when explosives are present. Protection from inadvertent exposure to x-radiation is provided by physical barriers, warning lights and chimes, safety interlocks, signs, and remote area monitoring. Before starting an x-ray operation, all personnel evacuate the fenced enclosures. A remote area monitor in the complex, which indicates radiation levels on a local readout meter and on a duplicate meter in the control room, activates the warning lights and chimes when radiation levels become high. Flashing magenta lights and pulsed chimes indicate an x-ray exposure is in progress. No one is allowed to enter the area at that time. The operating area is enclosed by a safety fence, and all gates are locked during operation of the machine.

Generated Wastes and Effluents

The wastes generated from this facility include photo-chemicals, spent fixers and developer, and photo-chemical rinse-waters. The photo-chemical rinse-waters are stored in retention tanks and pumped to the surface impoundment. The spent fixers and developers are handled by the materials management group and taken to the Livermore Site for silver recovery.

A.2.2.10 *Buildings 825, 826, and Building 827 Complex*

Buildings 825 and 826 and the Building 827 Complex comprise the Chemistry Control and Process Facility Area Complex (Chemistry Area), which is used for processing, developing, and testing explosives. As a pilot-plant scale-up facility for explosives, Chemistry Area operations include:

- Small-scale development;
- Explosives processes scale-up;
- Synthesis;
- Processes to plasticize explosives (slurry coating);
- Preparation of injection-moldable explosives;
- Mechanical pressing;
- Heating of explosives;
- Melt casting;
- Loading of explosives or propellants;
- Hand-packing or forming uncased plastic explosives;
- Certain assembly operations; and
- Accelerated aging and characterization of explosives and mock formulations (LLNL 2017t).

Other activities include inert operations related to mock explosive manufacture and other nonexplosive general chemistry activities including binder research, synthesis, and particle size analysis (LLNL 2017t).

Buildings 825 and 826 are in the southeast quadrant of Site 300 and have areas of 1,547 square feet and 1,547 square feet, respectively. The Building 827 Complex, consisting of Buildings 827A, B, C, D, and E, with office, laboratory, and storage areas, is located in the south-central section of Site 300. The Chemistry Area also includes Magazines M33, M36, and M51; Magazettes M825-1, M825-2, M825-3, M826-1a, and M826-1b; and associated equipment chemical storage lockers and retention tank systems (LLNL 2017t).

Building 825 is a newly renovated building and houses mechanical presses for pressing explosives as well as mechanical property testing equipment. There are thermal chambers in 825 for heating and annealing explosives for the pressing operation. Building 826 houses five temperature control chambers for material compatibility and aging studies. (LLNL 2017t).

The Building 827 Complex consists of Buildings 827A/B/C/D/E. Building 827A contains offices, a control room, and a small-scale explosives cell. Building 827B contains a machine shop and inert storage area. Buildings 827C/D/E are identical buildings, each containing two explosives operating cells, an equipment room, an inert storage area, and a temporary explosives storage vault. The complex also contains three electrically heated ovens for drying materials; small ball mills for reducing particle size; and a 50-pound deaerator loader for processing extrudable explosives, blenders, slurry kettles for preparing explosives, and slurry-coating equipment. Equipment also includes an environmental chamber and associated control and interlock modules, electrical resistance measurement devices, a gas sampling oven, a laser particle-size analyzer, and a computer system (LLNL 2017t).

Hazards Assessment

Hazards associated with these facilities include the detonation of explosives powder during the pressing/handling process and exposure to the toxics effects through the inhalation of dusts or vapors and absorption by skin contact or ingestion. Pressing explosives, balling milling, and large-scale chemical synthesis are conducted remotely. During remote operations, all personnel are alerted. Hazards also are associated with handling explosives, propellants, pyrotechnics, and oxidizers and burning or detonating materials through impact, frictional heat, shock, electrical arcs, or sparks from static electricity. Hazards also include those associated with a small, enclosed laser. There are no radioactive materials stored in the Chemistry Area (LLNL 2017t).

Mixing and loading of the explosives is conducted in-person and remotely depending upon the requirements. The fenced area around the building is locked, and warning lights and alarm systems are activated. Operating personnel are restricted to Buildings 827A or 827B. Safety documentation, including work control documents and the facility safety plans, is used to help ensure personnel safety. To limit the exposure of personnel to injury from accidental blast or fragments, the number of personnel present or exposed during an explosive operation is limited to the personnel limits listed in Table A-4. Personnel limits for an explosives area apply only when explosives are present in the area. Signs shall be posted at prominent locations in or near each explosives work or storage area listing the maximum number of personnel (explosives handlers) and casuals (*see* Note b in Table A-4) allowable at any time (LLNL 2017t).

Table A-4. Buildings and Magazines – Personnel Limits[a]

Building	Room	Workers (explosive handlers)	Casuals[b]
825	102	2	1
	108	2	1
826	102	3	2
	108	3	2
827A	102	3	2
827C	101	6	4
	103	3	1

Building	Room	Workers (explosive handlers)	Casuals[b]
	105	6	4
827D	101	6	4
	103	3	1
	105	6	4
	105A	6	4
827E	101	3	2
	103	3	1
	105	3	2
Magazines	All[c]	2	1

a. Personnel limits apply only when explosives are present in the noted area. Areas not listed do not have personnel limits.
b. A casual is a person, other than a worker (Explosives Handler), who intermittently visits an explosives operation to supervise, inspect, and maintain.
c. Includes Magazines M33, M36, and M51; Magazettes M825-1, M825-2, M825-3, M826-1a, and M826-1b.
Source: LLNL 2017t.

Generated Wastes and Effluents

The Chemistry Area generates wastes contaminated with high explosives. The explosives-contaminated trash is placed in plastic-lined containers for treatment at the EWTF and storage at the EWSF. Typical wastes include alkaline and acid solutions such as lab-packed solutions; lab-packed waste chemicals; nonhalogenated organic solutions; empty containers; debris, such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, wood and metal parts, and HEPA filters contaminated with explosives and other hazardous constituents; wastewater; residues; metals; flammable liquids; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; and contaminated equipment (LLNL 2017t).

Water used in the cleanup passes through two bag filters that trap the explosives waste. The waste is placed in plastic-lined containers for treatment at the EWTF and storage at the EWSF. The filtered water is collected in a retention tank where it is sampled prior to being trucked to the permitted surface impoundment or offsite. The suspended solids collected in the filter are stored for future use as product in R&D work (LLNL 2017t).

A.2.2.11 *Building 832 Complex*

The Building 832 Complex is in the southeast quadrant of Site 300 and consists of buildings labeled 832A/C/E and OSM832B/D, two explosives magazettes designated M-832-1 and M-832-2, and the explosives vehicle inspection station, for a total gross area of 2,456 square feet. The Building 832 Complex is the central explosives materials shipping and receiving facility for LLNL and the facility for shipping and receiving other controlled materials at Site 300.

- Building 832A is used for storage of non-explosive controlled chemical and radioactive materials required by the program. Explosives and other hazardous materials are not permitted in the building.
- Building 832B is a staging area for controlled chemical and radioactive materials, explosives, or assemblies; the assemblies may contain controlled chemicals and/or radioactive materials. Long-term storage is not allowed in Building 832B.

- B832C is used for shipping, receiving, and storage of non-explosive controlled chemical and radioactive materials required by the program. Explosives and other hazardous materials are not permitted in the building.

- Building 832D is used for shipping and receiving of controlled chemical and radioactive materials, explosives, or assemblies; the assemblies may contain controlled chemical and/or radioactive materials. Interim storage is permitted in Building 832D to complete shipping and receiving operations.

- Building 832E is used for administrative activities and includes office space and shipping, receiving, and storage of non-explosive controlled chemicals. Most of these buildings were constructed in 1957. Building 832E was constructed in 1981.

- Magazettes M832-1 and M832-2 are 4-foot x 5-foot x 6-foot explosives storage enclosures that are comprised of reinforced concrete standing on a concrete pad. The storage space is a 3-foot cube with a metal door at the front. These are free standing and have no earth covering. There are no service utilities to these magazettes. Each magazette has a 1-foot-thick concrete blast wall set on the slab, 4-feet from the front of the magazette that is 5 feet wide and 6 feet tall. The structures provide Faraday cage-like lightning protection to the contents (LLNL 2018q).

The explosives vehicle inspection station is used to inspect incoming commercial explosives transport vehicles prior to entering the Building 832 Complex. Explosives loading, unloading, and transloading are permitted at the explosives vehicle inspection station.

Hazards Assessment

The primary hazards associated with the Building 832 Complex include exposure to explosives; toxic, reactive, pyrophoric, and carcinogenic materials; and ionizing and non-ionizing radiation. Activities within this complex are controlled by facility and operation safety plans. All work with radioactive or toxic materials conforms to established health and safety guidelines. Safety features include alarms and warning signs. The cell doors are secured by combination locks and are alarmed. Access to these facilities is limited to authorized personnel.

Generated Wastes and Effluents

The 832 Complex is used primarily for shipping and receiving explosives and other controlled materials. No hazardous wastes or effluents are generated during normal facility operations. The quantity of waste generated is less than 1 cubic meter per year.

A.2.2.12 *Building 834 Complex*

The Building 834 Complex is in the eastern area of Site 300. The Building 834 Complex is primarily used for the thermal testing (cycling, shocking, and soaking) of test specimens that may contain explosives, radioactive, or toxic materials and mock high explosives (Buildings 834E and 834H). During testing, a component is exposed to a given temperature for a specified time. The component may be cycled between cold and hot temperatures for hours or days and may be thermally shocked by introducing hot or cold air over the specimen (LLNL 2017u).

The Building 834 Complex consists of: (1) Control building 834A is approved for occasional use of a portable 9-MeV LINAC; (2) Storage buildings 834B/C/D and J; (3) Test buildings 834E/G and H, also known as test cells; (4) Magazine M834M; and (5) Buildings 834F and L are currently being modified for new capabilities (thermal testing and manufacturing, respectively). Arrayed around these buildings are large earth barricades (berms). These barricades are intended to prevent blast wave fragments from traveling in a straight line toward the control building area or toward adjacent buildings should an accidental detonation occur. The control building and the mechanical equipment buildings are designed to withstand accidental detonation of explosives in the test cells. A vehicle and personnel access driveway connects each test building entrance with Buildings 834B/C/D, and the B834A control building entrance (LLNL 2018q, LLNL 2017u).

The functions at Building Complex 834 (and Building 836 Complex, *see* below) are proposed for replacement by the Weapons Environmental Testing Replacement Capability (*see* Section 3.3.1.3 in Chapter 3 of this SWEIS). Building 834E has been recapitalized and is a thermal testing facility, and the remainder of facilities in the Building 834 Complex (7,707 gross square feet) would undergo decontamination, decommissioning, and demolition (DD&D) in 2031 (see Table 3-6 in Chapter 3 of this SWEIS).

Hazards Assessment

A variety of materials and equipment are tested in Building 834 Complex. Authorized materials used include high explosives, mock explosives, depleted uranium, thorium, lithium, and beryllium in metallic form. All operations in the Building 834 Complex are controlled by a facility safety plan (LLNL 2017u). The plan ensures that explosives and explosives-contaminated materials are permitted only in test cells. No drilling, machining, sawing, or sanding of explosives and no operation requiring blending or mixing of explosives with other materials such as plastics, binders, adhesives, or metal dusts is permitted. Hazards also include those associated with the occasional use of a portable LINAC unit. Safety features in this complex include alarms and warning signs. The cell doors are secured by combination locks and have alarms. Access to these facilities is limited to authorized personnel.

Generated Wastes and Effluents

The Building 834 Complex is used primarily as a test facility, and there are no hazardous wastes generated. Occasionally, scrap and solid waste are left after testing is completed. The quantity of solid waste generated is less than 1 cubic meter per year.

A.2.2.13 *Building 836 Complex*

The B836 Dynamic Test Complex is in the eastern area of Site 300 and consists of a control building (Control Building 836A), two dynamic test buildings (Buildings 836C and D), and a mechanical equipment/storage building (Building 836B) (LLNL 2018q). The complex is used for the dynamic (vibration shock) testing of specimens containing explosives, radioactive materials, and/or toxic materials. An electrodynamic shaker can be programmed by computer to perform sine and random vibration and transient pulses. These tests can be performed at various temperatures in a thermal chamber. The Building 836 Complex is approved for occasional use of a portable 9-MeV LINAC (LLNL 2012b).

Building 836C walls, roof, and floor are designed to withstand an accidental detonation of 150 pounds of TNT (equivalent). The exterior walls are reinforced, load bearing concrete 18-inch thick, with two retaining walls opening outward in front of the facility. The building is covered with earth to an approximate depth of 3 feet above the roof with a tapering overfill on three of the sides. The retaining walls provide a barrier for the earth overfill and assist in directing fragments and debris to the adjacent canyon should an accidental explosion occur within the test building. The entrance wall (northeast wall) is constructed of lightweight structural members and frangible wall panels that are designed to fail and release overpressure in the direction away from the control room in the event of an accidental large explosion. The building has a wet-pipe sprinkler system for fire suppression (LLNL 2018q).

Arrayed around Buildings 836C and 836D are large earthen barricades (berms). These barricades are intended to prevent blast wave fragments from traveling in a straight line toward the control building area or toward adjacent buildings should an accidental detonation occur. A vehicle and personnel access driveway connects the test building entrance with Buildings 836A and 836B (LLNL 2012b).

The Building 836 Complex continues to be used for testing assemblies containing explosives and non-explosives components. With approval of the Site 300 Weaponization Program Tier 3 safety-basis document in 2008, Building 836C had been downgraded to LSI and removed from the Tier 3 safety-basis document facility complex. Building 836C was reinstated to the Tier 3 safety-basis document as an LSI facility segment in 2011 (LLNL 2012b).

Explosives operations in Building 836C comply with the limits and controls in the approved site plan for Building 836C and are bounded by the accident scenarios evaluated in the Site 300 Weaponization Program Facility Tier 3 safety-basis document and associated change control forms (LLNL 2012b).

Each test cell houses a large reaction mass needed as a counterweight and its associated hardware. This equipment is used in the testing and evaluation of various weapons systems and mechanical equipment subjected to vibration and shock environments. The Building 836 Complex has also been used for shock and vibration testing of rocket motors, seismic qualification of turbine-generator sets, and performance analysis of the rock bolts used in mine-tunnel construction. All of the facilities in the Building 836 Complex are scheduled to be kept and undergo recapitalization of building systems to meet ongoing requirements (LLNL 2019r).

Hazards Assessment

The principal operation of the Building 836 Complex has been to subject assemblies to shock, vibration, or thermal tests in order to check the structural integrity and to observe and evaluate the behavior of explosives and non-explosives components. Any test involving high explosives requires a safety review by an explosives safety engineer, who factors in the type of explosives being tested, the nature of the test (mechanical or thermal), and the general test setup. Generation of explosives dust or work with bare explosives outside of the chamber is not allowed without additional reviews and controls in place (LLNL 2012b).

A variety of materials and equipment are tested in the Building 836 Complex. Authorized materials include explosives, mock high explosives, metallic beryllium, depleted uranium, thorium, and lithium hydride. During the thermal and dynamic tests, there is a possibility of putting sufficient energy into the test to detonate the explosives (LLNL 2012b).

Personnel and work control documents are in effect. Tests with a moderate to high risk of reaction are done remotely. Remote procedures are required for tests involving mechanical shock or extrusion to the explosives and when the temperature of the explosives is above 170 degrees Fahrenheit. These remote operations are controlled from a central control room, protected from blast and fragments. During dynamic testing, musters limit the areas that personnel can enter. Continuous air monitoring is used during the test operation (LLNL 2012b).

Fissile materials currently are not allowed at Site 300, except with documented approval by Site 300 management. Explosives or explosive-contaminated material are permitted only in test cells. No operation is permitted that intentionally generates explosives dust or powder or that requires blending or mixing of explosives with other materials such as plastic, binders, glues, adhesives, or metal dust. When a test cell has been flushed with nitrogen during a thermal conditioning test, the air within the facility is monitored prior to allowing personnel to re-enter the facility (LLNL 2012b).

Generated Wastes and Effluents

The Building 836 Complex is used primarily for dynamic testing of equipment containing hazardous and toxic materials. Typical wastes would include alkaline and acid solutions; lab-packed waste chemicals; nonhalogenated organic solutions; empty containers; debris such as contaminated paper and rags, protective clothing, glassware, plasticware, tubing and fittings, and wood and metal parts; wastewater; residues; metals; cleaning solutions, including solvents; waste oil with trace gasoline, diesel, organics, and metals; and contaminated equipment. Occasionally, scrap and solid waste is left over when testing is completed.

A.2.2.14 *Building 845, Explosive Waste Treatment Facility*

The EWTF is a 357-square-foot facility located in the north-central section of Site 300. Explosives wastes are treated at the EWTF, which consists of three treatment areas. The EWTF is located at a point that is approximately 6,700 feet from the northernmost property line and 6,225 feet from the eastern property boundary. It consists of an Open Detonation Unit (ODU), two Open Burn Units (OBUs), and a decontamination pad. The OBUs and the ODU use a common control bunker, B845-A, an existing building that has been modified and outfitted with the control systems to remotely operate and monitor both the ODU and OBUs. B845-A is located below and down gradient of the ODU. Remote ignition and initiation capability are provided for the respective units. The EWTF is permitted under a hazardous waste permit issued by the California Department of Toxic Substance Control for the treatment of explosives waste. Treatment of other hazardous, radioactive, or mixed waste materials is prohibited at this facility (LLNL 2018q, LLNL 2017z).

The Open Burn area is located approximately 690 feet north-northeast of B845-A. Treatment units consist of the burn pan, decontamination pad, and burn cage. The support area of the Open Burn area contains Building 845-B, the equipment storage building, a self-contained container storage unit (five 55-gal. drum capacity), magazette, propane tank, and utilities. Building 845-B stores the combustible materials used to initiate burning operations. The magazette storage structure is specially designed for the storage of explosives, such as squibs, blasting caps, and other initiators but is non-operational. The support area is separated from the burn pan, decontamination pad and burn cage by an earthen barricade. The open detonation pad is approximately 128 feet from B845-A. The open detonation pad is an open gravel pad designed to preclude transmission of ground shock to the control bunker, B845-A (LLNL 2018q, LLNL 2017z).

Hazards Assessment

The main hazard associated with treating waste explosives is the possibility of detonation by mishandling. Personnel are limited in number and operations are conducted remotely. During operations, personnel are restricted to the control room, fencing is secured, and warning lights and the alarm system are activated appropriately.

Generated Wastes and Effluents

Ash resulting from the burning of explosives waste in the thermal treatment cage and open burn unit is collected, weighed, and stored in an approved storage area within the facility. The ash is hazardous and is shipped off site for proper disposal.

A.2.2.15 *Building 850 Complex*

The Building 850 Complex is a training and testing facility. This 5,095-square-foot complex consists of Bunker 850 and a magazine in the northwest quadrant of Site 300 and previously contained a firing, explosives test, and high-speed camera repair and test facility. Building 850 will also serve in the future as LLNL's auxiliary facility continuity of operations. If appropriate, mitigation methods are utilized to avoid any soil or groundwater contamination.

The facility would be revitalized, which would involve utility upgrades/replacements, including the electrical, water, sanitary, and septic systems. The work involves reconnecting the electrical, water, and sanitary septic systems in year one of the construction changes. The sanitary septic system would need to be replaced, requiring a permit from San Joaquin County. The surface soil and subsurface soil in this area have been remediated, and the integrity of the remedy in this area (consolidated and solidified soil) would continue to be protected. After the revitalization portion of this project, the facility would support LLNL programs, which may include small-scale explosives experiments, counterterrorism, counter proliferation, training area, continuity of operations facility, and classified communications area. The projects would involve the use of HE, shaped charges, projectiles, directed energy, and propellant deflagration. Various types of radiography would also be conducted (LLNL 2021b).

Hazards Assessment

Building 850 would be a radiological facility and would remain below HC-3 thresholds. The facility would have small quantities of chemicals (including metallics, acids and bases), BSL-1 biologicals, and radiological materials as a low hazard/radiological facility. The facility would use Category 3 and 4 lasers and RGD hazards. Small quantities of sealed sources would also be present in Building 850 (LLNL 2021b).

Generated Wastes and Effluents

Waste generated from the facility and firing table would include solid wastes, hazardous waste, HE wastes, radiological low-level and mixed waste, and wipe cleaning wastes. Low level (BSL 1) biological waste would be handled according to standard laboratory procedures (LLNL 2021b).

A.2.2.16 *Building 851 Complex*

The Building 851 Complex is a 13,176-square-foot facility in the northwest quadrant of Site 300. It is a firing complex that consists of two reinforced concrete structures (Building B851A and magazettes M851-1 and M851-2). Building 851A is a bunker constructed of reinforced concrete, which is adjacent to and below the level of the firing table. The flat concrete roof of the bunker has an overlying layer of pea gravel 2 to 5-feet deep. Conduits through the roof of the bunker carry electrical signal cables to and from the assembly and diagnostics on the firing table. The level area of the firing table is surrounded on at least three sides with a hillside or a high earth berm. Building 851A has pneumatically controlled blast dampers on the ventilation air intakes. The dampers are closed before firing to prevent pressure wave, dust, and debris from entering the ventilating system. The dampers are interlocked so that firing cannot take place when they are open (LLNL 2018q).

The second story is a long, narrow, reinforced concrete building with one end, called the bullnose, protruding into the firing table. The building is oriented behind the bullnose, away from the firing table. The bullnose is constructed of heavily steel-reinforced concrete and steel weldments faced with alternate layers of steel and plywood plates. They can withstand the full force of the maximum permitted blasts without appreciable damage. The bullnose is fitted with heavy metal radiation-collimating materials and other lighter materials that allow the x-rays to be transmitted but prevent shrapnel from penetrating the building (LLNL 2018q).

Building 851A was built in 1958. Major modifications added to it were a laser room, a diagnostics corridor, and increased area in the camera room in 1984. In 1997, the dirt fill was removed from an area to create the portable equipment x-ray room. The firing area is an open-air firing position located above and to the rear of B851A. Explosives experiments are conducted on the bunker's gravel firing table. This multi-diagnostic facility includes high-speed rotating mirror cameras, photodoplar velocimetry, and various other diagnostics equipment (LLNL 2018q).

Building 851A has a high-speed camera room that is fitted with an exhaust system for the camera rotor-drive turbines. The system exhausts the camera rotor-drive gas (helium or nitrogen) through HEPA filters to prevent possible contamination of the air by beryllium in the event a rotor disintegrates. Due to the high-volume discharge of inert gas during operation, the oxygen concentration of the high-speed camera rooms is continuously monitored when cameras are operating (LLNL 2018q).

Since approximately the mid-1980s, the Building 851 Complex was used for conventional high explosives shots. In 2013, LLNL proposed removing the LINAC from Building 851A and pursuing other modifications to the facility. In 2016, the remaining equipment of the original LINAC was removed.

Hazards Assessment

The common hazards associated with the firing facilities are handling and firing explosives, high voltages, toxic and radioactive materials, high levels of ionizing radiation, firing malfunctions and misfires, grass fires, lasers, cranes and machine tools, and high-pressure systems. The hazards associated with the photo-processing operations are laboratory reagents; photo-chemicals; and chemicals in spent developers, fixers, and rinse-waters. When film is processed, the developers and fixers are automatically replenished, and the generated waste is captured in separate barrels. The hazard associated with the high-speed photographic equipment is use of high-speed rotors. Some camera rotors are made of beryllium; if these rotors are allowed to revolve at too high of a speed, they will come apart, causing damage and scattering parts of the beryllium rotor around the camera room.

Formal work control documents have been prepared for the facility as a whole; these are supplemented for the unique requirements of individual tests and reviewed by the Hazards Control Department. All explosives are handled, transported, and test-fired following these plans. All work with radioactive materials and toxic materials conforms to established health and safety guidelines. Additional restrictions are imposed during the grass fire season.

Personnel safety is enhanced by positive key control of the various phases and aspects of the operation, including enabling of the firing console. Personnel are excluded from areas of x-ray flux by fences, barriers, and interlocked access doors and gates. The interferometer room is also interlocked. Equipment is electrically isolated from the shot assembly until personnel are under cover. A muster is used for positive control of personnel access to the test area.

Following a shot, personnel are not allowed to enter the firing table area until specific conditions are met, including waiting for a prescribed period of time in case of malfunction or misfire. Appropriate personal protective equipment is used to re-enter the firing table after experiments involving hazardous materials. Water may be used to extinguish fires on the table and minimize dust production.

Generated Wastes and Effluents

The firing table debris consists of gravel and fragments of wood, metal, and glass. Larger debris consists of tent poles, wood, steel, aluminum, concrete, plastic, glass, burlap bags, cables, and other inert testing materials. These wastes may be contaminated with lead, copper, barium, and vanadium, along with toxic or low-level radioactive materials.

The firing table debris is characterized to separate the LLW from chemically hazardous waste. The former is placed in containers and transported to the Building 804 waste staging area. All hazardous wastes (nonexplosive-contaminated) are transported to Building 883 for storage prior to shipment to the Livermore Site for treatment or to offsite disposal facilities.

A.2.2.17 *Building 855 Complex*

The Building 855 Complex is used for contact and remote machining explosives. Building 855A is the control room and Building 855B is a support building. Building 855C is utilized for the machining, fabrication, and inspection of explosives and inert materials. Workers use lathes, saws, and milling machines in the facilities (LLNL 2018q). The complex, which is located in the HE Process Area in the southeast quadrant of Site 300, is 1,916 gross square feet.

Hazard Assessment

Work control documents at the Building 855 Complex are in place to ensure safe operations and to protect workers and the public from the hazards normally associated with LSI operations. Operations include both remote and contact machining. Operational limits are in place for the amount of explosives at risk allowed in the Building 855 Complex, which are classified as Class II, Division I, under the National Electrical Code.

Generated Waste and Effluents

Building 855 generates wastes contaminated with high explosives. The explosives machining operations in the Building 855 Complex utilize water that comes into contact with explosives, and the water can collect particulate explosives. This water is collected and directed through filter systems to remove the particulate explosives, and then drains to a retention tank. The suspended solids collected in the filter are stored for future use in R&D work (LLNL 2017y).

A.2.2.18 *Explosives Storage Magazines*

All explosives at Site 300 are stored in vaults or bunkers called magazines. There are about 60 magazines located throughout the site, with floor areas typically ranging from 50 to 500 square feet. A magazine is defined as an approved structure specifically designed for the storage of explosives, excluding operating buildings. A storage magazine is used for the long-term storage of bulk explosives and assemblies. A service or ready magazine is used for short-term (maximum of 180 days) storage of explosives and assemblies currently being used in an operation. Magazettes, small magazines (not large enough for an entry), are used to store explosives that require separate storage. In addition to these storage magazines, a laboratory or building may contain a storage vault, which is typically a locked room or cabinet, for short-term storage of explosives that are currently being used in the operations.

Hazards Assessment

Proper packaging, explosives deterioration, and chemical compatibility are the major areas of safety concern. Packaging is monitored by periodic inspection of the magazines. Compatibility problems are controlled by assignment of explosives into storage compatibility groups, and the storage review program is designed to control the use of explosives that have deteriorated.

Each magazine has an associated weight limit, and the weight limit signs are posted near the entrance to the magazine. An inventory record is kept for each magazine and reflects the actual weight stored in the magazine. Storage magazines are inventoried once every 6 months and service magazines are inventoried every 3 months to verify that the weight of their contents is equal to or less than the posted weight limits.

The safety and operational controls are described below:

- Explosive assembly components are the only materials stored in the magazines.

- Propellants containing nitrocellulose vary widely with respect to stability, and the decomposition of some may lead to incidents of spontaneous ignition. There is a special surveillance system program for these propellants. One sample from each lot or batch is designated as a control item and is inspected annually. Deteriorated propellants are sent to disposal.
- Explosives devices, such as actuators, detonators, squibs, and ammunition, are never retained beyond the manufacturer's recommended shelf life.
- No smoking is permitted in the magazine area out to a distance of 50 feet.
- Most magazines are vented. Some magazines may require air conditioning or special ventilation systems to reduce deterioration of explosives due to hot, stagnant conditions. For safety reasons, air conditioning is also used in some instances to prevent overheating.
- Empty explosives containers must be marked as empty but may not be removed from the magazines. Packaging materials, such as wood and paper, are handled as explosives contaminated waste and are removed from the magazine.
- The magazine areas are equipped with emergency telephones. There are posted personnel limits for each magazine area and only qualified personnel are allowed.

Generated Wastes and Effluents

The magazines are used for storage of explosives and explosive assemblies and do not generate explosives wastes. Only small quantities of packaging materials are handled as explosives contaminated wastes.

Table A-5. Overview of Remaining Facilities at Site 300

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
801B	Technical Maintenance Shop	790			Yes		
801D	Administration	4,686	Yes				
802A	Camera Test Facility (optic lab – inactive)	2,934	Shutdown				
803	ES&H Storage/Warehouse	1,484				Yes	
804	Low-Level Waste Staging Area	107				Yes	
806C	Machining Storage	640				Yes	
806D	Machining Storage	192				Yes	
811	Storage	1,006				Yes	
812A	Firing Facility Support	2,656	Shutdown				
812D	Camera Room	325	Shutdown				
812E	Storage Facility	1,310				Yes	
813	Change House	2,822	Yes		Yes		
U815	Central Air Plant	1,219				Yes	
817D	HE Pressing Storage	207				Yes	
818A	HE Storage Facility	1,244				Yes	
818C	HE Storage Facility	578				Yes	
819	O&B Storage/Crafts	828			Yes	Yes	
821	Chemistry Storage	650				Yes	

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
824	HE Storage Facility	300				Yes	
828A/B/C	HE Machining/Thermal Test	683	Shutdown				
830	PE Maintenance	1,735	Shutdown				
833	ERD Service-R&D	1,851	Yes	Yes		Yes	
834B/C/D/G/J	Thermal Test	3,821	Shutdown				
835	ERD Storage	1,196				Yes	
837	Security Directorate Storage Facility	12,426				Yes	
841	Pesticide Storage – C&M Shop	1,680				Yes	
U842	Communication Hut	458			Yes		
843A	ERD Corp Yard	486			Yes	Yes	
843B	Machine Shop	402			Yes		
U844	Booster 1 (water)	374			Yes		
U846	Central Power Substation	497			Yes		
U847	Booster 2 (water)	292			Yes		
848	Weather Station	765	Shutdown				
U849	Communication Radio	-			Yes		
U853	Booster 3 (water)	292			Yes		
854A	Control Room	2,458		Yes			
856	Industrial Storage	1,484	Shutdown				
OS858	Drop Tower Complex	2,420		Yes		Yes	
859	Storage	1,484				Yes	
860	Storage	313				Yes	
865	Advanced Test Accelerator	64,731	Standby				
U866	Communications Hut	610			Yes		
867	Bunker Support Facility	4,342				Yes	
869	Maintenance Shop Storage	358				Yes	
870	ERD Facility	3,890	Yes		Yes	Yes	
871	Administration	7,895	Yes				
872	O&B Paint Shop	1,925	Yes		Yes		
873	O&B Crafts	17,447	Yes		Yes		
874	Mechanical Shops	19,231	Yes	Yes	Yes	Yes	
875	O&B Supply & Maintenance	14,903	Yes		Yes		
876	Stores & Reclamation	2,400				Yes	
877	Computer Technical Support	3,352	Yes		Yes		
878	O&B Maintenance Shop Storage	440				Yes	
879	Motor Pool & Garage	2,797	Yes		Yes		
880	Cafeteria	2,759	Shutdown				
882	Communication Center	4,912	Yes		Yes		
OS883	RHWM Facility	3,283			Yes	Yes	

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
U887	Water Well	144			Yes		
U888	Water Well	70			Yes		
889	Medical Facility	2,719	Yes		Yes		
890	Fire Station	6,752	Yes		Yes		
OS891	Main Gate Kiosk	50					Yes
892	Central Control Post	884	Yes		Yes		
OS894	Process Area Post	143					Yes
895	EFA Office	363	Yes				
OS896A	East Observation Post	33					Yes
OS897	West Control Post	293					Yes
OS898	West Observation Post	411					Yes
899A/B	Small Firearms Training Facility	3,200	Yes		Yes		Yes
8340	ERD Service TF834 Monitoring	273		Yes			
8724	Offices	322	Shutdown				
8726	ERD Offices	1,000	Shutdown				
8825	Shower Facility	370					Yes
8826	Security Fitness Facility	943					Yes
Storage Magazines							
M1	Magazine - Storage Vault	386				Yes	
M7	Magazine - Storage Vault	386				Yes	
M8	Magazine - Storage Vault	386				Yes	
M10	Magazine - Storage Vault	120				Yes	
M15	Magazine	120				Yes	
M21	Magazine - Storage Vault	425				Yes	
M22	Magazine - Storage Vault	425				Yes	
M23	Magazine - Storage Vault	427				Yes	
M24	Magazine - Storage Vault	67				Yes	
M30	Magazine - Storage Vault	386				Yes	
M31	Magazine - Storage Vault	386				Yes	
M32	Magazine - Storage Vault	386				Yes	
M33	Magazine - Vault	139				Yes	
OSM34	Magazine - HE Cubical	52				Yes	
M35	Magazine - Storage Vault	386				Yes	
M36	Magazine - Storage Vault	386				Yes	
OSM37	Magazine - HE Cubical	52				Yes	
M38	Magazine - Storage Vault	751				Yes	
M41	Magazine - Storage Vault	751				Yes	
M51	Magazine - Vault	138				Yes	
M52	Magazine - Storage Vault	492				Yes	
M58	Magazine	NA				Yes	
M70	Magazine - Storage Vault	288				Yes	
M71	Magazine - Storage Vault	138				Yes	
M72	Magazine - Storage Vault	138				Yes	
M80	Ready Vault	386				Yes	

Facility Number	Facility Name	Square Feet	Office	Laboratory/ Research	Service/ Support	Storage	Other
M82	Magazine - Storage	55				Yes	
M83	Ready Vault	373				Yes	
M817C	HE Storage	345				Yes	
818A	HE Storage Facility	1,244				Yes	
818C	HE Storage Facility	291				Yes	
824	HE Storage Facility	294				Yes	
M832B	Explosives Storage	568				Yes	
M832D	HE Shipping and Receiving	1,690			Yes	Yes	
834M	Thermal Test Facility	1,690				Yes	
M854H	Magazine – Storage Vault	3,205				Yes	
M854V	Storage	500				Yes	

ERD = Environmental Restoration Division; EWSF = explosives waste storage facility; HE = high explosive; NNSA = National Nuclear Security Administration; R&D = research and development.

A.3 Major Site-Wide Changes at LLNL since Publication of the 2005 SWEIS

The Proposed Action in the 2005 LLNL SWEIS continued the ongoing support of major DOE/NNSA programs, and the continued construction and subsequent operation of major facilities including the NIF, BSL-3 Facility, and the Terascale Simulation Facility (TSF). In addition, the Proposed Action included a number of programmatic and facility enhancements, including use of other materials in NIF experiments (including plutonium, other fissile materials, fissionable materials, and lithium hydride), an increase in the administrative limit for plutonium in the Superblock, an increase in the administrative limit for tritium in the Tritium Facility, and other proposed changes. On November 29, 2005, NNSA issued a ROD in the *Federal Register* (70 FR 71491; 2005 ROD), announcing the decision to implement individual components of the Proposed Action over the ensuing decade. Over the past 15 years, NNSA has been implementing the 2005 LLNL SWEIS ROD, as well as other new actions addressed in appropriate NEPA documents. For example, the 2011 SA (DOE 2011) identified and evaluated the potential environmental impacts of new and modified plans, projects or operations for the 2010-2015 period as well as new information that was not available for consideration in the 2005 LLNL SWEIS. This section discusses major site-wide changes that have occurred at LLNL since publication of the 2005 LLNL SWEIS ROD.

A.3.1 Facility and Operational Changes

Major ongoing activities at LLNL are discussed in detail in SWEIS Yearbooks 2010 through 2019 and Site Annual Environmental Reports (SAER) and are incorporated by reference into this SWEIS. Those SWEIS Yearbooks and SAERs provide detailed information on Livermore Site operations during each calendar year, and specifically address the following:

- Facility or process modifications and the status of projected activities for which the 2005 SWEIS provided NEPA coverage.
- Certain other activities for which the SWEIS did not provide NEPA coverage. For these activities, the Yearbooks also identify the additional NEPA documentation (i.e., Categorical Exclusions [CX] and Environmental Assessments [EA]) that were prepared for those activities.

- Site-wide environmental data for the year, including the number of workers, radiation doses, utility usage, air emissions, liquid effluents, and solid wastes. These data also include changes in other resources for which the DOE/NNSA has long-term stewardship responsibilities.

- Presentation of SWEIS mitigation measures and updates of mitigation measures.

The major projects addressed in the 2005 LLNL SWEIS (including the No Action Alternative) are listed in Table A-6. That table also identifies the relevant NEPA compliance documentation. The current status of new projects and modifications in site operations evaluated in the 2011 SA are presented in Table A-7. If further NEPA review has been performed in relation to the 2011 SA proposed projects, it is also noted in Table A-8. New activities not addressed in the 2005 LLNL SWEIS, along with identification of the associated NEPA documentation, are shown in Table A-8.

Table A-6. Status of Projects Identified in the 2005 LLNL SWEIS

Project Identified in SW/SPEIS	Status as of 2019	NEPA Documentation
National Ignition Facility (NIF)	Facility complete	SSM PEIS, Supplement Analyses (SA) to SSM PEIS, and NIF Supplemental EIS
Biosafety Level 3 (BSL-3) Facility	Completed	EA, FONSI
Terascale Simulation Facility (TSF)	Completed	EA, FONSI
Superblock Stockpile Stewardship Program Operations	Completed	SSM PEIS, 2005 SW/SPEIS ROD, 2008 Complex Transformation SPEIS
Container Security Testing Facility	Cancelled	Categorical Exclusion
East Avenue Security Upgrade	Completed	EA, FONSI
Central Cafeteria Replacement	Completed	Categorical Exclusion
International Security Research Facility	Completed	Categorical Exclusion
Waste Isolation Pilot Plan Mobile Vendor	Completed	Categorical Exclusion
Engineering Technology Complex Upgrade	Completed	Categorical Exclusion
Tritium Facility Modernization	Completed	Categorical Exclusion
Biosafety Laboratories	Completed	2005 SW/SPEIS ROD
Reclassify Building 446 as BSL-2 Facility	Cancelled	Categorical Exclusion
Remove and Replace Offices	Ongoing	2005 SW/SPEIS ROD
Westgate Drive Improvements	Completed	2005 SW/SPEIS ROD
Extend Fifth Street	Completed	Categorical Exclusion
Superblock Security Upgrade	Completed	Categorical Exclusion
Site Utilities Upgrade	Ongoing	2005 SW/SPEIS ROD
Protection of Real Property (roofs)	Ongoing	2005 SW/SPEIS ROD
Building 298 Roof Replacement	Ongoing	2005 SW/SPEIS ROD
Plutonium Facility ductwork replacement	Completed	Categorical Exclusion
Special Nuclear Material (SNM) tests with Optical Science Laser	Completed	2005 SW/SPEIS ROD
Use of Proposed Materials on the NIF	Completed	2005 SW/SPEIS ROD

Increased Administrative Limits for Plutonium in the Superblock	Completed – Now reduced due to deinventory of Security Category I and II SNM	2005 SW/SPEIS ROD, 2008 Complex Transformation SPEIS
Increased Material-At-Risk Limits for the Plutonium Facility	Completed	2005 SW/SPEIS ROD, 2008 Complex Transformation SPEIS, 2011 SA
Increase of Tritium Facility Material Limits	Completed	2005 SW/SPEIS ROD
NIF Neutron Spectrometer	TBD	2005 SW/SPEIS ROD
High Explosives Development Center Project (HEDC)	Project excepted from Proposed Action	2005 SW/SPEIS ROD
Energetic Material Processing Facility (EMPC)	Project excepted from Proposed Action	2005 SW/SPEIS ROD
Material Science Modernization	Ongoing	2005 SW/SPEIS ROD
Chemical and Biological Nonproliferation Program Expansion	Ongoing	2005 SW/SPEIS ROD
Petawatt Laser Prototype	Completed	2005 SW/SPEIS ROD
Consolidated Security Facility	TBD	2005 SW/SPEIS ROD
Waste Management	Completed	2005 SW/SPEIS ROD
Building 625 Waste Storage	Completed	2005 SW/SPEIS ROD
Direct Shipment of Transuranic Wastes from the Plutonium Facility	TBD	2005 SW/SPEIS ROD
Lawrence Berkeley Waste Drums	Completed	2005 SW/SPEIS ROD
Building Utilities Upgrade	Ongoing	2005 SW/SPEIS ROD
Building Seismic Upgrades	Ongoing	2005 SW/SPEIS ROD
Deactivation and D&D Projects	Ongoing	2005 SW/SPEIS ROD
Increased Administrative Limit for Highly Enriched Uranium for Building 239	Completed	2005 SW/SPEIS ROD, 2008 Complex Transformation SPEIS

Source: LLNL 2020h.

Table A-7. Status of Projects Identified in the 2011 SA for Continued Operations

Project Identified in 2011 SA for Continued Operations	Status as of 2019	NEPA Documentation
D&D of TRU legacy work stations; temporary increase in TRU waste generation	Ongoing	2011 SA
MegaRay accelerator with primary beam energies up to 750 MeV and average beam powers less than 450 Watts	Completed	2005 SW/SPEIS, 2011 SA
Modification of NIF Operational Parameters: tritium inventory 8,000 Ci; routine tritium release limit of 80 Ci/yr; maximum credible single shot yield at 120 MJ; and beryllium inventory as particulate at 1 k	Completed	2011 SA
De-inventory of Security Category I and II SNM	Completed	2008 PEIS, 2011 SA
Revision of radiological curie-limit per container in Radioactive and Hazardous Waste Management facility to be consistent with current documented safety analysis	Completed	2011 SA
Modification of fence lines and security access requirements in the northwest corner and eastside of the Livermore Site	Completed and Ongoing, Respectively	2011 SA
Applied Energy Simulation Center, a new approximately 132,000 square-foot computational and office facility	TBD	2011 SA
High-Energy Density Science Center, a new approximately 42,000 square-foot office and laboratory facility	Included in Proposed Action (*see* Table 3-4)	2011 SA
Commons/Visitor/Collaboration Center, a new approximately 25,000 square-foot facility to provide office and conference space, and a new cafeteria	Included in Proposed Action (see Table 3-4)	2011 SA
Livermore Site and Site 300 environmental restoration activities	Ongoing	2011 SA
Size-reduction and repackaging of TRU waste boxes	Ongoing	2011 SA
Facility beryllium decontamination	Ongoing	2011 SA
Livermore Site and Site 300 Programmatic Biological Assessments with a Conservation Set Aside at Site 300	Cancelled	NA
Space Consolidation Initiative to accelerate footprint reduction identified in the DOE/NNSA Complex Transformation PEIS	Ongoing	2011 SA
Revision of controlled burning practices at Site 300	Completed	2011 SA
Next phase Site 300 erosion control of several areas	Ongoing	2011 SA

Source: LLNL 2020h.

Table A-8. New Activities and Associated NEPA Documentation not in 2005 LLNL SWEIS

Project	NEPA Documentation
Construction and Operation of an Administrative and Technical Support Facility, Building 264	2004 Categorical Exclusion
Superblock Security Barriers	2004 Categorical Exclusion
Building 412 Deactivation, Decontamination, Decommissioning & Demolition	2004 Categorical Exclusion
Arroyo Mocho Road Improvement and Anadromous Fish Passage Project	2004 Categorical Exclusion
Demolition of Trailers 4181, 5928 and Building 232	2004 Categorical Exclusion
Use of a 6 MeV Portable Linatron at Various Location at Site 300	2004 Categorical Exclusion
Development of a Room-Scale Aerosol Test Facility in Building 281	2004 Categorical Exclusion
Closure of the Building 233 Container Storage Unit	2004 Categorical Exclusion
Increase to the Single Container Limit at Decontamination and Waste Treatment Facility (DWTF) from 8 Plutonium Equivalent Curies (PE-Ci) to 12 PE-Ci	2004 Categorical Exclusion
Chemical and Physical Microbial Forensics in Buildings 151, 154, 235, and 446	2004 Categorical Exclusion
Erosion Control Activities at Site 300, LLNL	2004 Categorical Exclusion
Closure of the Surface Impoundment Ponds at Site 300, LLNL	2004 Categorical Exclusion
D&D of Buildings 854B, 854C, 854D, 854E, 854F, 854G, and 854J at Site 300	2004 Categorical Exclusion
Construction and Operation of Building 583	2004 Categorical Exclusion
Water System Upgrades at Site 300	2004 Categorical Exclusion
Construction and Operation of Building 161A	2004 Categorical Exclusion
SATRN Short Air Optic Link at California Water Service Property	2005 Categorical Exclusion
D&D of Building 326	2005 Categorical Exclusion
Interim Action Request for the Demolition of Trailer 3629	2005 Categorical Exclusion
Soil Removal Project at Building 855, Site 300	2005 Categorical Exclusion
Tiger Salamander Mitigation Pond at Lower Ambrosino Pond, Site 300	2005 Categorical Exclusion
Pond at Round Valley, Site 300	2005 Categorical Exclusion
Demolition of the Lab Pool	2005 Categorical Exclusion
High-Throughput Mobile Laboratory	2005 Categorical Exclusion
Forensic Evidence Curatorial Facility	2005 Categorical Exclusion
Offsite Well Modification	2005 Categorical Exclusion
Special-status Species Protection in the Drainage Retention Basin	2005 Categorical Exclusion
SATRN Short Air Optic Link Project at Doolan Canyon Road, Livermore, CA	2005 Categorical Exclusion
Construction and Operation of Evidence Receiving and Temporary Storage Facilities in Support of the Forensic Science Center's Analyses Programs	2005 Supplement Analysis
Temporary Siting and Erecting of a Sun Collector	2006 Categorical Exclusion
D&D of Building 811 and 830 at Site 300	2006 Categorical Exclusion
Installation of E85 Fueling Station North of Building 611	2006 Categorical Exclusion
Construction and Operation of Treatment Facility B812-SCR at Site 300	2006 Categorical Exclusion
Construction and Operation of Building 178	2006 Categorical Exclusion
Characterization of Biological Materials in Building 282	2006 Categorical Exclusion
D&D of Building 377	2006 Categorical Exclusion
Proposed Environmental Remediation at the Site 300 Pit 7 Complex	2006 EA (NNSA 2006)
Long-Range Detection of Radiation Sources at Offsite Locations	2007 Categorical Exclusion
Beryllium Coating Operations in Building 153	2007 Categorical Exclusion

Project	NEPA Documentation
Offsite Emergency Response Training and Equipment Storage	2007 Categorical Exclusion
Removal of Boulders from Arroyo Mocho	2007 Categorical Exclusion
Outdoor Short-Pulse Laser Propagation Experiment	2007 Categorical Exclusion
Erosion Control Maintenance Activities at Arroyo Mocho	2008 Categorical Exclusion
B850 Soil Remediation Project, Site 300	2008 Supplement Analysis
2008 Site 300 Sediment Control Project	2008 Categorical Exclusion
Offsite Compact Proton Therapy Accelerator Development	2009 Categorical Exclusion
Lead Removal at Small Firearms Training Facility Pistol Ranges, Site 300	2009 Categorical Exclusion
Cooling Tower Cell Addition for Building 453	2009 Categorical Exclusion
Mobile Hydrogen-Fueling Station and use of Hydrogen Buses	2010 Categorical Exclusion
Building 850 Mitigation Pond (Pool BC), Site 300	2011 Categorical Exclusion
High-Pressure Cryogenic Pump and Hydrogen Filling Station	2012 Categorical Exclusion
Radiography of Explosive Samples	2012 Categorical Exclusion
M1 a and b Habitat Enhancement Project, Site 300, LLNL	2013 Categorical Exclusion
Expansion of the LLNL Mobile Analytical Laboratory Support Operations	2013 Categorical Exclusion
Experimental Detector Construction and Operation	2013 Categorical Exclusion
M2 Pool Habitat Enhancement Project, Site 300, LLNL	2013 Categorical Exclusion
Relocation of the Central General Services Area Operating Unit Misting Towers	2013 Categorical Exclusion
Vessel Burst Test, Site 300, LLNL	2014 Categorical Exclusion
Livermore Site Solar Photovoltaic (PV) Farm	2014 Categorical Exclusion
LLNL Unmanned Aircraft Systems (UAS) Testing and Operations	2015 Categorical Exclusion
Amsinckia grandiflora Recovery Efforts	2015 Categorical Exclusion
Lease for Monopole Communication Cell Tower Installation and Operation	2015 Categorical Exclusion
Ground-based Laser Field Experiments	2015 Categorical Exclusion
East Gate and Vasco Gate Kiosk Modifications	2015 Categorical Exclusion
Vessel Burst Test, Site 300	2015 Categorical Exclusion
Livermore Site Heating, Ventilation and Air Conditioning Modernization	2016 Categorical Exclusion
Construction and Operations of Security Fitness and Training Center	2016 Categorical Exclusion
Cellular Phone Service at Site 300	2016 Categorical Exclusion
Supplement Analysis for LLNL, Superblock Facilities	2017 Supplement Analysis
Building 231 Applied Materials and Engineering Facility	2017 Categorical Exclusion
Electric Vehicle Charging Station Installation and Operation	2017 Categorical Exclusion
Roof Replacements at LLNL	2017 Categorical Exclusion
Proposal to Extend Special Use Lease Agreement No. 1717	2017 Categorical Exclusion
Greenhouse Installation and Operation	2017 Categorical Exclusion
Proposed Increase in the Weight of Explosives Detonated at Lawrence Livermore National Laboratory Experimental Test Site (Site 300)	2018 EA (NNSA 2018a)
Security Surveillance Project	2017 Categorical Exclusion
Lease Office 490, L'Enfant Plaza SW Suite 2202 Washington DC	2017 Categorical Exclusion
Wood to Fuel for Transportation Sector Using Autothermal Pyrolysis	2017 Categorical Exclusion
Supplement Analysis for Exascale Computing Facility Modernization (ECFM)	2017 Supplement Analysis
Site 300 Granulated Activated Carbon (GAC) Filtration System	2017 Categorical Exclusion

Project	NEPA Documentation
D&D of Building 363 and Site Restoration	2017 Categorical Exclusion
Trailer Facilities Deconstruction, Demolition and Site Restoration	2017 Categorical Exclusion
Proposed Construction and Operation of a Water Disinfection Facility at LLNL	2018 EA (NNSA 2018b)
Security Kiosk Canopy Installation	2018 Categorical Exclusion
Remote Firing Facilities Office	2018 Categorical Exclusion
Small Firearms Training Facility Project	2018 Categorical Exclusion
Building 292 Complex Deconstruction, Demolition, and Site Restoration	2019 Categorical Exclusion
B341 BSL-2 Laboratory Conversion	2019 Categorical Exclusion
Tritium Air Monitoring Stations	2019 Categorical Exclusion
Supplement Analysis of the 2005 Site-wide Environmental Impact Statement for D&D Projects	2019 SA
Building 173 Demolition & Jupiter Laser Facility Power Conditioning Systems Upgrades	2019 Categorical Exclusion

Source: LLNL 2020h.

A.3.2 Hazard Classification of LLNL Facilities

LLNL's Integrated Safety Management System (ISMS) requires the identification, assessment, and control of hazards associated with the conduct of work. The safety analysis process formalizes this assessment and is applicable to both nuclear and nonnuclear facilities and activities. When coupled with the ISMS methods and other Requirement Source Documents (RSDs) for assuring worker safety, they assure that the impacts of LLNL operations are well understood and controlled to protect the health of workers, the public, and the environment. All nonnuclear LLNL facilities and activities are classified based on the potential for adverse health impacts to collocated workers (a worker within 100 meters from the facility being analyzed) and the public (at the site boundary) from an unmitigated release. Table A-9 identifies the hazard classification of LLNL facilities with biological, chemical, explosive, radiological, or industrial hazards. The terms "Low hazard," "Moderate hazard," and "High hazard" are used to classify nonnuclear facilities and activities. In addition, LLNL has identified another classification, termed Light Science and Industry (LSI), for facilities that are less than "Low hazard" (*see* footnotes to Table A-9).

Table A-9. Hazard Classification of LLNL Facilities

Facility Number	Facility Description	Biological Materials[a]	Chemical Classification[b]	Explosive Classification[c]	Radiological Inventory Classification[d]	RGD Classification[e]	Industrial Classification[f]
131HB	Weapons Engineering	NA[g]	LOW[h]	LSI[i]	LOW	LSI	LSI
132N	Building 132 North	LSI	LSI	LOW	LOW	LSI	LSI
132S, 134, OS135	Building 132 South, Building 134, and Other Structure 135	LSI	LSI	NA	LOW	LSI	LSI
140	International Security Research Facility	LSI	LSI	LSI	LSI	LSI	LSI
141	Engineering Tech Development	LSI	LSI	LSI	LSI	LSI	LSI
151, 152, 154	Nuclear, Analytical, and Radiochemistry Facility	LSI	LOW	LSI	LOW	LSI	LSI
153	Microfabrication Lab	LSI	LSI	NA	LSI	LSI	LSI
161	High Energy Density Physics Laboratory	NA	LSI	NA	LSI	LSI	LSI
162, 164	Crystal Growth, Machine Shop	NA	LSI	NA	LSI	NA	LSI
165	Optics/Development Lab	NA	LSI	NA	LSI	NA	LSI
166	Development Lab	NA	LSI	NA	LSI	NA	LSI
OS169	RHWM Other Structure 169	NA	LOW	NA	LOW	LSI	LSI
174 Complex	Jupiter Facility (173, 174, 176, T1727)	NA	LSI	NA	NA	LSI	LSI
179	HED and X-ray Science Lab	NA	LSI	NA	LSI	LSI	LSI
190	Center for Accelerator Mass Spectrometry (CAMS) Lab Facility	LSI	LSI	NA	LOW	LOW	LSI
191	High Explosives Application Facility (HEAF)	LSI	LSI	MOD[j]	LSI	LSI	LSI
193A, 193B, 195, 196, 196A, S3332571, U193	Building 196 Complex—Sewer Diversion	LSI	LSI	NA	NA	LSI	LSI

Facility Number	Facility Description	Biological Materials[a]	Chemical Classification[b]	Explosive Classification[c]	Radiological Inventory Classification[d]	RGD Classification[e]	Industrial Classification[f]
194	Accelerator Tunnel Complex	LSI	LSI	LSI	LOW	LOW	LSI
223	Poymers and Engineering Facility	NA	LSI	NA	LSI	LSI	LSI
231	Engineering Development and Assembly Facility	NA	LSI	LSI	LOW	LSI	LSI
231V, OS232FA, 233GV	Building 231 Vault, Other Structure 232 Fenced Area, Building 233 Garage Vault	NA	LOW	LSI	LOW	LSI	LSI
235	Materials Science Division Offices and Labs	LSI	LSI	LSI	LOW	LOW	LSI
239	Radiography Facility[k]	CATEGORY 3 NUCLEAR FACILITY					
243	Energy and Environment Lab	NA	LSI	NA	NA	LSI	LSI
253	Hazard Control Dept Offices and Labs	LSI	LSI	NA	LSI	NA	LSI
254	Hazard Control Bio Assay Lab	LSI	LSI	NA	LSI	NA	LSI
255	Hazard Control Special Programs Division Labs and Offices	LSI	LSI	LSI	LOW	LSI	LSI
262	Radiation Detector Development	LSI	LSI	NA	LOW	LSI	LSI
T2632	Security Organization Trailer 2632	NA	NA	NA	LSI	LSI	LSI
272, OS273	Material Science Laboratory	NA	LSI	LSI	LSI	LSI	LSI
282	Analytical and Quantum Science	LSI	LSI	NA	LSI	LSI	LSI
298, OS298A	Target Development	NA	LSI	LSI	LOW	LSI	LSI
321A	Materials Fabrication Shop	NA	LSI	NA	LSI	NA	LSI
321C/F	Materials Fabrication Shop	NA	LSI	LSI	LOW	LSI	LSI
322	Metal Finishing Facility	NA	LSI	NA	LSI	NA	LSI
327	Radiography	LSI	LSI	LOW	LOW	LSI	LSI

Facility Number	Facility Description	Biological Materials[a]	Chemical Classification[b]	Explosive Classification[c]	Radiological Inventory Classification[d]	RGD Classification[e]	Industrial Classification[f]
329	Laser Weld Shop	NA	LSI	NA	LSI	NA	LSI
331	Tritium Facility	CATEGORY 3 NUCLEAR FACILITY					
332	Plutonium Facility	CATEGORY 2 NUCLEAR FACILITY					
334	Hardened Engineering Test Building	CATEGORY 2 NUCLEAR FACILITY					
335	Support Facility	NA	LSI	NA	LSI	NA	LSI
341	Engineering Mechanical Testing	LSI	LSI	LSI	LSI	LSI	LSI
361, OS361WAA	Bio Research Cornerstone Facility	LSI	LSI	NA	LSI	LSI	LSI
362	Bio Research Cornerstone Facility	LSI	LSI	NA	LSI	NA	LSI
364	Bio Research Support Facility	LSI	LSI	NA	LOW	NA	LSI
365	Biosafety Level 2 Laboratory	LSI	LSI	NA	NA	NA	LSI
366	Bio Research Facility	LSI	LSI	NA	LSI	NA	LSI
368	Biosafety Level 3 Laboratory	LOW	LSI	NA	NA	NA	LSI
378	Marshall Island Project Lab	LSI	LSI	NA	LSI	LSI	LSI
381	Target Fabrication and Offices	NA	LSI	LSI	LSI	LSI	LSI
391	NIF Optics and Diagnostic Labs	NA	LSI	NA	LSI	LSI	LSI
392	Optics Lab Facility	NA	LSI	NA	NA	NA	LSI
411, T4199	Building 411 Shipping and Receiving Complex	NA	LSI	NA	NA	LSI	LSI
431	Beam Research Labs	NA	LSI	LSI	LSI	LSI	LSI
432	NIF Target Fabrication Machining	NA	LSI	NA	LSI	LSI	LSI
442	WCI Facility/Flight Test Group	NA	LSI	NA	LSI	LSI	LSI

Facility Number	Facility Description	Biological Materials[a]	Chemical Classification[b]	Explosive Classification[c]	Radiological Inventory Classification[d]	RGD Classification[e]	Industrial Classification[f]
490	NIF Engineering & Diagnostics Lab	NA	LSI	NA	LSI	LSI	LSI
OS495	NIF & PS OS495 Consolidated Waste Accumulation Area	NA	LOW	NA	LOW	NA	LSI
581/582	National Ignition Facility	NA	LOW	NA	LOW	LOW	LSI
684	NIF Chemical Storage	NA	LSI	NA	NA	NA	LSI
Area 612, OS612A, 614, 6197B, 624, 624A/B, OS624A	RHWM Waste Treatment, Storage and Disposal Facility	NA	LOW	NA	LOW	LSI	LSI
Area 625 & Yard Area	RHWM Waste Storage Facilities	CATEGORY 2 NUCLEAR FACILITY					
B693 & Yard Area	RHWM Waste Storage Facilities	CATEGORY 2 NUCLEAR FACILITY					
B696R	RHWM Waste Storage Facilities	CATEGORY 2 NUCLEAR FACILITY					
655	Advanced Manufacturing Laboratory	LSI	LSI	NA	NA	LSI	LSI
663, OS665	Health Services Complex	LSI	LSI	NA	NA	LSI	LSI
681	Optics Assembly Building (OAB)	NA	LSI	NA	LSI	LSI	LSI
695	RHWM Liquid Waste Processing	NA	LOW	NA	LOW	LSI	LSI
696	RHWM TRU Waste Storage	NA	LOW	NA	LOW	LSI	LSI
697	RHWM Chem Exchange	NA	LOW	NA	LOW	LSI	LSI
Site 300	Site 300 WCI Facilities: Segmented Complexes containing multiple structures	NA	LSI	HIGH[l]	LOW	LOW	LSI
OS883	Other Structure 883 Radiological Hazardous Waste Management	NA	LOW	NA	LOW	LSI	LSI

a. Biological materials classification is based on a graded approach. Biosafety level (BSL) is the level of containment required to perform biohazardous operations safely. Work practices and techniques, safety equipment, and laboratory facilities appropriate for the operations are based on the potential hazards imposed by the agents used and for the laboratory function and activities. BSL-1 and BSL-2 facilities are classified as LSI, and BSL-3 is classified as a Low Hazard Facility.

b. Chemical classification relies on Emergency Prediction Information-Code (EPI-Code) calculations to determine the chemical inventory (Q value) for each chemical that, if released, would result in exposures equal to the Protective Action Criteria (PAC) values at fixed distances from the release point. The PAC values are posted on DOE’s Chemical Safety Office website. The Chemical Quantity List of Q values is used to classify facilities where hazardous chemicals are used. LSI-level chemical facilities are generally small-scale chemical labs, dye labs, and small quantity chemical storage.

c. Explosives classification is based on the maximum limits denoted by the Hazard Division (HD). Facility limits (includes all types of explosives except HD 1.4S) are as follows: LSI—not to exceed 200 grams; Low—not to exceed 5,000 grams; Moderate—all activities that are not allowed in LSI or Low hazard facilities but that meet the quantity-distance (QD) requirements in DOE-STD-1212-2019; High—any activities necessitating an exemption from the QD specified in DOE-STD-1212-2019.

d. Radiological inventory classification, as defined in DOE-STD-1027 revisions approved for use at LLNL: 1) A Hazard Category 2 Nuclear Facility is one with the potential for nuclear criticality events, or, with sufficient quantities of hazardous materials and energy, could require on-site emergency planning activities; 2) A Hazard Category 3 Nuclear Facility is one with the potential for significant but localized consequences, and has quantities of hazardous radioactive materials which meet or exceed Table A.1 values in the standard; and 3) Facilities that do not meet or exceed Category 3 threshold criteria but still possess some amount of radioactive material may be considered Radiological Facilities. For the purposes of this document, an LSI facility is one in which the sum of all radionuclides is <1/20th DOE-STD-1027 revisions approved for use at LLNL.

e. Radiation-Generating Devices (RGDs) are particle accelerators or photon emitters that produce ionizing radiation (e.g., X-rays, electrons, neutrons) and are grouped by class. RGDs that are non-complex in nature and produce only local work area impacts can be safely managed under the provisions of 10 CFR 835 and 10 CFR 851. RGDs that do not meet this description fall under the additional provisions of DOE O 420.2C. Class I devices are incapable of reasonably producing an accidental dose > 0.1 rem per incident to either a localized area of the body or to the whole body. Class IV devices (e.g. particle accelerators, high dose rate radiography units) could reasonably produce an accidental dose in excess of three times the occupational annual dose limit to the whole body (> 15 rem).

f. Industrial hazards are those hazard sources (material or energy) routinely encountered by the general public, or in general industry and construction, for which national consensus codes and/or standards exist to govern handling or use without the need for special analysis to define safety design and/or operational parameters. Examples of LSI-level industrial hazards are plumbing, carpentry, and machine shops; electronics shops; laser labs; and equipment design and testing labs.

g. NA = Not applicable.

h. LOW = Low Hazard. In accidental conditions, health effects to a collocated worker within the Low Hazard classification could be no irreversible or other serious health effects or symptoms that may impair a person’s abilities to take protection. The public impact may be no more than mild, transient adverse health effects or the perception of a clearly defined objectionable odor or sensation.

i. LSI = Light Science & Industry. In accidental conditions, health effects to a collocated worker within the LSI classification could be no more than mild, transient adverse health effects or the perception of a clearly defined objectionable odor or sensation. The public impact would be no appreciable risk of health effects.

j. MOD = Moderate Hazard. In accidental conditions, health effects to a collocated worker within the Moderate Hazard classification could have irreversible or other serious health effects or symptoms that may impair a person’s abilities to take protective action. The public impact could have no irreversible or other serious health effects or symptoms that may impair a person’s abilities to take protection.

k. Nuclear facilities are subject to DOE-STD-1027 and are not classified in the same way as nonnuclear facilities.

l. HIGH = High Hazard. In accidental conditions, health effects to a collocated worker within the High Hazard classification would have the potential for unmitigated release of hazards with impacts to collocated workers that are believed to include life-threatening health effects. The public impact would be irreversible or other serious health effects or symptoms that could impair a person’s abilities to take protective action. The High designation for explosives is made when specific chemicals are collocated with high explosives. These six chemicals are: (1) Cobalt, (2) Beryllium, (3) Beryllium Oxide, (4) Lithium Hydride, (5) Lithium Hydroxide, and (6) Mercury. The computational basis for assigning High Hazard to these six chemicals is conservative and involves release durations of less than one hour.

A.3.3 Environmental Changes

SWEIS Yearbooks 2010 through 2019 and SAERs 2010-2019 provide ten years of detailed environmental data for the Livermore Site, Site 300, and the surroundings. Those data have been incorporated into Chapter 4 of this SWEIS to update the affected environment at LLNL. In addition, the SWEIS Yearbooks compare actual operating data to projected levels as discussed in the SWEIS for land resources, socioeconomics, community services, prehistoric and historic cultural resources, aesthetics and scenic resources, geology and soils, biological resources, air quality, water, noise, traffic and transportation, utilities and energy, materials and waste management, human health and safety, site contamination, and bounding accident scenarios. A high-level summary of those comparisons from the 2019 SWEIS Yearbook (LLNL 2020h) is presented in Table A-10.

Table A-10. Summary Comparison of 2005 LLNL SWEIS Projected Impacts and Actual Changes/Performance (2005-2019)

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
Land Use	The SWEIS projected a small increase in the developed space at the Livermore Site with no changes in land uses, or future land uses adjacent to the Site. As a result, the SWEIS projected a small land-use impact for continued operation at the Livermore Site. The SWEIS projected that the primary impact on land uses at Site 300 would occur from the development of certain projects but with no major alteration occurring in the types of land uses and no changes in land ownership. The SWEIS projected 370,000 square-feet of new facilities would be constructed under the Proposed Action Alternative. The SWEIS projected 820,000 square-feet would undergo DD&D (or approximately 82,000 square-feet a year).	LLNL's proposed activities at the Livermore Site continue to be compatible with those designations. Projects and activities enacted since the 2011 SA continue to be consistent with DOE's determination. The land uses at Site 300 remain compatible with the existing land uses, approved land-use designations surrounding the site, and open space policies applicable to areas near the site. As of the end of 2019, LLNL added 166,741 square-feet of new facilities. As for DD&D, only 659,755 square-feet were actually demolished through 2019.	Land use has been consistent with, and compatible with the projections in the 2005 LLNL SWEIS. Actual land development and DD&D actions have been less than projections in the 2005 SWEIS.
Visual Resources	Activities proposed in the SWEIS that would change the built environment at the Livermore Site and at Site 300 included improvements to existing buildings and infrastructure, DD&D of existing buildings, and construction of new facilities with developments and modifications occurring within the developed portion of the Site. The offsite views of the Livermore Site would change due to the completion of the East Avenue security upgrade project, the International Security Research Facility, and the NIF. At Site 300, the proposed changes would have little or no impact on aesthetics and scenic resources. Changes would be consistent with the existing character of LLNL.	Offsite views of the Livermore Site have changed since the 2005 SWEIS but are consistent with the existing character of LLNL. Since completion of the 2011 SA, other new facilities were completed that are visible from offsite. At the Livermore Site, a ten-acre solar photovoltaic array in the north west buffer zone and construction of a computing center. Other new facilities including one and two-story office facilities, a BSL-3 laboratory, and a central cafeteria replacement cannot be seen offsite. The offsite views of Site 300 have changed slightly with completion of utility upgrades, environmental remediation projects, and erosion control efforts.	Visual resource impacts have not notably changed since the SWEIS was prepared.
Geology and Soils	The SWEIS analysis evaluated the amount of disturbance that might affect the geology and/or soils of areas at the Livermore Site and Site 300. According to the SWEIS, 462,000 square-feet would be disturbed by construction activities in undeveloped zones in the Livermore Site, and 40,000 square-feet at Site 300.	Since publication of the SWEIS, NNSA has completed construction of new facilities, including the TSF, BSL-3 laboratory, new office facilities in previously developed locations, and a solar photovoltaic array. As of the end of 2019, LLNL added 166,741 square-feet of new facilities.	Since the SWEIS was issued, less land disturbance has resulted in less geology/soil impacts.
Water Resources	Groundwater quality was projected to improve because of ongoing remediation at treatment facilities. No negative impacts to ground water were expected from operations because LLNL does not discharge to groundwater. Impacts on groundwater quality from surface water recharge were also	The new and modified projects and modifications in site operations at both LLNL sites, such as new buildings and associated infrastructure improvements, have not changed the impact to water resources from those analyzed in the SWEIS. In 2014, the State Water Resources Control Board issued a new General Permit	Impacts to water resources have not notably changed since the SWEIS was prepared.

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
	projected to be minimal because LLNL continues to comply with National Pollutant Discharge Elimination System (NPDES) requirements. Because Site 300 is largely undeveloped and contains permeable soils, it had no noticeable impact to ground water recharge. No impacts on floodplains were expected in the SWEIS because no activities under the ROD occur within the 100-year floodplain. No projects were anticipated to contribute significant amounts of surface water runoff to cause substantial flooding because the 100-year base flood event would be contained within all channels. Due to the high infiltration rates and lack of appreciable floodplains at Site 300, hydrologic impacts from the Proposed Action were projected to be minimal, but because of the steep slopes, high run-off velocities within the channels could occur during a storm. However, because no facilities are located in these areas, the SWEIS did not project any impact from flooding.	for Storm Water Discharges Associated with Industrial Activities. The industrial storm water pollution prevention programs at the Livermore Site and Site 300 were modified in July 2015 to follow the requirements of the new Industrial General Permit based on standard industrial codes. LLNL continues to follow prevention and mitigation steps for spill response, comply with NPDES requirements, follow SWPPP requirements, and follow all applicable requirements to protect site hydrology.	
Air Quality (Nonradiological)	All LLNL activities with the potential to produce air pollutant emissions were evaluated in the SWEIS to determine the need for permits and assessed for continued compliance. The areas of major concern for air quality at LLNL are criteria air pollutants, toxic and hazardous air pollutants, and radiological emissions. The SWEIS estimated that, under the Proposed Action in the worst-case year for the regulated pollutants, the Livermore Site would emit a total of approximately 60 tons/year. The Livermore Site's nonradioactive air emissions under the Proposed Action were projected to be: • 20 tons/year of carbon monoxide • 22 tons/year of nitrogen oxides • 12 tons/year of particulate matter • 2.1 tons/year of sulfur oxides • 3.8 tons/year of precursor organic compounds. Air pollutants were projected in the SWEIS to be much lower at Site 300 than the Livermore Site.	Based on actual emission data for the past five years (2015-2019), the Livermore Site has emitted approximately 38.7-41.4 tons/year. The Livermore Site's nonradioactive air emissions have been approximately: • 16.9 tons/year of carbon monoxide • 14.7 tons/year of nitrogen oxides • 1.8 tons/year of particulate matter • 0.7 tons/year of sulfur oxides • 6.1 tons/year of precursor organic compounds. Air pollutants are much lower at Site 300 than the Livermore Site. Emissions estimates are well below the applicable conformity thresholds for air quality; therefore, the SWEIS projected air emissions and the actual emissions are still in conformance with Clean Air Act requirements.	Nonradiological air emissions have been less than SWEIS projections, except for precursor organic compounds. Emissions are in compliance with Clean Air Act requirements.
Air Quality (Radiological)	The SWEIS projected that LLNL activities would emit small quantities of radioactive materials	The 2010 through 2019 LLNL Annual Site Environmental Reports show that radioactive air	Potential impacts from LLNL radiological air emissions are

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
	(predominantly tritium, but also plutonium and uranium, and activation gases such as argon-41 and nitrogen-13 from NIF operations). The SWEIS estimated that the MEI dose for the Livermore Site would be 0.13 millirem per year under the Proposed Action. The population dose for the Livermore Site would be 1.8 person-rem per year under the Proposed Action. At Site 300, the MEI dose would be 0.055 millirem per year under the Proposed Action. The population dose for Site 300 would be 9.8 person-rem per year under the Proposed Action.	emissions and doses to the MEIs at both the Livermore Site and Site 300 are generally much lower than SWEIS projections. Over the past three years (2017-2019), the MEI dose for the Livermore Site averaged 0.0043 millirem per year and the population dose averaged 0.31 person-rem per year. MEI doses and population doses from Site 300 activities were a fraction of the Livermore Site values.	well below estimates in the SWEIS, and doses to the public are below regulatory requirements.
Noise	The SWEIS concluded that noise generated during construction activities related to facility and infrastructure renovations at the Livermore Site and Site 300 would generally not be noticeable in nearby communities because of the relatively large spatial area, perimeter buffer zones, and intervening roadways. No additional noise impacts were identified in the SWEIS. The SWEIS projected a slight increase in heavy-duty vehicle activity at both the Livermore Site and Site 300, and a corresponding increase in the frequency of associated peak noise levels. Vehicles serving LLNL would be required to be properly muffled to reduce noise impacts, and activities would be limited to those times that noise would be less noticeable and less objectionable. Also, continuing operations were projected to require a workforce increase, and a corresponding increase in vehicular activity and ambient noise levels.	Although new projects and modifications in site operations may contribute to noise generation, impacts are consistent with those analyzed in the SWEIS. In addition, because the current LLNL workforce is smaller than the SWEIS projection, vehicular activity and ambient noise levels have not increased. LLNL continues explosives research testing at both the Livermore Site (in the High Explosives Application Facility) and at Site 300 (within the Contained Firing Facility and on an open firing table). LLNL uses blast forecasting as a tool to determine if explosives testing would adversely affect the surrounding community and to restrict operations when peak-impulse noise levels are predicted to exceed the 126-dB (A) level in populated areas. The removal of 820,000 square-feet of excess and legacy facilities over a 10-year period was identified as new activity in the SWEIS. However, through 2019 only 659,755 square-feet were actually demolished. The lower than projected rate of demolition combined with relatively large spatial area and perimeter buffer zone has prevented noise from DD&D activities from having additional impacts on offsite areas.	Noise impacts are not notably different from SWEIS estimates.
Biological Resources	As a result of consultation with the U.S. Fish and Wildlife Service (USFWS), it was identified that LLNL operations could potentially affect six federally-listed endangered, threatened, proposed threatened, or candidate species due to potential disturbance of habitat. The six species include the California red-legged frog, California tiger salamander, San Joaquin kit fox, large-flowered	Through monitoring and compliance activities in 2018, LLNL has been able to avoid significant impacts on special status wildlife and plants. Habitat enhancement, avian protection, and invasive species control efforts resulted in benefits to protected species. LLNL continues to monitor and maintain several restoration sites, habitat enhancements, and conservation set asides that are beneficial to native	There have been no substantial changes in general site conditions, ecology, and species compositions at the Livermore Site and Site 300 since the 2005 SWEIS was completed.

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
	fiddleneck, valley elderberry longhorn beetle, and Alameda whipsnake. All of these species are at Site 300 with only one species, the California red-legged frog, at the Livermore Site. NNSA completed necessary Biological Assessments and obtain Biological Opinions from USFWS on any identified impacts on critical habitats.	plants and animals at the Livermore Site or Site 300 and ensures the protection of listed and special status species. Surveys and monitoring activities through 2019 show no indications of substantial changes in general site conditions, ecology, and species compositions at the Livermore Site and Site 300 since the 2005 SWEIS was completed.	
Cultural Resources	The probability of impacting cultural and prehistoric resources at the Livermore Site would be low because: (1) field and archival research have not identified any cultural and prehistoric resources; (2) the geomorphic setting of the site makes it unlikely that any such resources exist; and (3) extensive modern horizontal and vertical development has disturbed much of the site. In 2004, an assessment of LLNL's built environment for potential historic significance determined that four individual buildings and selected objects within another building at the Livermore Site are eligible for listing in the National Register of Historic Places (NRHP) because of their association with important research and development that was undertaken within the context of the Cold War. Archaeological surveys undertaken at Site 300 over the past 40 years have resulted in the recordation of 31 prehistoric and historic archaeological sites and isolated artifacts. Of the eight prehistoric archaeological resources recorded at Site 300, NNSA concluded that two qualify for listing in the NRHP because of their ability to yield information important in prehistory. The California State Historic Preservation Officer (SHPO) concurred with this determination.	In 2014, the SHPO requested project-specific compliance with Section 106 of the NHPA in which case Memorandum of Agreements would be negotiated between DOE/NNSA, the ACHP, and the SHPO. Four consultations were initiated in 2014 and two were initiated in 2015 to address mitigations for potential adverse effects. As of 2016, the Advanced Test Accelerator (B865) and the NOVA facility (B391) were mitigated and determined to no longer be eligible properties. As of 2017, the Hydrodynamic Test Facilities District (B850/851), the Plutonium Facility (B332), and the Process Area and Chemistry Area Historic District (B805, B806, B807, B817A/B/F, B825, B826, B827) were mitigated and determined to no longer be eligible properties. As of 2019, the Livermore Pool-Type Reactor (B280) and the 100-MeV Electron-Positron LINAC Facility (B194) were mitigated and determined to no longer be eligible properties.	Potential impacts to cultural resources remain low, consistent with the conclusions presented in the SWEIS.
Socioeconomics	For the Proposed Action, 11,150 workers would be required at the Livermore Site and 250 workers would be required at Site 300. Alameda, San Joaquin, Contra Costa, and Stanislaus Counties were considered impacted by LLNL operations because most of the workforce resided in those counties. Given the relatively large population in those four counties, the SWEIS did not estimate any significant impacts to housing or community services in those four counties or the region as a whole. The SWEIS	At the end of 2019, the actual LLNL-affiliated workforce, including subcontractors, was 7,378 people, 34 percent fewer people than the SWEIS projection. Given the region's large socioeconomic base, the lower employment at LLNL has not notably impacted socioeconomic conditions, including housing and community services, in the region. LLNL operations continue to provide positive economic benefits to the region.	The reduction in LLNL employment has not notably impacted the socioeconomic conditions, housing, or community services in the region.

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
	projected continued positive economic benefits to the region from LLNL operations.		
Environmental Justice	No predominantly minority or low-income populations are located within 5 miles of Livermore Site or Site 300. LLNL operations that were analyzed in the SWEIS were projected to have minimal impact in the resource areas analyzed, including human health effects to offsite residents and onsite workers. Therefore, no disproportionately high and adverse impacts to minority or low-income populations were anticipated, and no mitigation measures were required.	The have been no notable changes in the environmental justice populations surrounding LLNL. As discussed in this table, LLNL operations have continued to result in minimal impacts, including human health effects to offsite residents and onsite workers, and there are no disproportionately high and adverse impacts to minority or low-income populations.	There are no disproportionately high and adverse impacts to minority or low-income populations from LLNL operations.
Transportation (Traffic)	Commuting workers and deliveries of materials needed for the operation of facilities continue to comprise most of LLNL-generated traffic in 2018. Traffic volume at the Livermore Site was projected to increase by approximately 500 workers under the SWEIS Proposed Action, which was a small fraction of the current traffic level in the heavily congested Tri-Valley area.	Due to the decrease in the size of the LLNL-affiliated workforce, traffic volume from LLNL commuting workers has decreased compared to SWEIS estimates.	The reduction in LLNL employment has reduced the number of LLNL commuting workers; however, as a result of the large regional population traffic in the region remains challenging.
Transportation (Hazardous and radiological materials)	The SWEIS analyzed more than 1,400 shipments of wastes and hazardous/radiological wastes/materials annually. The SWEIS projected an increase in routine LLW generation (from 200 cubic meters per year under the No Action Alternative to 330 cubic meters per year under the Proposed Action). Routine TRU waste was projected to remain steady at 50 cubic meters per year under both the No Action Alternative and the Proposed Action. The SWEIS modeling of offsite radioactive shipments yielded a collective dose to the public of 9.0 person-rem per year, which translates into 5×10^{-3} latent cancer fatalities (LCFs) annually. The amount of explosives materials transported to/from Site 300 was also projected to increase slightly.	Overall shipments of wastes and hazardous/radiological wastes/materials have remained below SWEIS projections for the past decade. Over the past seven years (2013-2019), shipments have been less than 1,250 annually. Over the past three years (2016-2018), LLW and TRU waste shipments have been less than SWEIS projections. Similarly, hazardous waste shipments, which include explosives, have been approximately 10 percent of SWEIS estimates.	Quantities of hazardous and radiological waste requiring transportation have been well below SWEIS estimates.
Infrastructure	Annual electric use for the Proposed Action was estimated at 442 million kilowatt-hours and was projected to be flat thereafter due to an ongoing commitment to energy conservation and a cumulative reduction of LLNL floorspace. Water use was estimated at 297 million gallons per year. Natural gas was estimated at 23,000 therms per day.	Electricity use over the period 2005-2018 has been 406-429 million kilowatt-hours, which is consistent with the relatively stable trend in recent years at both the Livermore Site and Site 300, and below SWEIS estimates. Water use over the period 2015-2019 has been 217-267 million gallons per year, which is consistent with the relatively stable trend in recent	Utility use has been below the SWEIS estimates. The existing LLNL infrastructure has adequate capacity to support utility demands.

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
		years at both the Livermore Site and Site 300, and below SWEIS estimates. Natural gas consumption over the period 2015-2019 was 11,613-12,52 therms per day, which is consistent with the relatively stable trend in recent years and below the SWEIS projections. The SWEIS projected fuel oil use for both the Livermore Site and Site 300; however, fuel oil is no longer used at the Livermore Site or Site 300.	
Waste Management	The SWEIS projected an increase in total LLW generation (from 250 cubic meters per year under the No Action Alternative to 1,040 cubic meters per year under the Proposed Action). Total TRU waste generation was estimated at 112.8 cubic meters per year in the SWEIS. Total generation of hazardous waste was estimated at 760 metric tons per year. Levels of waste generation are within the capacities for treatment, storage, and disposal, either onsite or offsite at waste repositories such as WIPP for TRU waste, and the Nevada Nuclear Security Site (NNSS) for LLW.	Beginning in 2011, there was an increase in routine LLW volumes due to wipe cleaning wastes and personal protective equipment disposal; an increase in Site 300 shot activities in 2012 generated additional routine LLW. NIF implemented numerous program improvements that resulted in a 65 percent reduction of LLW in 2012. Over the past three years (2017-2019), total LLW generation has averaged 512 cubic meters per year, which is well below the SWEIS projections. Total TRU waste generation over 2017-2019 has averaged about 14.1 cubic meters per year, which is well below SWEIS estimates. Similarly, total hazardous waste generation, which includes explosive wastes, has averaged 430 metric tons per year, which is well below SWEIS estimates.	Waste generation remains below SWEIS estimates and within the capacities for treatment, storage, and disposal.
Human Health	The SWEIS estimated that the Proposed Action would increase total worker dose to approximately 93 person-rem per year, including approximately 19 person-rem per year from the NIF. Latent cancer fatalities (LCFs) calculated from these exposures would be 5.6 x 10^{-2} per year of exposure under the Proposed Action. The dose to the 50-mile population was estimated to be 1.8 person-rem per year from the Livermore Site and 9.8 person-rem per year from Site 300. The corresponding LCFs would be 1.1×10^{-3} from the Livermore site and 5.9×10^{-3} from Site 300.	Working conditions at LLNL have remained essentially the same as those identified in the SWEIS, and more than half of the workforce remains routinely engaged in activities that are typical of office and computing industries. Much of the remainder of the workforce is engaged in light industrial and bench-scale research activities. Over the past three years (2017-2019), the total worker dose has averaged 8.8 person-rem, which is approximately 90 percent less than the SWEIS estimated. The average worker dose has been 64.4 millirem per year. Over the past three years (2017-2019), the MEI dose for the Livermore Site averaged 0.0043 millirem per year and the population dose averaged 0.31 person-rem per year. These doses are a fraction of the SWEIS estimates. The corresponding LCFs to the population would be essentially zero (i.e., a maximum of 1.9×10^{-4}). MEI doses and population doses from Site 300 activities were a fraction of the Livermore Site values.	Impacts on human health remain consistent with impacts projected in the SWEIS. Doses to workers would remain as low as reasonably achievable (ALARA), and public doses would be less than the DOE standard of 100 mrem/year, and well below the National Emission Standards for Hazardous Air Pollutants (NESHAPs) standard of 10-mrem/year.

Resource or Impact Area	2005 SWEIS Projected Impact	Actual Impacts and Performance Changes (2005–2019)	Assessment
Accidents	For the Proposed Action, the SWEIS analyzed bounding radiological accidents for nuclear material handling operations, waste management operations, and chemical, explosive, and biological accidents. For nuclear material handling operations, the bounding accident is an unfiltered fire involving radioactive material in the Building 332 Plutonium Facility resulting in 0.112 LCF within the offsite population. The bounding radiological accident for waste management operations is a single engine piston aircraft accident at the Building 625 Radiological and Hazardous Waste Storage Facility that would result in 1.21 LCFs to the offsite population. Bounding accident scenarios for chemical, explosive, and biological accidents are unlikely to result in fatalities to the general public.	The deinventory of Security Category I/II SNM from LLNL in 2012 has significantly reduced the MAR in some LLNL facilities. For most bounding radiological accidents, potential consequences are directly related to the amount of MAR in a given facility. Given these MAR reductions, potential accident consequences are expected to be bounded by the consequences presented in the SWEIS.	Accident impacts are small and have decreased due to the deinventory of Security Category I/II SNM from LLNL.
Contamination/Remediation	The SWEIS projected activities that included the continued operations of investigation, cleanup, and long-term stewardship (including treatment system modifications and reporting). A general increase in mission activity levels across LLNL was projected; consequently, an increase in hazardous material management and waste management activities would increase, and an associated spill or release could occur. No adverse impacts to future land use were expected. No adverse effects on groundwater were expected.	LLNL's cleanup remedies are designed and implemented to achieve the goals of reducing risks to human health and the environment and satisfying remediation action objectives, meeting cleanup standards for chemicals and radionuclides in water and soil, and preventing contaminant migration in groundwater to the extent technically and economically feasible. Remediation activities remove contaminants from groundwater and soil vapor, and documentation and investigations continue to meet regulatory milestones. Beneath the Livermore Site and Site 300, groundwater concentration and hydraulic data indicate subtle but consistent declines in pollutant concentrations and areal extent of contaminant plumes in 2018.	Remediation efforts continue to comply with regulatory requirements and have reduced the amount and extent of contamination in groundwater and soils.

Source: LLNL 2020h, LLNL 2020j, NNSA 2005.

A.4 References

29 CFR 1910.119 "Occupational Safety and Health Standards." *Labor*. Occupational Safety and Health Administration, Department of Labor. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-H/section-1910.119

40 CFR Part 302 "Designation, Reportable Quantities, and Notification." *Protection of Environment*. Environmental Protection Agency. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=8e5b65ce921d4925521ae510c892ab31&mc=true&node=pt40.30.302&rgn=div5

40 CFR Part 355 "Emergency Planning and Notification." *Protection of Environment*. Environmental Protection Agency. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-J/part-355

DOE 2011 U.S. Department of Energy. *Supplement Analysis of the 2005 Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory*. DOE/EIS-0348-SA-03. ID 20191. August 2011. Available online: https://www.energy.gov/sites/prod/files/EIS-0348-SA_03-2011.pdf

DOE 2019 "Explosives Safety." DOE-STD-1212-2019. November 2019. Available online: https://www.standards.doe.gov/standards-documents/1200/1212-astd-2019/@@images/file DOE Technical Standard Explosives Safety (DOE-STD-1212-2019). November 2019. Available online: https://www.standards.doe.gov/standards-documents/1200/1212-astd-2019/@@images/file.

DOE-STD-1027-92 "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports." DOE STD-1027-92. December 1992, Change Notice No. 1 September 1997. Available online: https://www.standards.doe.gov/standards-documents/1000/1027-AStd-1992-cn1/@@images/file

DOE-STD-1027-2018 "Hazard Categorization of DOE Nuclear Facilities." DOE-STD-1027-2018. November 2018. Available online: https://www.standards.doe.gov/standards-documents/1000/1027-astd-2018/@@images/file

LLNL 2008 Lawrence Livermore National Laboratory. Revised Hazardous Waste Facility Permit. Department of Toxic Substances Control

(DTSC). Permit Number: 99-NC-006. EPA ID Number CA2890012584. ID 2146. Livermore, CA. July 16, 2008.

LLNL 2011b Lawrence Livermore National Laboratory. "Facility Screening Report Building 365." ID 1025. Livermore, CA. November 2011. **OFFICIAL USE ONLY.**

LLNL 2012b Lawrence Livermore National Laboratory. Nuclear Weapon Engineering Facilities, Site 300 (S300 Weaponization Program Facility) Tier-3 Safety Basis Document. ID 1747. Livermore, CA. December 12, 2012.

LLNL 2013 Lawrence Livermore National Laboratory. Tier-2 Safety Basis Document, NIF & Photon Science Directorate, OS495 Consolidated Waste Accumulation Area. ID 1477. Livermore, CA. January 2013.

LLNL 2015 Lawrence Livermore National Laboratory. "National Atmospheric Release Advice Center Overview." LLNL-PRES-609358-Rev1. Livermore, CA. January 27, 2015. Available at: https://narac.llnl.gov/content/mods/publications/summaries-overviews/LLNL-PRES-609358.pdf

LLNL 2016a Lawrence Livermore National Laboratory. "Remodeling of Building 151, Radiochemistry Laboratories." ID 2042. Livermore, CA. December 19, 2016.

LLNL 2016b Lawrence Livermore National Laboratory. "Building 153 Facility Screening Report." ID 1622. Livermore, CA. November 28, 2016.

LLNL 2016c Lawrence Livermore National Laboratory. "Weapons and Complex Integration Radiography Facility—Building 239 Facility Safety Plan." ID 1006. September 2016. **OFFICIAL USE ONLY.**

LLNL 2016d Lawrence Livermore National Laboratory. "Building 321B Facility Screening Report." ID 1626. Livermore, CA. December 12, 2016.

LLNL 2016e Lawrence Livermore National Laboratory. "Building 321C Tier-2 Safety Basis Document." ID 1628. Livermore, CA. May 11, 2016.

LLNL 2016f Lawrence Livermore National Laboratory. *Facility Safety Plan for WCI Hardened Engineering Test Building: Building 334*. ID 1015. Livermore, CA. August 2016. **OFFICIAL USE ONLY.**

LLNL 2016g Lawrence Livermore National Laboratory. "Facility Screening Report for Building 366." ID 1736. Livermore, CA. July 2016.

LLNL 2016h Lawrence Livermore National Laboratory. "Building 391 Tier-2 Safety Basis Document." ID 1485. Livermore, CA. February 9, 2016.

LLNL 2016i Lawrence Livermore National Laboratory. "Physical & Life Science Site 300 Safety Basis Document." ID 1755. Livermore, CA. December 29, 2016.

LLNL 2016j Lawrence Livermore National Laboratory. "Building 321D Facility Screening Report." ID 1629. Livermore, CA. December 12, 2016.

LLNL 2016k Lawrence Livermore National Laboratory. "Building 321E Facility Screening Report." ID 1630. Livermore, CA. December 8, 2016.

LLNL 2016l Lawrence Livermore National Laboratory. "Plutonium Facility—Building 332, Facility Safety Plan." ID 1012. Livermore, CA. March 2016. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2017a Lawrence Livermore National Laboratory. "Building 131 High Bay Tier 3 Safety Basis Document." ID 1789. Livermore, CA. December 2017.

LLNL 2017b Lawrence Livermore National Laboratory. "Weapons and Complex Integration, Facilities Safety Plan, Building 131, High Bay." ID 1159. Livermore, CA. August 2017.

LLNL 2017c Lawrence Livermore National Laboratory. "Building 141 Facility Screening Report." ID 1621. Livermore, CA. August 25, 2017.

LLNL 2017d Lawrence Livermore National Laboratory. "Building 162 Complex with Building 164 Facility Screening Report." ID 1607. Livermore, CA. August 22, 2017.

LLNL 2017e Lawrence Livermore National Laboratory. "Building 166 Complex with Building 164 Facility Screening Report." ID 1598. Livermore, CA. August 4, 2017.

LLNL 2017f Lawrence Livermore National Laboratory. "Tier -2 Safety Basis Document for High Explosives Applications Facility (HEAF) Building 191." ID 1146. Livermore, CA. December 2017. **OFFICIAL USE ONLY.**

LLNL 2017i Lawrence Livermore National Laboratory. "Building 322 Facility Screening Report." ID 1631. Livermore, CA. January 23, 2017.

LLNL 2017j Lawrence Livermore National Laboratory. "Weapons and Complex Integration Plutonium Facility—Building 332 Documented Safety

Analyses." ID 1011. Livermore, CA. May 2017. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2017k Lawrence Livermore National Laboratory. "Building 334 Documented Safety Analyses, Weapons and Complex Integration, Hardened Engineering Test Building." ID 1014. Livermore, CA. January 2017. **OFFICIAL USE ONLY.**

LLNL 2017l Lawrence Livermore National Laboratory. "Building 335 Complex Facility Screening Report." ID 1790. Livermore, CA. August 4, 2017.

LLNL 2017m Lawrence Livermore National Laboratory. "Building 381 Facility Screening Report." ID 1482. Livermore, CA. October 25, 2017.

LLNL 2017p Lawrence Livermore National Laboratory. "Building 453 Facility Screening Report." ID 1602. Livermore, CA. November 2017.

LLNL 2017q Lawrence Livermore National Laboratory. *Supplement Analysis of the Lawrence Livermore National Laboratory Final Site-wide Environmental Impact Statement for the Exascale Computing Facility Modernization (ECFM) Project*. ID 1137. Livermore, CA. December 2017.

LLNL 2017r Lawrence Livermore National Laboratory. "Building 490 Facility Screening Report." ID 1481. Livermore, CA. October 2017.

LLNL 2017t Lawrence Livermore National Laboratory. "Weapons and Complex Integration Facility Safety Plan." ID 1156. Livermore, CA. July 2017. **OFFICIAL USE ONLY.**

LLNL 2017u Lawrence Livermore National Laboratory. "Weapons and Complex Integration Facility Safety Plan—Engineering Test Facilities." ID 1157. Livermore, CA. July 2017. **OFFICIAL USE ONLY.**

LLNL 2017v Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document: Radioactive and Hazardous Waste Management, Area 612. Revision 2." ID 1496. Livermore, CA. July 2017.

LLNL 2017w Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document: Radioactive and Hazardous Waste Management, Building 695, Revision 3." ID 1497. Livermore, CA. July 2017.

LLNL 2017x Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document: Radioactive and Hazardous Waste Management, Building 697, Revision 2." ID 1499. Livermore, CA. July 2017.

LLNL 2017y Lawrence Livermore National Laboratory. "Weapons and Complex Integration Facility Safety Plan – High Explosives (HE) Process Area." ID 1161. Livermore, CA. October 2017. **OFFICIAL USE ONLY.**

LLNL 2017z Lawrence Livermore National Laboratory. "Weapons and Complex Integration Facility Safety Plan - Explosives Waste Storage Facility (EWSF) and Explosives Waste Treatment Facility (EWTF)." ID 1158. Livermore, CA. July 2017. **OFFICIAL USE ONLY.**

LLNL 2017aa Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document: Radioactive and Hazardous Waste Management, Building 696S. Revision 3." ID 1498. Livermore, CA. July 2017.

LLNL 2017bb Lawrence Livermore National Laboratory. "Building 231 Applied Materials and Engineering (AME) Capabilities Consolidation Portfolio. NEPA Environmental Checklist, NNSA/LFO Log No. NA-17-01." Livermore, CA. March 1, 2017.

LLNL 2017cc Lawrence Livermore National Laboratory. "Safety Assessment Document Multi-User Tandem Building 190." ID 1710. Livermore, CA. July 17, 2017. **OFFICIAL USE ONLY.**

LLNL 2017dd Lawrence Livermore National Laboratory. "Radiography Facility— Building 239 Documented Safety Analyses." ID 1005. Livermore, CA. December 2017. **OFFICIAL USE ONLY.**

LLNL 2017ee Lawrence Livermore National Laboratory. "Biological Waste Management." ID 1174. Livermore, CA. November 22, 2017.

LLNL 2018a Lawrence Livermore National Laboratory. "Building 131 High Bay Emergency Planning Hazards Assessment, Revision 6. LLNL-TR-754498." ID 1643. Livermore, CA. June 2018. **OFFICIAL USE ONLY.**

LLNL 2018b Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document for Building 132 Complex, Building 132N and Building 132S Segments." LLNL-AR-797973. ID 1267. Livermore, CA. April 2018. **OFFICIAL USE ONLY.**

LLNL 2018c Lawrence Livermore National Laboratory. "Facility Safety Plan for Building 190." LLNL-MI-799746. ID 1709. Livermore, CA. May 2018. OFFICIAL USE ONLY.

LLNL 2018d Lawrence Livermore National Laboratory. "Facility Safety Plan for High Explosives Applications Facility (HEAF) Building 191." ID 1145. Livermore, CA. May 2018. **OFFICIAL USE ONLY.**

LLNL 2018e Lawrence Livermore National Laboratory. "Facility Safety Plan for Building 194." ID 1712. Livermore, CA. July 2018. **OFFICIAL USE ONLY.**

LLNL 2018f Lawrence Livermore National Laboratory. "Building 231 Tier-2 Safety Basis Document, Revision 4." ID 1624. Livermore, CA. August 2018.

LLNL 2018g Lawrence Livermore National Laboratory. "Facility Safety Plan for Building 235." LLNL-MI-799703. ID 1715. Lawrence Livermore National Laboratory, Livermore, CA. July 2018. **OFFICIAL USE ONLY.**

LLNL 2018h Lawrence Livermore National Laboratory. "Building 253 Complex (HCD-1) Facility Screening Report." ID 1651." Livermore, CA. September 2018. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2018i Lawrence Livermore National Laboratory. "Weapons and Complex Integration Tritium Facility—Building 331 Documented Safety Analyses." ID 1008. Livermore, CA. May 2018. **OFFICIAL USE ONLY.**

LLNL 2018j Lawrence Livermore National Laboratory. "Building 361 Facility Screening Report." ID 1732. Livermore, CA. February2018.

LLNL 2018k Lawrence Livermore National Laboratory "Building 362 Facility Screening Report." ID 1734. Livermore, CA. July 2018.

LLNL 2018l Lawrence Livermore National Laboratory. "Building 392 Facility Screening Report." ID 1609. Livermore, CA. September 24, 2018.

LLNL 2018n Lawrence Livermore National Laboratory. "Building 581-582 Complex Tier-2 Safety Basis Document." ID 1276. Livermore, CA. March 19, 2018.

LLNL 2018p Lawrence Livermore National Laboratory. "Facility Screening Report for Building 663 Complex." ID 1615. Livermore, CA. December 2018.

LLNL 2018q Lawrence Livermore National Laboratory. "Site 300, Tier 3 Safety Basis Document, Revision 1." LLNL–TM–938865. ID 1757. Livermore, CA. June 2018. **OFFICIAL USE ONLY.**

LLNL 2018s Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document Building 235." ID 1717. Livermore, CA. July 2018. **OFFICIAL USE ONLY.**

LLNL 2018t — Lawrence Livermore National Laboratory. "NEPA Checklist 18-15373." ID 1703. Livermore, CA. May 2018.

LLNL 2018u — Lawrence Livermore National Laboratory. "Facility Safety Plan Building 364." ID 1718. Livermore, CA. December 2018. **OFFICIAL USE ONLY.**

LLNL 2018v — Lawrence Livermore National Laboratory. "National Ignition Facility Safety Plan for Buildings 581/582, 682, 683, and 684." ID 1275. Livermore, CA. August 2018.

LLNL 2019a — Lawrence Livermore National Laboratory. "EAM Database." ID 1066. Livermore, CA. November 15, 2019.

LLNL 2019c — Lawrence Livermore National Laboratory. "Tier 3 Safety Basis Document for Building 151 Complex, Building 151, 152, and 154." LLNL-MI-808089. ID 1708. Livermore, CA. February 2019. **OFFICIAL USE ONLY.**

LLNL 2019d — Lawrence Livermore National Laboratory. "Facility Safety Plan for Building 151, 152, and 154. LLNL-MI-808090." ID 1707. Livermore, CA. April 2019. **OFFICIAL USE ONLY.**

LLNL 2019e — Lawrence Livermore National Laboratory. "Facility Screening Report for Building 174 Complex." ID 1724. Livermore, CA. February 2019.

LLNL 2019f — Lawrence Livermore National Laboratory. "Safety Assessment Document for Electron-Positron Linear Accelerator (LINAC) Facility Building 194, Revision 11." ID 1713. Livermore, CA. September 2019. **OFFICIAL USE ONLY.**

LLNL 2019g — Lawrence Livermore National Laboratory. "Facility Screening Report for Building 254." ID 1652. Livermore, CA. September 2019. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2019h — Lawrence Livermore National Laboratory. "Building 255 Facility Safety Plan." ID 1653. Livermore, CA. June 2019. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2019j — Lawrence Livermore National Laboratory. "Facility Screening Report for Building 272 Complex." ID 730. Livermore, CA. August 2019.

LLNL 2019k — Lawrence Livermore National Laboratory. "Building 327 Tier-2 Safety Basis Document." ID 1633. Livermore, CA. March 2019.

LLNL 2019l Lawrence Livermore National Laboratory. "Building 341 Facility Screening Report." ID 1635. Livermore, CA. February 2019.

LLNL 2019m Lawrence Livermore National Laboratory. "Building 341 Categorical Exclusion Determination Form, BSL-2 Laboratory Conversion." ID 1124. Livermore, CA. February 2019.

LLNL 2019n Lawrence Livermore National Laboratory. "Building 391 Facility Safety Plan." ID 1479. Livermore, CA. November 1, 2019.

LLNL 2019o Lawrence Livermore National Laboratory. "Building 491 Facility Screening Report." ID 1610. Livermore, CA. August 19, 2019.

LLNL 2019q Lawrence Livermore National Laboratory. "Building 655 Facility Screening Report." ID 1638. Livermore, CA. August 2019.

LLNL 2019r Lawrence Livermore National Laboratory. "NNSA Capital Acquisition Planning (CAP) Process FY2022 Project Proposal Form, Weapons Environmental Testing Replacement Capability (Building 834/Building 836)." ID 1516. Livermore, CA. September 26, 2019. **OFFICIAL USE ONLY.**

LLNL 2019s Lawrence Livermore National Laboratory. "Building 165 Facility Screening Report." ID 1608. Livermore, CA. March 5, 2019.

LLNL 2019t Lawrence Livermore National Laboratory. "Facility Safety Plan:" RHWM Radiological Facilities (Area 612, Building 695, Building 696S, and B697)." ID 1500. Livermore, CA. January 2019.

LLNL 2019u Lawrence Livermore National Laboratory *Medical Waste Management and Emergency Action Plan for the Lawrence Livermore National Laboratory Biosafety Level 2 (and Lower) Facilities.* LLNL-AR-785698 External.. Livermore, CA. August 2019.

LLNL 2019v Lawrence Livermore National Laboratory. *Medical Waste Management and Emergency Action Plan for the Lawrence Livermore National Laboratory Biosafety Level 3 Facility*. LLNL-AR-785697 External. Livermore, CA. August 2019.

LLNL 2019w Lawrence Livermore National Laboratory. "Documented Safety Analyses for the Waste Storage Facilities." LLNL-TM-688339 REV 2. ID 2120. Livermore, CA. September 2019.

LLNL 2019x Lawrence Livermore National Laboratory. "Technical Safety Requirements for the Waste Storage Facilities." LLNL-TM-688321 REV 2. ID 2119. Livermore, CA. September 2019.

LLNL 2019y Lawrence Livermore National Laboratory. "Tier 2 Safety Basis Document for Building 262. Revision 4." LLNL-AR-797974. ID 1269. Livermore, CA. February 2019. **OFFICIAL USE ONLY.**

LLNL 2019z Lawrence Livermore National Laboratory. "Building 321A Facility Screening Report." ID 1625. Livermore, CA. May 2019.

LLNL 2019aa Lawrence Livermore National Laboratory. "Building 132 Change Control Form." ID 1266. Livermore, CA. December 4, 2019. **OFFICIAL USE ONLY.**

LLNL 2019bb Lawrence Livermore National Laboratory. "Safety Assessment Document, Electron-Positron Linear Accelerator (LINAC) Facility Building 194." ID 1714. Livermore, CA. September 24, 2019. **OFFICIAL USE ONLY.**

LLNL 2019cc Lawrence Livermore National Laboratory. "Building 321G NEPA Environmental Checklist 19-16613." ID 1673. Livermore, CA. September 2019.

LLNL 2019dd Lawrence Livermore National Laboratory. "Plutonium Facility—Building 332 Documented Safety Analysis." ID 2115. Livermore, CA. November 2019. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2019ee Lawrence Livermore National Laboratory. "Building 298 Facility Safety Plan." ID 1483. Livermore, CA. November 2019.

LLNL 2020a Lawrence Livermore National Laboratory. "Building 191 HEAF Atrium: Conversion to Shot Ready Workplace." ID 1821. Livermore, CA. October 19, 2020.

LLNL 2020b Lawrence Livermore National Laboratory. Lawrence Livermore National Laboratory. "Future Program/Project/Facility Information Report, Next Generation Life Extension Program (LEP) R&D Component Fabrication Facility." ID 1533. Livermore, CA. January 13, 2020. **OFFICIAL USE ONLY.**

LLNL 2020d Lawrence Livermore National Laboratory. "Pu-AVLIS in EIS." Email from Mark Bronson, LLNL, to Hank Khan, LLNL. ID 1977. Livermore, CA. October 27, 2020.

LLNL 2020e Lawrence Livermore National Laboratory. "Emergency Planning Hazards Assessment Superblock: Buildings 239, 331, 332, & 334." ID 1648. Livermore, CA. January 6, 2020. **OFFICIAL USE ONLY.**

LLNL 2020f Lawrence Livermore National Laboratory. "Future Program/Project/Facility Information Report, Exascale Computing Facility Modernization." ID 1519. Livermore, CA. January 1, 2020. **OFFICIAL USE ONLY.**

LLNL 2020g Lawrence Livermore National Laboratory. "Building 511 Facility Screening Report." ID 1580. Livermore, CA. January 2020.

LLNL 2020h Lawrence Livermore National Laboratory. *2019 Annual Yearbook for the LLNL SW/SPEIS*. LLNL-AR-811785. Livermore, CA. June 2020.

LLNL 2020i Lawrence Livermore National Laboratory. "Site 300 Construction Schedule." ID 1678. Livermore, CA. April 20, 2020. **OFFICIAL USE ONLY. UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION.**

LLNL 2020j Lawrence Livermore National Laboratory. *2019 Site Annual Environmental Report, Lawrence Livermore National Laboratory Environmental Report 2018*. UCRL-TR-50027-19. Livermore, CA. October 2020.

LLNL 2020k Lawrence Livermore National Laboratory. "Documented Safety Analyses for the Waste Storage Facilities." LLNL-TM-688339 Rev 2. ID 2120. Livermore, CA. September 2019.

LLNL 2020l Lawrence Livermore National Laboratory. "Building 432 Facility Screening Report." ID 2132. Livermore, CA. April 2020.

LLNL 2020m Lawrence Livermore National Laboratory. "Building 431 Facility Screening Report." ID 2133. Livermore, CA. March 2020.

LLNL 2020n Lawrence Livermore National Laboratory. "Radiological Control Manual MAN-2050." ID 1343. Effective date: January 1, 2020.

LLNL 2020o Lawrence Livermore National Laboratory. "Emergency Planning Hazard Assessment Superblock: Buildings 239, 331, 332, and 334, Rev 1." ID 1439. Livermore, CA. January 2020.

LLNL 2020p Lawrence Livermore National Laboratory. "Building 368 Tier 2 Safety Basis Document." ID 1035. Livermore, CA. July 2020. **OFFICIAL USE ONLY.**

LLNL 2020q Lawrence Livermore National Laboratory. "Facility Screening Report for Building 490." ID 1991. Livermore, CA. October 2020.

LLNL 2021a Lawrence Livermore National Laboratory. “Building 231V, OS232FA, Building 233GV Safety Basis Document, Rev.5.” ID 2135. Livermore, CA. September 2021.

LLNL 2021b Lawrence Livermore National Laboratory. “Building 850 Discussion.” ID 2154. Livermore, CA. December 3, 2021.

LLNL 2021c Lawrence Livermore National Laboratory. “Facility Safety Plan B368.” ID 1034. Livermore, CA. July 31, 2021. **OFFICIAL USE ONLY.**

LLNL 2021d Lawrence Livermore National Laboratory. “NIF and the LLNL SWEIS Update.” ID 1799. Livermore, CA. No date.

NNSA 2005 Lawrence Livermore National Laboratory. *Final Sitewide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement*. DOE/EIS-0348 and DOE/EIS-0236-S3. Livermore, CA. March. Available online: https://www.energy.gov/nepa/downloads/eis-0348-and-eis-0236-s3-final-site-wide-environmental-impact-statement.

APPENDIX B

Methodologies Used in this SWEIS

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B METHODOLOGIES USED IN THIS SWEIS

B.1 INTRODUCTION

This SWEIS was prepared in accordance with the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the *National Environmental Policy Act* (NEPA) (40 CFR 1500-1508) and the Department of Energy (DOE) Procedures for Implementing NEPA (10 CFR 1021). In accordance with 40 CFR 15021, this SWEIS is intended to "provide a full and fair discussion of significant environmental impacts" and "to inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment." This SWEIS includes a discussion of: direct effects and their significance and indirect effects and their significance in Chapter 5 (40 CFR 1508.8); and cumulative impacts in Chapter 6 (40 CFR 1508.7). Effects could be adverse or beneficial.

This appendix describes the methodologies used to assess the potential direct and indirect impacts of the alternatives in this SWEIS. The analysis in this LLNL SWEIS considers ongoing activities and proposed activities that could occur over approximately the next 15 years (2020-2035). This SWEIS evaluates the environmental impacts of the alternatives within a defined region of influence (ROI), as described for each resource below. The ROIs encompass geographic areas within which any notable impact would be expected to occur. The level of detail in the description of each resource methodology varies with the likelihood of a potential impact to the resource. Resource methodologies are presented in the same order as the resources in Chapters 4 and 5. For each resource, NNSA developed key metrics to provide a comparative basis of evaluation appropriate for that resource. The No-Action Alternative is compared against the 2019 existing environment baseline and the Proposed Action is compared against the No-Action Alternative.

As discussed in Chapter 3, both the No-Action Alternative and the Proposed Action encompass a multitude of discreet projects/actions that could give rise to environmental impacts. A primary challenge in preparing a site-wide analysis is to address the impacts of the individual projects/actions while also addressing the totality of impacts. To accomplish those dual goals, NNSA defined and accumulated data for each of the projects/actions defined by the No-Action Alternative and the Proposed Action (*see* Section 3.4). The accumulated parameters are shown in Table 3-7 (for construction) and Table 3-8 (for operations) for both the No-Action Alternative and the Proposed Action. In developing the key parameters for the SWEIS analysis, NNSA is able to account for projects/actions both individually and in totality, and the analysis in this SWEIS addresses each of these aspects.

The methodology for addressing accidents and intentional destructive acts is presented in Appendix C. The methodology for assessing cumulative impacts is presented in Chapter 6. For any new projects, a combination of design features and best management practices (BMPs) would be implemented to avoid or reduce potential environmental impacts that could result from implementing the Proposed Action (*see* Section 5.19).

B.2 LAND USE

Description of Affected Resources and Region of Influence. Land use is the term used to describe the designation and use of land. It represents the economic and cultural activities (e.g., agricultural, residential, commercial, industrial, recreational, and conservation) that are practiced at a given place. The analysis of impacts to land use considers land use plans and policies, zoning regulations, and existing land use as appropriate for the site analyzed. This analysis identifies temporary and permanent changes of land uses associated with the No-Action Alternative and the Proposed Action.

The affected project area or ROI for land use is the Livermore Site, Site 300, Arroyo Mocho, and leased and nearby offsite areas. The land use designations of nearby locations were determined through review of land ownership maps and agency planning documents where available, and land uses as observed through publicly available aerial and street imagery. The ROI includes the limits of operational/physical disturbance, as well as the construction-related impact area, which includes additional areas of temporary disturbance (e.g., laydown areas) required for construction activities.

Description of Impact Assessment. Land use changes could potentially affect previously disturbed land and undisturbed land. Key metrics in this analysis are: (1) amount of land disturbance; (2) amount of new facilities; and (3) a qualitative analysis of consistency with current land use plans, classifications, and policies. Activities under the No-Action Alternative and Proposed Action were reviewed to identify actions that would change or cause adverse effects to use, designation, development density, ownership, or local planning and zoning. The land use analysis also considers potential impacts resulting from the conversion of, or the incompatibility of, land use changes with special-status lands, such as national parks/monuments or prime farmland, and other protected lands, such as Federal- and State-controlled lands (e.g., public land administered by the Bureau of Land Management [BLM] or other government agency). Land use data gathered for this analysis was also used in analyzing impacts on the visual environment, the results of which are described in greater detail immediately below in Section B.3.

B.3 AESTHETICS AND SCENIC RESOURCES

Description of Affected Resources and Region of Influence. Visual resources are natural and manmade features that give a particular landscape its character and aesthetic quality. The features that form the overall impression a viewer receives of an area include landform, vegetation, water, color, adjacent scenery, rarity, and manmade modifications. The visual ROI is the location of the facilities and views of the facilities from on-site and public viewpoints off-site. Special consideration is given to actions within visually sensitive locations and viewpoints from visually sensitive locations.

Description of Impact Assessment. The key metric in this analysis is visual compatibility (i.e., whether actions would be consistent with existing landscapes; or obscure views; or increase the visibility of structures or otherwise detract from the scenic perspectives of existing and planned residential developments adjacent to the sites; or cause glare). This SWEIS uses the following criteria in the visual resources analysis: scenic quality, visual sensitivity, distance, and visibility zones from key public viewpoints. The analysis is comparative in nature and consists of a qualitative examination of potential changes in visual resources, scenic values (attractiveness), and view corridors (visibility). Aspects of visual modification examined include site development or modification activities that could alter the visibility of structures at each of the sites or obscure views of the surrounding landscape, and changes in land cover that could make structures more visible.

To rate the scenic quality of the Livermore Site, Site 300, and surrounding areas, BLM's Visual Resource Management (VRM) Classification System was used (BLM 1986). Although this classification system is designed for undeveloped and open land managed by BLM, this is one of the only systems of its kind available for the analysis of visual resource management and planning activities.

The VRM Classification System provides a systematic approach for evaluating the potential changes to visual resources that may result from the projects/actions, and is typically used by DOE/NNSA in its NEPA evaluations. The major concepts of the BLM's VRM methodologies that this SWEIS followed are as listed:

- Establish an understanding of the existing visual character and qualities of the landscape environment of the project area;
- Determine areas from which the projects/actions would be visible;
- Estimate the visual expectations and response of the viewers to visual changes resulting from projects/actions; and
- Identify the visual contrast resulting from changes to the existing landscape character and qualities in the project area as a result of projects/actions.

B.4 GEOLOGY AND SOILS

Description of Affected Resources and Region of Influence. The ROI for geology and soils consists of the Livermore Site, Site 300, and nearby offsite areas. This SWEIS presents collated and summarized information on the regional structural geology, stratigraphy, and soils. In addition, the SWEIS evaluates the seismicity of the region surrounding each site to provide a perspective on the probability of earthquakes in the area and their likely severity. This information is also used in the SWEIS evaluation of accidents from natural phenomena.

Description of Impact Assessment. Key metrics in this analysis include: (1) the amount of soil disturbance; (2) the potential for causing erosion, soil loss, or impacts to prime farmland; and (3) analysis of whether soils and geologic features would support new facilities (e.g., potential for landslides and flooding). The SWEIS evaluates the projects/actions based on the amount of disturbance that may affect the geology and/or soils of the ROI. These impacts could include potential erosion impacts and impacts to geologic economic resources. Impacts, if any, are evaluated and a determination made as to severity. In addition, the analysis identifies and discusses seismic requirements for new facilities.

B.5 WATER RESOURCES

Description of Affected Resources and Region of Influence.

Surface Water**.** The affected environment discussion includes a description of local surface water resources at LLNL (Livermore Site and Site 300), flow characteristics and relationships, existing water quality, and the location of floodplains. The water quality of potentially affected receiving waters was determined by reviewing current monitoring data for contaminants of concern. Focus was given to parameters that exceeded applicable water quality criteria as determined by the State of California. Monitoring reports for discharges permitted under the National Pollutant Discharge Elimination System (NPDES) were examined for compliance with permit limits and requirements.

Groundwater. Groundwater is described in terms of the regional groundwater system in which LLNL is located; more specifically, in terms of the local aquifers. The SWEIS presents the local groundwater system of aquifers and confining units in terms of general water quality, depths from the ground surface, and rates and direction of groundwater movement. The discussion of groundwater quality from past LLNL activities and the associated ongoing remedial activities includes mapped locations of groundwater contaminant plumes.

Description of Impact Assessment. Key metrics presented in this analysis include: (1) increases in impervious areas and stormwater effects; (2) analysis of effluents and the potential for surface/groundwater contamination; and (3) potential floodplain impacts. Potential impacts to wetlands are discussed in Section B.8 (Biological Resources). Potential impacts associated with water use are discussed in Section B.12 (Infrastructure).

Surface Water**.** The impacts analysis evaluates the following: (1) possible changes in quantity or quality of stormwater runoff during construction activities; (2) the type, rate, and characteristics of any wastewater generated during operations; and (3) the type and quantity of water needed to support construction and operations. Changes in stormwater volumes and directions have the potential to adversely impact existing discharge points or receiving waters. Spills or leaks of contaminants from heavy equipment during construction could affect stormwater runoff. The analysis evaluates wastewater from operations in terms of treatment and capacity of existing facilities. Lastly, the impacts analysis evaluates the potential for projects/actions to be within the 100- or 500-year floodplains.

Groundwater. The SWEIS evaluates potential impacts to groundwater resources that could result from a potential release of contaminants during construction and discharge of wastewaters during operations that could reach groundwater. The evaluation also considers whether the alternatives could affect or be affected by existing groundwater contaminant plumes and cleanup activities.

B.6 AIR QUALITY

Description of Affected Resources and Region of Influence. The ROI for air quality is the Livermore Site, Site 300, Arroyo Mocho, and nearby offsite areas within the Air Quality Control Region, where air quality impacts could occur. The air quality impact analysis evaluated the criteria pollutants, hazardous/toxic air pollutants, and greenhouse gases (GHG) from the alternatives. Criteria pollutants are defined in 40 CFR Part 50. The National Ambient Air Quality Standards (NAAQS) set standards for primary and secondary sources. Title III of the 1990 *Clean*

Air Act amendments, known as the National Emission Standards for Hazardous Air Pollutants (NESHAPS), regulate hazardous air pollutants, such as carcinogens, mutagens, and reproductive toxins. California has incorporated the federal NAAQS and NESHAPS by reference, and establishes maximum allowable ambient concentrations for both criteria pollutants and toxic air pollutants that is more restrictive than the Federal hazardous air pollutant list. Title V of the *Clean Air Act* requires major sources of air pollutants, and certain other sources, to obtain and operate in compliance with an operating permit. Sources with these "Title V permits" are required by the Act to certify compliance with the applicable requirements of their permits at least annually. NNSA activities at LLNL comply with Title V requirements.

Description of Impact Assessment. Key metrics presented in the air quality analysis include: (1) quantities of air emissions and comparisons to air quality standards; (2) quantities of GHG emissions and comparison to state-wide emissions; and (3) quantities of radiological emissions (note: potential human health impacts from radiological emissions are discussed in Section B.14 [Human Health and Safety]). The SWEIS analysis used the Air Conformity Applicability Model (ACAM)[1] to determine whether emissions from new sources would exceed the general conformity rule's *de minimis* threshold values for assessing effects to air quality.

Construction and operational emissions from the Livermore Site, Site 300, and Arroyo Mocho were estimated. For purposes of analysis, peak annual emissions were assessed. Therefore, regardless of the ultimate implementation schedule of any phase of development, annual emissions would be less than those specified. Small changes in facilities site and ultimate design, and moderate changes in quantity and types of equipment used would not substantially change the emission estimates, and would not change the determination under the general conformity rule or the effects.

Because LLNL is currently in a nonattainment area for some criteria pollutants (*see* Section 4.6), new construction or modifications to existing facilities must be evaluated for Nonattainment New Source Review and Prevention of Significant Deterioration (PSD) permitting. If the emissions from the planned construction exceed one of the major source thresholds, then modification to the existing permit may be required.

Construction and demolition emissions were estimated for fugitive dust, on- and off-road diesel equipment and vehicles, worker trips, and off-gasses from new pavements. There would be temporary increases in air quality impacts from construction equipment, trucks, and construction employee vehicles. Exhaust emissions from these sources would result in releases of criteria pollutants such as sulfur dioxide, nitrogen oxide, PM_{10}, total suspended particulates, volatile organic compounds, and carbon monoxide. The alternatives would disturb land during construction. Fugitive dust generated during the clearing, grading, and other earth-moving operations is dependent on a number of factors, including silt and moisture content of the soil, wind speed, and area disturbed. There would be no radiological emissions during construction activities. Several facilities have used or stored radiological materials and are known to contain

[1] As described in Appendix B, Section B.3.6, the ACAM model was specifically designed to estimate air emission from the construction and operation of facilities. The ACAM model uses stationary and mobile source emission factors to estimate emissions for projects that require the construction and operation of multiple facilities phased in over several years. As such, this model was considered ideal for this SWEIS.

residual contamination. Consequently, there is a potential for short-term radiological air emissions for these DD&D actions.

Operational emissions were estimated for heating and cooling of buildings and vehicles. The impacts of nonradiological emissions from operations were evaluated based on results of ACAM analysis. Estimates of GHG emissions from stationary (e.g., backup diesel generators) and mobile sources (e.g., vehicles) were based on EPA emission factors and number of employees for the alternatives. With regard to operations, as discussed in Section 4.6.5, LLNL operations release radioactivity to the environment through stacks and from diffuse sources. The SWEIS estimated the radiological emissions for both the No-Action Alternative and the Proposed Action; and in some cases, emissions limits were used for the analysis. The potential human health impacts from radiological emissions are discussed in Section B.14 (Human Health and Safety).

B.7 Noise

Description of Affected Resources and Region of Influence. Information on noise was obtained from current LLNL documentation (e.g., site annual reports, recent environmental documents). Resources potentially affected by noise include workers, members of the public, wildlife and sensitive receptors in the vicinity of the project site. The ROI for noise is the Livermore Site, Site 300, and nearby offsite areas where notable noise impacts could occur.

Description of Impact Assessment. Key metrics presented in the noise analysis include: (1) identification of construction and operational noise sources; (2) identification of new projects within approximately 400-800 feet of site boundaries, which may cause offsite noise impacts; (3) qualitative analysis of potential noise levels offsite to determine whether there would be a violation of any federal, state, or local noise regulation; and (4) traffic noise analysis.

In the noise assessment, NNSA included a description of the noise sources and noise levels anticipated for construction and operations. A review of both existing and proposed facility noise at both sites was conducted. With regard to noise from traffic, the analysis estimated the increase in traffic on area roads to determine whether there would be perceptible noise effect. An evaluation of noise associated with open air detonation activities at Site 300 was completed using Blast Noise Version 2 (BNOISE2). BNOISE2 is a Department of Defense noise impact assessment software that enables modeling of high-energy impulsive noise impacts. Operations were reviewed to ensure there would be no change in the noise in nearby areas when compared to existing conditions.

B.8 Biological Resources

Description of Affected Resources and Region of Influence. The affected biological resources include vegetation, fish and wildlife, protected and sensitive species, and wetlands at the Livermore Site, Site 300, and the Arroyo Mocho Pumping Station. The ROI for biological resources is defined by the boundaries of the three sites. According to the 2015 California State Wildlife Action Plan (CDFW 2015), the project areas are in the Bay Delta and Central Coast Province and the relevant conservation units are Central California Coast and Central California Coast Ranges ecoregions. The description of the affected environment includes information on vegetation, fish and wildlife, protected and sensitive species, and wetlands. Information from the 2021 biological surveys (*see* Appendix I) were included in the analysis.

Description of Impact Assessment. Key metrics presented in the analysis include: (1) identify disturbances to land/vegetation and discuss impact on habitats, fish and wildlife, and protected and special status species; (2) identify and discuss wetland impacts; and (3) quantify tritium levels and potential impacts on vegetation and commodities. In general, the analysis of impacts was qualitative rather than quantitative. The impact assessment was based on the degree to which various habitats or species could be affected relative to the existing affected environment. Where appropriate, impacts were evaluated against Federal and State protection regulations and standards.

Vegetation**.** Potential impacts on vegetation were evaluated by comparing data on site vegetation to land requirements for construction and operational activities for the alternatives. Changes to the existing vegetation, cleared areas, or disturbed sites proposed to be redeveloped for construction were determined. Potential impacts on vegetation and commodities from increased tritium emissions were evaluated to determine the potential level of contamination that could occur.

Fish and Wildlife**.** Potential impacts on fish and wildlife were based primarily on the amount of habitat changed or lost due to the activities involving clearing of vegetation and construction and operation of facilities. The construction and operational activities proposed in previously disturbed sites and those in undeveloped areas were evaluated for assessment of habitat changes, loss of habitats, and whether any sensitive or unique habitats would be impacted. The availability of suitable habitat adjacent to the proposed construction and operational activities as well as human disturbance, including construction and operational noise, were also considered in the assessment of potential impacts on fish and wildlife.

Protected and Sensitive Species**.** Potential impacts on protected and sensitive species were generally based on the same approach taken for fish and wildlife. The co-location of protected and sensitive species as well as the presence of designated critical habitat with the proposed construction and operational activities were primary concerns for assessing potential impacts. The occurrence or potential occurrence of protected and sensitive species in the proposed sites was secondarily considered in the evaluation of potential impacts.

Wetlands**.** Potential impacts on wetlands were generally based on the same approach taken for vegetation. The amount of wetlands and waters of the U.S that would be impacted by the construction and operational activities was considered in the assessment of direct impacts. Indirect impacts such as runoff sedimentation were based on the proximity of wetlands and waters of the U.S. to the construction and operational activities.

B.9 CULTURAL AND PALEONTOLOGICAL RESOURCES

Description of Affected Resources and Region of Influence. Cultural resources are divided into three general categories for this SWEIS: archaeological resources, historic resources, and Native American resources. The analysis of impacts to cultural resources is organized by these three categories of resources and is focused on those resources that have been determined eligible for listing on the National Register.

Section 106 of the *National Historic Preservation Act* (NHPA) and its implementing regulations (36 CFR Part 800) state that an undertaking has an effect on a significant historic property (i.e., eligible to the National Register) when that undertaking may alter those characteristics of the property that qualify it for inclusion in the National Register of Historic Places (NRHP). An undertaking is considered to have an adverse effect when it diminishes the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Adverse effects include, but are not limited to:

- Physical destruction, damage, or alteration of all or part of the property;
- Removal of a property from its historic location;
- Change to the character of the property's use or of physical features in its setting when that character contributes to the property's historic significance;
- Introduction of visual, audible, or atmospheric elements that are out of character with the property, or changes that alter its setting;
- Neglect of a property resulting in its deterioration or destruction; or
- Transfer, lease, or sale of a property out of Federal ownership without adequate provisions to protect the property's historic integrity (36 CFR 800.5(a)(2)).

Paleontological resources are the fossil remains of past life forms. Fossils are the remains of once-living organisms such as plants, animals, fungi, and bacteria that have been replaced by minerals. Fossils also include imprints or traces of organisms preserved in rock, such as impressions, burrows, and trackways. Paleontological resources are considered a fragile and nonrenewable scientific record of the history of life on earth, and so represent an important component of America's natural heritage.

The ROI for the alternatives includes the area within which cultural and paleontological resources could be affected by construction and operations activities, and includes those resources located within the boundaries of the Livermore Site, Site 300, and the Arroyo Mocho Pumping Station.

Description of Impact Assessment. Key metrics presented in the cultural and paleontological analysis include: (1) identification of land disturbances; and (2) qualitative analysis of the potential to impact cultural and paleontological resources. Because there are no structures eligible for listing for the National Register at any LLNL sites, there would be no Section 106 impacts.

The analysis of potential impacts to paleontological resources from construction activities and operations is focused on impacts resulting from ground-disturbing activities. The analysis takes into account the previous ground-disturbance that has occurred from LLNL development activities. With regard to cultural resources of significance to Native Americans, no such resources were identified. NNSA consulted with the California Native American Heritage Commission and no responses were received.

B.10 SOCIOECONOMIC CHARACTERISTICS AND ENVIRONMENTAL JUSTICE

Socioeconomics

Description of Affected Resources and Region of Influence. The analysis of socioeconomics considers the attributes of human social and economic interactions from the alternatives and the impacts on the ROI, which is defined as the four-county area in which a majority of LLNL employees reside— Alameda, San Joaquin, Contra Costa, and Stanislaus counties. The potential for socioeconomic impacts is greatest in local jurisdictions. The SWEIS socioeconomic analysis reviews the local demographics, regional and local economy, local housing, and community services.

Description of Impact Assessment. Key metrics presented in the socioeconomics analysis are: (1) employment and population changes; (2) changes in economic activity (e.g., earnings/monetary value added); and (3) impacts to housing and community services. Estimates of the potential impacts on economic output, employment, and earnings under each alternative are derived using multipliers provided from the Regional Input-Output Modeling System (RIMS II) developed by the U.S. Bureau of Economic Analysis (BEA) for a select region (BEA 2021). Multipliers were developed for an aggregation of the four-county ROI. The BEA develops RIMS II multipliers using input-output tables that show the distribution of inputs purchased and outputs sold for each industry. A national input-output table, representing approximately 500 different industries, is adjusted using BEA regional economic accounts to accurately reflect the structure of a given area.

The impacts analysis examines potential impacts with respect to employment, population, and local economic conditions. The value added from the direct economic activity to the local economy includes employee compensation, tax on production and imports, and proprietary and other property income and indirect employment compensation. The analysis considered vacant housing units in the ROI to determine whether an influx of workers/families into the ROI would impact housing availability. The analysis also analyzed potential effects on fire protection, police protection services, or medical services, and estimated the effects on schools. Generally, effects that result in greater employment or income, or that otherwise improve the quality of life for the local population, are considered beneficial socioeconomic impacts.

Environmental Justice

Description of Affected Resources and Region of Influence. The potential for disproportionately high and adverse human health or environmental impacts from the alternatives on minority and low-income population was examined in accordance with EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Federal agencies are responsible for identifying and addressing the possibility of disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands. In January 2021, Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad" was issued. The order formalizes the commitment to make environmental justice a part of the mission of federal agencies to develop programs, policies, and activities to address the disproportionate health, environmental, economic, and climate impacts on disadvantaged communities and required federal agencies to "make achieving environmental justice part of their missions." Minority populations refer to persons of any race self-designated as Asian, Black, Native American, or Hispanic. Low-income populations refer to households with incomes below the federal poverty thresholds. The potentially affected area for this SWEIS includes parts of 19 counties in California that comprise an area within a 50-mile radius of the Livermore Site and Site 300.

Description of Impact Assessment. The environmental justice analysis (Section 5.10.2) identifies and addresses any disproportionately high and adverse human health or environmental effects on minority or low-income populations. Environmental justice concerns the environmental impacts that alternatives may have on minority and low-income populations, and whether such impacts are disproportionate to those on the population as a whole in the potentially affected area. The SWEIS uses population data from the U.S. Census Bureau and State population projections for California to calculate the population within a 50-mile radius of the center of the Livermore Site and Site 300. The 50-mile radius population surrounding the Livermore Site is 8,457,535 and 7,353,150 surrounding Site 300. The population is based on the Census Bureau's 2019 American Community Survey data.

The threshold for identifying minority and low-income communities surrounding LLNL is consistent with CEQ guidance (CEQ 1997) for identifying minority populations using either the 50-percent threshold or a "meaningfully greater" percentage of minority or low-income individuals in the general population. For this SWEIS, NNSA defines "meaningfully greater" as 20 percentage points above the population percentage in the general population. Once minority and low-income communities were identified, the impacts analysis focused on whether there would be any high and adverse environmental or human health effects.

Meaningfully greater low-income populations are identified using the same methodology described above for identifying meaningfully greater minority populations. The low-income population in California is 13.4 percent, and the low-income population percentage of the counties surrounding the Livermore Site and Site 300 is 10.8 percent. Comparatively, a meaningfully greater low-income population percentage using these statistics would be 20 percentage points greater than the low-income population for counties surrounding the Livermore Site and Site 300 (or 30.8 percent). Therefore, the county threshold was used to identify areas that have meaningfully greater low-income populations within a 50-mile radius of the Livermore Site and Site 300.

B.11 TRAFFIC AND TRANSPORTATION

Description of Affected Resources and Region of Influence. The ROI for transportation is the Livermore Site, Site 300, adjacent areas, and the corridors between LLNL and other sites where radiological and hazardous material transportation could occur. For the existing environment, the SWEIS describes the transportation infrastructure (road network and mass transit) utilized by workers for commuting. The level of service (LOS) on area roads is presented to describe operational conditions as they relate to the traffic stream and perceptions by motorists and passengers. The existing circulation and transportation network within the Livermore Site is described, as well as parking conditions. The description of the existing environment also includes a discussion of the transport of radiological materials/wastes and non-radiological hazardous materials/waste shipments between LLNL and other sites.

Description of Impact Assessment. Key metrics presented in the traffic and transportation analysis include: (1) traffic changes on area roads; and (2) impacts to the public and transport crews from shipments of radiological and hazardous materials. Non-radiological/non-hazardous transportation impacts utilized workforce estimates to evaluate the impact of commuting workers on the LOS of area roads. Within the Livermore Site, the analysis focused on the impact of workforce changes on circulation and parking.

Because the SWEIS alternatives involve offsite transport of radiological materials/wastes and non-radiological hazardous materials/waste shipments between LLNL and other sites, the analysis addressed the impacts of transporting these types of materials/wastes. For this analysis, NNSA determined the types and quantities of materials/wastes that would be transported, as well as the origin and destinations for the shipments. Impacts were calculated from incident-free or routine transportation and impacts from transportation accidents.

For transportation accidents, both radiological and non-radiological impacts were presented. Radiological impacts from accident conditions consider foreseeable scenarios that could damage transportation packages, leading to releases of radioactive materials to the environment and are expressed in terms of latent cancer fatalities (LCFs).[2] The radiological risks from transporting materials and wastes are estimated in terms of the number of LCFs among the crew and the exposed population. Non-radiological impacts are expressed in terms of traffic fatalities and are determined by multiplying the number of miles to be driven, based on the number of shipments, by the route-specific fatality rate. Appendix D presents more details regarding the methodology for offsite transport of radiological materials/wastes and non-radiological hazardous materials/waste shipments.

B.12 INFRASTRUCTURE

Description of Affected Resources and Region of Influence. Potentially affected site infrastructure resources include electrical distribution systems, natural gas, fuel, domestic water, and sanitary sewer systems. The affected environment is considered to be the land area and resources within the LLNL site boundary (Livermore Site and Site 300).

Description of Impact Assessment. Key metrics presented in the infrastructure analysis are: (1) quantities of water, sanitary sewer (wastewater), electricity, and fuel (petroleum and natural gas) associated with construction, DD&D, modernization/upgrade/utility projects, and operations; and (2) analysis of the current infrastructure to meet demands. The SWEIS assessment of potential impacts to site infrastructure focuses on the ability of the site to support the alternatives. Based on estimated requirements for the alternatives, site development plans, and other DOE/NNSA planning documents, infrastructure requirements are projected over the planning periods for the alternatives. The analyses identify any significant demands and potential impacts to the existing infrastructure from implementation of the alternatives. The analysis takes into account NNSA site sustainability goals to reduce infrastructure demands and impacts.

B.13 WASTE MANAGEMENT AND MATERIALS MANAGEMENT

Description of Affected Resources and Region of Influence.

Waste. Affected resources in this discussion are the Livermore Site and Site 300 processes and facilities currently in place to manage (treat, store, and dispose) waste. The ROI consists of the

[2] Radiological doses can cause cancer. Consequently, the primary impact of radiological exposure is LCF risk. A health risk conversion factor of 0.0006 LCF per rem or person-rem of exposure is used for both the public and workers (DOE 2003).

LLNL (Livermore Site and Site 300) and any off-site facilities where LLNL waste is sent for management. The LLNL waste streams considered in this case include the following:

- Radioactive waste
  - Low-level radioactive waste (LLW)
  - Transuranic (TRU) waste, including mixed TRU waste
- Hazardous waste, including explosives waste
- Mixed low-level radioactive waste (MLLW)
- California Combined Waste
- Biohazardous/medical waste
- Other wastes
  - Municipal solid waste
  - Construction and demolition (C&D) waste

The emphases for the affected resources are those waste types and quantities that are currently generated within LLNL and that would be generated under the No-Action Alternative or the Proposed Action. The description of affected resources consists of a brief discussion of each waste type that includes typical characteristics of the waste involved, the amount generated per year, and the manner in which it is managed. Waste management actions or processes are described in terms of throughput and capacity to the extent possible. They are also evaluated with respect to the identification of any regulatory or permit issues (e.g., throughput limitations, violations, adverse findings, etc.) that might indicate adverse environmental impacts could be associated with additional waste generation. The discussions of affected resources include both Livermore Site and Site 300 elements if wastes are managed in the same manner. Discussions are site specific if wastes are unique or are managed differently.

Materials. The affected resources and the ROI are the Livermore Site and Site 300 facilities that use or otherwise manage materials warranting special considerations or procedures in order to protect workers, the public, or the environment. The materials of primary focus are:

- Radioactive materials;
- Chemicals; and
- Explosives.

The description of affected resources provides an overview of how the materials are controlled when brought onto the sites. This is primarily in the form of how the materials are inventoried and tracked, which provides the mechanism to ensure that supplies are not larger than necessary, that shelf-lives are not exceeded, and that the quantity within any facility does not exceed what can be safely managed in that facility. The description also provides an overall description of the types and quantities of these materials typically present within LLNL.

Description of Impact Assessment. Key metrics for the waste analysis include: (1) the capacity of the existing LLNL waste management system to appropriately manage any expected increases in waste quantities, and (2) the capacity of offsite facilities to receive additional LLNL waste for subsequent treatment and/or disposal. Key metrics for the materials management analysis are the capacity and capability of the existing LLNL materials management system to accommodate any expected increases in hazardous material quantities.

Waste. Potential impacts associated with waste management are evaluated based on the waste types and estimated volumes that would be generated by the No-Action Alternative or the Proposed Action. Waste types are evaluated to determine if they are consistent with existing LLNL waste streams and appropriate for management in the same procedures and processes as used for similar waste streams. Projections for waste volumes from the No-Action Alternative and the Proposed Action are each compared to the routine waste generation within LLNL to determine if procedures, processes, or infrastructure capacity could possibly be overwhelmed by the additional waste loads. The regulatory or permit status of existing waste management activities is also evaluated to determine if additional waste volumes could impact regulatory compliance.

LLNL employs several types of waste treatment processes within the Livermore Site or Site 300 and for some waste types uses recovery and reuse methods, but does not dispose of waste at either site. In many cases, LLNL's waste treatment is intended to make the waste suitable for offsite disposal or to reduce its volume to make offsite treatment or disposal more efficient. Accordingly, a key element of evaluating the impact of managing LLNL waste is considering how offsite treatment and disposal facilities might be affected. Two DOE facilities, the Waste Isolation Pilot Plant (WIPP) in New Mexico and the Nevada Nuclear Security Site (NNSS), are identified as disposal sites for LLNL TRU and LLW/MLLW, respectively.[3] The analysis focuses on how increased waste quantities associated with the No-Action Alternative and the Proposed Action could impact disposal capacities and ongoing waste receipt operations. Long term impacts associated with potential impacts to WIPP's capacity and planned life span are addressed in the cumulative analysis in Chapter 6.

Materials. Potential impacts associated with material management are expected to be in the form of changes to the types or quantities of materials in the LLNL inventory as a result of implementing the No-Action Alternative or the Proposed Action. Such changes might result from increasing or decreasing existing operations, or by adding operations that are different from those currently performed at the Livermore Site or at Site 300. Impacts would be considered adverse, or potentially adverse, if increased quantities of materials or new types of materials were potentially released and presented increased risk to workers, the public, or the environment.

B.14 HUMAN HEALTH AND SAFETY

Description of Affected Resources and Region of Influence. Potential impacts on public and worker health and safety include radiological and non-radiological exposure pathways and occupational injuries, illnesses, and fatalities resulting from construction activities and normal (accident-free) operations for the alternatives. Exposure pathways include inhalation, immersion, ingestion, and exposure to external sources. Occupational ROIs include involved and noninvolved

[3] Commercial, offsite facilities that routinely receive LLNL LLW/MLLW are similarly evaluated for potential operational capacity impacts due to increased quantities of waste from the No-Action Alternative and the Proposed Action. If existing conditions are such that a waste category is sent to a variety of offsite locations based on specific waste characteristics or contract terms, then the evaluation may be based on the general availability of treatment or disposal facilities to accommodate waste of that category. That is, is it reasonable to assume that a variety of suitable treatment or disposal facilities will remain available if an increased volume of waste is generated from LLNL activities.

workers. The ROI for human health and safety is the Livermore Site and Site 300 and offsite areas within a 50-mile radius of those sites due to potential release of materials to the environment.

Because operations at LLNL have the potential to release radionuclides to the environment that result in exposure to the worker and the public, NNSA conducts environmental surveillance and monitoring activities at LLNL and surrounding areas. These activities provide data that are used to evaluate potential radiation exposures that may contribute doses to the public. Each year, environmental data from LLNL are collected and analyzed. The results of these environmental monitoring activities are summarized in the annual site environmental reports. The environmental monitoring conducted at LLNL consists of two major activities: effluent monitoring and environmental surveillance.

Effluent monitoring involves the collection and analysis of samples or measurements of liquid (waterborne) and gaseous (airborne) effluents prior to release into the environment. These analytical data provide the basis for the evaluation and official reporting of contaminants, assessment of radiation and chemical exposures to the workers and the public, and demonstration of compliance with applicable standards and permit requirements.

Environmental surveillance data provide a direct measurement of contaminants in air, water, groundwater, soil, food, biota, and other media subsequent to effluent release into the environment. These data verify LLNL's compliance status and, combined with data from effluent monitoring, allow the determination of chemical and radiation dose and exposure assessment of NNSA operations and effects, if any, on the local environment. The effluent and environmental surveillance data presented in the environmental reports were used as the primary source of data for the analysis of radiation exposure to the public for the No-Action Alternative.

Description of Impact Assessment. Key metrics presented in the human health analysis are: (1) radiological doses and potential LCFs to the public and workers from normal operations; (2) occupational injuries/deaths to workers; and (3) health impacts to workers and the public from normal operations involving chemical and biological materials. A summary of the methodology used to assess the human health impacts during normal operations is presented below. Additional details are documented in Appendix C.

Radiological impacts were assessed for workers involved in LLNL operations (both involved workers and noninvolved workers) and for the public (maximally exposed individual [MEI] and population within the 50-mile radius of the sites). Similarly, health impacts to the MEI and population are based on doses calculated by the radiological air analyses.

Radiological doses were calculated for the MEI and the entire population residing within 50 miles of the Livermore Site and Site 300. The analysis calculated doses from normal operations using the U.S. Environmental Protection Agency (EPA)-mandated air dispersion dose model, CAP88-PC Version 4.0.1.17 (USEPA 2014). The CAP88 dose model was developed under EPA sponsorship to demonstrate compliance with 40 CFR Part 61, Subpart H, which governs the emissions of radionuclides other than radon from DOE facilities.

Meteorological data used in the calculations were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. For occupants of residences within the ROI, the dose calculations assumed that the occupant remained at home (unprotected outside the house) during the entire year and obtained food according to the rural pattern defined in the NESHAP background documents. For workers, radiological doses were estimated by NNSA based on historical dose information.

Occupational injury, illness, and fatality estimates were evaluated using occupational incidence rates of major industry groups based on U.S. Department of Labor, Bureau of Labor Statistics injury, illness, and fatality information for similar activities (BLS 2021). These rates were compared to person-hour estimates for the alternatives. Occupational injury, illness, and fatality categories used in this analysis are in accordance with Occupational Safety and Health Administration definitions. Incident rates were developed for facility construction and operations.

Facility operations were evaluated to determine if any chemical-related or biological-related health impacts would be associated with normal (accident-free) operations. Facility design features that minimize the worker exposures during facility operations act as defense-in-depth controls. In addition to these controls, worker protection is augmented by programs such as the Integrated Safety Management System (ISMS), an Environmental Management System (EMS), an Operational Health and Safety Management System (OHSMS), a Worker Safety and Health Program, Work Planning and Control (WP&C) documents, chemical hygiene, industrial hygiene personnel monitoring, and emergency preparedness.

B.15 Site Contamination and Remediation

Description of Affected Resources and Region of Influence. The Livermore Site was placed on the EPA National Priorities List in 1987. Site 300 was placed on the National Priorities List in 1990. Remedial activities are overseen by the EPA, the San Francisco Bay and Central Valley Regional Water Quality Control Boards, and the California EPA Department of Health Services (now Department of Toxic Substances Control [DTSC]) under the authority of a Federal Facility Agreement (FFA) under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) Section 120 (DOE 1988).

Groundwater and soils at both the Livermore Site and Site 300 are contaminated from historical operations; the contamination, for the most part, is confined to each site. However, some contamination has occurred offsite. The affected environment is considered to be the land area and resources within the LLNL site boundary (Livermore Site and Site 300) and offsite areas that may be contaminated.

Description of Impact Assessment. With regard to remediation activities, NNSA complies with provisions specified in the FFA. Any future remediation actions would be conducted in accordance with the FFAs, and NNSA is not proposing any specific future remediation activities in this SWEIS. As such, this SWEIS summarizes the status of ongoing remediation activities and accomplishments.

B.16 References

10 CFR 1021 — "National Environmental Policy Act Implementing Procedures." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=7badeb153b53b77d8297172e1d76d083&mc=true&node=pt10.4.1021&rgn=div5

36 CFR 800 — "Protection of Historic Properties." *Parks, Forests, and Public Property*. National Park Service, Department of the Interior. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=02fe62e5397b7b60855ade6d08915e81&mc=true&node=pt36.3.800&rgn=div5

40 CFR 1500-1508 — "Purpose, Policy, and Mandate." *Protection of Environment*. Council on Environmental Quality. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=7badeb153b53b77d8297172e1d76d083&mc=true&node=pt40.37.1500&rgn=div5.

40 CFR Part 61 — "National Emission Standards for Hazardous Air Pollutants; Subpart H: National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities." *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-61/subpart-H?toc=1.

BEA 2021 — Bureau of Economic Analysis. "Regional Input-Output Modeling System (RIMS II)." Generated April 2021. Multipliers for Alameda Contra Costa, San Joaquin, and Stanislaus Counties, California.

BLM 1986 — U.S. Bureau of Land Management. "BLM Manual H-8410-1 – Visual Resource Inventory." Rel. 8-28. January 17, 1986. Available online: https://blmwyomingvisual.anl.gov/docs/BLM_VRI_H-8410.pdf

BLS 2021 — U.S. Bureau of Labor Statistics. "Injuries and Fatalities." Available at: https://www.dir.ca.gov/oprl/Injuries/Demographics/2019/PrivateIndustry/2019Table7-PrivateIndustry.html (accessed November 2021).

CEQ 1997 — Council on Environmental Quality. *Environmental Justice Guidance Under the National Environmental Policy Act*. December 10, 1997. Available online: https://www.epa.gov/sites/production/files/2015-02/documents/ej_guidance_nepa_ceq1297.pdf

CDFW 2015 California Department of Fish and Wildlife. *California State Wildlife Action Plan, 2015 Update: A Conservation Legacy for Californians*. Edited by Armand G. Gonzales and Junko Hoshi, PhD. Prepared with assistance from Ascent Environmental, Inc., Sacramento, CA. for California Department of Fish and Wildlife. September 30, 2015. Available online: https://wildlife.ca.gov/SWAP/Final

DOE 1988 U.S. Department of Energy. "Federal Facilities Agreement under CERCLA Section 120 between the U.S. Environmental Protection Agency and the U.S. Department of Energy and the California Department of Health Services and the California Regional Water Quality Control Board." ID 2069. November 2, 1988.

DOE 2003 U.S. Department of Energy. "Estimating Radiation Risk from Total Effective Dose Equivalent (TEDE)." ISCORS Technical Report No. 1. DOE/EH-412/0015/0802, Rev. 1. ID 1970. Office of Environmental Policy and Guidance. January. Available online: https://www.osti.gov/servlets/purl/1374991 (accessed July 2020).

EO 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." February 11, 1994. Available online: https://www.archives.gov/files/federal-register/executive-orders/pdf/12898.pdf

EO 14008 "Tackling the Climate Crisis at Home and Abroad." 86 Federal Register 7619; January 27, 2021. Available online: https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad

USEPA 2014 U.S. Environmental Protection Agency. "Clean Air Act Assessment Package – 1988 (CAP88)." Version 4.0. September 2014. Available online: https://www.epa.gov/radiation/cap-88-pc

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APPENDIX C

Human Health, Safety, Accidents, Intentional Destructive Acts, and Emergency Management

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C HUMAN HEALTH, SAFETY, AND ACCIDENTS AND EMERGENCY MANAGEMENT

The purpose of this appendix is two-fold: (1) to discuss the environment, safety, and health (ES&H) programs at Lawrence Livermore National Laboratory (LLNL); and (2) support the sections in Chapters 4 and 5 of this SWEIS related to health and safety (Sections 4.14 and 5.14) and accident analyses and intentional destructive acts (Section 5.16). The detailed analyses and discussions presented in this appendix are for the Proposed Action (unless otherwise noted).

Section C.1 discusses the ES&H programs at LLNL, regulatory requirements for ES&H, and the responsibilities to address ES&H requirements. Section C.2 discusses occupational exposures/impacts from radiation, chemicals, and other industrial hazards arising from the normal operations of facilities. Section C.2 also discusses environmental monitoring programs and the impact of releases of radioactive and hazardous materials from normal plant operations. The potential impact to workers and members of the general public from hypothetical accidents is discussed in Section C.3, and transportation accidents are discussed in Appendix D. Section C.4 discusses intentional destructive acts. Section C.5 discusses emergency management.

C.1 ES&H PROGRAMS AND REGULATORY REQUIREMENTS

The Laboratory's ES&H policies commit the organization to perform work in a manner that ensures the protection of employee health and safety, the environment, and the public. These policies provide that these ES&H protections are ensured by the systematic and consistent use of the LLNL Integrated Safety Management System (ISMS), Environmental Management System (EMS), and Occupational Health and Management System (OHSMS) to drive safe work practices at all levels. These policies also state commitments to continuous improvement (i.e., feedback solicitation and iterative refinement). The Laboratory's policies commit LLNL to comply with all ES&H requirements, including laws, regulations, and other related requirements (LLNL 2018a).

The ISMS is the model and construct used to prescribe the procedures and processes necessary to "Do Work Safely." As discussed in Section C.1.1 below, the ISMS employed at LLNL consists of eight Guiding Principles (GP) and five Core Functions (CF) that form the basis for how work is to be performed. The National Nuclear Security Administration (NNSA) and Lawrence Livermore National Security, LLC (LLNS), the prime contractor for LLNL, are committed to fully implement an ISMS to ensure the public, workers, and the environment are protected. NNSA and LLNS management firmly believe that the use of an ISMS for planning and performing work facilitates a safer work environment in which Laboratory missions are met or surpassed (LLNL 2018b).

The LLNL ISMS begins with the development of a set of requirements primarily identified in laws, regulations, and DOE directives contained in the LLNS Prime Contract (DE-AC52-07NA27344), but also including requirements identified in such overarching documents as the scope of work (SOW) and contract clauses. These requirements form the basis for the development of institutional processes, guided by the ISMS principles and CFs that permeate the LLNL organization from senior management through the programs and directorates, facilities, and activities, to the worker, with a primary focus on the worker. This integration is achieved at several levels through a number of mechanisms such as Functional Area Managers and Subject Area Managers (FAMs/SAMs), work processes, committees (e.g., Stakeholder Advisory Groups [SAG] Institutional Operations Review Board [IORB], and the Contractor Assurance System [CAS]). The result is a coherent and comprehensive methodology to achieve best-in-class safety performance. The EMS and OHSMS employed at LLNL are integrated components of ISMS (LLNL 2018b).

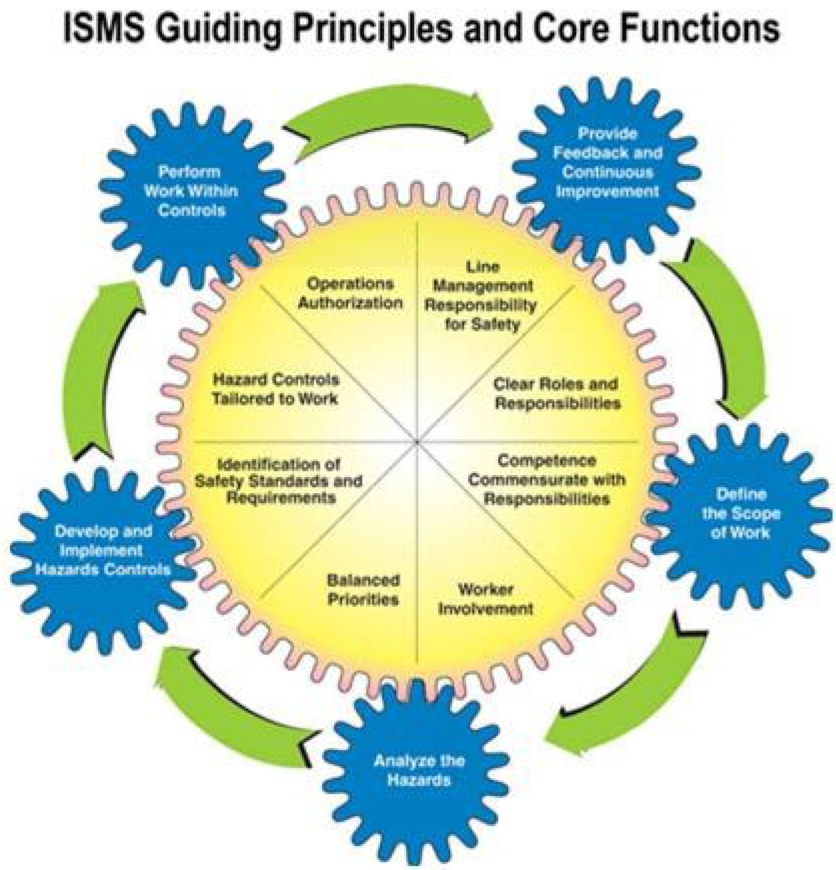
DOE Order 436.1 ("Departmental Sustainability") requires DOE Contractors to develop and implement an EMS that is certified to or conforms with ISO 14001:2004 (DOE 2011a). This requirement is implemented by the Laboratory's EMS, which was ISO 14001 certified in 2009. The Laboratory's EMS was certified to the ISO 14001:2015 standard in 2018. Likewise, requirements in 10 CFR 851 outlines the requirement for a worker safety and health program to ensure contractors and their workers operate a safe workplace. The LLNL safety and health program adopted the ISO 18001 2007 OHSMS. In August 2019, the safety and health program converted to ISO 45001 2018 OHSMS program. DOE/NNSA and LLNS integrate the overlapping elements of EMS and OHSMS to ensure similar processes are seamlessly managed and executed without duplication (LLNL 2018c).

C.1.1 Guiding Principles and Core Functions

DOE/NNSA/LLNS have established eight GPs that are the fundamental policies for use in the management of safety at LLNL (Figure C-1). These GPs are the attributes or elements that must be established throughout an organization to support the eventual safe performance of work. They are:

1. **Line Management Responsibility for Safety** – Line management is directly responsible for the protection of the public, the workers, and the environment.
2. **Clear Roles and Responsibilities** – Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels.
3. **Competence Commensurate with Responsibilities –** Personnel possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
4. **Balanced Priorities** – Resources are effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment is a priority whenever activities are planned and executed.
5. **Identification of Safety Standards and Requirements** – Before work is performed, the associated hazards are evaluated, and an agreed-upon set of safety standards and requirements is established that, when properly implemented, provides adequate assurance that the public, the workers, and the environment are protected from adverse consequences.
6. **Hazard Controls Tailored to the Work Being Performed** – Administrative and engineering controls to prevent and mitigate hazards are tailored to the work being performed and associated hazards. Hazards are analyzed at the facility-level and the activity-level to address ES&H hazards.
7. **Operations Authorization** – The conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and agreed upon.
8. **Worker Involvement** – Performance of ISMS is focused where work is performed, both at the institutional level, and at the facility and activity levels. Worker input and support,

along with line management direction and ownership, combined with effective processes, must be present to ensure success (LLNL 2018b).



Source: LLNL 2018b.

Figure C-1. ISMS Guiding Principles and Core Functions

DOE/NNSA/LLNS have defined five CFs for ISMS that comprise the underlying process for any work activity that could potentially affect the public, the workers, and the environment. They are:

1. **Define the SOW** – Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.
2. **Analyze the Hazards** – Hazards to workers, the public, and the environment associated with the work are identified, analyzed, and categorized.
3. **Develop and Implement Hazard Controls** – Applicable standards and requirements are identified and agreed-upon, controls to prevent/mitigate hazards are documented, and controls are implemented prior to beginning work.
4. **Perform Work within Controls** – Readiness is confirmed, and work is performed safely, such that the worker, the public, and the environment are protected.
5. **Provide Feedback and Continuous Improvement** – Feedback information on the adequacy and effectiveness of controls is gathered, opportunities for improving the

definition and planning of work are identified and implemented, and line and independent oversight is conducted.

The five CFs are applied as a continuous cycle with the degree of rigor appropriate to address the type of work activity and the hazards involved (LLNL 2018b).

C.1.2 Responsibilities to Address ES&H

The Laboratory's ISMS, a comprehensive and structured approach to managing health, safety, and environmental aspects at the Laboratory, is the core of the EMS. The Laboratory Director's role is to establish and maintain the policies, goals, and requirements for LLNL's overall ES&H programs, processes, and performance. This includes the responsibility to provide a workplace where recognized hazards are appropriately controlled. The Director has the lead role in communication regarding ES&H with LLNL workers, customers, and the public (LLNL 2018c).

Responsibility for safety clearly rests with line management – line management "owns" safety, including the responsibility and accountability for safety, safety management, and the integration of safety into business and operations. While safety and environmental professionals provide expert advice and oversight, line management understands and accepts its responsibilities for protecting personnel, the public, and the environment.

The line management chain at LLNL begins with the Director's Office (LLNL Director, Deputy Director, and Deputy Director for Science and Technology), and flows down to the Principal Associate Directors and Associate Directors responsible for the performance of work. Every work activity is authorized by a single Authorizing Organization (AO) (e.g., Directorate, Principal Directorate, Department) responsible for ensuring adequate funding is available to conduct the work and determining the priorities in completing the work objectives. The AO ensures the work is within the safety basis of the facilities in which it is performed and ensures the hazards and environmental aspects are identified and appropriately controlled. The AO designates an Authorizing Individual (AI) who formally approves work to proceed. During this process, the AI ensures the work activities have been planned to address technical, financial, administrative, and ES&H objectives, and that work control documents (WCDs) meet the quality expectations of the Laboratory's Work Planning and Control (WP&C) system. Each activity has a Responsible Individual (RI), who is the person directly responsible for the activity. The RI is formally identified by the activity's AI, communicates work expectations to workers on their activities, and holds workers accountable for their performance. RIs may have job titles such as Principal Investigator (PI), laboratory or shop supervisor, craft supervisor, or engineering superintendent. RIs may also be workers on the activities for which they are responsible (LLNL 2018b).

C.2 Radiation, Chemicals, and Other Industrial Hazards Arising from Normal Operations

C.2.1 Radiation and Impacts to Human Health

Humans are constantly exposed to naturally occurring radiation through sources such as from cosmic radiation and from the Earth's rocks and soils. This type of radiation is referred to as *background radiation* and it is always around us. Background radiation remains relatively constant over time and is present in the environment today just as it was hundreds of years ago. In addition, humans are also exposed to manmade sources of radiation, including medical and dental x-rays, household smoke detectors, materials released from coal burning power plants, and nuclear facilities. The following sections describe some important principles concerning the nature, types, sources, and effects of radiation and radioactivity.

C.2.1.1 *What Is Radiation?*

Some atoms have large amounts of energy and are inherently unstable. They may reach a stable, less energetic state through the emission of subatomic particles or electromagnetic radiation, a process referred to as radioactivity. *Ionizing radiation* has enough energy to free electrons from atoms, creating ions that can cause biological damage. Although it is potentially harmful to human health, ionizing radiation is used in a variety of ways, many of which are familiar to us in our everyday lives. An x-ray machine is one source of ionizing radiation. Likewise, most home smoke detectors use a small source of ionizing radiation to detect smoke particles in the room's air. The two most common mechanisms in which ionizing radiation is generated are the electrical acceleration of atomic particles such as electrons (as in x-ray machines) and the emission of energy from nuclear reactions in atoms.

Some elements, such as uranium, radium, plutonium, and thorium, share a common characteristic: they are unstable or radioactive. Such radioactive isotopes are called *radionuclides* or *radioisotopes*. As these elements attempt to change into more stable forms, they emit invisible rays of energy or particles at rates which decrease with time. This emission is known as radioactive decay. The time it takes a material to lose half of its original radioactivity is referred to as its half-life. Each radioactive isotope has a characteristic half-life. The half-life may vary from a millionth of a second to millions of years, depending upon the radionuclide. Eventually, the radioactivity will essentially disappear.

As a radioactive element emits radioactivity, it often changes into an entirely different element that may or may not be radioactive. Eventually, however, a stable element is formed. This transformation may require several steps, known as a decay chain. Radium, for example, is a naturally occurring radioactive element with a half-life of 1,622 years. It emits an alpha particle and becomes radon, a radioactive gas with a half-life of only 3.8 days. Radon decays to polonium and, through a series of steps, to bismuth, and ultimately to lead.

Nonionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. In this SWEIS, the term radiation is used to describe ionizing radiation.

C.2.1.2 *What Are Some Sources of Radiation?*

Several different sources of radiation have been identified. Most sources are naturally occurring, or background sources, which can be categorized as cosmic, terrestrial, or internal radiation sources. Manmade radiation sources include consumer products, medical sources, and other miscellaneous sources. The average American receives a total of about 625 millirem per year from all sources of radiation, both natural and manmade (Table C-1; NCRP 2009).

Cosmic radiation is ionizing radiation resulting from energetically charged particles from space that continuously hit the Earth's atmosphere. These particles and the secondary particles and photons they create are referred to as cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For example, a person in Denver, Colorado, at an altitude of 5,280 feet above sea level, is exposed to more cosmic radiation than a person in Livermore, California, at an altitude of only 600 feet above sea level. The average annual dose from cosmic radiation to a person in the United States is about 33 millirem.

Terrestrial radiation is emitted from the radioactive materials in the Earth's rocks, soils, and minerals. Radon, radon progeny, potassium, isotopes of thorium, and isotopes of uranium are the elements responsible for most terrestrial radiation. The average annual dose from terrestrial radiation is about 21 millirem, but the dose varies geographically across the country.

Internal radiation arises from the human body metabolizing natural radioactive material that has entered the body by inhalation, ingestion, or through an open wound. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, bismuth, polonium, potassium, rubidium, and carbon. The major contributors to the annual dose equivalent for internal radioactivity are the short-lived decay products of radon which contribute about 200 millirem per year. The average dose from other internal radionuclides is about 29 millirem per year, most of which results from potassium-40 and polonium-210.

Consumer products also contain sources of ionizing radiation. In some products, like smoke detectors and airport x-ray machines, the radiation source is essential to the operation of the product. In other products, such as televisions and tobacco products, the radiation occurs incidentally to the product function. The average annual dose from consumer products is about 13 millirem.

Medical source radiation is an important diagnostic tool and is the main source of exposure to the public from manmade radiation. Exposure is deliberate and directly beneficial to the patient exposed. In general, medical exposures from diagnostic or therapeutic x-rays result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Nuclear medicine examinations and treatments involve the internal administration of radioactive compounds or radiopharmaceuticals by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body. Radiation and radioactive materials also are used in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Diagnostic x-rays and nuclear medical procedures result in an average annual exposure of 300 millirem. It is recognized that the averaging of medical doses over the entire population does not account for the potentially significant variations in annual dose among individuals, where greater doses are received by older or less healthy members of the population.

A few additional sources of radiation contribute minor doses to individuals in the United States. The doses from nuclear fuel cycle facilities, such as uranium mines, mills, and fuel processing plants, nuclear power plants, and transportation routes have been established to be less than 1 millirem per year. Radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive material from DOE facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials contributes less than 1 millirem per year to the average individual dose. Air travel contributes approximately 1 millirem per year to the average dose.

Table C-1. Background Radiation Exposure Unrelated to LLNL Operations

Source[a]	Individual Dose[b] (millirem per year)	Collective Dose[c] (person-rem per year)
Natural Background Radiation[d]		
Cosmic radiation	33	257,000
Terrestrial radiation	21	164,000
Internal (food and water consumption)	29	226,000
Radon and Thoron in homes (inhaled)	228	1,780,000
Other Background Radiation		
Diagnostic x-rays and nuclear medicine	300	2,340,000
Consumer products	13	101,000
Industrial plus occupational	0.8	6,240
Total	**625**	**4,874,240**

a. From National Council on Radiation Protection and Measurements, Report No. 160, Table 8.1 (NCRP 2009).
b. This dose is an average over the U.S. population.
c. The collective dose is the combined dose for all individuals residing within a 50-mile radius of the Livermore Site (approximately 7.8 million people [LLNL 2019b]).
d. These values vary with location.
Source: LLNL 2019b.

C.2.1.3 *How Does Radiation Affect the Human Body?*

Ionizing radiation affects the body through two basic mechanisms. The ionization of atoms can generate chemical changes in body fluids and cellular material. Also, in some cases the amount of energy transferred can be sufficient to actually knock an atom out of its chemical bonds, again resulting in chemical changes. These chemical changes can lead to alteration or disruption of the normal function of the affected area. At low levels of exposure, such as the levels experienced in an occupational or environmental setting, these chemical changes are small and innocuous. The body has a wide variety of mechanisms that repair the damage induced. However, occasionally, these changes can cause irreparable damage that could ultimately lead to initiation of a cancer, or change to genetic material that could be passed to the next generation. The probability for the occurrence of health effects of this nature depends upon the type and amount of radiation received, and the sensitivity of the part of the body receiving the dose.

At much higher levels of acute whole-body exposure, at least 10–20 times higher than the legal limits for occupational exposures (the limit for annual occupational exposures is 5 rem), damage is much more immediate, direct, and observable. Health effects range from reversible changes in the blood to vomiting, loss of hair, temporary or permanent sterility, and other changes leading ultimately to death at acute exposures (above about 100 times the regulatory limits). In these cases, the severity of the health effect is dependent upon the amount and type of radiation received. Exposures to radiation at these levels are quite rare.

For low levels of radiation exposure, the probabilities for induction of various cancers or genetic effects have been extensively studied by both national and international expert groups. The problem is that the potential for health effects at low levels is extremely difficult to determine without extremely large, well-characterized populations. For example, to get a statistically valid estimate of the number of cancers caused by an external dose equivalent of 1 rem, 10 million people would be required for the test group, with another 10 million for the control group. The risk factors for radiation-induced cancer at low levels of exposure are small, and it is extremely important to account for the many non-radiation-related mechanisms for cancer induction, such as smoking, diet, lifestyle, chemical exposure, and genetic predisposition. These multiple factors also make it difficult to establish cause-and-effect relationships that could attribute high or low cancer rates to specific initiators.

The most significant ill-health effects that result from environmental and occupational radiation exposure are cancer fatalities. These ill-health effects are referred to as "latent" cancer fatalities (LCFs) because the cancer may take many years to develop and for death to occur. Furthermore, when death does occur, these ill-health effects may not actually have been the cause of death.

Health impacts from radiation exposure, whether from sources external or internal to the body, generally are identified as somatic (affecting the individual exposed) or genetic (affecting descendants of the exposed individual). Radiation is more likely to produce somatic effects rather than genetic effects. The somatic risks of most importance are the induction of cancers.

For a uniform irradiation of the body, the incidence of cancer varies among organs and tissues. The thyroid and skin demonstrate a greater sensitivity than other organs; however, such cancers also produce relatively low mortality rates because they are relatively amenable to medical treatment.

C.2.1.4 *How Is Radiation Exposure Regulated?*

The release of radioactive materials and the potential level of radiation doses to workers and the public are regulated by DOE for its contractor facilities. Under conditions of the *Atomic Energy Act* (as amended by the *Price-Anderson Amendments Act* of 1988), DOE is authorized to establish Federal rules controlling radiological activities at the DOE sites. The act also authorizes DOE to impose civil and criminal penalties for violations of these requirements. Some NNSA activities are also regulated through a DOE Directives System that is contractually enforced.

Occupational radiation protection is regulated by 10 CFR Part 835, Occupational Radiation Protection. DOE has set occupational dose limits for an individual worker at 5,000 millirem per year. NNSA sites have set administrative exposure guidelines at a fraction of this exposure limit to help enforce the goal to manage and control worker exposure to radiation and radioactive material as low as reasonably achievable (ALARA). The regulatory dose limit for an individual worker is 5,000 millirem/year (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c).

Environmental radiation protection is currently regulated contractually through DOE Order 458.1, Radiation Protection of the Public and the Environment. This Order is applicable to all DOE/NNSA contractor entities managing radioactive materials. This Order sets annual dose standards to members of the public, as a consequence of routine DOE operations, of 100 millirem through all exposure pathways. The Order requires that no member of the public receive an annual dose greater than 10 millirem from the airborne pathway and 4 millirem from ingestion of drinking water. In addition, the dose requirements in the Radionuclide National Emission Standards for Hazardous Air Pollutants (Rad-NESHAP) limit exposure of an individual member of the public to airborne releases of radionuclides to a maximum of 10 millirem per year.

Limits of exposure to members of the public and radiation workers are derived from International Commission on Radiological Protection (ICRP) recommendations. The U.S. Environmental Protection Agency (USEPA) uses the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection recommendations and sets specific annual exposure limits (usually less than those specified by the Commission) in *Radiation Protection Guidance to Federal Agencies* documents.

Each regulatory organization then establishes its own set of radiation standards. The various exposure limits set by DOE and the USEPA for radiation workers and members of the public are given in Table C-2.

Table C-2. Exposure Limits for Members of the Public and Radiation Workers

Guidance Criteria (organization)	Public Exposure Limit at the Site Boundary	Worker Exposure Limit
10 CFR Part 835 (DOE)	--	5,000 millirem per year [a,b]
DOE Order 458.1 (DOE) [c]	10 millirem per year (all air pathways) 4 millirem per year (drinking water pathways) 100 millirem per year (all pathways)	--
40 CFR Part 61 (USEPA)	10 millirem per year (all air pathways)	--
40 CFR Part 141 (USEPA)	4 millirem per year (drinking water pathways)	--

a. Although this is a limit (or level) that is enforced by DOE, worker doses must be managed in accordance with ALARA principles. Refer to footnote b.
b. The regulatory dose limit for an individual worker is 5,000 millirem/year (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c).
c. Derived from 40 CFR Part 61, 40 CFR Part 141, and 10 CFR Part 20.

C.2.1.5 *Sources at LLNL That May Lead to Radiation Exposure*

Releases of radionuclides to the environment from LLNL operations are another source of radiation exposure to workers and individuals in the vicinity of LLNL. This section describes the primary types of radioactive sources at LLNL and describes how DOE/NNSA monitors, measures, and regulates radiation and radioactive materials.

The environment potentially affected by radiological site releases includes air, water, and soil. These transport pathways (the environmental medium through which a contaminant moves) require an associated exposure pathway (e.g., inhaling air, drinking water, or dermal contact with soil) to affect human health.

Airborne emissions contribute to the potential for radiation dose at, and around, LLNL with operations involving radioactive materials. National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations specify that any source that potentially can contribute greater than 0.1 millirem per year Total Effective Dose Equivalents (TEDE) to an offsite individual is to be considered a "major source" and emissions from that source must be continuously sampled.

In addition to major sources, there are a number of minor sources that have the potential to emit radionuclides to the atmosphere. Minor sources are composed of any ventilation systems or components such as vents, laboratory hoods, room exhausts, and exhaust stacks that do not meet the criteria for a major source but are located in or vent from a radiologically controlled area. Emissions from LLNL facility ventilation systems are estimated from radiation control data collected on airborne radioactivity concentrations in the work areas. Other emissions from unmonitored processes and laboratory exhausts are categorized as minor emission sources. Additionally, as explained in Section C.3, accidents can release radionuclides that can result in radiation exposure.

In addition, there are also areas of potential fugitive and diffuse sources at LLNL, such as contaminated soils and structures. Diffuse and fugitive sources include any source that is spatially distributed, diffuse in nature, or not emitted with forced air from a stack, vent, or other confined conduit. Radionuclides are transported entirely by diffusion or thermally driven air currents. Typical examples include emissions from building breathing; resuspension of contaminated soils, debris, or other materials; unventilated tanks; ponds, lakes, and streams; wastewater treatment systems; outdoor storage and processing areas; and leaks in piping, valves, or other process equipment.

Liquid discharges are another source of radiation release and exposure. Three types of liquid discharge sources at LLNL include treatment facilities, other point- and area-source discharges, and in-stream locations. A radiological monitoring plan is in place at LLNL required to address compliance with DOE orders and National Pollutant Discharge Elimination System (NPDES) Permits. Radiological monitoring of storm water is also usually required by the applicable NPDES permits.

LLNL operates facilities in which radionuclides are handled and stored, and radiological emissions to the air are possible. These facilities are subject to USEPA NESHAPs in 40 CFR Part 61, which regulates radionuclide emissions to air from DOE facilities. The USEPA Region IX has enforcement authority for LLNL compliance with radiological air emission regulations (LLNL 2020a, LLNL 2020b).

In accordance with 40 CFR Part 61, Subpart H, LLNL performs air effluent monitoring of atmospheric discharge points to evaluate its compliance with local, state, and Federal laws and regulations and to ensure that human health and the environment are protected. That monitoring is used to determine the actual radionuclide releases from individual facilities during routine and nonroutine operations and to confirm the operation of facility emission control systems. Subpart H requires continuous monitoring of facility radiological air effluents if the potential off-site (fence-line) dose equivalent is greater than 0.1 millirem/year, as calculated using the USEPA -mandated air dispersion dose model, CAP88-PC, without credit for emission control devices. The results of monitoring air discharge points provide the actual emission source information for modeling, which is used to ensure that the NESHAPs standard of 10 millirem/year total site effective-dose equivalent from the airborne pathway is not exceeded (LLNL 2020a, LLNL 2020c).

Many different radioisotopes were present at LLNL in 2019 including biomedical tracers, tritium, mixed fission products, transuranic isotopes, and others. Radioisotope handling procedures and work enclosures are determined for each project or activity, depending on the isotopes, the quantities being used, and the types of operations being performed. Work enclosures include glove boxes, exhaust hoods, and laboratory bench tops. Exhaust paths to the atmosphere include High Efficiency Particulate Air (HEPA) filtered ventilation systems, roof vents and stacks without abatement devices, resuspension of deposited depleted uranium in the soil from previous open-air explosives testing at Site 300, and releases to ambient air from a variety of diffuse sources (LLNL 2020c).

LLNL groups radionuclide emission sources into two categories: major sources or minor sources. Major sources are defined as those that have the potential to emit radionuclides that could result in an annual potential effective dose of 0.1 millirem or more to a member of the public at an offsite location; the radionuclide NESHAPs regulation requires continuous monitoring of the stack effluent when the annual potential effective dose exceeds 0.1 millirem to an off-site member of the public. Minor sources are defined as sources that do not have the potential to cause an annual effective dose of 0.1 millirem to an off-site member of the public. At LLNL, all major sources of emissions are point sources, i.e., stack emission points; however, minor sources include both point sources and diffuse sources (LLNL 2020c).

In 2019, there were five facilities at the Livermore Site and one facility at Site 300 that had radionuclide air effluent continuous monitoring systems. These facilities are listed in Table C-3, along with the number of samplers, the types of samplers, and the analytes of interest. Some of these facilities have the potential to emit radionuclides that would cause an annual effective dose greater than the 0.1 millirem NESHAPs standard; these sources are major sources following the definition given above. Other facilities have had the potential from radioactive air emissions in the past requiring monitoring, and the monitoring continues to be maintained to assure that the potential impact to the public and the environment is well understood. Additionally, monitoring may be in place for site-wide environmental impact statement commitments made to the public regarding the potential for radioactive air emissions (LLNL 2020c).

Many of the monitored stacks at LLNL have effluent controls, such as HEPA filters, to collect materials before they are emitted to the atmosphere. Air samples for particulate emissions are extracted downstream of HEPA filters and prior to the discharge point to the atmosphere. Particles are collected on high efficiency cellulose membrane filters. The sample filters are removed and analyzed for radioactive particulate activity on a weekly or bi-weekly frequency depending on the facility. In all cases, continuous passive filter aerosol collection systems are used. At some facilities, continuous air monitors also sample the stack air exhaust for radionuclide activity. Continuous air monitors have an alarm capability in the event of an unplanned release of radionuclide activity. Continuous air monitors are used for facility personnel safety; they are not used for NESHAPs compliance demonstration (LLNL 2020c).

Table C-3. Radiological Air Effluent Sampling Systems and Locations

Building	Facility	Analytes	Sample Type	Number of Samples
235	Building in Physical and Life Sciences Directorate	Gross alpha, beta on particles	Filter	1
331	Tritium Facility	Gaseous tritium/ tritiated water vapor	Ionization Chamber[a]	4
		Gaseous tritium/ tritiated water vapor	Glycol Bubblers	2
332	Plutonium Facility	Gross alpha, beta on particles	Filters	15
		Gross alpha, beta on particles	CAM[a]	14
581	National Ignition Facility	Gross alpha, beta on particles, Gamma suite on particles	Filter	1
		Radioiodine (volatile)	TEDA cartridge	1
		Gaseous tritium/ tritiated water vapor	Glycol Bubbler	1
		Gaseous tritium/ tritiated water vapor	Ionization Chamber[a]	1
695/696	Decontamination and Waste Treatment Facility	Gross alpha, beta on particles	Filter	1
801A	Contained Firing Facility (Site 300)	Gross alpha, beta on particles	Filter	1

CAM = continuous air monitor; TEDA = triethylenediamine.
a. Alarmed systems used for notification for any unplanned release.
Source: LLNL 2020c.

For LLNL to comply with the NESHAPs regulations, the site-wide maximally exposed individual (MEI) cannot receive an effective dose equivalent greater than 10 millirem/year per site. A sitewide MEI is defined as a *hypothetical* member of the public at a single residence, school, business, church, or other such facility who receives the greatest LLNL induced dose from the combination of all evaluated radionuclide source emissions, as determined by modeling. At the Livermore Site, the 2019 site-wide MEI is located at the Integrative Veterinary Care facility, which is approximately 115 feet outside the eastern fence line of the site. At Site 300, the 2019 site-wide MEI is located at the Site 300 boundary with the Carnegie State Vehicular Recreation Area (CSVRA), managed by the California Department of Parks and Recreation, approximately 1.9 miles south-southeast of the firing table at Building 851 (LLNL 2020c). The locations of the site-wide MEIs for both the Livermore Site and Site 300 are shown in Figure C-2. The MEIs identified in Figure C-2 represent hypothetical members of the public at a fixed public location who, over an entire year, would receive the maximum effective dose equivalent (summed over all pathways) from site-wide releases of radionuclides to air during normal operations. As discussed in Section C.3, for accident analyses, individual facilities have different MEIs at fence line locations.

Source: LLNL 2020c.

Figure C-2. Location of Site-Wide MEI at Livermore Site and Site 300

LLNL operations involving radioactive materials have minimal impact on ambient air. Releases of radioactivity to the environment from LLNL operations occur through stacks and from diffuse area sources. In 2019, radioactivity released to the atmosphere was monitored at five facilities on the Livermore Site and one at Site 300. In 2019, 126.4 Curies (Ci) of tritium was released from the Tritium Facility, and 2.8 Ci of tritium was released from the NIF. The CFF at Site 300 had measured stack emissions in 2019 for depleted uranium. A total of 1.2×10^{-7} Ci of uranium-234, 1.7×10^{-8} Ci of uranium-235, and 9.2×10^{-7} Ci of uranium-238 was released in particulate form (LLNL 2020aa). Table C-4 presents tritium emissions for the Tritium Facility and NIF for 2015–2019.

Table C-4. Tritium Air Emissions from Tritium Facility and NIF (2015–2019)

Location	2015 (Ci)	2016 (Ci)	2017 (Ci)	2018 (Ci)	2019 (Ci)	Average (Ci)
Tritium Facility	43.7	75.3	43.8	183.5	126.4	94.5
NIF	1.44	1.11	1.15	8.6[a]	2.8	3.0

a. Includes release of 5.53 Ci from unplanned event on June 11, 2018 (LLNL 2019b).
Source: LLNL 2016a, LLNL 2017a, LLNL 2018d, LLNL 2019b, LLNL 2020a.

There were two unplanned radioactive air releases from the Livermore Site in 2019. On October 11, 2019, the Physical and Life Sciences Directorate (Building 235) had a uranium fire as a result of material transfer when one ball valve was accidently left open on a two-valve system. When the container was moved out of alignment, approximately 0.00002 Ci of depleted uranium dropped into a photo tray under the ball valve of the machine. The material began to spark and was placed inside a fume hood. The fire was extinguished with a spray bottle and the sash was lowered. Work was suspended until a Group Management Concerns/Issues process was completed. LLNL implemented proper corrective actions to reduce the possibility of an accidental valve misalignment from becoming a reoccurring event. The unplanned release of 0.00002 Ci of depleted uranium is less than one-tenth of a percent of the USEPA Reportable Quantities (40 CFR Part 302) (LLNL 2020a).

On October 26, 2019, the Physical and Life Sciences Directorate (Building 235) had a second uranium fire that occurred during the cleaning of a plasma-based particle spheroidizer. Approximately 0.000004 Ci of uranium dropped onto a contamination barrier and began to smolder. The beginning fire was extinguished with a Metal-X extinguisher. The work was suspended with no routine access allowed in the room until a Group Management Concerns/Issues process was completed. LLNL implemented proper corrective actions to reduce the possibility of an accidental uranium release from maintenance activities becoming a reoccurring event. The unplanned release of 0.000004 Ci of depleted uranium is less than one-tenth of a percent of the USEPA Reportable Quantities (40 CFR Part 302) (LLNL 2020a).

For radioactive liquid discharges, DOE Order 458.1 provides the criteria DOE has established for the application of best available technology to protect public health and minimize degradation of the environment. These criteria (known as "Derived Concentration Technical Standards," but abbreviated as "DCS")[1] limit the concentration of each radionuclide discharged to publicly owned treatment works. If the measured monthly average concentration of a radioisotope exceeds its concentration limit, LLNL is required to improve discharge control measures until concentrations are again below the DOE limits. DOE Order 458.1 sanitary sewer discharge numerical limits include the following annual discharge limits for radioactivity: 5 Curies of tritium; 1 Curie of carbon-14; and 1 Curie of all other radionuclides combined. The radioisotopes with the potential to be found in sanitary sewer effluent at LLNL and their discharge limits are discussed below. LLNL determines the total radioactivity contributed by tritium, gross alpha emitters, and gross beta emitters from the measured radioactivity in the monthly effluent samples. As shown in Table C-5, the 2019 combined release of alpha and beta sources was 0.011 Curies), which is 0.8 percent of the corresponding DOE Order 458.1 limit of 1 Curie. The tritium total was 0.15 Curies, which is 3.0 percent of the DOE Order 458.1 limit of 5 Curies (LLNL 2020a).

[1] The derived concentration standard (DCS), which complements DOE Order 458.1, specifies the concentrations of a radionuclide that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 100 millirem/year effective dose equivalent.

Table C-5. Estimated Total Radioactivity in LLNL Sanitary Sewer Effluent (2019)

Radioactivity	Estimate based on effluent activity (Curies)	MDC (Curies)
Tritium	0.15	0.019
Gross alpha	0.0014	0.0026
Gross beta	0.0069	0.0014

MDC = Minimum detectable concentration.
Source: LLNL 2020a.

For 2019, the annual total discharges of cesium-137 and plutonium-239 were far below the DOE DCSs. Plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge. The highest plutonium concentration observed in 2019 sludge was 0.007 pCi/gram, which is many times lower than the NCRP recommended soil screening limit of 12.7 pCi/gram for commercial or industrial property (LLNL 2020a).

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. Table C-6 summarizes the radioactivity in sanitary sewer effluent over the past 10 years. During 2019, a total of 0.15 Curies of tritium was discharged to the sanitary sewer. While this is moderately higher than tritium activities discharged during the past 10 years, this amount is in a similar range to historical values, well within regulatory limits, and fully protective of the environment (LLNL 2020a).

Table C-6. Radioactive Liquid Effluent Releases from Livermore Site (2009–2019)

Year	Tritium (Curies)	Plutonium-239/240 (Curies)
2009	0.027	1.6×10^{-7}
2010	0.040	1.4×10^{-7}
2011	0.037	5.4×10^{-8}
2012	0.042	1.9×10^{-7}
2013	0.052	1.6×10^{-6}
2014	0.042	8.7×10^{-7}
2015	0.060	3.0×10^{-7}
2016	0.017	2.5×10^{-7}
2017	0.12	3.9×10^{-7}
2018	0.15	2.4×10^{-7}
2019	0.15	5.4×10^{-7}

Source: LLNL 2020a.

C.2.1.6 *Methodology for Estimating Radiological Impacts for Normal Operations*

The public health consequences of radionuclides released to the atmosphere from normal operations at NNSA sites are characterized and calculated in the applicable Site Annual Environmental Report (SAER). Radiation doses are calculated for the MEI and the entire population residing within 50 miles of the center of the site. In this SWEIS, dose calculations from normal operations were made based on the CAP-88 package of computer codes, version 3 (USEPA 2008), which was developed under USEPA sponsorship to demonstrate compliance with 40 CFR Part 61 (found in Subpart H), which governs the emissions of radionuclides other than radon from DOE facilities. This package implements a steady-state Gaussian plume atmospheric dispersion model to calculate concentrations of radionuclides in the air. Meteorological data used in the calculations were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. The results are discussed in Section C.2.1.7.

C.2.1.7 *Risk Estimates and Health Effects for Potential Radiation Exposures to the Public for the No-Action Alternative and the Proposed Action*

The Interagency Steering Committee on Radiation Standards (Lawrence 2002) recommended a risk estimator of 6×10^{-4} excess (above those naturally occurring) fatal cancers per person-rem of dose in order to assess health effects to the public and to workers. The probability of an individual worker or member of the public contracting a fatal cancer is 6×10^{-7} per millirem. Radiation exposure can also cause nonfatal cancers and genetic disorders. The probability of incidence of these is one third that of a cancer fatality (Lawrence 2002). In this SWEIS, only estimates of potential excess fatal cancers are presented.

The radiation exposure risk estimators are denoted as excess because they result in fatal cancers above the naturally occurring annual rate, which is 171.4 per 100,000 population nationally (Ries et al. 2002). Based on the fact that there are approximately 7.8 million people living within 50 miles of the Livermore Site (LLNL 2019b), approximately 13,370 fatal cancer deaths per year would be expected to naturally occur. The doses to which they are applied is the EDE, which weights the impacts on particular organs so that the dose from radionuclides that affect different organs can be compared on a similar (effect on whole body) risk basis. All doses in this document are effective dose equivalent unless otherwise noted.

Because fatal cancer is the most probable serious effect of environmental and occupational radiation exposures, this SWEIS presents estimates of latent cancer fatalities (LCFs). The number of LCFs in the general population or in the workforce is determined by multiplying 600 LCFs per million person-rem with the calculated collective population dose (person-rem), or calculated collective workforce dose (person-rem). For example, in a population of 7.8 million people exposed only to natural background radiation of 0.625 rem per year, 2,925 cancer fatalities per year would be inferred to be caused by the radiation (7,800,000 persons x 0.625 rem per year × 0.0006 cancer fatalities per person-rem = 2,925 cancer fatalities per year).

As shown in Table C-7, the annual radiological doses from the Livermore Site and Site 300 are well below the applicable standards for radiation protection of the public. The doses to the sitewide MEIs resulting from Livermore Site and Site 300 operations are less than one percent of the NESHAPs (10 millirem/year) standard. For all five years, the measured radionuclide particulate and tritium concentrations in ambient air at the Livermore Site and Site 300 were all less than one percent of the DOE primary radiation protection standard for the public (LLNL 2016a, LLNL 2017a, LLNL 2018d, LLNL 2019b, LLNL 2020a). The MEI doses from both the Livermore Site and Site 300 are much less than one-tenth of one percent of the total dose from sources of natural radioactivity shown in Table C-1.

Table C-7. Annual Radiation Exposures to Public from LLNL Operations (2015–2019)

Members of the Public	Year	Livermore Site	Site 300	Total
MEI (millirem)	2015	1.7×10^{-3}	4.8×10^{-4}	N/A[a]
	2016	2.8×10^{-3}	2.2×10^{-4}	N/A[a]
	2017	1.9×10^{-3}	4.8×10^{-5}	N/A[a]
	2018	6.7×10^{-3}	9.6×10^{-5}	N/A[a]
	2019	4.3×10^{-3}	9.5×10^{-8}	N/A[a]
	2015–2019 Average	**3.5×10^{-3}**	**1.7×10^{-4}**	**N/A[a]**
Population within 50 miles (person-rem)[b]	2015	0.13	2.4×10^{-5}	0.13[c]
	2016	0.22	3.0×10^{-5}	0.22[c]
	2017	0.13	7.2×10^{-5}	0.13[c]
	2018	0.47	2.8×10^{-5}	0.47[c]
	2019	0.33	2.9×10^{-5}	0.33[c]
	2015–2019 Average	**0.26**	**3.7×10^{-5}**	**0.26[c]**
Average annual dose to a person within 50 miles (millirem)	2015	1.7×10^{-5}	1.0×10^{-8}	1.7×10^{-5}
	2016	2.8×10^{-5}	4.2×10^{-9}	2.8×10^{-5}
	2017	1.7×10^{-5}	1.0×10^{-8}	1.7×10^{-5}
	2018	6.0×10^{-5}	3.0×10^{-9}	6.0×10^{-5}
	2019	4.2×10^{-5}	4.1×10^{-9}	4.2×10^{-5}
	2015–2019 Average	**3.3×10^{-5}**	**6.3×10^{-9}**	**3.3×10^{-5}**

MEI = site-wide maximally exposed individual member of the public.

a. MEI at Livermore Site and Site 300 are different people; therefore, their doses are not additive. If the MEI were additive, the MEI dose for the Livermore Site would account for approximately 97 percent of the combined dose.

b. The population dose is the combined dose for all individuals residing within a 50-mile radius of LLNL (approximately 7.8 million people for the Livermore Site and 7.1 million for Site 300), calculated with respect to distance and direction from each site.

c. Although the 50-mile population surrounding the Livermore Site and Site 300 are different, the population dose from Site 300 is insignificant compared to the population dose from the Livermore Site; therefore, the total population dose equals the population dose for the Livermore Site.

Source: LLNL 2016a, LLNL 2017a, LLNL 2018d, LLNL 2019b, LLNL 2020a.

Impacts for the No-Action Alternative and the Proposed Action. Table C-8 shows the estimated radiological emissions during normal operations for both the No-Action Alternative and the Proposed Action. As shown, the largest increase in radiological emissions is associated with tritium emissions limits from the Tritium Facility and the NIF at the Livermore Site under the Proposed Action. Radiological emissions at Site 300 are expected to be the same under both the No-Action Alternative and the Proposed Action.

Table C-8. Estimated Radiological Emissions during Normal Operations for the No-Action Alternative and the Proposed Action

Parameter	No-Action Alternative	Proposed Action
Radiological air emissions (Curies/year)	**Livermore Site** Tritium Facility: 210 Ci tritium limit NIF: 80 Ci tritium limit Building 298: 10 Ci tritium Miscellaneous other diffuse emissions	**Livermore Site** Tritium Facility: 2,000 Ci tritium limit[a] NIF: 1,600 Ci tritium limit[a] HED Capability Support Facility Replacement (replacement for Building 298): 10 Ci/yr tritium Miscellaneous other diffuse emissions
	Site 300 CFF: 1.2×10^{-7} U-234; 1.1×10^{-8} U-235; 8.9×10^{-7} U-238	**Site 300** CFF: 1.2×10^{-7} U-234; 1.1×10^{-8} U-235; 8.9×10^{-7} U-238

a. Actual operational emissions from the Tritium Facility and NIF are not expected to increase; however, the use of tritium reservoirs with substantially greater amounts of tritium could result in the potential for greater tritium releases from routine operations with these reservoirs. Although the potential for higher discharges are greater (within limits identified above), the facilities would continue to operate engineered systems that have proven to be highly effective at capturing tritium emissions.

Source: Table 3-8.

As shown in Table C-9, under normal operations, there would be minimal public health impacts from radiological releases associated with the No-Action Alternative. Public radiation doses would occur from airborne releases, plus the radiation dose from neutrons penetrating the roof of the NIF. The dose to the Livermore Site MEI from neutrons produced at the NIF is a result of exposure to these neutrons (and the gamma rays produced) after they collide with the molecules in the air and scatter to the ground, which is referred to as "skyshine."

Table C-9. Annual Radiological Impacts to the Public from Operational Radiological Emissions under the No-Action Alternative at the Livermore Site and Site 300

Receptor/Dose/Risk	Baseline (Existing Environment)		No-Action Alternative	
	Livermore Site	Site 300	Livermore Site	Site 300
Offsite MEI[a]				
Dose (millirem)	4.004[b,e]	1.7×10^{-4}	4.01[b]	1.7×10^{-4}
LCF risk[c]	2.4×10^{-6}	1.0×10^{-10}	2.4×10^{-6}	1.0×10^{-10}
Population Within 50 Miles[d]				
Collective dose (person-rem)[e]	0.26	3.7×10^{-5}	0.60	5.0×10^{-5}
LCF[c]	1.6×10^{-4}	2.0×10^{-8}	3.6×10^{-4}	3.0×10^{-8}

a The MEI is a hypothetical individual located offsite who could potentially receive the maximum dose of radiation. The MEI at the Livermore Site is located at the Integrative Veterinary Care facility, about 35 meters outside the site's eastern perimeter. The MEI at Site 300 is located on the site's south-central perimeter, which borders the CSVRA.

b. Includes maximum of four mrem/year in skyshine dose from NIF operations. Skyshine doses are not covered by USEPA limits (40 CFR Part 61, Subpart H), but are limited by DOE Order 458.1, which sets annual dose standards from routine DOE operations of 100 millirem through all exposure pathways to members of the public.

c. Based on an LCF risk estimate of 0.0006 LCF per rem or person-rem.

d. Based on projection of 8,364,520 people living within 50 miles of the Livermore Site in the year 2030 and 7,613,858 people living within 50 miles of Site 300 in the year 2030.

e. Skyshine would not increase the overall population dose because exposure to skyshine would be limited to close proximity to the Livermore Site boundary near the NIF. Skyshine estimates are based on shot yields totaling 1,245 megajoules per year, which is considered a NIF practical operational constraint that would not be exceeded under the No-Action Alternative. Actual values are less than this value as NIF is currently conducting yields less than 1,245MJ per year.

Source: LLNL 2020c, 2020a, LLNL 2021b, LLNL 2021c.

At both the Livermore Site and Site 300, the annual radiation dose to the offsite MEI would be much less than the limit of 10 millirem per year set by both the USEPA (40 CFR Part 61, Subpart H) and DOE (DOE Order 458.1) for airborne releases of radioactivity. The risk of an LCF to the

MEI from operations at either the Livermore Site or Site 300 would be 2.4×10^{-6} at the Livermore Site and 1.0×10^{-10} at Site 300 per year. The projected number of LCFs to the population within a 50-mile radius of either the Livermore Site or Site 300 would be 3.6×10^{-4} at the Livermore Site and 3.0×10^{-8} at Site 300.

For the Proposed Action, as shown in Table C-10, the potential radiological impacts to the public during normal operations would also be small. At both the Livermore Site and Site 300, the annual radiation dose to the offsite MEI would be much smaller than the limit of 10 millirem per year set by the USEPA (40 CFR Part 61, Subpart H) and 100 millirem per year set by DOE (DOE Order 458.1) for airborne releases of radioactivity. Skyshine doses are not covered by USEPA limits (40 CFR Part 61, Subpart H), but are limited by DOE Order 458.1, which sets annual dose standards from routine DOE operations of 100 millirem through all exposure pathways to members of the public. The risk of an LCF to the MEI from operations at either the Livermore Site or Site 300 would be 2.4×10^{-6} at the Livermore Site and 1.0×10^{-10} at Site 300 per year. The projected number of LCFs to the population within a 50-mile radius of either the Livermore Site or Site 300 would be 4.3×10^{-3} at the Livermore Site and 3.0×10^{-8} at Site 300.

Table C-10. Annual Radiological Impacts to the Public from Operational Radiological Emissions under the Proposed Action at the Livermore Site and Site 300

Receptor/Dose/Risk	No-Action Alternative		Proposed Action	
	Livermore Site	Site 300	Livermore Site	Site 300
Offsite MEI[a]				
Dose (millirem)	4.01[b]	1.7×10^{-4}	4.21[b]	1.7×10^{-4}
LCF risk[c]	2.4×10^{-6}	1.0×10^{-10}	2.5×10^{-6}	1.0×10^{-10}
Population Within 50 Miles[d]				
Collective dose (person-rem)[e]	0.60	5.0×10^{-5}	7.1	5.0×10^{-5}
LCF[c]	3.6×10^{-4}	3.0×10^{-8}	4.3×10^{-3}	3.0×10^{-8}

a The MEI is a hypothetical individual located offsite who could potentially receive the maximum dose of radiation. The MEI at the Livermore Site is located at the Integrative Veterinary Care facility, about 35 meters outside the site's eastern perimeter. The MEI at Site 300 is located on the site's south-central perimeter, which borders the CSVRA.

b. Includes maximum of four mrem/year in skyshine dose from NIF operations. Skyshine doses are not covered by USEPA limits (40 CFR Part 61, Subpart H), but are limited by DOE Order 458.1, which sets annual dose standards from routine DOE operations of 100 millirem through all exposure pathways to members of the public.

c. Based on an LCF risk estimate of 0.0006 LCF per rem or person-rem.

d. Based on projection of 8,364,520 people living within 50 miles of the Livermore Site in the year 2030 and 7,613,858 people living within 50 miles of Site 300 in the year 2030.

e. Skyshine would not increase the overall population dose because exposure to skyshine would be limited to close proximity to the Livermore Site boundary near the NIF. Skyshine estimates are based on shot yields totaling 1,245 megajoules per year, which is considered a NIF practical operational constraint that would not be exceeded under the Proposed Action.

Source: LLNL 2020c, LLNL 2021b, LLNL 2021c.

In comparing the results of Table C-9 to Table C-10, the MEI and public dose at Site 300 would be the same for both the Proposed Action and the No-Action Alternative. This is due to the fact that the estimated radiological air emissions from Site 300 activities would be the same under both alternatives. In contrast, at the Livermore Site, the public doses would be higher for the Proposed Action (7.1 person-rem) than under the No-Action Alternative (0.60 person-rem). This is largely due to the proposal described in Section 3.3.3 to increase the tritium emissions limits at the NIF (Buildings 581) and the Tritium Facility (Building 331). Under that proposal, annual tritium emission limits from the Tritium Facility have the potential to increase from 210 curies per year to 2,000 curies per year, and annual tritium emission limits from the NIF have the potential to increase from 80 curies per year to 1,600 curies per year. Actual operational emissions from the

Tritium Facility and NIF are not expected to increase; however, the use of tritium reservoirs with higher amounts of tritium results in the potential for greater tritium releases from routine operations with these reservoirs. The facilities would continue to operate with engineered systems and solutions that have proven to be highly effective at capturing tritium.

While the increase in the tritium emissions limits at the NIF and the Tritium Facility could also increase the MEI dose for the Proposed Action compared to the No-Action Alternative at the Livermore Site, that increase is minimized by the fact that skyshine dose accounts for approximately 99 percent of the MEI dose for the No-Action Alternative and 95 percent of the MEI dose for the Proposed Action. As a result of the proposed increases in tritium emissions, the annual MEI dose would increase from 4.01 millirem to 4.21 millirem, an insignificant increase. The estimated LCFs for the MEI and the population would remain low (much less than one LCF).

C.2.1.8 *Risk Estimates and Health Effects for Potential Radiation Exposures to Workers for the No-Action Alternative and the Proposed Action*

For the purpose of evaluating radiation exposure on an ongoing basis, LLNL workers may be designated as radiation workers, non-radiation workers, or visitors, based upon the potential level of exposure they are expected to encounter in performing their work assignments. For purposes of estimating radiation doses to workers resulting from potential accidents, NNSA looks at involved workers (those workers actually working with radioactive materials) and non-involved workers (those workers performing other tasks near the involved workers).

Radiation workers have job assignments that place them in proximity to radiation-producing equipment and/or radioactive materials. These workers are trained for unescorted access to radiological areas, and may also be trained radiation workers from another DOE site. These workers are assigned to areas that could potentially contribute to an annual TEDE of more than 100 millirem per year.

Nonradiation workers are those not currently trained as radiation workers but whose job assignment may require their occasional presence within a radiologically controlled area with an escort. They may be exposed to transient radiation fields as they pass by or through a particular area, but their job assignments are such that annual dose equivalents in excess of 100 millirem are unlikely.

Visitors are individuals who are not trained radiation workers and are not expected to receive 100 millirem in a year. Their presence in radiologically-controlled areas is limited, in terms of time and access. These individuals generally enter specified radiologically-controlled areas on a limited basis for walk-through or tours with a trained escort. As appropriate, visitors participate in dosimetry monitoring when requested by the hosting division.

External exposures are those received from radiation-emitting sources outside the body; e.g., accelerators, radioactive sources, and radioactive equipment. At LLNL, radiological workers or workers who need unescorted access to Radiation Areas or High Radiation Areas are assigned dosimeters that are attached to their security badge. The badge and dosimeter must be worn at all times when onsite. The dosimeter measures the external radiation dose of the badge wearer.

Dosimeters are read monthly for workers who are likely to receive a measurable external radiation dose under normal conditions, or who could receive a radiation dose under off-normal conditions and might not otherwise be aware of it. They are read quarterly for workers who handle radioactive material but are not likely to receive a measurable external radiation dose under normal conditions, or who would otherwise be aware of off-normal conditions that may result in radiation exposure. They are read semi-annually for workers who are not likely to receive a measurable external radiation dose under normal conditions.

LLNL workers receive the same dose as the general public from background radiation, but also receive an additional dose from working in facilities with nuclear and radiological materials and RGDs. Table C-11 presents the annual average individual and collective worker doses from LLNL operations from 2015 to 2019. These doses fall within the regulatory limits presented in Table C-2. Using the risk estimator of 0.0006 LCF per 1 person-rem, the annual average LCF risk to a representative member of the LLNL workforce due to radiological releases and direct radiation exposure from LLNL operations from 2015 to 2019 is estimated to be 4.2 x 10^{-5}. That is, the estimated probability of a worker developing a fatal cancer at some point in the future from radiation exposure associated with one year of LLNL operations is about 1 in 24,000. No excess fatal cancers are projected in the total worker population from one year of normal operations during the period 2015–2019.

Table C-11. Radiation Doses to LLNL Workers from Operations (2015–2019)

Occupational Personnel	From Outside Releases and Direct Radiation by Year					
	2015	2016	2017	2018	2019	Average
Number of workers receiving a measurable dose	105	98	115	145	152	123
Total (collective) worker dose (person-rem)	7.57	8.22	7.134	8.69[b]	10.65[b]	8.45
Average radiation worker (millirem)[a]	72.1	83.8	62.0	59.9	70	69.6

a. No standard is specified for an "average radiation worker"; however, the maximum dose to a worker is limited as follows: The regulatory dose limit for an individual worker is 5,000 millirem/year (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c).
b. The small number of workers with measurable dose below 0.01 are included with the workers not receiving a measurable dose in the totals in 2018 and 2019.
Source: LLNL 2021d.

Impacts for the No-Action Alternative and the Proposed Action. The estimates of annual radiological doses to workers for the No-Action Alternative are provided in Table C-12. As shown in the table, the annual doses to individual workers would be well below the DOE limit of 5,000 millirem (10 CFR Part 835). The regulatory dose limit for an individual worker is 5,000 millirem/year (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c).

Under the No-Action Alternative, NNSA has estimated that worker dose at the Livermore Site would increase as NIF continues making progress on its path towards ignition. Under the 2019 baseline, only approximately 152 workers at LLNL received a measurable dose in 2019. As a result of higher yield experiments at NIF, NNSA is estimating that all 450 radiation workers at

NIF would receive a measurable dose. For the 100 primary operations workers, a maximum dose of 600 millirem per year could result. For 350 non-primary operations workers, a dose of 100 millirem per year is estimated.

As shown in Table C-12, operations at LLNL may result in an average individual worker dose of approximately 180 millirem annually. The total annual collective dose to all LLNL radiological workers would be 103.5 person-rem under the No-Action Alternative. Statistically, a total annual dose of 103.5 person-rem would result in 0.06 LCFs annually to the LLNL radiological workforce.

Table C-12. Annual Radiological Impacts to Workers from Operations under the No-Action Alternative at the Livermore Site and Site 300

Receptor/Dose/Risk	Baseline (2015-2019 Average)	No-Action Alternative: LLNL (includes workers at both the Livermore Site and Site 300)
Radiological Workers [a]		
Number of radiological workers receiving a measurable dose	123	575
Average annual dose to radiological worker (millirem)	69.6	180
Average annual radiological worker risk (LCFs)	4.2×10^{-5}	1.1×10^{-4}
Collective annual dose to radiological workers (person-rem)	8.45	103.5
Total Annual Radiological Worker Risk (LCFs) [b]	**0.005**	**0.06**

LCF = latent cancer fatality.

a. Radiological worker is defined as a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who have the potential to be occupationally exposed above 100 millirem per year.

b. Based on a LCF risk estimator of 0.0006 LCF per rem or person-rem.

Note: The regulatory dose limit for an individual worker is 5,000 millirem/year (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c).

Source: LLNL 2021a.

The estimates of annual radiological doses to workers for the Proposed Action are provided in Table C-13. As shown in the table, the annual doses to individual workers would be well below the DOE limit of 5,000 millirem (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c). Under the Proposed Action, worker doses would increase compared to the No-Action Alternative. The increase in worker dose under the under the Proposed Action is due to the Next Generation LEP R&D Component Fabrication Building, the Domestic Uranium Enrichment Program, and sample preparation work in Building 235. For operations associated with the Next Generation LEP R&D Component Fabrication Building and the Domestic Uranium Enrichment Program NNSA has estimated that approximately 25 additional workers could receive an average annual dose of approximately 70 millirem per year. For Building 235 operations, NNSA has estimated that approximately 15 workers would receive a measurable dose of approximately 100 mrem/year. There would no additional measurable worker doses from the Materials Analysis Laboratory.

Table C-13. Annual Radiological Impacts to Workers from Operations under the Proposed Action at the Livermore Site and Site 300

Receptor/Dose/Risk	No-Action Alternative	Proposed Action: LLNL (includes workers at both the Livermore Site and Site 300)
Radiological Workers[a]		
Number of radiological workers receiving a measurable dose	575	615
Average annual dose to radiological worker (millirem)	180	173.5[c]
Average annual radiological worker risk (LCFs)	1.1×10^{-4}	1.1×10^{-4}
Collective annual dose to radiological workers (person-rem)	103.5	106.7
Total Annual Radiological Worker Risk (LCFs)[b]	**0.06**	**0.06**

a. Radiological worker means a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who have the potential to be occupationally exposed above 100 millirem per year.
b. Based on a LCF risk estimator of 0.0006 LCF per rem or person-rem.
The increase in worker dose under the under the Proposed Action is due to the Next Generation LEP R&D Component Fabrication Building, the Domestic Uranium Enrichment Program, and sample preparation work in Building 235. For operations associated with the Next Generation LEP R&D Component Fabrication Building and the Domestic Uranium Enrichment Program NNSA has estimated that approximately 25 additional workers could receive an average annual dose of approximately 70 millirem per year. For Building 235 operations, NNSA has estimated that approximately 15 workers would receive a measurable dose of approximately 100 mrem/year.
Note: The regulatory dose limit for an individual worker is 5,000 millirem/year (10 CFR Part 835). At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval (LLNL 2019c).
Source: LLNL 2021a.

C.2.1.9 *LLNL's Radiation Protection Program*

A primary goal of the LLNL Radiation Protection Program (LLNL 2017b) is to keep worker exposures to radiation and radioactive material as low as reasonably achievable (ALARA). The ALARA philosophy is based on the supposition that radiation dose increases one's risk of cancer—the smaller the dose, the smaller the risk. Such a program must evaluate both external and internal exposures with the goal to minimize worker radiation dose. The worker radiation dose presented in this SWEIS is the total TEDE incurred by workers as a result of normal operations. Table C-14 presents the worker dose distribution of annual radiation doses (external + internal) received by LLNL workers for the recent five-year period 2015–2019. As shown in Table C-14 only two workers received a dose greater than 500 millirem during 2019. Most worker doses were less than 10 millirem.

Table C-14. Distribution of Worker Doses (2015–2019)

Dose Range (rem)	Number of Workers				
	2015	2016	2017	2018[a]	2019
≥2	0	0	0	0	0
1.5–1.999	0	0	0	0	0
1.000–1.499	1	1	0	0	0
0.5–0.999	1	2	3	2	2
0.1–0.499	15	12	9	15	20
0.01–0.099	77	53	79	111	115
<0.01	7,196	7,784	7,209	2,769[a]	2,868

a. In July 2017, LLNL changed its dosimetry issue policy from universal issuance to targeted issuance; consequently, the number of monitored workers in 2018 dropped considerably from prior years.
Source: LLNL 2019d.

LLNL provides data to DOE for occupational radiation exposure every year. Oftentimes, LLNL provide updates to previous years' data, revising such values. As a result, there may be slight differences in Tables C-11 and C-14 regarding the number of workers who received measurable doses. For example, Table C-11 shows that 145 workers received a measurable dose in 2018, while Table C-14 shows that 128 workers received a measurable dose in 2018.

C.2.2 Hazardous Chemicals, Other Industrial Hazards, and Impacts to Human Health

C.2.2.1 *Chemicals and Human Health*

LLNL is a research site in which a large variety of hazardous materials are used and represent a potential for exposure of some workers to these hazardous materials (such as solvents, metals, and carcinogens). The nature of LLNL activities is also such that chemical inventories can change significantly over time and from facility to facility as programs change or research findings dictate changes in direction. The general following chemical types, many using DOE designations, are used and stored at LLNL (LLNL 2019e):

- corrosives (liquids, solids, and gases);
- toxic substances (including gases);
- flammables and combustibles (including solids, liquids, and gases);
- nonflammable gases;
- water reactives/pyrophorics/spontaneously combustibles;
- oxidizing substances;
- organic peroxides; and
- explosives.

Carcinogens are only used in LLNL operations when it is not possible to use a noncarcinogenic material. Any use of carcinogens requires stringent controls to be in place to prevent exposures to workers, the public, and the environment.

The quantities of chemicals used at LLNL can be, in most cases, considered small. LLNL operations with chemicals are deemed consistent with OSHA's definition of "laboratory scale," as given in 29 CFR 1910.1450, i.e., work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. Chemicals present in laboratory scale quantities (LSQ) have the potential for unmitigated release with impacts to non-involved workers that are no more than mild, transient adverse health effects or the perception of an objectionable odor or sensation and with impacts to the public that present no appreciable risk of health effects.

A key element of LLNL's strategy in managing its chemical inventory is to ensure chemicals are used safely and appropriately. For new or planned actions, this is done largely through implementing the following hierarchy of controls, in order of preference: (1) select materials and process designs that avoid or minimize use of hazardous materials; (2) use engineered controls to confine, shield, or remove hazards; (3) use administrative or procedural controls; and (4) use personal protective equipment (LLNL 2019f, LLNL 2019g). By controlling operations through specific work control procedures, worker exposures are maintained at low levels, and generally below a threshold of concern.

Beryllium metal, alloys, and compounds are used at LLNL. Although LLNL is not a major facility in terms of hazardous air pollutant emission rates, specific NESHAP requirements (40 CFR Part 61[c]) apply for beryllium. Beryllium is identified with respiratory and immune system toxicity and is regulated under both state and federal programs. Beryllium is the only nonradiological emission from LLNL that is monitored in ambient air. LLNL requested and was granted a waiver by the BAAQMD for source-specific monitoring and recordkeeping for beryllium operations, provided that LLNL can demonstrate that monthly average beryllium concentrations in air are well below regulatory limits of 10,000 picograms per cubic meter (pg/m^3).

C.2.2.2 *How Do Chemicals Affect the Body?*

Industrial pollutants may be released either intentionally or accidentally to the environment in quantities that could result in health effects to those who come in contact with them. Chemicals that are airborne, or released from stacks and vents, can migrate in the prevailing wind direction for many miles. The public may then be exposed by inhaling chemical vapors or particles of dust contaminated by the pollutants. Additionally, the pollutants may be deposited on the surface soil and biota (plants and animals) and subsequent human exposure could occur. Chemicals may also be released from industries as liquid or solid waste (effluent) and can migrate or be transported from the point of release to a location where exposure could occur.

Exposure is defined as the contact of a person with a chemical or physical agent. For exposure to occur, a chemical source or contaminated media such as soil, water, or air must exist. This source may serve as a point of exposure, or contaminants may be transported away from the source to a point where exposure could occur. In addition, an individual (receptor) must come into either direct or indirect contact with the contaminant. Contact with a chemical can occur through ingestion, inhalation, dermal contact, or external exposure. The exposure may occur over a short (acute or subchronic) or long (chronic) period of time. These methods of contact are typically referred to as exposure routes. The process of assessing all of the methods by which an individual might be exposed to a chemical is referred to as an exposure assessment.

Once an individual is exposed to a hazardous chemical, the body's metabolic processes typically alter the chemical structure of the compound in its efforts to expel the chemical from the system. For example, when compounds are inhaled into the lungs they may be absorbed depending on their size (for particulates) or solubility (for gases and vapors) through the lining of the lungs directly into the blood stream. After absorption, chemicals are distributed in the body and may be metabolized, usually by the liver, into metabolites that may be more toxic than the parent compound. The compound may reach its target tissue, organ, or portion of the body where it will exert an effect, before it is excreted via the kidneys, liver, or lungs. The relative toxicity of a compound is affected by the physical and chemical characteristics of the contaminant, the physical and chemical processes ongoing in the human body and the overall health of an individual. For example, infants, the elderly, and pregnant women are considered more susceptible to certain chemicals.

C.2.2.3 *How Does DOE/NNSA Regulate Chemical Exposures?*

Environmental Protection Standards. DOE Order 450.1 requires implementation of sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by the DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, executive orders, and DOE requirements. Applicable Federal and State environmental acts/agreements include:

- *Resource Conservation and Recovery Act* (RCRA)
- *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) as amended by the *Superfund Amendments and Reauthorization Act* (SARA)
- Federal Facility Compliance Agreement
- *Endangered Species Act*
- *Safe Drinking Water Act*
- *Clean Water Act* (CWA)(which resulted in the establishment of the NPDES and pretreatment regulations for Publicly-Owned Treatment Works [POTW])
- *Clean Air Act* (CAA) (Title III, Hazardous Air pollutants Rad-NESHAP, Asbestos NESHAP)
- *Toxic Substances Control Act* (TSCA)
- *Federal Insecticide, Fungicide, and Rodenticide Act*

Many of these acts/agreements include environmental standards that must be met to ensure the protection of the public and the environment. Most of the acts/agreements require completed permit applications in order to treat, store, dispose of, or release contaminants to the environment. The applicable environmental standards and reporting requirements are set forth in the issued permits and must be met to ensure compliance.

The *Emergency Planning and Community Right-To-Know Act*, also referred to as SARA Title III, requires reporting of emergency planning information, hazardous chemical inventories, and environmental releases to Federal, State, and local authorities. The annual Toxics Release Inventory report addresses releases of toxic chemicals into the environment, waste management activities, and pollution prevention activities associated with those chemicals.

Regulated Occupational Exposure Limits. Occupational limits for hazardous chemicals are regulated by the Occupational Safety and Health Administration (OSHA). The permissible exposure limits (PELs) represent the legal concentration levels set by OSHA that are safe for 8-hour exposures without causing noncancer health effects. Other agencies, including the National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) provide guidelines. The NIOSH guidelines are Recommended Exposure Limits, and the ACGIH guides are threshold limit values (TLVs). Occupational limits are further defined as time-weighted averages (TWAs), or concentrations for a conventional 8-hour workday and a 40-hour workweek, to which it is believed nearly all workers may be exposed, day after day, without adverse effects. Often ceiling limits, or airborne concentrations that should not be exceeded during any part of the workday, are also specified. In addition to the TWA and ceiling limit, short-term exposure limits may be set. Short-term exposure limits are 15-minute TWA exposures that should not be exceeded at any time during a workday, even if the 8-hour TWA is within limits. OSHA also uses action levels to trigger certain provisions of a standard (e.g., appropriate workplace precautions, training, and medical surveillance) for workers whose exposures could approach the PEL.

C.2.2.4 *Other Industrial Hazards*

During normal operations, LLNL workers may be exposed to hazardous conditions that can cause injury or death. The potential for health impacts varies among facilities and workers. Workers are protected from workplace hazards through appropriate training, protective equipment, monitoring, materials substitution, and engineering and management controls. Under 10 CFR Part 851, DOE lists the requirements for a worker safety and health program to ensure that DOE contractors and their workers operate a safe workplace. DOE establishes procedures for investigating whether a violation of a requirement of this part has occurred, for determining the nature and extent of any such violation, and for imposing an appropriate remedy. In addition, 10 CFR Part 851 incorporates many OSHA requirements and other protections. Appropriate monitoring that reflects the frequency and quantity of chemicals used in the operational processes ensures that these standards are not exceeded. DOE also requires that conditions in the workplace minimize hazards that cause, or are likely to cause, illness or physical harm.

LLNL's occupational health and safety performance is measured by injury and illness rates (Total Recordable Case [TRC] and Days Away with Restricted Time [DART]) pursuant to DOE orders that use OSHA criteria. As shown on Table C-15, the TRC rate at LLNL has varied between 0.99 and 1.29 over the past five years; this means that for every 100 workers at LLNL, there is approximately one work-related injury or illness annually that results in either death, days away from work, or days of restricted work activity or job transfer. In 2019, the TRC rate was the lowest in the past five years. DART represents severe injuries per 100 workers annually. As shown in Table C-15, the DART rate at LLNL has varied between 0.28 and 0.58 over the past five years; this means that for every 100 workers at LLNL, there is less than one work-related severe injury or illness annually that results in days away from work or days of job restriction or transfer.

The LLNS CAIRS Log shows that of the 894 injuries and illnesses recorded on the LLNS Injury Log between 2015 and 2017, LLNS determined 217 to be OSHA recordable (DOE 2018a). In 2018, work-related injuries included eye exposure to hazardous chemicals while not wearing eye protection, skin burns from flash powder, trips and falls that resulted in wrist/leg/foot fractures, concussions, serious cuts from machining operations, and electric shocks (DOE 2020a). No work-related fatalities occurred at LLNL between 2015 and 2019.

Table C-15. Occupational Injury Statistics for LLNL (2015–2019)

Year	TRC Rate[a]	DART Rate[b]	Number of TRCs[c]	DART Cases[d]	Workdays Lost[e]	Number of DART Days[f]
2015	1.02	0.39	45	17	691	1,191
2016	1.22	0.41	57	19	515	1,103
2017	1.19	0.32	59	16	381	1,304
2018	1.29	0.58	64	29	171	1,194
2019	0.99	0.28	53	15	84	616

DART = Days Away, Restricted Time; TRC = Total Recordable Case.

a. TRC Rate: Total Recordable Cases per 200,000 work-hours (approximately 100 person-years).
b. DART Rate: Days Away, Restricted or on Job Transfer per 200,000 work-hours (approximately 100 person-years).
c. Number of TRCs: The total number of work-related injuries or illnesses that resulted in either death, days away from work, days of restricted work activity, or days of job transfer.
d. DART Case: An injury or illness case where the most serious outcome of the case resulted in days away from work or days of job restriction or transfer.
e. Workdays Lost: The number of days away from work (consecutive or not) on which the employee would have worked but could not because of occupational injury or illness.
f. Number of DART days: The total number of work-related injuries or illnesses that resulted in days away from work or days of job restriction or transfer.

Source: DOE 2020a.

Impacts for the No-Action Alternative and the Proposed Action. Under the No-Action Alternative, major changes in the types of occupational, toxic, or physical hazards encountered by site personnel would not be expected compared to the current baseline. Occupational impacts during No-Action Alternative operations would involve 9,130 workers (8,810 workers at the Livermore Site and 320 workers at Site 300). Injury/illness/fatality rates at DOE/NNSA sites are historically lower than Bureau of Labor Statistics (BLS) values due to the increased focus on safety fostered by ISMS, EMS, OHSMS, a Worker Safety and Health Program, and WP&C.

Consequently, the potential risk of occupational injuries/illnesses and fatalities to workers engaged in operations at LLNL would be comparable to injury/illness and fatality rates for general manufacturing. Table C-16 presents the potential estimates of injuries/illnesses and fatalities for the average year of operations under the No-Action Alternative. In an average year, 77.5 days of lost work from illness/injury and less than one fatality would be expected from LLNL operations under the No-Action Alternative.

Table C-16. Occupational Injury/Illness and Fatality Estimates at LLNL for Construction, DD&D, and Operations under the No-Action Alternative

Injury, Illness, and Fatality Categories	Baseline (Existing Environment)			No-Action Alternative			Percent Change versus Baseline[f]
	Construction and DD&D[c]	Operations[c]	Total	Construction and DD&D[d]	Operations[e]	Total	
Lost days due to injury/illness[a]	1.5	63.5	65.0	3.2	74.3	77.5	19.2%
Number of fatalities[b]	0.006	0.12	0.13	0.01	0.14	0.15	15.4%

a. Based on 152.6 injuries in California per 10,000 workers for construction/DD&D and 81.4 injuries in California per 10,000 workers for manufacturing (operations).
b. Based on 6.5 fatalities in California per 100,000 workers for construction/DD&D and 1.5 fatalities in California per 100,000 workers for manufacturing (operations).
c. Existing workforce of 7,909 workers is assumed to have 7,809 operational workers and 100 construction workers.
d. Based on 210 construction workers annually.
e. Based on 9,130 operational workers annually.
f. Percent change is presented for the "Total."
Source: BLS 2021.

The new facilities and modernization/upgrade/site utility projects identified and described in Section 3.3 would not introduce any new nonradiological hazards at either the Livermore Site or Site 300 that would be substantial enough to change safety bases classifications. Nonradiological hazards include non-ionizing radiation, chemicals, and industrial (occupational) hazards. Several of the proposed new facilities (SMRDC, High Bay, Pulse Power Laboratory, Dynamic Radiography Development Facility, and Advanced 3-D Hydrotest Facility) would include equipment hazards from RGDs/accelerators. Because RGD/accelerators are currently present in existing LLNL facilities, the occupational hazards would not be notably different. Occupational impacts during Proposed Action operations would involve 10,060 workers (9,654 workers at the Livermore Site and 406 workers at Site 300). Table C-17 presents the potential estimates of injuries/illnesses and fatalities for the average year of operations under the Proposed Action. In an average year, 92.5 days of lost work from illness/injury and less than one fatality would be expected from LLNL operations under the Proposed Action.

Table C-17. Occupational Injury/Illness and Fatality Estimates at LLNL for Construction, DD&D, and Operations under the Proposed Action

Injury, Illness, and Fatality Categories	No-Action Alternative			Proposed Action			Percent Change versus No-Action Alternative[f]
	Construction and DD&D[c]	Operations[c]	Total	Construction and DD&D[d]	Operations[e]	Total	
Lost days due to injury/illness[a]	3.2	74.3	77.5	10.7	81.8	92.5	19.3%
Number of fatalities[b]	0.01	0.14	0.15	0.03	0.15	0.18	20.0%

a. Based on 152.6 injuries in California per 10,000 workers for construction/DD&D and 81.4 injuries in California per 10,000 workers for manufacturing (operations).
b. Based on 6.5 fatalities in California per 100,000 workers for construction/DD&D and 1.5 fatalities in California per 100,000 workers for manufacturing (operations).
c. No-Action Alternative workforce would have 210 construction workers and 9,130 operational workers annually.
d. Based on 700 construction workers annually.
e. Based on 10,060 operational workers annually.
f. Percent change is presented for the "Total."
Source: BLS 2021.

Overall site usage of toxic substances would increase under both the No-Action Alternative and the Proposed Action as activity levels increase at existing facilities and as new facilities are constructed and begin operation. However, no notable chemical-related health impacts are associated with normal (accident-free) operations at LLNL. Initial screens for the hazard analyses did not result in the identification of any controls necessary to protect the public or workers from direct chemical exposures during normal operations. Facility design features that minimize worker exposures during facility operations act as defense-in-depth controls. In addition to these controls, worker protection is augmented by ISMS, EMS, OHSMS, a Worker Safety and Health Program, WP&C, chemical hygiene, industrial hygiene personnel monitoring, and emergency preparedness. Potential impacts from chemical accidents are presented in Section C.3.

C.2.2.5 *Biological Operations and Hazards*

Biological operations at LLNL include using and safely handling biohazardous materials, agents, or their components (e.g., microbial agents, bloodborne pathogens, recombinant deoxyribonucleic acid, and human or primate cell cultures), and research proposals and activities concerning animal or human subjects. Biological materials can cause illness and infection. Examples of potential sources of exposure to biological hazards are as follows:

- Human fluids, secretions, or feces
- Risk Group (RG) 2 and 3 etiologic agents
- Infectious agents from animal infestation or droppings
- Biological toxins
- Research involving animals
- Research involving allergens of biological origin (e.g., certain plants and animal products, danders, urine, and some enzymes)
- Laundry soiled with blood or other potentially infectious materials

- Contaminated sharps
- Unfixed human tissues or organs

Biosafety Level 1 (BSL-1) standard practices, safety equipment, and facility specifications are generally appropriate for undergraduate and secondary educational training and teaching laboratories and for other laboratories that work with defined and characterized strains of viable biological agents not known to consistently cause disease in healthy adult humans. Work is typically conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is not required nor generally used. Laboratory personnel have specific training in the procedures conducted in the laboratory and are supervised by a scientist with general training in microbiology or a related science.

Biosafety Level 2 (BSL-2) standard practices, safety equipment, and facility specifications are applicable to laboratories in which work is performed using a broad-spectrum of biological agents and toxins that are associated with causing disease in humans of varying severity. It differs in that laboratory personnel have specific training in handling pathogenic agents and are directed by competent scientists, access to the laboratory is limited when work is being conducted, extreme precautions are taken with contaminated sharp items, and certain procedures in which infectious aerosols or splashes may be created are conducted in biological safety cabinets or other physical containment equipment (NNSA 2002, NNSA 2008). DOE has determined that operations involving BSL-1 and BSL-2 facilities would not result in significant impacts to workers or the public (10 CFR Part 1021, Subpart D, Appendix B).

Biosafety Level 3 (BSL-3) standard practices, safety equipment, and facility specifications are applicable to laboratories in which work is performed using indigenous or exotic biological agents with a potential for respiratory transmission and those that may cause serious and potentially lethal infection. BSL-3, operations up to Risk Group 3, are conducted in the existing BSL-3 facility located at the Livermore Site. The building housing the BSL-3 is a purpose-built facility to comply with the Centers for Disease Control and Prevention guidance contained within the *Biosafety in Microbiological and Biomedical Laboratories* (BMBL) publication and the federal regulations for working with Risk Group 3 agents to include the Federal Select Agent Program regulations. The laboratories are applicable to diagnostic/environmental sample testing and research with indigenous or exotic agents which have the potential to cause a serious disease as a result of exposure by the inhalation route. Laboratory personnel have specific training in handling Risk Group 3 agents, completed required security checks and are supervised by competent scientists experienced in working with these agents. All procedures involving the manipulation of infectious materials are conducted within biological safety cabinets or other physical containment devices by personnel wearing appropriate personal protective clothing in laboratories designed to contain the agents and provide protection to the researchers, community and the environment.

LLNL has other biological facilities (BSL-1 and BSL-2) which are appropriate for diagnostic, clinical and research activities with Risk Group 1 and 2 microorganisms and biological toxins. Personnel exposure to biological hazards is minimized by use of administrative controls, engineered controls, and personal protective equipment (see text box). By analyzing the hazards for each specific operation, LLNL personnel develop and implement the appropriate controls to protect themselves, the community, and the environment from potential exposure. Since January 2010, when the LLNL BSL-3 facility became operational, LLNL have maintained this track record of no infections associated with operations and no unintentional releases to the environment or to the public (LLNL 2020d).

Measures to Minimize Hazards from Biological Operations

Engineered controls—These include facility design requirements, such as high-efficiency particulate air filters, interlocks, and negative airflow units, and safety equipment, which include mechanical aids such as tongs and tweezers, dead air boxes, sharps containers, laboratory-type fume hoods, biological safety cabinets, also referred to as biosafety cabinets, shielding, safety centrifuge cups, and special shipping containers for transporting biological materials and animals.

Administrative controls—These include the hazard review process and the use of procedures and operational controls for the performance of work.

Personal protective equipment—Equipment includes gloves, coats, gowns, shoe covers, safety shoes, boots, respirators, face shields, and safety glasses or goggles. Personal protective equipment is only used as supplemental protection if there is still a residual risk of exposure after engineered and administrative controls are implemented.

C.2.2.6 *Department of Energy Regulation of Worker Safety*

DOE Order 440.1A, Worker Protection Management for DOE Federal and Contractor Employees, regulates the health and safety of workers at all DOE sites. This comprehensive standard directs the contractor facilities to establish the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE Federal and contractor workers with a safe and healthful workplace. Baseline exposure assessments are outlined in this requirement, along with day-by-day health and safety responsibilities.

Industrial hygiene limits for occupational chemical exposures at Federal sites are regulated by 29 CFR Part 1910 and 29 CFR Part 1926, Occupational Safety and Health Standards, including the PELs set by OSHA. DOE requires that all sites comply with the PELs unless a lower limit (more protective) exists in the ACGIH TLVs.

As discussed in Section C.1, operations at LLNL are conducted in accordance with an ISMS, EMS, OHSMS, Worker Safety and Health Program, and a WP&C to protect the health and safety of workers and the public, preserve the quality of the environment, and prevent property damage. The ISMS, OHSMS, Worker Safety and Health Program, and WP&C minimize the occurrence and mitigates the consequences of worker impacts by identifying and analyzing potential hazards during the planning stages of work activities. Site workers conduct work in accordance with established site-wide and project-specific programs.

Each employee at LLNL, from Director to laboratory worker, is required to know and understand the ES&H requirements of his or her assignment, the potential hazards in the work area, and the controls necessary for working safely. Employees must participate in all required ES&H training and health monitoring programs. All work assignments must be performed in full compliance with applicable ES&H requirements as published in LLNL manuals and guidelines and established in safety procedures. All employees are responsible for working in a manner that produces high-quality results, preserves environmental quality, and protects the health and safety of workers and members of the public.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements (e.g., via NESHAP and NPDES permits) contribute to minimizing health impacts on the public. The effectiveness of these controls is verified through the use of environmental monitoring information and inspection of mitigation measures.

Workers are provided with information and training on identified hazards and follow requirements in specific WP&C documents to protect them and minimize hazards and exposures. LLNL has several programs and procedures in place to provide direction for monitoring, handling, storing, and using these materials. These programs and safety procedures include the Hazard Communication Program, Chemical Hygiene Program, Respiratory Protection Program, and written safety procedures (such as the WP&C documents) for the handling and use of carcinogens and biohazard materials. Work activities are periodically monitored with measurements performed at personal breathing zones and general work areas. ES&H monitoring records indicate that personnel exposure to hazardous materials is maintained well below established regulatory requirements and exposure guidelines (LLNL 2017a, LLNL 2018d, LLNL 2019b).

C.3 ACCIDENT ANALYSIS

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. The LLNL buildings and facilities contain radiological, chemical, biological, and explosive materials. An accident can involve a combined release of energy and hazardous materials (radiological, chemical, or biological) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released.

If an accident were to occur involving the release of radioactive, chemical, or biological materials, or accidental high explosive (HE) explosions, workers, members of the public, and the environment would be at risk. Workers in the facility where the accident occurs would be particularly vulnerable to the effects of the accident because of their close proximity to the incident. The offsite public and non-involved workers would also be at risk of exposure or effect to the extent that meteorological conditions exist for the atmospheric dispersion of released materials.

The DOE *Recommendations for Analyzing Accidents under the National Environmental Policy Act* (DOE 2002a), provides guidance for preparing accident analyses in DOE environmental impact statements and environmental assessments. It states that documents prepared under NEPA should inform the decisionmakers and the public about chances that reasonably foreseeable accidents associated with proposed actions and alternatives could occur, and about their adverse consequences. The term "reasonably foreseeable" extends to events that may have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason (40 CFR 1502.22). "Credible" means having reasonable grounds for believability and the "rule of reason" means that the analysis is based on scientifically sound judgment.

C.3.1 Approach to the Analysis of Potential Accidents

For this LLNL SWEIS, the approach to the accident analysis was to examine the accidents that were evaluated in the 2005 LLNL SWEIS (NNSA 2005), the 2011 Supplement Analysis (NNSA 2011), the building/area specific Documented Safety Analyses (DSAs) or Safety Basis Documents (SBDs), the building/area specific Emergency Planning Hazards Assessments (EPHAs), and other documents that analyze LLNL accidents/hazards that have been prepared since the 2005 LLNL SWEIS, and that calculate impacts to the following (DOE 2002a):

- Involved workers, non-involved workers, and the general public,
- Maximally exposed individual in each category and collective impact to each population,
- The environment including biota and environmental media, such as land and water.

A simple, commonly used equation to calculate the radiological or chemical source term (ST) used in the accident analysis is:

$$ST = MAR \times DR \times ARF \times RF \times LPF$$ **Equation C-1**

where:

ST = The amount and form of radioactive or chemical material released to the environment under accident conditions.

MAR = The amount and form of radioactive or chemical material at risk of being released to the environment under accident conditions.

DR = The damage ratio reflecting the fraction of MAR that is damaged in the accident and available for release to the environment.

ARF = The airborne release fraction reflecting the fraction of damaged MAR that becomes airborne as a result of the accident.

RF = The respirable fraction reflecting the fraction of airborne radioactive material that is small enough to be inhaled by a human.

LPF = The leak path factor reflecting the fraction of respirable radioactive material that has a pathway out of the facility for dispersal in the environment.

However, there are certain accidents that require more detailed and complex modeling than is provided with Equation C-1, e.g., the evaporative source term following a chemical spill. In those cases, there are computer programs that are used to calculate the source term. Section C.3.1.3 describes the computer programs that were used to calculate the source terms for this SWEIS. The equations used by these computer programs to calculate release may be found in the program's documentation.

Next, the meteorological model is used to transport source term from the release point to the receptor location. There are numerous documents that describe the various meteorological models, e.g., NRC's Regulatory Guide 1.145 (NRC 1983) describes several variations of the Gaussian transport and dispersion model. Both the HotSpot (Homann & Aluzzi 2019) and MACCS2 (Sandia 1990) computer codes use the Gaussian plume model to transport and disperse a release of radiological material to the atmosphere. Although the Gaussian model is relatively straight forward, there are several parameter assumptions that the analyst must make which can have a significant effect on the magnitude of the calculated dispersion. These parameters include wind speed, atmospheric stability class, distance to the MEI, release elevation, plume buoyancy, terrain factors, building wake, wind direction, and off-centerline distance.

Accident frequencies in this LLNL SWEIS are grouped into the following four bins:

1. Event sequences with an estimated frequency of occurrence greater than 10^{-2} event per year (i.e., greater than or equal to 1 in 100 [$\geq 1\times10^{-2}$]). These sequences are anticipated to occur in the lifetime of the facility.

2. Event sequences with an estimated frequency of occurrence between 10^{-2} event per year and 10^{-4} event per year (i.e., between 1 in 100 and 1 in 10,000 [$\leq 1\times10^{-2}$ to 1×10^{-4}]). These sequences are unlikely and are not anticipated to occur in the lifetime of the facility.

3. Event sequences with an estimated frequency of occurrence between 10^{-4} event per year and 10^{-6} event per year (i.e., between 1 in 10,000 and 1 in 1 million [$\leq 1\times10^{-4}$ to 1×10^{-6}]). These sequences are considered to be extremely unlikely and borderline incredible events.

4. Event sequences with an estimated frequency of occurrence less than 10^{-6} event per year (i.e., between 1 in 1 million and 1 in 10 million [$\leq 1\times10^{-6}$ to 1×10^{-7}]). These sequences are not considered credible, and their consequences are not routinely required to be calculated.

Accidents that are reasonably foreseeable fall within the four bins described above. Generally, frequencies lower than 10^{-7} are not considered in NEPA documents (DOE 2002a). As defined above, the accident frequencies are based on the frequency of the entire event sequence, not just the initiating event. For example, an accident may be initiated by an event, such as human error (e.g., 0.1 yr^{-1}), but in order for a hazardous material release to occur, that event must be followed by another event, such as the failure of a valve to close (e.g., 0.01 yr^{-1}), thus this hypothetical accident scenario has a frequency (e.g., 0.1 × 0.01 =) of 10^{-3} yr^{-1}. This approach for determining the accident frequency is equivalent to that recommended by DOE-STD-3009 "Preparation of Nonreactor Nuclear Facility Documented Safety Analysis" (DOE 2014) and ensures that the LLNL NEPA document is consistent with the LLNL safety basis documents.

C.3.1.1 *Accident Scenarios Analyzed*

As stated above, an accident can involve a combined release of energy and hazardous materials (radiological, chemical, or biological) that might cause prompt or latent health effects. Therefore, this SWEIS postulated and analyzed the following five types of facility accident scenarios:

1. Radioactive Material Release
2. Toxic Chemical Release
3. High Explosives
4. Biological Hazard Release
5. Site-Wide Multiple-Building Scenarios

Site-wide multiple-building scenarios are accidents that could potentially involve more than a single LLNL facility, such as an earthquake or a wildfire.

In addition to the five types of facility accident scenarios list above, this SWEIS includes an analysis of accidents that could occur during the onsite transport of material between LLNL facilities (Section C.3.8).

Whenever possible, the accidents scenarios presented in this SWEIS are based on scenarios that have been previously analyzed at LLNL. Documents consulted for these previous analyses include the 2005 LLNL SWEIS, the 2011 SWEIS Supplement Analysis, and the facility specific Documented Safety Analyses (DSAs), Safety Basis Documents (SBDs), and Emergency Planning Hazard Assessments (EPHAs), as well as calculations prepared by LLNL in support of these documents. Each of the documents consulted is identified in the following text and listed in the reference section at the end of this appendix (i.e., Section C.6).

Additionally, Section 3.2 of this SWEIS describes each project anticipated under the No-Action Alternative and Section 3.3 describes each project anticipated under the Proposed Action. Each No-Action Alternative and Proposed Action project was reviewed to determine whether a revision to the DSA/SBD/EPHA analyses was necessary. With three exceptions, it was determined that neither the No-Action Alternative nor the Proposed Action projects would change the results of the previous DSA/SBD/EPHA analyses. The three exceptions include two radiological accidents at the NIF (Building 581) and one for Building 235 under the Proposed Action, as described in Section C.3.3 and analyzed in Section C.3.4.

C.3.1.2 *Facilities Included in the Analysis*

Accident analyses have been performed at LLNL since it was first established in 1952, and safety-related documents have been prepared for all of the major Livermore Site and Site 300 facilities that handle radiological, chemical, biological, or explosive materials. As shown in Table C-18, the safety-related documents include documented safety analysis (DSA), safety basis document (SBD), facility screening report (SCR), and emergency planning hazard assessment (EPHA). The selection of accidents for inclusion in this SWEIS was built upon these existing accident analyses. All of the documents in Table C-18, as well as other documents, were reviewed to select the facilities to be included in this SWEIS.

Most of the DSAs and SBDs identify a complete spectrum of accidents, meaning that low consequence/high probability accidents, as well as high consequence/low probability accidents, and accidents in-between, are considered and analyzed. For example, the Plutonium Facility DSA (LLNL 2019l) identified over 250 potential hazard events, but only analyzed those with the most severe consequences (e.g., the Plutonium Facility DSA analyzed 11 design-basis events [DBEs], plus two beyond-DBEs). The accidents selected for inclusion in this SWEIS were selected from the analyzed DBEs for each of the major LLNL facilities. DOE 2002a recognizes this as an acceptable approach to NEPA accident analyses and refers to it as "bounding." Specifically, the DSAs, SBDs, and/or EPHAs provided the initiating events, the accident frequencies, the material at risk (MAR), and the source term for each of the accident scenarios analyzed in this SWEIS. The specific initiating event, the accident frequency, MAR, and source term used in the analysis are provided in Sections C.3.2, C.3.3, C.3.4, and C.3.5 for the radiological, chemical, explosive, and biological hazard analyses, respectively. Section C.3.6 describes the rationale for the selection of multiple buildings used in the site-wide seismic and wildfire analyses.

Table C-18. LLNL Facility/Area/Other Structure Safety Documents Reviewed

Documented Safety Analysis (DSA)
Radiography Facility (Building 239) Tritium Facility (Building 331) Plutonium Facility (Building 332) Hardened Engineering Test Building (Building 334) Waste Storage Facilities (Area 625, Building 696R, and Building 693 Yard)
Safety Basis Document (SBD)
Area 612, Radioactive and Hazardous Waste Management Building 131 High Bay Building 132N, Building 132S Building 151 Complex (Building 151, Building 152, Building 154) Building 190, Multi-User Tandem Building (Safety Assessment Document) Building 190, Multi-User Tandem Building Building 191, High Explosives Application Facility (HEAF) Building 194, Electron-Positron Accelerator (LINAC) Facility (Safety Assessment Document) Building 194, Electron-Positron Accelerator (LINAC) Facility Building 231, Engineering Development and Assembly Facility Building 231V-233 Complex Building 235, 4 MV Ion Accelerator (Safety Assessment Document) Building 235, Non-Accelerator Related Operations Building 255, ES&H Technical Services Division Labs and Offices Facility Building 262, Radiation Detector Development Facility Building 298 Complex (Building 298, Other Structure 298) Building 321C, Material Fabrication Shops Building 327, Radiography Facility Building 364, Bio Research Facility Building 368, Bio Research Facility (BSL-3) Building 391, Laser and Physics Laboratories Building 581-582, Complex, National Ignition Facility Building 695, Radioactive and Hazardous Waste Management Building 696S, Radioactive and Hazardous Waste Management Building 697, Radioactive and Hazardous Waste Management Building 801, FXR Safety Assessment Document Other Structure 169, Radioactive and Hazardous Waste Management Other Structure 495, Consolidation Waste Accumulation Area Other Structure 883, Radioactive and Hazardous Waste Management Site 300 Weapons and Complex Integration
Emergency Planning Hazard Assessment (EPHA)
Building 131 High Bay Building 231 Complex (Building 231 Vault, Other Structure 232 Fenced Area and Building 233 Garage Vault) Metal Finishing Facility (Building 322) Biosafety Level 2/3 Facilities (Buildings 365/368/255) Superblock (Buildings 239, 331, 332, & 334) Waste Storage Facilities (Area 625, Building 696R, and Building 693 Yard) Site 300
Facility Screening Report (SCR)
Building 141, Engineering Tech Development Building 153, Microfabrication Laboratory Building 162/ Building 164, Crystal Growth/Machine Shop Building 165, Optics/Development Lab Building 166, Development Lab Building 174 Complex, Jupiter Laser Facility (B174, 173, 174, T1727) Building 197, Center for Accelerator Mass Spectrometry Lab

Building 253, HC Dept Offices and Labs
Building 254, HC Bio Assay Lab
Building 272, Material Science Laboratory
Building 321A, Materials Fabrication Shop
Building 322, Plating Shop
Building 329, Laser Weld Shop
Building 341, Engineering Mechanical Testing
Building 361, Bio Research Facility
Building 362, Bio Research Facility
Building 365, Bio Research Facility
Building 366, Bio Research Facility
Building 381, Target Fabrication and Offices
Building 392, Optics Laboratory Facility
Building 431, Beam Research Labs
Building 432, Engineering Mechanical Shop
Building 490, NIF Engineering & Diagnostics Labs
Building 492, Laser Dye Pump Facility
Building 491, Development Lab
Building 655, Advanced Manufacturing Laboratory
Building 681, Optics Assembly Building (OAB)

Note: Throughout this appendix, buildings are sometimes identified by a capital "B" followed by the building number. For example, the Tritium Facility (Building 331) is sometimes identified as B331.

Livermore Site Facilities and Hazards Evaluation. Hazards at the Livermore Site include the use of radiological, chemical, HE, and biological materials. Safety-related documents reviewed for the Livermore Site include the documented safety analysis, safety basis documents, emergency planning hazards assessments, and facility screening reports. The Livermore Site facilities that were included in the SBD evaluation are shown in Table C-18.

Radioactive Material Release. For purposes of this document, radiological hazard categorization primarily uses DOE-STD-1027-92 Change Notice 1 (DOE 1997), which is the currently applicable standard at LLNL per the terms of the prime contract. Because the SWEIS is a forward-looking document, some proposed projects will use the more recent revision, DOE-STD-1027-2018 (DOE 2018), which NNSA expects to implement at LLNL in the future. Use of either of these revisions is acceptable by the guidance provided by DOE. For this analysis the facility SBD, DSA, and/or EPHA were reviewed to develop the list of potential facilities with radiological materials subject to analysis for the impacts to the non-involved workers and the public. A total of 58 facilities managing radionuclides were reviewed, and the following facilities in Table C-19 were analyzed for potential accidental impacts.

Table C-19. Livermore Site Facilities with Radiological Materials Subject to Analysis

Building/Facility Number	Building/Facility Description	Radionuclides subject to analysis	Source
Area 625	Waste Storage Facilities	TRU Waste	DSA (LLNL 2021j)
B693 and Yard	Waste Storage Facilities	TRU Waste	DSA (LLNL 2021j)
B696R	Waste Storage Facility	TRU Waste	DSA (LLNL 2021j)
Building 235	Materials Science Division Offices and Labs	Weapons Grade Pu	Memo (Pinkston 2022)
Building 332	Plutonium Facility	Fuels-grade-equivalent Pu	DSA (LLNL 2019l)
Building 334	Hardened Engineering Test Building	Fuels-grade-equivalent Pu	DSA (LLNL 2017g)
Building 239	Radiography Facility	Fuels-grade-equivalent Pu	DSA (LLNL 2017f)
Building 331	Tritium Facility	Tritium	DSA (LLNL 2018f)
Building 581	National Ignition Facility	Tritium Plutonium	Memo (LLNL 2021e)

Chemical Material Release. For this analysis the facility SBD, DSA, and/or EPHA were reviewed to develop the list of potential facilities and chemicals subject to analysis for the impacts to the non-involved workers and the public. Table C-20 shows the resulting chemicals subject to analysis, which are evaluated further in Section C.3.3; the "Source" column indicates whether the information was obtained from the facility's SBD, DSA, or EPHA.

Table C-20. Livermore Site Facilities with Chemicals Subject to Analysis

Building/Facility Number	Building/Facility Description	Chemicals subject to analysis	Source
131HB	Weapons Engineering	Lithium hydride (LiH)/deuteride	EPHA
		Uranium	
		Beryllium/Beryllium oxide (Be/BeO)	
151	Analytical and Nuclear Chemistry Facility and Storage	Chlorine trifluoride (ClF_3)	SBD
231V	Building 231 Vault	Lithium hydride (LiH)	EPHA
		Uranium	
OS232FA	Other Structure 232 Fenced Area	Lithium hydride (LiH)	EPHA
		Uranium	
233GV	Building 233 Garage Vault	Lithium hydride (LiH)	EPHA
		Uranium	
239	Radiography Facility	Beryllium/Beryllium oxide (Be/BeO)	DSA, EPHA
		Lithium hydride (LiH)	
		Uranium	
321C	Materials Fabrication Shop	Lithium hydride (LiH)	CalARP/RMP
		Uranium	
322/322A	Plating Shop	Nitric, Hydrofluoric, and Hydrochloric Acids	EPHA
331	Tritium Facility	Lithium hydride (LiH)	DSA
332	Plutonium Facility	Chlorine, Hydrogen Chloride Lithium Hydride	DSA, EPHA
		Uranium	
334	Hardened Engineering Test Building	Lithium hydride (LiH)	DSA, EPHA
		Beryllium/Beryllium oxide (Be/BeO)	
		Uranium	

High Explosives. Based upon recommendations from the United Nations Economic Commission for Europe (UNECE) (UNECE 2019), the DOE has classified explosives into the eight hazard categories shown in Table C-21, depending on the type of hazard they represent (DOE-STD-1212-2019).

Table C-21. DOE Explosive Hazard Categories

Hazard Category	Hazard Description
1.1	Mass detonating
1.2.1	Non-mass explosion, fragment producing with net explosives weight > 1.6 pounds (lbs)
1.2.2	Non-mass explosion, fragment producing with net explosives weight ≤ 1.6 lbs
1.2.3	Non-mass explosion, fragment producing based on single package test only No reaction greater than burning from the external fire test, bullet impact test or slow cook-off test
1.3	Mass fire, minor blast or fragment
1.4	Moderate fire, no significant blast or fragment
1.5	Explosive substance, very insensitive (with a mass explosion hazard)
1.6	Explosive article, extremely insensitive

For LSI and Low hazard classification, the LLNL ES&H Manual, Document 3.1 (LLNL 2016b) has established the explosive quantity limits shown in Table C-22.

Table C-22. LLNL LSI and Low Hazard Facility Explosive Classification Quantity Limits

Hazard Category[a]	Limits[a, c]	
	LSI	Low
Primary High Explosives	≤ 1 gram	≤ 10 grams
Secondary High Explosives that are classified as 1.1, 1.5, and 1.6	≤ 10 grams	≤ 350 grams
1.2	Not Allowed	Not Allowed
1.3 and 1.4 (except 1.4S)	≤ 200 grams	≤ 5,000 grams
1.4S	Unlimited[b]	Unlimited[b]
—	Facility Limits[a]	
Total Facility	≤ 200 grams	≤ 5,000 grams

a. See LLNL ES&H Manual, Document 3.1, Table 11 for additional requirements.
b. When placed in segregated and specifically designated areas.
c. LSI is based on Room limits and Low is based on maximum credible event.

Furthermore, if a facility exceeds the Low quantity limits but complies with the quantity-distance requirements, it is assigned a Moderate hazard classification by LLNL ES&H Manual, Document 3.1. The quantity-distance requirement is the distance between the explosive and the worker/public that provides protection from the blast of a specified quantity of explosive. These quantity-distance requirements are specified in DOE-STD-1212-2019.

Table C-23 shows the assigned explosive classification for Livermore Site HE facilities. No facilities at the Livermore Site have been assigned the High hazard classification. Because the High Explosives Application Facility (HEAF) is the only Moderate classified facility, that facility was selected for further analysis in Section C.3.4. Site 300 includes some facilities which are classified as High hazard for explosives because of explosively driven chemical hazards.

Table C-23. Livermore Site Facility Explosive Classification

Hazard Category	Building/Facility Number	Building/Facility Description
LSI	LLNL facilities assigned the LSI classification are shown in Table A-9	
Low	B132N	Defense Programs Research Facility
	B327	Radiography
Moderate	B191	HEAF
High	No facilities at the Livermore Site have been assigned the High hazard classification	

Biological Hazard Release. Livermore Site facilities with the highest authorized biosafety levels, as defined in each facility's SBD or SCR, are shown in Table C-24. Appendix B to Subpart D of 10 CFR, Part 1021 contains categorical exclusion B3.12, which states:

> Siting, construction, modification, operation, and decommissioning of microbiological and biomedical diagnostic, treatment and research facilities (excluding Biosafety Level-3 and Biosafety Level-4), in accordance with applicable requirements or best practices (…) including, but not limited to, laboratories, treatment areas, offices, and storage areas, within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible). Operation may include the purchase, installation, and operation of biomedical equipment (such as commercially available cyclotrons that are used to generate radioisotopes and radiopharmaceuticals, and commercially available biomedical imaging and spectroscopy instrumentation).

Thus, all of the Livermore Site facilities that have a highest authorized biosafety level of BSL-2 or lower are covered by the DOE's categorical exclusion and are not further analyzed in this SWEIS. The only facility classified as BSL-3 is the Bio Research Facility (Building 368). Consequently, that facility was selected for further analysis in Section C.3.5.

Table C-24. Livermore Site Facility Biosafety Level Categories

Highest Authorized Biosafety Level (BSL)[a]	Building/Facility Number	Facility Description
BSL-3	368	Biosafety Level 3 Laboratory
BSL-2	132N	Defense Programs Research Facility
	132S	Global Security Research Facility
	151	Analytical and Nuclear Chemistry Facility and Storage
	153	Micro- and Nano-Fabrication Laboratory
	361	Bio Research Facility
	362	Bio Research Facility
	364	Bio Research Facility
	365	Bio Research Facility
	366	Bio Research Facility

a. BSL-1 facilities are not included as they pose little or no threat of infection in healthy adults, and no specialized containment equipment is needed.

Site 300 Facilities and Hazards Evaluation. Hazards at Site 300 include the use of radiological, chemical, HE, and biological materials. Safety-related documents reviewed for Site 300 include the Site 300 SBD (LLNL 2018e) and the Site 300 Emergency Planning Hazards Assessment (LLNL 2019h). The Site 300 facilities that were included in the SBD evaluation are shown in Table C-25.

Radioactive Material Release. For purposes of this document, radiological hazard categorization primarily uses DOE-STD-1027-92 Change Notice 1 (DOE 1997), which is the currently applicable standard at LLNL per the terms of the prime contract. Because the SWEIS is a forward-looking document, some proposed projects use the more recent revision, DOE-STD-1027-2018 (DOE 2018), which NNSA expects to implement at LLNL in the future. Use of either of these revisions is acceptable by the guidance provided by DOE. At all Site 300 facilities, the radiological inventory must be below the Hazard Category-3 (HC-3) thresholds DOE-STD-1027. Therefore, each Site 300 facility is designated as a Low classification for radiological hazards. As stated above, for this SWEIS only facilities that are designated HC-3 or above are included in the Section C.3.4 radiological hazards analysis. As such, no Site 300 facilities have been included in the Section C.3.4 radiological hazards analysis.

Chemical Material Release. At all Site 300 facilities the chemical inventory is managed to maintain and comply with an LSI hazard category. For each chemical brought onto Site 300, LLNL determines a maximum LSI quantity. Before a chemical is brought into a facility, its quantity is added to any already existing quantity in the facility. If the total exceeds the maximum LSI quantity, the chemical is not allowed into the facility.

Notwithstanding the Site 300 SBD, the EPHA determined that a fire at a Site 300 facility could disperse lithium hydride (LiH). No other chemicals were analyzed in the Site 300 EPHA. Highly toxic specialty chemicals infrequently arrive at Site 300 and are not intended for long term storage. Nonetheless, due to their capacity to harm humans, these chemicals have additional controls to ensure safety and maintain quantities at *de minimus* levels. In conclusion, the Section C.3.5 chemical hazard analysis includes a fire that releases LiH from a Site 300 facility. No other Site 300 chemicals, including highly toxic specialty agents, are included in the Section C.3.5 chemical hazard analysis.

Table C-25. Site 300 Facilities Evaluated

Engineering Test Area Facilities	
●	B834 Environmental Test Complex: B834E, B834H, and B834M
●	B836 Dynamic Test Complex: B836C, and B836D
Site 300 Firing Operations Facilities	
●	B801 Complex: B801A
●	B851 Complex: B851A, M851-1, and M851-2
●	M80
●	M82
●	M83
●	OSM812-1, OSM812-2
Forensic Receival Facilities	
●	858 Forensic Receival Facility: B858 Forensic Chemical Receival, B858 Forensic Explosive Receival, B858 Forensic Chemical Storage, and M58

Chemistry Area Facilities	
●	B825/B826 Complex: B825, M825-1, M825-2, M825-3, B826, M826-1, and M-51
●	B827 Complex: B827-A, B827-B, B827-C, B827-D, B827-E, M-33, and M-36
Process Area Facilities	
●	B805
●	B806 Complex: B806A, B806B, and B806C
●	B807
●	B809 Complex: B809A, B809B, B809C, and M10
●	B810 Complex: B810A, B810B, B810C, and M810-1
●	B817 Complex: B817A, B817B, B817F, B817G, B817H, and M-817C
●	B823 Complex: B823B
●	B855 Complex: B855A, B855B, B855C, and M15
●	Explosives Waste Storage Facility (EWSF): M-816, M-2, M-3, M-4, and M-5
●	Explosives Waste Treatment Facility (EWTF): B845 Open Detonation Unit, B845A, B845B, B854C, and EWTF Burn Cage and Burn Pan
Materials Management Facilities	
●	B818 Complex: B818A and B818C
●	B824
●	B832 Complex: M832-1, M832-2, M832-B, M832-D, B832A, B832C, and B832E
●	M1, M7, and M8
●	M21, M22, M23, and M24
●	Chemistry Magazine Loop: M30, M31, M32, M34, M35, M37, M38, and M41
●	M52
●	M70, M71, and M72
●	B854 Complex: M854H and M854V
●	M857
●	V822A-D

Source: LLNL 2018e.

High Explosives. Site 300 was established in 1955 as a remote explosives testing ground for the theoretical weapons developed at LLNL. As such, explosives are pervasive at Site 300. However, the high hazard classification of the Site 300 facilities is not driven by pure explosive hazards. Instead, it is driven by the toxicity of plumes from detonation of chemicals commingled with explosives[2]. Therefore, the Section C.3.6 explosive hazard analysis does not contain an analysis of a pure explosive event, but does contain analyses of explosive events commingled with radioactive or chemical materials.

Furthermore, administrative controls are in place to ensure that highly toxic specialty agents cannot be commingled with any explosives in more than trace amounts (i.e., <1 mg of primary explosives and <10 mg of secondary explosives). Additionally, explosives above trace amounts shall not be handled while such highly toxic specialty agents are present. Therefore, the Section C.3.4 explosive hazard analysis does not contain an analysis of explosive events commingled with highly toxic specialty agents.

Biological Hazard Release. The SBD show that none of the Site 300 facilities are authorized to conduct any biological research, even at the lowest BSL-1 level. Therefore, no Site 300 facilities are included in the Section C.3.7 biological hazards analysis.

[2] Explosives in close proximity to or direct contact with chemical or radiological material, i.e., comingled explosives.

C.3.1.3 *Analytical Tools*

The DOE maintains a list of "toolbox" computer codes (i.e., analytical tools) that have been evaluated against DOE safety software quality assurance (SSQA) requirements of DOE O 414.1D (DOE 2020b) and the safety software guidance in DOE G 414.1-4 (DOE 2010). All analytical results presented in this section were determined by computer code that are listed in the DOE "toolbox," either specifically for this SWEIS or in a referenced document used in this SWEIS.

Radioactive Material Release. Two computer codes from DOE's "toolbox" were considered appropriate for calculating impact from a radioactive materials release accident: HotSpot and MACCS2. Both codes are similar in that they calculate doses to individuals based on the straight line Gaussian plume dispersion and transport model. As such, both codes have been used in past LLNL radioactive materials release accident analyses (e.g., the 2005 SWEIS, DSAs, SBDs, EPHAs, etc.), and either would be appropriate for performing any analyses required for this SWEIS. Nonetheless, HotSpot was chosen to perform analyses for this SWEIS, primarily due to its ease of use. MACCS2 on the other hand, was developed to support probability risk assessment, and contains many features with are not necessary for a SWEIS analysis (e.g., food ingestion, sheltering, relocation, evacuations, economic cost).

However, there is one limitation with HotSpot—it does not calculate population doses. Therefore, the similarity of the equations used to calculate the MEI and population doses was used to calculate the population dose. For example, the inhalation dose is calculated via:

$$D_{MEI} = \sum_{m=1}^{M} (R_m \times X/Q_{MEI} \times BR \times DCF_m) \quad \textbf{Equation C-2}$$

$$D_{Pop} = \sum_{m=1}^{M} (R_m \times DCF_m) \times BR \times \sum_{k=1}^{K} \left(X/Q_k \times \sum_{n=1}^{N} f_n \, P_{k,n} \right) \quad \textbf{Equation C-3}$$

Where:

D_{MEI} = Calculated MEI dose (rem)
D_{Pop} = Calculated population dose (person-rem)
M = Number of radionuclides released
R_m = Amount of radionuclide m release (Ci)
DCF_m = Radionuclide m inhalation dose factor (rem/Ci)
BR = Breathing rate (m^3/s)
X/Q_{MEI} = Atmospheric dispersion at the MEI location (s/m^3)
K = Number of offsite distances for 0-50 mile population
X/Q_k = Atmospheric dispersion at the distance k (s/m^3)
N = Number of offsite directions
f_n = Frequency wind blow towards direction n
$P_{k,n}$ = Offsite population at distance k and direction n (people)
1,000 = Units conversion factor (millirem/rem)

For the MEI dose, Equation C-2 shows that the radionuclide release (R_m) is multiplied by the dispersion factor to the MEI location (X/Q_{MEI}), with gives the concentration at the MEI location. That concentration is multiplied by the MEI's breathing rate (BR), which gives the amount taken into the MEI's body. Finally, the amount taken into the MEI's body is multiplied by the dose conversion factor (DCF_m), which results in the dose to the MEI. This is repeated for each radionuclide and summed over all radionuclides to give the MEI dose. Mathematically the above MEI dose equation is the same as Regulatory Guide 1.195, Equation 7 (NRC 2003).

The population dose Equation (C-3) takes the individual dose at each downwind distance and multiplies it by the number of individuals at the distance. Because the wind direction at the time of the accident is unknown, for each distance the population equation multiplies the population in each direction at that distance ($P_{k,n}$) by the probability that the wind is blowing in that direction (f_n) and then sums the products over all directions. The 16 directional sector, 0 to 50 mile 2010 population distributions for LLNL and Site 300 are shown in Table C-26 and Table C-27, respectively.

Table C-26. Livermore Site: 0-50 Mile Population Estimates

Direction	Distance (miles) from Livermore Site					
	0-10[a]	10-20	20-30	30-40	40-50	0-50
N	4,603	50,952	51,137	7,792	1,670	116,154
NNW	8,306	2,745	139,294	316	205,660	356,321
NW	6,524	30,164	303,953	126,916	115,478	583,035
WNW	25,489	107,100	223,714	757,007	248,993	1,362,303
W	71,906	107,349	333,955	451,185	501,855	1,466,250
WSW	16,937	157,636	148,012	339,533	19,998	682,116
SW	1,183	114,211	412,258	157,789	4,542	689,983
SSW	408	23,676	752,857	280,018	49,939	1,106,898
S	184	14	55,832	71,355	73,855	201,240
SSE	353	3	52	22	1,300	1,730
SE	227	52	26	427	14,103	14,835
ESE	1,589	130	1,345	20,868	74,302	98,234
E	285	24,193	4,631	192,319	206,376	427,804
ENE	303	61,658	96,564	21,120	4,351	183,996
NE	474	5,142	117,528	287,466	21,648	432,258
NNE	3,720	11,446	1,792	3,562	31,044	51,564
Total	142,491	696,471	2,642,950	2,717,695	1,575,114	7,774,721

a. The 0-10 mile population was divided into 0-1, 1-2, 2-3, 3-4, 4-5, and 5-10 mile populations based on the areas of each segment (i.e., a constant population density was assumed).
Source: NESHAPs Report for 2018 (LLNL 2019b), Appendix A.3.1

Table C-27. Site 300: 0-50 Mile Population Estimates

Direction	Distance (miles) from Site 300					
	0-10[a]	10-20	20-30	30-40	40-50	0-50
N	5,615	3,457	1,896	4,880	12,496	28,344
NNW	401	20,707	124,388	6,373	75,585	227,454
NW	26	145	64,103	269,493	148,777	482,544
WNW	5,032	18,097	125,359	317,499	590,429	1,056,416
W	10,536	131,506	209,722	366,132	899,386	1,617,282
WSW	288	1,351	265,880	336,275	168,555	772,349
SW	50	22	437,134	819,824	14,140	1,271,170
SSW	26	1	88,891	201,189	15,024	305,131
S	13	43	24	34,136	66,497	100,713
SSE	2	6	33	1	424	466
SE	60	2	2,680	10,933	9,207	22,882
ESE	165	868	19,088	57,566	67,281	144,968
E	1,021	2,270	139,601	234,692	13,111	390,695
ENE	28,653	45,774	35,505	12,505	1,051	123,488
NE	50,245	17,601	165,338	8,051	7,348	248,583
NNE	2,686	715	199,143	79,849	31,433	313,826
Total	104,819	242,565	1,878,785	2,759,398	2,120,744	7,106,311

a. The 0-10 mile population was divided into 0-1, 1-2, 2-3, 3-4, 4-5, and 5-10 mile populations based on the areas of each segment (i.e., a constant population density was assumed).
Source: NESHAPs Report for 2018 (LLNL 2019b), Appendix A.3.2

Thus, to calculate the population dose, one would multiply the MEI dose by the following Population to MEI ratio, which is Equation C-3 divided by Equation C-2:

$$R_{Pop/MEI} = \frac{\sum_{k=1}^{K}\left(X/Q_k \times \sum_{n=1}^{N} f_n\, P_{k,n}\right)}{X/Q_{MEI}}$$

Figure C-3 shows the results of solving for the population dose to MEI dose ratio at the Livermore Site as a function of distance to the MEI and for stability classes D (average meteorology) and F (conservative meteorology) (for more discussion of accident meteorology see Section C.3.1.4). For example, at 940 meters and stability class F, Figure C-3 shows the population dose to MEI dose ratio to be 290 person-rem/rem (see the dashed-dotted line in Figure C-3). Consequently, if the HotSpot calculated the 940 meter MEI dose as 10 rem, the population dose would be 2,900 person-rem.

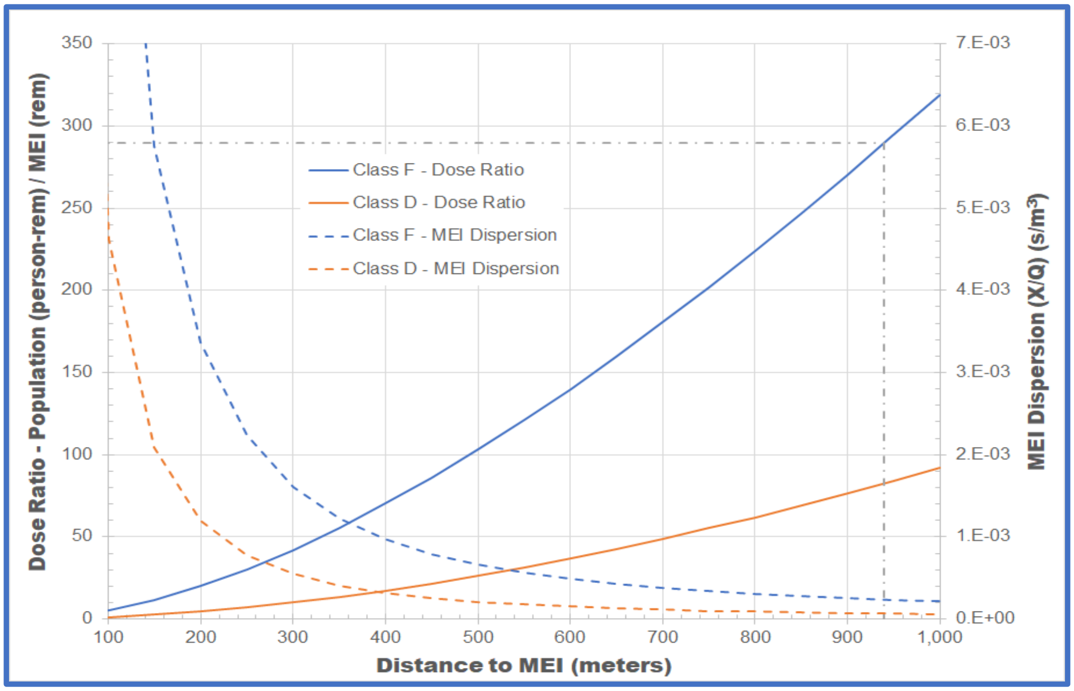


Figure C-3. Population Dose to MEI Dose Ratio as a Function of MEI Distance

The LLNL NESHAP's Annual Report (LLNL 2020b) provides the 2019 0-50 mile population in each of the 16 compass sectors surrounding the Livermore Site, with a total 0-50 mile population of 7.8 million people. All population doses presented in this SWEIS were based on that population distribution. The LLNL NESHAP's Annual Report also provides the 0-50 mile, 16 sector population surrounding Site 300, with a total of 7.1 million people.[3] Because it is conservative, a total population of 7.8 million people was used for all population dose calculations performed for this SWEIS. The 0-50 mile populations are expected to continue to increase, reaching 8.4 million and 7.6 million people for the Livermore Site and Site 300, respectively, by 2030. If the population increase is uniform across all distances and directions, then these 7.24 percent increases in the 0-50 miles populations would result in a corresponding 7.24 percent increase in the population doses. It is noted that the exact increase in the population dose would ultimately depend upon where the increased population is located.

Toxic Chemical Release. Two computer codes from DOE's "toolbox" were used to calculate the impact from a toxic chemical release accident: Areal Locations of Hazardous Atmospheres (ALOHA) (USEPA 2013, USEPA 2022) and EPIcode (Homann 2015). LLNL has used both codes in past analyses. For example, EPIcode was used for lithium hydride analysis in the 2016 LLNL Site 200 Risk Management Plan Technical Supplement (LLNL 2016c), the 2020 Superblock Emergency Planning Hazards Assessment (LLNL 2020f), and the Site 300 Emergency Planning Hazards Assessment (LLNL 2019h), while ALOHA was used for the 2017 Plutonium Facility DSA lithium hydride and chlorine analyses and the B322 EPHA (LLNL 2019l, LLNL

[3] The 2019 LLNL Site Annual Environmental Report (SAER) also gives 7.8 million and 7.1 million people as the 0-50 mile populations surrounding Livermore Site and Site 300, respectively. Although it provides the total populations, the SAER does not breakdown the population by distance and direction. This breakdown is necessary to calculate population doses. Thus, since it provides a distance and direction breakdown, the NESHAPS 2018 Annual Report (LLNL 2019i) is listed as the reference for the 0-50 mile populations.

2021b). For this SWEIS the analysis is based on the information provided in these and other previously LLNL prepared documents, although some modifications were necessary for consistency.

High Explosives. The HotSpot computer code contains an explosive release model that the user has the option for selecting. However, for this SWEIS, the Section C.3.6 analysis is based on the information provided in the HEAF Safety Basis Document (LLNL 2017e) and the Site 300 SBD (LLNL 2018e).

Biological Hazard Release. This SWEIS did not conduct a separate analysis of biological hazard release, but instead tiered from previous NEPA analyses performed for the BSL-3 facility, including the *Final Revised Environmental Assessment for The Proposed Construction and Operation of a Biosafety Level 3 Facility at Lawrence Livermore National Laboratory, Livermore, California* (DOE/EA-1442R) (NNSA 2008), the *Evaluation of LLNL BSL-3 Maximum Credible Event Potential Consequence to the General Population and Surrounding Environment*, LLNL-TR-455072, September 2010,the *Supplement Analysis of the 2005 Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory* (DOE/EIS-0348-SA-03) (NNSA 2011). Therefore, no analytical tools were used in this SWEIS to analyze biological hazard release accidents.

Site-Wide Multiple-Building Scenarios. Consequences for the site-wide seismic event were analyzed using the same tools discussed above for radioactive material release (i.e., HotSpot and/or MACCS2).

Onsite Transportation Accidents. Onsite transportation accidents involve the release of radioactive and/or chemical materials. They were analyzed using the same tools discussed above for radioactive material release and toxic chemical release.

C.3.1.4 *Meteorological Assumptions*

There are several meteorological assumptions that are necessary to perform the accident analyses, including wind speed, atmospheric stability class, distance to the MEI, release elevation, plume buoyancy, terrain factors, building wake, wind direction, and off-centerline distance.

Wind Speed and Atmospheric Stability Class. DOE O 151.1D states that accident impacts should be calculated under conservative and average dispersion conditions. Based on this guidance and five years of Livermore site meteorological data (i.e., 2010 through 2014) (LLNL 2020e), it was found that for ground level releases the 95 percent worst case corresponded to F stability and 1 m/s wind speed and the average case corresponds to D stability and 3 m/s. Similarly, at Site 300 for ground level releases the 95 percent worst case also corresponds to F stability and 1 m/s wind speed and the average case corresponds to D stability and 7 m/s. For accidents with releases modeled as elevated (e.g., an accident involving fire) the conservative and average stability class and wind speed were determined based on the characteristics of the release.

Distance to the MEI. The Livermore Site covers approximately one square mile (2.6 square kilometers) and has buildings located at various locations on the site. The MEI is a hypothetical individual who remains at a location closest to the point on the site boundary fence line. Each building on the LLNL site potentially has its own MEI distance. In the subsequent sections of this appendix, the MEI distance for each building analyzed is presented.

Elevated Releases. The standard atmospheric dispersion models assume that the plume spread has a Gaussian distribution in both the horizontal and vertical planes. The maximum downwind concentration occurs at the horizontal and vertical centerlines. For ground level releases the concentration continually decreases with distance from the release point, as demonstrated in Figure C-4. In the case of an elevated or buoyant release, the maximum concentration would occur at the release elevation and an individual standing on the ground would be exposed to a lesser concentration. For an elevated release the maximum ground level concentration occurs at "some" downwind distance from the release point. The exact distance at which the maximum concentration occurs is a function of the release height and the stability class. Figure C-4 demonstrates this for a 100-foot release.

Populati

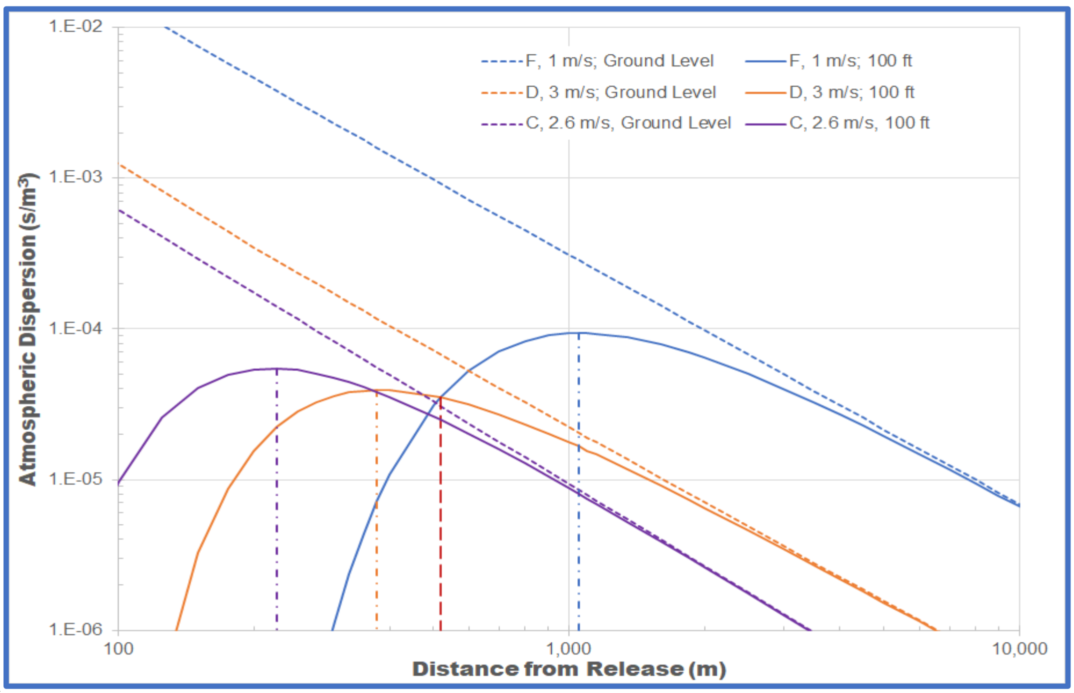


Figure C-4. Off-Site Concentration from a 100 ft Elevated Release

For a 100-foot elevated release (either from a stack or due to buoyancy or exit velocity), Figure C-4 shows that the maximum downwind concentration occurs at 400 and 1,050 meters for stability classes D and F, respectively. The MEI exposures would be determined at these distances or the site boundary, whichever is larger. For example, if the site boundary is at 800 meters, then for stability class D the MEI exposures would be determined at 800 meters, but the class F exposures would be determined at 1,050 meters. This approach is consistent with DOE guidance, which states that the MEI "is evaluated where the off-site ground level consequence is maximized", which for elevated or buoyant releases, "could be beyond the DOE site boundary" (DOE 2014).

Figure C-4 also shows that for elevated releases, the exposure of the non-involved worker, located at 100-meters, is negligible. This is due to the fact that the contamination plume would pass well over the head of the worker at this location.

The final effect shown in Figure C-4 of an elevated release is the fact that at distances close to the release point, the average meteorology (i.e., Class D, 3 m/s) results in concentrations and exposures that are greater than those under the conservative meteorology (i.e., class F, 1 m/s). In Figure C-4 this effect can be seen out to a distance of about 519 meters. Additionally, at even closer distances other, more unstable, meteorological conditions may result in still greater concentrations and exposures. For example, as shown in Figure C-4, out to a distance of about 375 meters the combination of stability class C and 2.6 m/s wind speed results in greater concentrations than either the average or conservative meteorological conditions.

Wind Direction and Horizontal Off-Centerline Distance. For the MEI and the non-involved worker, it was assumed that the wind was always blowing directly towards the individual (i.e., both individuals are located on the centerline). As described in Section C.3.1.4, for the population impacts each sector's population was weighted by the annual frequency the wind blows towards the sector.

Terrain Factors and Building Wake. To determine atmospheric dispersion the Pasquill-Gifford horizontal and vertical diffusion coefficients (commonly referred to as σ_y and σ_z, respectively) are necessary. To account for different terrain types there exist two sets of diffusion coefficients; the first or standard set is for a flat rural terrain and the second is for an urban or city terrain. Urban or city diffusion coefficients account for the increased plume dispersion from crowded structures and the heat retention characteristics of urban surfaces, such as asphalt and concrete. A city terrain factor will result in lower concentrations than the standard or rural coefficients, due to the increased dispersion from large urban structures and materials.

The many buildings at the Livermore Site justify the use of the urban or city diffusion coefficients for the Livermore Site hazard analyses, with one exception: for accidents involving transuranic (TRU) radionuclides, DOE-STD-5506 (DOE 2007) specifies that the standard or rural diffusion coefficient be used, unless justification is provided for using the urban or city coefficients. Accidents involving TRU radionuclides are most likely to occur at the waste storage facilities (i.e., Area 625 [A625] and the Building 693 [B693] Yard Area) or on the onsite roadways leading to these two areas. Since these two areas and the onsite roadway are located close to the Livermore Site fence line, without many structures between them and the fence, the standard or rural diffusion coefficient were used for accidents at these locations. Because Site 300 is located in a more rural area, and has fewer buildings spread over a larger area than at the Livermore Site, the standard or rural diffusion coefficients were used for all Site 300 analyses.

The building wake effect is the enhanced dispersion of the plume due to mechanical mixing of the air as it flows over and around structures. Wakes can be generated by the building releasing the material, as well as by structures in the flow path of the release. Because the terrain type selection (discussed above) already accounts for structures in the flow path of the release, this discussion is focused on wakes generated by the building releasing the material. Credit for enhanced dispersion caused by the building wake has not been taken in any of the SWEIS accident analyses.

C.3.1.5 *Involved Worker Impacts*

For all accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. Estimation of potential health effects becomes increasingly difficult to quantify as the distance between the accident location and the worker decreases because the exposure cannot be adequately established with respect to the presence of shielding and other protective features. The worker also may be acutely injured or killed by physical effects of the accident.

No major consequences for the involved worker are expected from leaks, spills, and smaller fires. These accidents are such that involved workers would be able to evacuate immediately or would be unaffected by the events. Explosions could result in immediate injuries from flying debris, as well as the uptake of radioactive particulates through inhalation. If a criticality occurred, workers in the immediate vicinity could receive high to fatal radiation exposures from the initial burst. The dose would strongly depend on the magnitude of the criticality (number of fissions), the distances of the exposed workers from the criticality, and the amount of shielding provided by structures and equipment between workers and the accident. While an earthquake with subsequent fire could also have substantial consequences, ranging from workers being killed by debris from collapsing structures to high radiation exposure and uptake of radionuclides, the probability of such an event occurring at LLNL is less than once in ten thousand years. Accelerator operations pose potential hazards to involved workers due to exposure to prompt radiation, air activation products, and toxic gases generated during operations. However, LLNL has many controls, including passive structural shielding, venting requirements, and exclusion areas that mitigate and control these hazards.

For most accidents, immediate emergency response actions would likely reduce the consequences for workers near the accident. Established emergency management programs would be activated in the event of an accident. Following initiation of accident/site emergency alarms, workers would evacuate the area in accordance with site emergency operating procedures and would not be vulnerable to additional radiological or chemical risk of injury. First response organizations develop plans and protocols that address radiation protection during a radiological incident and that ensure appropriate training is provided to responders and decisionmakers. The radiological impacts to first responders are controlled during the accident by incident commanders using the USEPA's emergency worker protective action guides (USEPA 2017). Generally, the protective action guide is 5 rem, but may be exceeded to prevent further destruction and/or loss of life. Each first responder makes an informed decision as to how much radiation risk he or she is willing to accept to complete a particular critical infrastructure/key resources or lifesaving mission. Therefore, the first responder's potential radiological exposures are administratively controlled, even during an accident.

C.3.2 No-Action Alternative Projects Accident Impacts

Under the No-Action Alternative, LLNL would use existing capabilities to continue to support major DOE/NNSA capabilities/programs described in Chapter 2 of this LLNL SWEIS and would proceed with projects that have been approved, or are in the process of being approved, for implementation, as shown on Tables 3-1, 3-2, and 3-3. Each of these new facilities, modernization/upgrade/site utility projects, and DD&D projects is described in Section 3.2 of this LLNL SWEIS. For this section, each of these projects was reviewed to determine whether the consequences from a radiological, chemical, biological, or HE accident resulting from the project could potentially result in greater consequences than the previous analysis of existing buildings and facilities. Many of the No-Action Alternative projects involve infrastructure improvement and similar projects, which by their nature would not result in any potential for a radiological, chemical, biological, or HE accident. However, there are several No-Action Alternative projects for which that conclusion is not intuitively obvious, those projects have been discussed below in further detail.

HEAF Lab Capability Expansion (HEX)— A review of this project found that, due to the assumed quantity of HE, the analysis presented in Section C.3.6 bounds the consequences.

Seismic Risk Reduction— This project involves the following facilities: 235, 321A, 411 271, 381B, and 431. None of these facilities affect the accident analyses, and none contain sufficient quantities of radiological, chemical, biological, or high explosives to exceed the quantities assumed in the accident analyses.

Building 850 Revitalization Project— A review of this project found that, due to the assumed quantity of HE, the analysis presented in Section C.3.6 bounds the consequences.

National Ignition Facility (NIF) Tritium Limit — Under the No Action Alternative, NIF would continue to operate under a limit of 8,000 Ci of tritium. The consequences of a B581 Tritium Processing System Fire accident are provided in Tables C-37, C-38, and C-39.

C.3.3 Proposed Action Projects Impacts

The Proposed Action includes the scope of the No-Action Alternative and an increase in current facility operations or enhanced operations that may require new or modified facilities and that are reasonably foreseeable over the next 15 years. The new facilities, modernization/upgrade/site utility projects, DD&D projects, and operational changes associated with the Proposed Action are identified in Tables 3-4, 3-5, and 3-6 and described in Section 3.3 of this LLNL SWEIS. For this section, each of these Proposed Action projects was reviewed to determine whether the consequences from a radiological, chemical, biological, or HE accident resulting from the project could potentially result in greater consequences that the previous analysis of existing buildings and facilities. Many of the Proposed Action projects involve infrastructure improvements and similar projects, which by their nature would not result in any potential for a radiological, chemical, biological, or HE accident. However, there are several Proposed Action projects for which that conclusion is not intuitively obvious, and those projects are discussed below in further detail.

High Explosives Infrastructure Revitalization Projects— This series of projects include: Dynamic Radiography Development Facility, HE Manufacturing Incubator (HEMI), HE Safety Facility (HESF), High Explosives Applications Facility (HEAF) Modular Aging Facility, HEAF Dynamic Studies Facility, etc. Section 3.3.1.2 provides a complete list of and description of these HE Infrastructure Revitalization Projects. Each of these projects is designed to enhance LLNL's HE capabilities. A review of these projects found that, due to the assumed quantity of HE, the analysis presented in Section C.3.6 bounds the consequences from these Proposed Action projects.

Packaging and Transportation Safety Operational Support Facility—Section C.3.4 includes a TRUPACT-II crane drop and fire in the A625 Yard accident. Because the proposed location of the Packaging and Transportation Safety Operational Support Facility is further from the site boundary than the A625 Yard, a similar accident at the new facility would result in lower offsite consequences.

Decrease Administrative Limit for Fuels Grade Equivalent Plutonium in the Superblock—Section C.3.4 includes a plutonium release accident. The MAR used in this accident was based on the fuels grade plutonium equivalent room limits for B332 (LLNL 2019l). Although the Proposed Action operational change would reduce the fuels grade plutonium equivalent Administrative Limit for the entire Superblock, the room limits for B332 remain unchanged. Thus, the accident MAR, Source Term, and consequences would remain unchanged. The consequences from a B332 accident are presented in Section C.3.4.

Biosecurity/Biosciences Facility Upgrade and Animal Care Facility—Section C.3.7 includes an analysis of accidents occurring at LLNL BSL 2/3 facilities. Because the Proposed Action would replace the current facility with a new modernized facility, with upgraded safety systems and storage capability, the consequences presented in Section C.3.7 are considered to be conservative for this project.

Domestic Uranium Enrichment Program—As described in Section 3.3.1.5, NNSA is proposing to develop pilot-scale laser-based uranium enrichment technology at LLNL. The proposed facility would be a radiological facility that would remain below HC-3 thresholds. DOE-STD-1027 describes accidents at HC-3 facilities as having "only local significant consequences." Thus, the proposed facility would be bounded by the analyses performed for HC-3 facilities, and is not further analyzed in this SWEIS.

Revised National Ignition Facility Radioactive Materials Administrative Limits—Under the Proposed Action, NNSA is proposing that the quantities of radioactive material allowed in NIF would be limited to below the applicable DOE-STD-1027 Hazard Category 3 threshold values. This would increase NIF's tritium inventory from 8,000 Ci to 16,000 Ci, and would also allow plutonium isotopes to be used within experimental platforms up to 38.2 g for plutonium-239. Future NIF experiments are expected to require the occasional transfer between NIF and other onsite LLNL locations of radioactive materials representing large fractions of HC-3 threshold limits. Consequence analyses have been conservatively performed based on the upper limits of plutonium and tritium defined for a Low Hazard Facility (HC-3 lower threshold values defined in DOE-STD-1027-2018).

Revised Building 235 Plutonium Inventory Limits—Under the Proposed Action, the quantities of radioactive material allowed in B235 would be limited to below the applicable DOE-STD-1027 Hazard Category 3 threshold values. NNSA is proposing an increase to the plutonium mixture limits, which would increase the plutonium-239 inventory to below 38.2 g. This is consistent with the less-than-HC-3 designation per DOE-STD-1027-2018 (DOE 2018). Consequence analyses have been conservatively performed based on the upper limit of plutonium defined for a Low Hazard Facility (HC-3 lower threshold values defined in DOE-STD-1027-2018).

Materials Analysis Laboratory—The facility would have the ability to do high sensitivity and high-resolution chemical and nuclear analysis but would remain a low-hazard radiological facility with similar emissions, hazards, and waste streams as Building 151. The proposed facility would be a radiological facility that would remain below HC-3 thresholds. DOE-STD-1027 describes accidents at HC-3 facilities as having "only local significant consequences." Thus, the proposed facility would be bounded by the analyses performed for HC-3 facilities and is not further analyzed in this SWEIS.

These accident scenarios are addressed in Sections C.3.4, C.3.6, and C.3.7.

C.3.4 Accident Scenarios Involving Radioactive Material

LLNL uses radioactive materials in a wide variety of operations including scientific and weapons research and development, diagnostic research, research on the properties of materials, isotope separation, surveillance and aging studies, machining and inspection, chemical processing, analytical chemistry, metallurgy, weapon component processing, and as calibration and irradiation sources. Radioactive materials are collected as waste products in forms varying from contaminated laboratory equipment and metal filings to contaminated trash and liquids. Radioactive materials are transported onsite. Therefore, there is a potential for releases of radioactive materials due to human error, failure or malfunctioning of equipment, accidents during the treatment, handling, or transportation of radioactive wastes, and severe natural events like earthquakes.

As indicated in Section C.3.1.2, the following Livermore Site facilities have sufficient radioactive material subject to analysis. For this SWEIS, the DSAs and other safety basis documents/reference documents for all these facilities were reviewed to determine the types of radioactive material contained in each facility. The following is a summary of the results of those reviews:

- Radioactive material within the Radiography Facility (Building 239) includes fuel-grade plutonium and natural, depleted, and highly enriched uranium. Furthermore, transitory TRU waste drums may be brought into the facility for radiography (LLNL 2017f).

- Radioactive material within the Tritium Facility (Building 331) includes tritium, 30-yr-old fuel- and weapons-grade plutonium, and natural and highly enriched uranium. Radioactive materials in the facility are limited to less than the nuclear criticality quantities or, by the nature of the process involved, preclude the potential for a criticality (LLNL 2018f).

- While uranium and plutonium, and smaller amounts of other radioactive materials (e.g., Np-237, Am-241, Am-243, Th-232, Th-228, Cm-246, and Cm-244) are stored, handled, and processed in the Plutonium Facility (B332), plutonium is the dominant hazard. Fission products krypton, xenon, and iodine may be released from Building 332 in the event of an inadvertent criticality (LLNL 2019l).

- Radioactive material within the Hardened Engineering Test Building (Building 334) includes 30-yr-old fuel- and weapons-grade plutonium, natural and highly enriched uranium, and tritium. The most limiting radioactive material in Building 334 is plutonium (LLNL 2017g).

- With the exception of tritium, radioactive material (i.e., TRU waste) located in the Waste Storage Facilities (WSF) (A625 and Building 693 Yard) is converted to units of plutonium-239 equivalent curie (PE-Ci). The WSF DSA evaluated only accidents involving TRU or tritium radioactive material (LLNL 2021j).

- Radioactive materials within the National Ignition Facility such as tritium (fusion target fuel) and isotopes of plutonium (for experimental studies).
- Radioactive materials within Building 235 such as isotopes of plutonium.
- Transuranic waste storage in plutonium-239 equivalent curies (PE-Ci) are present in Building 696R

Based upon the information from the LLNL safety documents, this SWEIS has included analyses for accidents involving the following types of radioactive material:

1. Plutonium
2. Tritium
3. Transuranic (TRU) Material
4. Mixed Fission Products (inadvertent criticality)

The Livermore Site DSAs show that the uranium accident consequences are bounded by the plutonium consequences. Therefore, accidents involving uranium have not been included in this SWEIS analysis. For each of the four types of radioactive materials, the DSAs were reviewed to identify potential accidents. For each type of radioactive material, Sections C.3.2.1 through C.3.2.4 present the bounding accidents for the Livermore Site facilities.

C.3.4.1 *Plutonium Release*

The following plutonium release accident scenarios are analyzed:

- Hydrogen Explosion with Room Fire at the Plutonium Facility (B332)
- National Ignition Facility (B581) Transfer Vehicle Fire
- Building 235 General Facility Fire

Hydrogen Explosion with Room Fire at the Plutonium Facility (B332).—After reviewing the accidents analyzed in the DSAs for the HC-2 and HC-3 facilities, a hydrogen explosion followed by a room fire at the Plutonium Facility (B332) was determined to be the bounding plutonium release accident for this SWEIS. To calculate the radiological source term, the MAR, DR, ARF, and RF were taken from the B332 DSA (LLNL 2019l), while two different LPFs were assumed. The LPF was assumed to be 2×10^{-6}, obtained from DSA and represents a fire in which the HEPA filters are available. According to the B332 DSA, two stages of HEPA filters are provided in each final plenum. These HEPA filters remove material from the exhaust stream with an assumed filter efficiency of 99.9 percent for the first stage and 99.8 percent for the second. The overall LPF is thus $(1.0 - 0.999) \times (1.0 - 0.998) = 2.0\times10^{-6}$. The frequency of this accident occurring was estimated to be between 1 in 100 and 1 in 10,000 (i.e., $\leq1\times10^{-2}$ to 1×10^{-4}) per year.

The B332 DSA evaluated three hydrogen explosion scenarios: (1) a hydrogen explosion in the Metal Conversion Glovebox (MCG) glovebox, (2) a hydrogen explosion in the hydride/nitride furnace, and (3) a hydrogen explosion in the oxidation furnace. In each scenario, a post-hydrogen explosion fire is postulated. Due to its larger source term, the bounding scenario for inclusion in the SWEIS is the hydrogen explosion in the hydride/nitride furnace.[4] The radionuclide source terms that result from the Plutonium Facility hydrogen explosion with room fire accident scenario for all three LPFs are summarized in Table C-28.

Table C-28. Plutonium Facility Source Terms: Hydrogen Explosion with Room Fire

Parameter[a]		Fuel-Grade Plutonium (FGPu) Form				
		PuH Powder in Furnace		Pu in Room 1006		Total
		Explosive	Oxidizes	Solution	Metal	
MAR	Material at Risk (g)	4,500		880	14,620	20,000
DR	Damage Ratio	1.0	1.0	1.0	1.0	—
ARF	Airborne Release Fraction	0.1	0.01	0.002	0.0005	—
RF	Respirable Fraction	0.7	1.0	1.0	0.5	—
LPF	Leak Path Factor	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	—
	Source Term (g)	6.30×10^{-4}	9.00×10^{-5}	3.52×10^{-6}	7.31×10^{-6}	7.31×10^{-4}

a. See text for the source for these parameter values.

Because the Plutonium Facility's stacks are less than two and a half times the height of the facility, no credit was taken for an elevated release per DOE-STD-1027-92 (DOE 1997). Also, as described in the DSA (LLNL 2019l), no credit was taken for plume thermal buoyancy.

Per the DSA, the shortest distance to an area with unrestricted public access from the Plutonium Facility is a distance of 800 meters. The calculated consequences from the Plutonium Facility hydrogen explosion accidents are provided in Section C.3.4.5.

National Ignition Facility (B581) Transfer Vehicle Fire. The NIF contains the world's largest and most energetic laser for research and development. Accidents at the NIF have previously been analyzed in the B581-582 Complex SBD (LLNL 2018g) and most recently in "Accident Scenario Analyses for the National Ignition Facility" (LLNL 2021e).

For the Proposed Action, NIF experiments are expected to require the occasional transfer of radioactive materials representing large fractions of DOE STD-1027-2018 Category 3 threshold limits. Because these transfers are not expected to occur under the No-Action Alternative, there is no comparable event.

The bounding Proposed Action accident involves a transfer vehicle fire which may be caused by a variety of circumstances (e.g., initiated by a leaking fuel line). While the possibility of a vehicle fire exists at any point along the transfer route, when the material is managed by NIF the loading area to the southeast of the NIF building is the closest location to the site boundary. Once the transfer leaves NIF the LLNL Transportation Safety Document (TSD) (LLNL 2018j) addresses onsite nuclear quantity transfers of radiological material, see Section C.3.8.

The radionuclide specific MARs were obtained from LLNL 2021e, as were the DR, ARF × RF, and LPF. The MARs were specified such that the total NIF activity would remain below the DOE-

[4] Although the hydrogen explosion in the MCG glovebox has a larger MAR (40 kilograms) then the explosion in the hydride/nitride furnace (20 kg), the explosion in the hydride/nitride furnace has a larger source term due primarily to the 20 times larger ARF for the furnace explosion (0.1) than for a glovebox explosion (0.005). The oxidation furnace explosion has a slightly lower source term than the hydride/nitride furnace explosion due to its lower release from the furnace during the post explosion fire.

STD-1027-2018 (DOE 2018) Category 3 threshold. Table C-29 presents the resulting source term for evaluating the Transfer Vehicle fire.

Table C-29. Source Term for NIF Transfer Vehicle Fire

Radionuclide	MAR (Ci)	DR	ARF × RF	LPF	Source Term (Ci)
Pu-239	1.72	1.0	0.001	1.0	1.7×10^{-3}
Pu-240	0.38				3.8×10^{-4}
Pu-241	9.09				9.1×10^{-3}
Pu-238	0.1				1.0×10^{-4}
Am-241	0.02				2.0×10^{-5}

The estimated frequency for a Transfer Vehicle fire from all potential causes is 2×10^{-5} per year (LLNL 2021e), making it an extremely unlikely accident under safety analysis, however, reasonably foreseeable for this SWEIS. The transfers would originate or terminate at the NIF loading area to the southeast of the NIF building, 380 meters to the nearest off-site location. The calculated radiological consequences from a Transfer Vehicle fire at B582 are provided in Section C.3.4.5.

General Facility Fire at the Materials Science Division Offices and Labs (B235). Under the Proposed Action LLNL is considering an increase to the B235 plutonium mixture inventory limits consistent with less-than-HC-3 designation per DOE-STD-1027-2018 (DOE 2018). Currently, B235 is limited to a plutonium mixture inventory consistent with less-than-HC-3 designation per DOE-STD-1027-92 (DOE 1997). Adoption of the new limits will lead to expanding the laboratory space dedicated to the preparation of plutonium samples for experimental work outside of B235. Under the No-Action Alternative, these plutonium sample preparations could not be performed in B235.

To calculate the potential risk associated with the increased MAR, the maximum B235 inventory was characterized as 25.8 grams of weapons grade (WG) Pu, consisting of 23.8 grams as metal and 2 grams as TRU waste. The bounding plutonium release scenario identified was a fire involving this entire plutonium inventory. Based on the guidance from DOE-HDBK-3010 (DOE 1994) the ARF × RF for Pu release from metal and waste during a fire were taken as 2.5×10^{-4} and 5.0×10^{-4}, respectively. For both metal and waste, both the DR and LPF were conservatively assumed to be 1.0 (Pinkston, 2022). The radionuclide composition of WG Pu was obtained from LLNL 2019l. The source term for the B235 general facility fire is shown in Table C-30.

Table C-30. Source Term for B235 General Facility Fire

Radionuclide	WG Pu Mass Fraction	MAR (g)		Source Term (Ci)		
		Waste	Metal	Waste	Metal	Total
Pu-238	3.0×10^{-4}	6.0×10^{-4}	0.0071	5.1×10^{-6}	3.1×10^{-5}	3.6×10^{-5}
Pu-239	0.93	1.9	22.2	5.8×10^{-5}	3.5×10^{-4}	4.0×10^{-4}
Pu-240	0.060	0.12	1.4	1.4×10^{-5}	8.1×10^{-5}	9.5×10^{-5}
Pu-241	0.0014	0.0028	0.033	1.4×10^{-4}	8.6×10^{-4}	1.0×10^{-3}
Pu-242	4.0×10^{-4}	8.0×10^{-4}	0.0095	1.6×10^{-9}	9.4×10^{-9}	1.1×10^{-8}
Am-241	0.0045	0.009	0.11	1.5×10^{-5}	9.2×10^{-5}	1.1×10^{-4}
Total	**1.00**	**2.0**	**23.8**	$\mathbf{2.4\times10^{-4}}$	$\mathbf{1.4\times10^{-3}}$	$\mathbf{1.6\times10^{-3}}$

The estimated frequency for a B235 general facility fire is between 1×10^{-4} and 1×10^{-6} per year (LLNL 2017n). The distance from B235 to the MEI is 730 meters (Pinkston 2022). The calculated radiological consequences from a B235 general facility fire are provided in Section C.3.4.5.

C.3.4.2 *Tritium Release*

Three tritium release accident scenarios were analyzed:

- Aircraft Crash at the Tritium Facility (B331)
- National Ignition Facility (B581) Tritium Processing System Fire
- Waste Storage Facilities Fire

Aircraft Crash at the Tritium Facility (B331).—The Tritium Facility DSA (LLNL 2018f) evaluated the following two aircraft crash accidents:

- Aircraft crashes into building causing a radioactive spill or a fire that burns radioactive material (LLNL 2018f).

- Aircraft crashes into building at increment fire barrier causing a radioactive spill or fire that burns radioactive material (LLNL 2018f).

These two accidents are also evaluated in this SWEIS. The MARs for these accidents are shown in Table C-31. The Tritium Facility radiological inventory as is limited to less than 35 grams (g) for both increments combined. The B331 inventory limit of Pu-239, U-233, and U-235 shall not exceed the criticality limits of 450 grams, 500 grams, and 700 grams, respectively (LLNL 2018f). The Superblock EPHA clarifies that the "facility's inventory limit for Pu-239 is 450 grams per increment, or 900 grams overall" (LLNL 2020a), and that while the total tritium inventory is limited to 35 grams, and single increment may contain up to 30 grams (LLNL 2020f).

As shown in Table C-31, a DR of 1.0 was conservatively assumed for all radionuclides. The ARF and RF were both assumed as 1.0 for tritium and were obtained from DOE-HDBK-3010, for plutonium and uranium. A LPF of 1.0 was based on the aircraft penetrating B331, resulting in an unfiltered, ground-level release. The resulting source term is given in Table C-31.

Table C-31. Aircraft Crash at the Tritium Facility Source Term

Radionuclide	MAR (g)[a]		DR	ARF	RF	LPF	ST (g)	
	Increment	Total					Increment	Total
Tritium (H-3)	30	35	1.0	1.0	1.0	1.0	30	35
Pu-239	450	900	1.0	0.0005	0.5	1.0	0.11	0.23
U-233	500	1,000	1.0	0.001	1.0	1.0	0.50	1.0
U-235	700	1,400	1.0	0.001	1.0	1.0	0.70	1.4

Note: The frequency of an aircraft crashing into Building 331 has been estimated to be between 1 in 10,000 and 1 in 1 million (i.e., $\leq 1\times10^{-4}$ to 1×10^{-6}) per year, while the frequency of an aircraft crashing into the increment wall was calculated by LLNL (2014) to be 8.6×10^{-7} per year (LLNL 2018f).

a. This value is conservative based on DOE-STD-1027 since this combination of materials could not occur and still satisfy the hazard category characterization of the facility.

The shortest distance to the site boundary (i.e., the MEI) is given in the B331 DSA as 800 meters. The calculated consequences from these two aircraft accidents at the Tritium facility are provided in Section C.3.4.5.

National Ignition Facility (B581) Tritium Processing System Fire. The NIF is capable of firing up to 192 laser beams onto a wide variety of targets. Isotopic mixtures of hydrogen, including tritium (i.e., H-3), constitute the basic fuel for the fusion targets. A tritium inventory of up to 8,000 Ci has been established for the NIF (LLNL 2021e), which would not be modified under the No-Action Alternative. The NIF is equipped with a Tritium Processing System (TPS), where elemental tritium is oxidized by an arrangement of heaters and catalyst beds and captured on molecular sieve beds. For this accident analysis, all 8,000 Ci of NIF-allowed tritium was conservatively assumed to be contained within the TPS and available for release. The tritium inventory in the TPS is controlled and maintained by the periodic removal of the molecular sieve and shipping it off-site for disposal. Thus, the MAR for this accident is 8,000 Ci of tritium. Because the DR, ARF, RF, and LPF for tritium are all conservatively assumed to be equal to 1.0, the source term for the TPS accident is the same as the MAR (i.e., 8,000 Ci of tritium).

Under the Proposed Action, LLNL is proposing that the allowable NIF tritium inventory be modified to the DOE-STD-1027 2018 (DOE 2018c) HC-3 tritium threshold, Thus, for the Proposed Action the MAR is specified as the DOE-STD-1027 2018 (DOE 2018c) HC-3 tritium threshold of 16,000 Ci (1.6 g). All other aspects of the TPS fire under the Proposed Action are the same as under the No-Action alternative.

The frequency for a TPS enclosure fire is 1×10^{-6} per year (LLNL 2021i). The shortest distance to an area with unrestricted public access is about 395 meters (i.e., from the NIF stack to the nearest off-site location on Greenville Road). The calculated radiological consequences from a TPS enclosure fire for the No-Action Alternative and the Proposed Action at the NIF are provided in Section C.3.4.5.

Waste Storage Facilities Fire. The WSF DSA (LLNL 2021j) states that the waste in every yard area and every building within the WSF could contain up to 40,000 Ci and 15,000 Ci of tritium, respectively. The DSA postulates that a fire could release all of the stored tritium. A fire is necessary to release this amount of tritium, because the largest tritium sources are the spent molecular sieves from the TPS, which capture contaminated, low concentration, or low-quality tritium for disposal as waste. The molecular sieves effectively bind the tritium and have zero release potential from a drop or impact accident. The elevated temperatures from a fire are required to begin releasing from the molecular sieves tritium at any significant rate (LLNL 2021j).

A fire in B693 was chosen as the bounding WSF tritium release accident because 1) B693 is the closest WSF building to the fence line (130 meters), and 2) a release from a WSF building fire uses zero plume lofting due to the assumption that there is no open breach in the building, whereas a release from a yard fire would loft due to plume buoyancy (LLNL 2021j). Ground level release is more conservative as buoyancy causes the plume centerline to pass overhead, resulting in lower ground level concentrations at the fence line MEI location. The bounding frequency for a fire involving large amounts of tritium at the WSF is 1×10^{-4} to 1×10^{-6} per year.

C.3.4.3 *Transuranic Release*

Three TRU release accident scenarios are analyzed:

- TRUPACT-II Crane Drop and Fire in the A625 Yard
- Yard TRU Waste Event at the Plutonium Facility (B332)
- Waste Storage Facilities Aircraft Crash

TRUPACT-II Crane Drop and Fire in the A625 Yard. The Transuranic Package Transporter Model 2 (TRUPACT-II) has been developed for DOE and approved by the U.S. Nuclear Regulatory Commission (NRC) as a safe means for the transportation of contact-handled TRU (CH-TRU) materials to the Waste Isolation Pilot Plant (WIPP) in New Mexico or elsewhere. LLNL uses the TRUPACT-II to transport its CH-TRU waste to WIPP. Loading of the TRUPACT-II is performed by a WIPP mobile loading crew, with the assistance of a LLNL crane operator and a spotter. Loading of the TRUPACT-II is performed outside in the A625 Yard. The TRUPACT-II payload is limited to 420 Pu-239-equivalent Curies (PE-Ci) (LLNL 2021j).

This accident postulates the crane dropping a payload of TRU Waste Containers while lifting them into a TRUPACT-II Type B cask, resulting in a breach of the containers. In addition, fuel (either from the crane or a crashing vehicle/equipment that caused the drop) is released, ignites, and causes the dropped TRU Waste Containers to burn. The MAR for this accident is the payload limit of 420 PE-Ci. Based on this MAR, three source terms were assumed: (1) the impact of the dropped container, (2) a fire of the spilled material on the ground, and (3) a fire of the material that remains in the container.

Table C-32 shows the values assumed for the DR, ARF & RF, and LPF for each of the three TRUPACT-II crane drop and fire accident (LLNL 2017c). The DR and ARF & RF values for this scenario were obtained from the DOE standard for the *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities* (DOE 2007). Because the accident is assumed to occur outdoors, the LPF was conservatory assumed to be equal to 1.0 for all three source terms.

Table C-32. TRUPACT-II Crane Drop and Fire in the A625 Yard Source Term

Event	MAR (PE-Ci)	DR	ARF & RF	LPF	Source Term (PE-Ci)
Drop Impact	420	0.1	0.002	1	0.084
Burn on Ground	420	0.1	0.01	1	0.42
Burn in Drum	420	0.9	0.0005	1	0.189
				Total Source Term	**0.693**

Source: LLNL 2021j.

The WSF DSA estimates the frequency of this accident based on number of lifts per year (12 – 18) to be 5.4 x 10^{-4}/year (LLNL 2021j), which is considered a reasonably foreseeable accident.

TRUPACT-II loading/unloading is only authorized in A625 Yard and not in B625, B696R, B693, or the B693 Yard (LLNL 2021j). The nearest site boundary with unrestricted public access per the DSA is located about 220 meters from the A625 Yard.

A ground level release was assumed for the drop impact source term, while for the two burn source terms an elevated release was calculated due to the heated plume buoyancy effect. To calculate the plume buoyancy effect, a 10 gallon gasoline fire (with a heat of combustion of 43.7 MJ/g) was assumed. As discussed in Section C.3.1.4, at the short distance from the A625 Yard to the site boundary, the exposure due to the two burn sources is small relative to the drop impact source term. At longer distances, the dose from the two burn sources contributes to the dose, but the total dose is smaller than at the site boundary due to the additional dispersion. Therefore, it was conservatively assumed that the MEI would be located at the site boundary.

The calculated radiological consequences from a TRUPACT-II crane drop and fire in the A625 Yard are provided in Section C.3.4.5.

Yard TRU Waste Event at the Plutonium Facility (B332). The bounding Yard TRU Waste event is as follows: a truck or forklift has an accident which spills diesel fuel spills and subsequently ignites and engulfs the entire Waste Accumulation Area A (WAA-A) outside of B332. The TRU waste material is released during this postulated consists of material released due to (1) the vehicle impact (all containers impacted), (2) the unconfined burning of the spilled TRU wastes, and (3) the confined burning of TRU wastes that remains in the container. The fires are assumed to burn long enough to cause a release of material from all containers. Thus, the MAR was conservatively assumed to be the administrative limit for the yard, or 1,500 grams of 30-year-old fuel-grade equivalent plutonium. The DR, ARF, and RF were provided in the B332 DSA (LLNL 2019l). Because the releases would occur in the yard, the LPF was set to 1.0. The resulting source term for this accident is shown in Table C-33.

Table C-33. Plutonium Facility Source Terms: Liquid Fuel Pool Fire

Parameter[a]		Fuel-Grade Plutonium (FGPu) Form			
		Impact Release	Spilled Waste Fire	Fire in Container	Total
MAR	Material at Risk (g)	1,500			1,500
DR	Damage Ratio	0.1	0.1	0.9	—
ARF	Airborne Release Fraction	0.001	0.01	5×10^{-4}	—
RF	Respirable Fraction	0.1	1.0	1.0	—
LPF	Leak Path Factor	1.0	1.0	1.0	—
	Source Term (g)	0.015	1.50	0.675	2.19

a. Parameter values from LLNL 2017g.

Both the natural combustible loading levels in the area and the activity level are low. Thus, a fire affecting the entire WAA-A inventory is considered to have a frequency of between 1 in 10,000 and 1 in 1 million (i.e., $\leq1\times10^{-4}$ to 1×10^{-6}) per year (LLNP 2017d).

Waste Storage Facilities Aircraft Crash. The Waste Storage Facilities (WSF) consist of Area 625 (A625) and the Building 693 (B693) Yard Area portion of the Decontamination and Waste Treatment Facility (DWTF) complex. A625 is located in the southeast quadrant of LLNL and includes Building 625 (B625), and associated tents and yard areas. The B693 Yard Area, which includes Building 693 (B693), Building 696 Radioactive Waste Storage Area (B696R), and associated yard areas and storage areas within the yard, is located in the northeast quadrant of LLNL.

An aircraft crash is considered to be a credible accident at the WSF. The nearest public airport to LLNL is the Livermore Municipal Airport, which is located 6 miles west. This airport primarily services small, privately owned, single- and twin-engine propeller, and turbo-propeller aircraft. The WSF DSA (LLNL 2021j) postulated a number of aircraft crashes, including crashes into B625 containing 55-gallon waste drums, into B696R containing standard waste boxes (SWB), and crashes followed by no, small (25 gallon), and large (100 gallon) fuel fires. Several source terms models, each with a different DR, ARF, and RF, were developed, including directly impacted, unconfined burning on ground, burning in drum/SWB, lid loss with unconfined burning on ground, lid loss with burning in drum/SWB, and burning in drum/SWB with seal failure. A LPF of 1.0 was used for each the models. Each drum/SWB was assigned a source term model depending on its location relative to the crash, e.g., 50 drums were assigned to be directly impacted by the cash. Also, for the B625 MAR, each drum was assumed to vary from a mean of 2.9 PE-Ci to a maximum of 75 PE-Ci, with the drum containing the maximum MAR conservatively assumed to be one of the 50 drums directly impacted by the crash. For the B696R MAR, it was assumed that each SWB was loaded to 12 PE-Ci. The source term for an aircraft crash into the B625 and B696R are shown in Table C-34 for two scenarios: (1) a small (25 gallons of aircraft fuel) fire results from the crash, and (2) a large 100 gallon (i.e., the nominal fuel capacity of the single-engine, fixed-wing aircraft) fire results from the crash.

Table C-34. Waste Storage Facilities Source Term: Aircraft Crash

Release Type	Source Term (PE-Ci)	
	B625	B696R
Small Fire: 25 gallons	2.00	0.421
Large Fire: 100 gallons	3.33	0.901

The frequencies of an aircraft crashing into B625 and B696R have been calculated to be 6.3×10^{-7} and 6.4×10^{-7} crashes per year, respectively (LLNL 2021j). Distances to the MEI from Buildings 696R and 625 are identified in the DSA as 150 m and 250 meters, respectively. The calculated consequences for these WSF aircraft crash accidents are provided in Section C.3.4.5.

C.3.4.4 *Inadvertent Criticality, Mixed Fission Product Release*

An inadvertent criticality may be initiated by any of the following:

- inadvertent transfer or leakage of solution of fissile material into an anomalous configuration,
- introduction of excess material to the vessel or to a solution,
- over-concentration of a solution,
- failure to maintain neutron absorbing material in the vessel,
- precipitation of fissile solids from a solution and their retention in a vessel,
- introduction of neutron moderator or reflector,
- deformation of or failure to maintain safe storage arrays, or
- similar actions that can lead to an increase in the reactivity of fissile systems.

While any individual inadvertent criticality examined may not be credible, all potential events in aggregate are assumed to make the overall risk of an inadvertent criticality is between 10^{-4} and 10^{-6} per year, or once in 10,000 to 1 million years (LLNL 2019l). The Tritium Facility DSA (LLNL 2018f) states:

> Radioactive materials in the facility are limited to less than the nuclear criticality quantities or, by the nature of the process involved, *preclude the potential for a criticality*. [emphasis added] Thus, the facility's inventory limit of ^{239}Pu, ^{233}U, and ^{235}U shall not exceed the criticality limits of 450 g, 500 g, and 700 g, respectively, or by the nature of the process shall preclude the potential for a criticality (LLNL 2018f).

The Building 239 Radiography Facility and the Building 334 Hardened Engineering Test Building DSAs each contain similar statements:

> An evaluation of frequency further substantiates that an inadvertent nuclear criticality accident in Building 239 is *Beyond Extremely Unlikely* [i.e., less than 10^{-6} per year, or less than once in a million years] and is precluded due to the nature of the process for Building 239 operations. [emphasis in original] (LLNL 2017f).
>
> An evaluation of frequency substantiates that an inadvertent nuclear criticality accident in Building 334 is *beyond extremely unlikely* [i.e., less than 10^{-6} per year,

> or less than once in a million years] and is precluded due to the nature of the process for Building 334 operations (…). [emphasis added] (LLNL 2017g).

In addition, the Waste Storage Facilities DSA states:

> For Waste Storage Facilities operations, criticality safety is assured through multiple (more than two) barriers that meet the requirements of the double-contingency principle. For example, storage arrays have the following barriers: fissionable materials mass limit, moderator limit, reflector limit, container size, and array spacing controls. A probabilistic risk assessment evaluation covering all credible external and internal events has concluded that *there is no credible risk of a criticality accident* (…). [emphasis added] (LLNL 2021j).

Because both the Building 332 Plutonium Facility's DSA (LLNL 2019l) and the Superblock EPHA (LLNL 2020f) analyze inadvertent criticality at the Plutonium Facility, and because inadvertent criticalities frequencies are less than 1 in 10 million ($<1\times10^{-7}$) per year at other Livermore Site facilities, both plutonium and uranium inadvertent criticalities at the Plutonium Facility are analyzed in this SWEIS. Table C-35 shows the noble gas and iodine source terms that were assumed for the criticality analyses. These source terms were adjusted to 10^{18} fissions from DOE-HDBK-3010 (DOE 1994), Table 6-8 and 6-9. In addition to the noble gas and iodine source terms, there is the potential for airborne release of plutonium from the original radiological material that yields the plutonium criticality. The analysis used a MAR of 1600 grams, based on the B332 Technical Safety Requirement limit, and a DR of 1.0, a ARF of 5×10^{-4}, a RF of 1.0, and a LPF of 2×10^{-6}, based on DOE-HDBK-3010 guidance and consistent with the B332 DSA. Due to their small dose potential, uranium releases from a uranium criticality were neglected for this SWEIS analysis, consistent with the Plutonium Facility DSA (LLNL 2019l).

Table C-35. Fission Products Released From 10^{18} Fission Uranium/Plutonium Criticality Events

Nuclide	Release (Ci)		Nuclide	Release (Ci)		Nuclide	Release (Ci)	
	Uranium	Plutonium		Uranium	Plutonium		Uranium	Plutonium
Kr-83m	16	11	Xe-131m	8.2×10^{-3}	1.0×10^{-2}	I-131	0.22	0.28
Kr-85m	15	7.1	Xe-133m	0.18	0.22	I-132	28	30
Kr-85	1.6×10^{-4}	8.1×10^{-4}	Xe-133	2.7	2.7	I-133	4	4
Kr-87	99	43	Xe-135m	2.2×10^{2}	3.3×10^{2}	I-134	1.2×10^{2}	1.1×10^{2}
Kr-88	65	23	Xe-135	36	41	I-135	12	12
Kr-89	4.2×10^{3}	1.3×10^{3}	Xe-137	4.9×10^{3}	4.9×10^{3}			
			Xe-138	1.3×10^{3}	1.1×10^{3}			

Source: DOE-HDBK-3010 (DOE 1994), Table 6-8 and 6-9 modified to 10^{18} fissions.

Workers in the immediate area of the criticality would receive prompt gamma and neutron doses following an inadvertent criticality. To calculate these distance dependent worker prompt doses equations from NUREG-1940 (PNNL 2012) were modified to include air attenuation, as per Willis (Willis 1976), and for consistent units (feet). The resulting formulas are:

$$D_g = 10^{-13} \frac{F_T}{x^2} e^{-(A_{g,a}x + A_{g,c}C)}$$

$$D_n = 10^{-12} \frac{F_T}{x^2} e^{-(A_{n,a}x + A_{n,c}C)}$$

Where:
D_g = Prompt gamma dose (rem)
10^{-13} = Empirical gamma dose constant (rem (fission-ft^2)$^{-1}$)
F_T = Number of fissions (fissions)
= 10^{18} (fissions) (LLNL 2019l)
x = Distance from criticality (ft)
$A_{g,a}$ = Air gamma attenuation factor (ft^{-1})
= 0.00104 (ft^{-1}) (Willis 1976)
$A_{g,c}$ = Concrete gamma attenuation factor (ft^{-1})
= 1.76 (ft^{-1}) (PNNL 2012)
C = Thickness of concrete (ft)
D_n = Prompt neutron dose (rem)
10^{-12} = Empirical neutron dose constant (rem (fission-ft^2)$^{-1}$)
$A_{n,a}$ = Air neutron attenuation factor (ft^{-1})
= 0.00158 (ft^{-1}) (Willis 1976)
$A_{n,c}$ = Concrete neutron attenuation factor (ft^{-1})
= 2.88 (ft^{-1}) (PNNL 2012)

The methodology from NUREG/CR-1940 (PNNL 2012) was used to calculate the distant dependent prompt gamma and neutron doses. The NUREG/CR-1940 methodology is based on NUREG/CR-6504, Volume 2 (ORNL 1998). The NUREG/CR-1940 prompt dose methodology is similar to that given by Willis 1976, which was also used in the 2005 LLNL SWEIS. The differences include: (1) NUREG/CR-1940 uses feet as its basic unit, whereas Willis 1976 uses kilometers; (2) NUREG/CR-1940 rounds the empirical gamma and neutron dose constants to the nearest order of magnitude; and (3) Willis 1976 includes air attenuation, whereas NUREG/CR-1940 includes concrete, steel, and water attenuation.

Table C-36 presents the results of the prompt dose calculation. The dose at 10 meters was included to allow for comparison to the 2005 LLNL SWEIS, Section D.2.5 doses.

Table C-36. Inadvertent Criticality Worker Prompt Dose

Dose Type	Prompt Dose (rem)					
	No Shield			8-inches Concrete		
	10 m	30 m	100 m	10 m	30 m	100 m
Gamma	89.8	9.3	0.66	27.7	2.9	0.20
Neutron	882.0	88.3	5.5	129.3	12.9	0.81
Total	971.8	97.6	6.2	157.0	15.8	1.01
LCF Risk	Lethal Dose	5.9×10^{-2}	3.7×10^{-3}	9.4×10^{-2}	9.5×10^{-3}	6.1×10^{-4}

The Table C-36 unshielded doses at 10 meters differ slightly from the prompt doses reported in the 2005 LLNL SWEIS, due to NUREG/CR-1940 rounding of the empirical dose constants, discussed above. However, the Table C-36 unshielded 10 meter dose is greater than the average lethal radiation dose to humans of approximately 450 rem (NRC 2021). Non-involved workers located at 30 and 100 meters would receive significantly lower unshielded doses, well below the prompt lethal dose. The unshielded dose to the MEI would be approximately 4 millirem, with an associated LCF risk of 2.4×10^{-6}.

In Building 332, the laboratory interior walls are a minimum of 8 inches of concrete. As shown in Table C-36, the calculated prompt doses attenuated through 8 inches of concrete would be significantly smaller than when all shielding is ignored (i.e., the gamma and neutron doses are reduced by factors of 3.2 and 6.8, respectively).

C.3.4.5 *Consequences of Potential Radioactive Material Release Accidents*

The preceding sections describe the accidents analyzed in this SWEIS, including the calculated source terms and the MEI distances for each No-Action Alternative and Proposed Action accident.

Since the mid-1980s, the USEPA has issued a series of federal guidance documents for the purpose of providing the Federal and State agencies technical information to assist their implementation of radiation protection programs. The 1988 Federal Guidance Report No. 11 (FGR 11) provided updated dose coefficients for internal exposure of members of the general public and limiting values of radionuclide intake and air concentrations. The FGR 11 dose coefficients are based on the biokinetic and dosimetric models of International Commission on Radiation Protection (ICRP) Publication 30 (ICRP 1979). NNSA used these values in the 2005 LLNL SWEIS accident scenario methodologies. In 1999, the USEPA issued FGR 13, which provided numerical factors for use in estimating the risk of cancer from low-level exposure to radionuclides (USEPA 1999). In conjunction with FGR 13, USEPA made available a CD that included not only the risk conversion factors that were documented in FGR 13, but also age- and organ-dependent dose conversion factors. The FGR 13 dose conversion factors are based on ICRP Publications 71 and 72.

In FGR 13, the USEPA states that although many of the biokinetic and dosimetric models used here are updates of models used in FGR 11, FGR 13 does not replace FGR 11 or affect its use for radiation protection purposes. USEPA also stated that the use of FGR 13 dose coefficients by Federal agencies is discretionary, but encouraged use to promote consistency.

The LLNL safety documents use the FGR 13 dose conversion factors. Hence, for this SWEIS, NNSA used the dose coefficients from FGR 13 for calculating the accident scenario consequences, which would provide consistency with the safety documents for those facilities, as well as utilize the dosimetric quantities and primary guidance of International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991) and the dosimetric models and methods used in ICRP Publication 68 (ICRP 1994). Table C-37 and Table C-38 present the radiological accident frequency and calculated consequences under conservative and average meteorological conditions, respectively.

Table C-37. Radiological Accident Frequency and Consequences Under the No-Action Alternative and the Proposed Action—Conservative Meteorology (Stability Class F and 1 m/sec.)

Accident Scenario[g]		Frequency (per year)	Maximally Exposed Individual[a, e]		Offsite Population[b]		Non-involved Worker[c, e]	
			Dose (rem)	Latent Cancer Fatalities[f]	Dose (Person-rem)	Latent Cancer Fatalities[f]	Dose (rem)	Fatalities[d]
B332 – Hydrogen explosion with subsequent Fire		≤1×10^{-4} to 1×10^{-6}	5.4×10^{-4}	3.0×10^{-7}	0.12	7.2×10^{-5}	0.021	1.3×10^{-5}
B332 – Yard Fire		≤1×10^{-4} to 1×10^{-6}	1.5	9.1×10^{-4}	340	0.2	64	0.039
B625 – Aircraft Crash		6.3×10^{-7}	4.9	0.0029	4,300	2.6	18	0.011
B696R – Aircraft Crash		6.4×10^{-7}	1.4	8.3×10^{-4}	970	0.58	2.7	0.0016
B582 NIF – Transfer Vehicle Fire	No-Action Alternative	There is not a comparable No-Action Alternative accident.						
	Proposed Action	2×10^{-5}	0.015	9.2×10^{-6}	0.98	5.9×10^{-4}	0.18	1.1×10^{-4}
B331 – Aircraft Crash – Increment		≤1×10^{-4} to 1×10^{-6}	0.97	5.8×10^{-4}	220	0.13	38	0.023
B331 – Aircraft Crash – Total		8.7×10^{-7}	1.1	6.8×10^{-4}	250	0.15	45	0.027
B581 – Tritium Processing System Fire	No-Action Alternative	1×10^{-6}	0.09	5.4×10^{-5}	5.8	0.0035	1	6.2×10^{-4}
	Proposed Action		0.18	1.1×10^{-4}	12	0.0069	2.1	0.0012
B693 – Waste Storage Facility Fire		≤1×10^{-4} to 1×10^{-6}	17	0.01	160	0.096	26	0.015
A625 Yard –TRUPACT-II Crane Drop and Fire		≤1×10^{-4} to 1×10^{-6}	16	0.0096	400	0.24	76	0.045
B332 – Plutonium Criticality		≤1×10^{-4} to 1×10^{-6}	0.1	6.0×10^{-5}	22	0.013	3.1	0.0019
B332 – Uranium Criticality		≤1×10^{-4} to 1×10^{-6}	0.035	2.1×10^{-5}	7.8	0.0047	6.2	0.0037
B235 – General Facility Fire	No-Action Alternative	There is not a comparable No-Action Alternative accident.						
	Proposed Action	≤1×10^{-4} to 1×10^{-6}	0.0017	1.0×10^{-4}	0.34	2.0×10^{-4}	0.062	3.7×10^{-5}

a. See text for distances from each facility to its MEI.
b. Based on a population of approximately 7.8 million persons residing within 50 miles of LLNL (LLNL 2019b).
c. At a distance of 100 meters from the facility.
d. If the dose is ≥1,000 rem, these are prompt fatalities, otherwise they are LCFs.
e. The MEI and the non-involved worker scenarios each assume that one person was exposed. If more than one person was exposed in either of these scenarios, then that scenario's dose would be per person and the fatalities would be multiplied by the number of persons exposed.
f. Based on an LCF risk estimate of 0.0006 LCF per rem or person-rem.
g. Where only one scenario is presented, it represents both No-Action Alternative and Proposed Action.

Table C-38. Radiological Accident Frequency and Consequences Under the No-Action Alternative and the Proposed Action —Average Meteorology (Stability Class D and 3 m/sec.)

Accident Scenario[f]		Frequency (per year)	Maximally Exposed Individual[a, d]		Offsite Population[b]		Non-involved Worker[c, d]	
			Dose (rem)	Latent Cancer Fatalities[e]	Dose (Person-rem)	Latent Cancer Fatalities[e]	Dose (rem)	Latent Cancer Fatalities
B332 – Hydrogen explosion with subsequent Fire		≤1×10^{-4} to 1×10^{-6}	5.1×10^{-5}	3.0×10^{-8}	0.0031	1.9×10-6	0.0027	1.6×10^{-6}
B332 – Yard Fire		≤1×10^{-4} to 1×10^{-6}	0.15	9.1×10^{-5}	9.4	0.0057	8	0.0048
B625 – Aircraft Crash		6.3×10^{-7}	1.8	0.0011	510	0.30	6.4	0.0038
B696R – Aircraft Crash		6.4×10^{-7}	0.52	3.1×10^{-4}	110	0.068	0.93	5.6×10^{-4}
B582 NIF – Transfer Vehicle Fire	No-Action Alternative	There is not a comparable No-Action Alternative accident.						
	Proposed Action	2×10^{-5}	0.0017	1.0×10^{-6}	0.027	1.6×10^{-5}	0.022	1.3×10^{-5}
B331 – Aircraft Crash – Increment		≤1×10^{-4} to 1×10^{-6}	0.094	5.6×10^{-5}	5.8	0.0035	5	0.003
B331 – Aircraft Crash – Total		8.7×10^{-7}	0.11	6.6×10^{-5}	6.8	0.0041	5.8	0.0035
B581 – Tritium Processing System Fire	No-Action Alternative	1×10^{-6}	0.01	6.0×10^{-6}	0.16	9.6×10^{-5}	0.14	8.2×10^{-5}
	Proposed Action		0.024	1.2×10^{-5}	0.32	1.9×10^{-4}	0.27	1.6×10^{-4}
B693 – Waste Storage Facility Fire		≤1×10^{-4} to 1×10^{-6}	0.82	4.9×10^{-4}	1.7	0.001	0.26	1.5×10^{-4}
A625 Yard –TRUPACT-II Crane Drop and Fire		≤1×10^{-4} to 1×10^{-6}	0.85	5.1×10^{-4}	5	0.003	3.9	0.0023
B332 – Plutonium Criticality		≤1×10^{-4} to 1×10^{-6}	0.01	6.0×10^{-6}	0.62	3.7×10^{-4}	0.39	2.3×10^{-4}
B332 – Uranium Criticality		≤1×10^{-4} to 1×10^{-6}	0.0035	2.1×10^{-6}	0.22	1.3×10^{-4}	0.78	4.7×10^{-4}
B235 – General Facility Fire	No-Action Alternative	There is not a comparable No-Action Alternative accident.						
	Proposed Action	≤1×10^{-4} to 1×10^{-6}	1.7×10^{-4}	1.0×10^{-7}	0.0092	5.5×10^{-6}	0.0078	4.7×10^{-6}

a. See text for distances from each facility to its MEI.
b. Based on a population of approximately 7.8 million persons residing within 50 miles of LLNL (LLNL 2019b).
c. At a distance of 100 meters from the facility.
d. The MEI and the non-involved worker scenarios each assume that one person was exposed. If more than one person was exposed in either of these scenarios, then that scenario's dose would be per person and the fatalities would be multiplied by the number of persons exposed.
e. Based on an LCF risk estimate of 0.0006 LCF per rem or person-rem.
f. Where only one scenario is presented, it represents both No-Action Alternative and Proposed Action.

Consistent with DOE NEPA accident analysis recommendations (DOE 2002a), the consequences presented in Table C-37 and Table C-38 represent the range or "spectrum" of reasonably foreseeable accidents, including low probability/high consequence accidents and high probability/low consequence accidents. Per DOE 2002a, because "risk" is a combination of the accident's probability (or frequency) and consequence, the accidents with the highest doses in Table C-37 and Table C-38 do not dominate LLNL's radiological accident risk, as the following discussion describes.

The LCFs identified in Table C-37 and Table C-38 are "conditional" risks, based on the assumption that the accident has occurred with the assumed meteorological conditions. Table C-39 shows the total fatality risk[5] for each analyzed accident, and the meteorological conditions (as described in Section C.3.1.4). As shown in Table C-39, the total risk from an accident is small-- even with conservative meteorology, the maximum offsite population risk is estimated to be 1.0×10^{-6} fatalities per year, or about one fatality for every 1 million years of operation. To put this risk into perspective, in 2019, the total annual death rate from all causes in California was 682.9 deaths per 100,000 people (CDC 2021). Within the 50-mile radius of LLNL, about 53,000 deaths occurred in 2019.

Table C-39 shows that the high consequence/low probability accidents have the largest total risk. The B625 Aircraft Crash accident contributes about 58 percent to the total offsite population risk, while the B693 Waste Storage Facility Yard Fire and A625 Yard TRUPACT-II Crane Drop and Fire accidents contribute about 43 percent and 42 percent to the MEI total risk, respectively. Because each facility has different individuals as both their MEI and non-involved worker, simply adding the risks from all accidents (as was done in Table C-39) conservatively overestimates the total risk to these individuals.

[5] Risk is determined by multiplying the consequence and frequency of an accident.

Table C-39. Radiological Accident Fatality Annual Risk Under the No-Action Alternative and the Proposed Action

Accident Scenario[a]	Conservative Meteorology (Stability Class F and 1 m/sec.)			Average Meteorology (Stability Class D and 3 m/sec.)		
	MEI	Offsite Population	Non-involved Worker	MEI	Offsite Population	Non-involved Worker
B332 – Hydrogen explosion with subsequent Fire	1.6×10^{-13}	3.6×10^{-11}	6.4×10^{-12}	1.5×10^{-14}	9.4×10^{-13}	8.0×10^{-13}
B332 – Yard Fire	4.6×10^{-10}	1.0×10^{-7}	1.9×10^{-8}	4.6×10^{-11}	2.8×10^{-9}	2.4×10^{-9}
B625 – Aircraft Crash	9.2×10^{-11}	8.2×10^{-8}	3.5×10^{-10}	3.5×10^{-11}	9.6×10^{-9}	1.2×10^{-10}
B696R – Aircraft Crash	2.7×10^{-11}	1.9×10^{-8}	5.2×10^{-11}	1.0×10^{-11}	2.2×10^{-9}	1.8×10^{-11}
B582 NIF – Transfer Vehicle Fire – No-Action Alternative	There is not a comparable No-Action Alternative accident.					
B582 NIF – Transfer Vehicle Fire – Proposed Action	9.2×10^{-12}	5.9×10^{-10}	1.1×10^{-10}	1.0×10^{-12}	1.6×10^{-11}	1.3×10^{-11}
B331 – Aircraft Crash – Increment	2.9×10^{-10}	6.5×10^{-8}	1.1×10^{-8}	2.8×10^{-11}	1.7×10^{-9}	1.5×10^{-9}
B331 – Aircraft Crash – Total	2.9×10^{-11}	6.5×10^{-9}	1.2×10^{-9}	2.8×10^{-12}	1.8×10^{-10}	1.5×10^{-10}
B581 – Tritium Processing System Fire – No-Action Alternative	2.7×10^{-12}	1.7×10^{-10}	3.1×10^{-11}	3.0×10^{-13}	4.8×10^{-12}	4.1×10^{-12}
B581 – Tritium Processing System Fire – Proposed Action	5.4×10^{-12}	3.5×10^{-10}	6.2×10^{-11}	6.0×10^{-13}	9.6×10^{-12}	8.2×10^{-12}
B693 – Waste Storage Facility Fire	5.2×10^{-9}	4.8×10^{-8}	7.7×10^{-9}	2.5×10^{-10}	5.1×10^{-10}	7.7×10^{-11}
A625 Yard – TRUPACT-II Crane Drop and Fire	5.0×10^{-9}	1.2×10^{-7}	2.3×10^{-8}	2.6×10^{-10}	1.5×10^{-9}	1.2×10^{-9}
B332 – Plutonium Criticality	3.0×10^{-11}	6.7×10^{-9}	9.3×10^{-10}	3.0×10^{-12}	1.9×10^{-10}	1.2×10^{-10}
B332 – Uranium Criticality	1.1×10^{-11}	2.4×10^{-9}	1.9×10^{-9}	1.1×10^{-12}	6.5×10^{-11}	2.3×10^{-10}
B235 – General Facility Fire – No-Action Alternative	There is not a comparable No-Action Alternative accident.					
B235 – General Facility Fire – Proposed Action	1.0×10^{-12}	2.0×10^{-10}	3.7×10^{-11}	1.0×10^{-13}	5.5×10^{-12}	4.7×10^{-12}

a. Where only one scenario is presented, it represents both No-Action Alternative and Proposed Action

C.3.5 Accident Scenarios Involving Toxic Chemicals

Chemicals are widely used at LLNL, however, with a few exceptions (e.g., the plating shop, RHWM facilities, B131 High Bay), the quantities involved at most facilities are small. LLNL operations with chemicals are deemed consistent with OSHA' definition of "laboratory scale," as given in 29 CFR 1910.1450, i.e., *work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person*. Chemical inventories consisting of laboratory chemicals, cleaners, and oils have been examined to determine the chemical hazard category. In the majority of facilities at LLNL, chemical inventories do not present a risk to the non-involved workers or the public.

Nonetheless, for this SWEIS, based on an independent review of the DSAs, SBDs, and EPHAs, NNSA determined that the following five categories of chemicals warranted further examination:

1. Beryllium / Beryllium Oxide
2. Lithium Hydride (LiH)
3. Chlorine, hydrogen chloride
4. Nitric, Hydrofluoric, and Hydrochloric Acids
5. Chlorine Trifluoride (ClF_3)
6. Uranium (for chemical hazards)

The evaluation of these chemicals utilizes protective action criteria (PAC) to quantify the significance of an accident on both non-involved workers and the public, as recommended by DOE Order 151.1D and DOE-STD-3009. The three level of PACs are:

PAC-1 The airborne concentration (expressed as ppm [parts per million] or mg/m^3 [milligrams per cubic meter]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects. However, these effects are not disabling and are transient and reversible upon cessation of exposure.

PAC-2 The airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape.

PAC-3 The airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

For chemical hazards, PAC values are based on the following hierarchy of exposure limit values:

- If available use 60-minute Acute Exposure Guideline Levels (AEGL) values published by the USEPA;
- If AEGLs are not available, use Emergency Response Planning Guideline (ERPG) values produced by the American Industrial Hygiene Association (AIHA);
- If neither AEGLs or ERPGs are available, use Temporary Emergency Exposure Limit (TEEL) values developed by DOE's Subcommittee on Consequence Assessment and Protective Actions.

The PACs for the chemicals discussed in this section are shown in Table C-40. AEGL and ERPG values are developed in units of either parts per million (ppm) or milligrams per cubic meter (mg/m^3). In Table C-40, the PACs are listed in the units provided in the PAC dataset (i.e., Revision 29A) (DOE 2021).

Table C-40. Toxic Chemical Protective Action Criteria

Chemical	Formula	PAC (mg/m^3)		
		PAC-1	PAC-2	PAC-3
Beryllium	Be	0.0023	0.025	0.11
Beryllium Oxide	BeO	0.0063	0.069	0.28
Lithium Hydride	LiH	0.025	0.1	0.5
Lithium Hydroxide	LiOH	0.091	1	42
Uranium Dioxide[a]	UO_2	0.068	10	30
Chlorine Trifluoride	ClF_3	0.45	7.6	79
Chemical	**Formula**	**PAC (ppm)**		
		PAC-1	**PAC-2**	**PAC-3**
Chlorine	Cl_2	0.50	2.0	20
Hydrogen Chloride/ Hydrochloric Acid	HCl	1.8	22	100
Nitric Acid	HNO_3	0.16	24	92
Hydrofluoric Acid	HF	1.0	24	44

Source: DOE 2021.

a. The PAC values for UO_2 are provided because in a uranium fire UO_2 is formed

C.3.5.1 *Beryllium/Beryllium Oxide Release*

Beryllium (Be) is a gray-white metal solid with no odor. Beryllium solid and powder is in metallic (including alloys) form. In metallic form, beryllium is used in high-energy accelerators and x-ray machines. It is a moderate fire hazard and a slight explosion hazard only in a powdered or finely divided state. It is highly toxic by inhalation and may cause ulcers on dermal contact. Long term inhalation of beryllium containing dust can cause a chronic life-threatening allergic disease in some people called berylliosis or chronic beryllium disease (CBD). Beryllium has been historically machined, handled and stored in facilities at LLNL since the 1950s. Additionally, outdoor testing of beryllium-containing components has been performed at the Site 300 facility. As such LLNL has developed a Chronic Beryllium Disease Prevention Program (CBDPP), in accordance with 10 CFR 850.

For this SWEIS, LLNL facilities were reviewed to identify those that contain beryllium in sufficient quantity to warrant analysis. Two levels of beryllium presence were specified: (1) those facilities that contain beryllium, but not in sufficient quantity to warrant analysis (e.g., Buildings 194, 331, and 332), and (2) those facilities that contain beryllium in sufficient quantity to warrant analysis (e.g., Buildings 131 High Bay, 239, and 334). This characterization was performed by reviewing the LLNL facility DSAs, SBDs, and EPHAs.

As discussed below, the three LLNL facilities that contain beryllium in sufficient quantities to warrant DSA, SBA, and/or EPHA analysis are the Engineering Facility High Bay (B131HB), Radiography Facility (B239), and the Hardened Engineering Test Building (B334).

Engineering Facility, High Bay (B131HB). The EPHA describes the use of beryllium in Building 131HB as:

> The maximum quantity of solid Be authorized in the High Bay is 1,300 kilograms (33 kilograms as powder), with an FSP-designated administrative limit of 1,040

> kilograms (26.4 kilograms as powder) [. The current quantity of Be located in B131 High Bay is 400 kilograms, of which 0.4 kilograms is in powder form (LLNL 2018h).
>
> Beryllium is used primarily in passive operations in B131 High Bay. At most, Be-containing materials are used in processes that do not generate fines, and where product and scrap materials are collected (i.e., inspection, characterization, and documentation operations) (LLNL 2018h).

The B131HB EPHA analyzed the following four accident scenarios involving beryllium powder:

- Spill with subsequent fire resulting in the release of material (powder)
- Earthquake with fire resulting in the release of material (powder)
- Fire resulting in the release of material (powder)
- Explosive release of material (powder).

The fire accident scenario resulted in the largest beryllium/beryllium oxide concentrations and is analyzed here. The EPHA used the following assumptions to calculate the source term for this accident:

> 26.4 kilograms of Be powder is subject to release by fire. Since the scenario involves multiple containers, a 5-m radius is assumed with an effective release height of 0. The DR, RF, and LPF are assumed to be at the conservative limit of 1.0. The ARF determined is 2 x 10^{-4} (LLNL 2018h).

During combustion beryllium is converted to beryllium oxide (BeO). The calculated BeO concentrations at the non-involved worker (i.e., at 100 meters) and at the MEI, assumed to be 442 meters at the fence line, are provided in Table C-15 for conservative meteorological conditions with standard/rural dispersion coefficients. Table C-16 provides calculated concentrations for average meteorological conditions.

Radiography Facility (B239). The Building 239 DSA (LLNL 2017f) states that only the solid form of beryllium is allowed in the B239 and that the Be and BeO limits are 25 kilograms and 50 kilograms (bulk solid), respectively. The Building 239 DSA also states that containers or other items with Be or BeO may be brought into the facility for radiography several times a month. Typically, an item brought into the facility in the morning is shipped out that evening. Be components are not stored in Building 239 (LLNL 2017f).

Consistent with the DSA, this SWEIS analysis assumes the most recently available airborne release fraction (ARF) times respirable fraction (RF) (i.e., ARF × RF) value for a fire involving bulk metal beryllium is 3×10^{-6}. The beryllium concentrations at the non-involved worker and the MEI for a B321C fire involving beryllium are provided in Table C-15 and Table C-16.

Regarding the frequency of a beryllium fire at B239 the DSA states:

> The unmitigated likelihood of a fire of sufficient magnitude to result in a beryllium release is *Unlikely*, even without considering the limited yearly residence time of the material. Given the simple nature of the operation, actual combustible loadings,

> and residence times, this scenario is more realistically an *Extremely Unlikely* event (emphasis in the original) (LLNL 2017f).

Hardened Engineering Test Building (Building 334). The DSA states that the Building 334 projected maximum quantities of beryllium and beryllium oxide are 200 and 400 kilograms, respectively (LLNL 2017g). Furthermore, the DSA specifies that:

> No beryllium work is allowed in the facility, regardless of the form of beryllium. Only beryllium articles, as defined in 10 CFR 850, or encapsulated beryllium items are allowed in the facility (LLNL 2017g).

> Items containing Be or BeO are brought into the facility up to several times a month for testing or radiation measurements. These precision-machined solids are not stored in the facility (LLNL 2017g).

Nonetheless, the DSA analyzes an accident scenario in which an item containing beryllium is involved in a fire, releasing BeO. An ARF × RF of 3×10^{-6} is assumed, resulting in 9×10^{-6} grams of BeO released for every gram of beryllium burned. The beryllium concentrations at the non-involved worker location and the MEI for a Building 334 fire involving beryllium are provided in Table C-41 and Table C-42.

The DSA also estimates that the frequencies of an accident involving the dropping of the beryllium containing item or a fire involving the item are between 1 in 10,000 and 1 in 1 million (i.e., $\leq1\times10^{-4}$ to 1×10^{-6}) per year (LLNL 2017g).

Table C-41. Beryllium Fire Assumptions and Impacts Under the No-Action Alternative and the Proposed Action – Conservative Meteorology (Stability Class F and 1 m/sec.)

Facility	MAR		Source Term (g)	Frequency (per year)	MEI Distance (m)	BeO Concentration (mg/m³)	
	kilograms (kg)	Form				Non-Involved Worker	MEI
B131HB	26.4	Powder	14.7	$\leq1\times10^{-2}$ to 1×10^{-4}	442	0.18	0.021
B239	25	Solid	0.21	$\leq1\times10^{-2}$ to 1×10^{-4}	780	0.0026	8.3×10^{-5}
B334	200	Solid	1.6	$\leq1\times10^{-4}$ to 1×10^{-6}	860	0.020	0.00053

Note: The beryllium oxide PAC-1, PAC-2, and PAC-3 values are 0.0063, 0.069, and 0.28 mg/m³, respectively.

As shown in Table C-41, one beryllium powder fire results in BeO concentrations that are greater than the PAC-2 value at the non-involved worker location; all of the other BeO concentrations are less than the BeO PAC-2 value, with many being less than the PAC-1 value.

The BeO concentrations at the non-involved worker and MEI locations resulting from a beryllium fire under average meteorological conditions are provided in Table C-42 for each of the accident scenarios discussed above.

Table C-42. Beryllium Fire Assumptions and Impacts Under the No-Action Alternative and the Proposed Action—Average Meteorology (Stability Class D and 3 m/sec.)

Facility	MAR		Source Term (g)	Fre-quency (per year)	MEI Distance (m)	BeO Concentration (mg/m^3)	
	(kg)	Form				Non-Involved Worker	MEI
B131HB	26.4	Powder	14.7	$\leq 1\times10^{-2}$ to 1×10^{-4}	442	0.013	0.0015
B239	25	Solid	0.21	$\leq 1\times10^{-2}$ to 1×10^{-4}	780	0.0014	3.8×10^{-5}
B334	200	Solid	1.6	$\leq 1\times10^{-4}$ to 1×10^{-6}	860	0.00019	6.0×10^{-6}

Note: The beryllium oxide PAC-1, PAC-2, and PAC-3 values are 0.0063, 0.069, and 0.28 mg/m^3, respectively.

As shown in Table C-42, under average meteorological conditions the BeO concentrations at both locations for all buildings would be less than the BeO PAC-2 value, with many being less than the PAC-1 value.

C.3.5.2 *Lithium Hydride Release*

Previous analyses performed by LLNL have identified that lithium hydride (LiH) is stored and used at a number of facilities on the LLNL site, including the Engineering High Bay (B131HB), Development and Assembly Engineering, Vault (B231V), Materials Management, Fenced Area (OS232FA), Materials Management, Ground Vault (B233GV), Radiography Facility (B239), Tritium Facility (B331), Plutonium Facility (B332), Hardened Engineering Test Building (B334), Materials Fabrication Shop, Wing C (B321C), and Site 300 (LLNL 2016c, LLNL 2019l, LLNL 2017g, LLNL 2021j). Those previous LLNL analyses determined that the bounding scenario involving lithium hydride involves a fire. Lithium hydride burns and releases lithium oxide. Once airborne, the lithium oxide reacts with moisture in the air to form lithium hydroxide (LiOH). The Building 334 DSA (LLNL 2017g) describes the net chemical reaction of a fire involving 1 gram of lithium hydride resulting in 9.6×10^{-4} grams of lithium hydroxide. As shown in Table C-40, lithium hydroxide is less toxic than lithium hydride.

The lithium hydroxide release duration is needed to perform the analysis. Consistent with the DSAs for both B239 and B334 this analysis conservatively assumes a 15-minute release duration. Likewise, the DSAs conservatively assume that the LiH combustion is completed and all of the lithium hydroxide produced is released within the release duration (LLNL 2016c, LLNL 2017g, LLNL 2021j).

The results of the lithium hydride fire analysis for all buildings, except the Plutonium Facility (B332), under conservative and average meteorology are provided in Table C-43 and Table C-44, respectively. The B332 lithium hydride accident results are discussed following Table C-44.

Table C-43. Lithium Hydride Fire Assumptions and Impacts Under the No-Action Alternative and the Proposed Action – Conservative Meteorology (Stability Class F, and 1 m/sec.)[a]

Building	Reference	Frequency (per year)	MAR (kg)	MEI Distance (m)	Lithium Hydroxide Concentration* (mg/m^3)	
					Non-involved Worker	MEI
B131HB	LLNL 2017m	≤1×10^{-2} to 1×10^{-4}	500	450	2.2	0.13
B321C	LLNL 2016c	≤1×10^{-2} to 1×10^{-4}	170	600	0.75	0.026
B231V	LLNL 2018l	≤1×10^{-2} to 1×10^{-4}	670	670	3.0	0.080
OS232FA	LLNL 2018l	≤1×10^{-2} to 1×10^{-4}	670	670	3.0	0.080
B233GV	LLNL 2018l	≤1×10^{-2} to 1×10^{-4}	670	670	3.0	0.080
B239	LLNL 2016c, LLNL 2021j	≤1×10^{-2} to 1×10^{-4}	50	780	0.22	0.0053
B331	LLNL 2018f	≤1×10^{-2} to 1×10^{-4}	45.4	760	0.2	0.0050
B334	LLNL 2016c, LLNL 2017g	≤1×10^{-4} to 1×10^{-6}	200	860	0.88	0.016
Site 300	LLNL 2019h	≤1×10^{-2} to 1×10^{-4}	96	200	4.7	1.2[b]

Note: The lithium hydroxide PAC-1, PAC-2, and PAC-3 values are 0.091, 1.0, and 42 mg/m^3, respectively.
a. Site 200 modeling for facilities in the central part of the site assume urban terrain. Site 200 facilities near the edge of the site and Site 300 facilities assume rural terrain.
b. PAC-2 distance is 35-m beyond site boundary

Table C-44. Lithium Hydride Fire Assumptions and Impacts Under the No-Action Alternative and the Proposed Action —Average Meteorology (Livermore site: Stability Class D, and 3 m/sec; Site 300: Stability Class D, and 7 m/sec.)[a]

Building	Reference	Frequency (per year)	MAR (kg)	MEI Distance (m)	Lithium Hydroxide Concentration* (mg/m^3)	
					Non-involved Worker	MEI
B131HB	LLNL 2017m	≤1×10^{-2} to 1×10^{-4}	500	450	0.29	0.016
B321C	LLNL 2016c	≤1×10^{-2} to 1×10^{-4}	170	600	0.098	0.0029
B231V	LLNL 2018l	≤1×10^{-2} to 1×10^{-4}	670	670	0.39	0.0087
OS232FA	LLNL 2018l	≤1×10^{-2} to 1×10^{-4}	670	670	0.39	0.0087
B233GV	LLNL 2018l	≤1×10^{-2} to 1×10^{-4}	670	670	0.39	0.0087
B239	LLNL 2016c, LLNL 2021j	≤1×10^{-2} to 1×10^{-4}	50	780	0.029	0.0005
B331	LLNL 2018f	≤1×10^{-2} to 1×10^{-4}	45.4	760	0.026	0.0005
B334	LLNL 2016c, LLNL 2017g	≤1×10^{-4} to 1×10^{-6}	200	860	0.12	0.0017
Site 300	LLNL 2019h	≤1×10^{-2} to 1×10^{-4}	96	200	0.29	0.0602

Note: The lithium hydroxide PAC-1, PAC-2, and PAC-3 values are 0.091, 1.0, and 42 mg/m^3, respectively.
a. Site 200 modeling for facilities in the central part of the site assume urban terrain. Site 200 facilities near the edge of the site and Site 300 facilities assume rural terrain.

Table C-43 shows that, with conservative meteorology, some of the building analyzed have non-involved worker concentration above PAC-2 (i.e., 1.0 mg/m^3), none have non-involved worker concentrations above PAC-3 (i.e., 42 mg/m^3). Likewise for the public, Table C-43 shows that the concentrations for most of the building are below PAC-1 (i.e., 0.091 mg/m^3), with the remaining below PAC-2 (PAC-2 (i.e., 1.0 mg/m^3), except for Site 300 which is below PAC-3 (i.e., 42 mg/m^3). The Site 300 concentration falls below PAC-2 at 235 meters from the release, or 35 meters beyond the Site 300 boundary.

The lithium hydride fire frequencies provided in Table C-43 were determined from the Building 239, Building 331, and Building 334 DSAs (LLNL 2017f, LLNL 2018f, LLNL 2017g, respectively). The Building 239 DSA (LLNL 2017f) estimated the frequency of occurrence of the lithium hydride fire as fires due to an impact on lithium hydride solid material is considered to be in the range of $<10^{-4}$ to $\geq 10^{-6}$ per year (LLNL 2017f). The Building 331 DSA states that any lithium hydride release requires reactants to leak into the container followed by reaction products leaking out. The release would involve significantly less material of concern in any unit of time, and the associated consequences would be less than PAC-2 to both the non-involved worker and the MEI. The DSA also identified the frequency of a lithium hydride accident at Building 331 as between $<10^{-2}$ to $\geq 10^{-4}$ per year (LLNL 2018f). The Building 334 DSA states the frequency of a significant fire that could involve lithium hydride is 1×10^{-3} per year (LLNL 2017g). Assuming LiH is in the facility 24 times a year yields a conservative fire frequency for fire involving lithium hydride of 6.6×10^{-5} per year. The RMP Technical Supplement does not provide an estimate of the frequency of a lithium hydride fire for any of the buildings it analyzed. Therefore, for the buildings identified and analyzed only in the RMP Technical Supplement (i.e., B131HB, B321C, B231V, B232FA, and B233GV), a frequency of between $<10^{-2}$ to $\geq 10^{-4}$ per year was conservative assigned, based on the Building 239, Building 331, and Building 334 DSAs (LLNL 2017f, LLNL 2018f, LLNL 2017g, respectively).

For the non-involved worker, Table C-44 shows that with average meteorology the lithium hydroxide concentrations for each of the buildings analyzed are below PAC-2, with B239, B331, and Site 300 below PAC-1. For the public, Table C-44 shows that the concentrations are below PAC-1 for all of the buildings and Site 300.

Plutonium Facility (B332). Although the Building 332 DSA (LLNL 2019l) identifies lithium hydride is present in the Plutonium Facility and discusses several potential accident scenarios, it does not provide an analysis of the impacts from any of the lithium hydride accident scenarios (LLNL 2019l). This SWEIS, however, provides the following discussion of the impact of an accident involving lithium hydride at the Plutonium Facility (Building 332).

The Building 332 DSA identified that the Plutonium Facility could contain kilogram quantities of lithium hydride. As such, the DSA identified the following five potential lithium hydride hazards:

- MI-11 Lithium hydride bulk solid objects handled in room, fume hood, ventilated enclosure or glovebox are dropped or impacted by other falling/moving objects.
- MI-12 Lithium hydride bulk solid objects handled in room, fume hood, ventilated enclosure or glovebox are dropped or impacted by other falling/moving objects; lithium hydride fire results.
- MI-13 Lithium hydride powder handled in room, fume hood, ventilated enclosure dropped or impacted by other falling/moving objects; fire is assumed to occur if the material spills.

MI-14 Lithium hydride bulk solid or powder is disposed of by combustion in a furnace. This could yield an explosive concern in a closed furnace volume.
MI-15 Lithium hydride solid objects handled in room, fume hood, or ventilated enclosure is involved in a localized fire (LLNL 2019l).

The impacts resulting from these lithium hydride potential hazards are summarized in Table C-45.

Table C-45. Building 332 DSA Lithium Hydride Hazard Potential Impacts

Hazard No.	Frequency (per year)	Consequence	
		Non-involved Worker	MEI
MI-11	$\geq 1\times10^{-2}$	<PAC-1	<PAC-1
MI-12	$\leq 1\times10^{-4}$ to 1×10^{-6}	<PAC-2	<PAC-1
MI-13	$\leq 1\times10^{-2}$ to 1×10^{-4}	<PAC-2	<PAC-1
MI-14	$\leq 1\times10^{-6}$ to 1×10^{-7}	High (see below)	<PAC-1
MI-15	$\geq 1\times10^{-2}$	<PAC-2	<PAC-1

Source: Modified from LLNL 2019l.

Except for hazard MI-14, all of the potential lithium hydride accident impacts have <PAC-1 impact or <PAC-2 impacts on the non-involved worker. All of the potential lithium hydride accident impacts have negligible impact on the MEI. The Building 332 DSA determined that the hazard MI-14 has a potential high impact on the non-involved worker. However, this high MI-14 impact is due to the physical effects of the explosion, rather than the toxic properties of the LiH or LiOH. Finally, to minimize the potential for an MI-14 accident to occur LLNL has implemented a Specific Administrative Control that states that, "Any calcination/oxidation operation involving more than trace amounts of lithium hydride shall use a limiting concentration of oxygen in argon inert gas not to exceed 3.33 percent and a limiting concentration of oxygen in nitrogen inert gas not to exceed 4.87 percent."

C.3.5.3 *Chlorine Release*

The Building 332 Plutonium Facility chlorination system is used to perform pyrochemical demonstration system operations, including molten salt extraction, electrorefining, metal and salt melting and casting, vacuum sampling, direct oxide reduction, direct chloride reduction, distillation, calcinations, loss on ignition, salt scrub, salt or metal filtering, metal chlorination, hydride or nitride chlorination, salt regeneration/molten salt transfer, and sample preparation. Chlorine or hydrogen chloride gases are supplied from cylinders to the Building 332 chlorination system. Building 332 workers are protected from hydrogen chloride and chlorine gas exposure by a toxic gas control system, which confines the toxic gas by detecting a gas leak and automatically turning off the toxic gas supply (LLNL 2019l).

Although chlorination operations are currently suspended and the toxic gas control system is non-operational, this analysis has been included in the SWEIS to allow LLNL the flexibility to bring back chlorination operations in the future.

The Building 332 DSA (LLNL 2019l) analyzed an unmitigated release through an opening in a 100-lb chlorine cylinder and a 55-lb HCl cylinder. Conservative assumptions were made for the parameters used in the analysis, e.g., temperature, pressure, size of the opening, meteorology.

Table C-46. present the results of the Building 332 DSA chlorine and hydrogen chloride analyses under both conservative and average meteorology, respectively.

Table C-46. Impacts from Accidents Involving Chlorine at Building 332 Under the No-Action Alternative and the Proposed Action – Conservative Meteorology (Stability Class F, and 1 m/sec.)

Toxic Chemical	Source Term (lb)	Frequency (per year)	Concentration (ppm)	
			Non-involved Worker	MEI
Chlorine gas	100	4.4×10^{-5}	145	3.22 (at 1,040 m)*
Hydrogen chloride	60	4.4×10^{-5}	1510	8.31

Note: The chlorine PAC-1, PAC-2, and PAC-3 values are 0.50, 2.0, and 20 ppm, respectively; the hydrogen chloride PAC-1, PAC-2, and PAC-3 values are 1.8, 22, and 100 ppm, respectively. Non-involved worker is assumed to be at 100 m. MEI is assumed to be at the fenceline.
* Distance at which the PAC-2 concentration would be met; 240 meters beyond the site boundary.
Source: LLNL 2019l.

Table C-47. Impacts from Accidents Involving Chlorine at Building 332 Under the No-Action Alternative and the Proposed Action – Average Meteorology (Stability Class D, and 3 m/sec.)

Toxic Chemical	Source Term (lb)	Frequency (per year)	Concentration (ppm)	
			Non-involved Worker	MEI
Chlorine gas	100	4.4×10^{-5}	59.9	1.05
Hydrogen chloride	60	4.4×10^{-5}	624	2.70

Note: The chlorine PAC-1, PAC-2, and PAC-3 values are 0.50, 2.0, and 20 ppm, respectively; the hydrogen chloride PAC-1, PAC-2, and PAC-3 values are 1.8, 22, and 100 ppm, respectively. Non-involved worker is assumed to be at 100 m. MEI is assumed to be at the fenceline.

As shown in Table C-46, the non-involved worker could be exposed to life-threatening (i.e., >PAC-3) concentrations following either a chlorine or hydrogen chloride release and that the MEI could be exposed to only mild, transient health effects (i.e., >PAC-1) or irreversible or other serious health effects (i.e., >PAC-2) following a hydrogen chloride or chlorine release, respectively. For the chlorine gas release accident under conservative meteorology condition the concentration is calculated to fall below the PAC-2 concentration of 2 ppm at a distance of 1,040 meters (240 meters beyond the Vasco Road fenceline).

C.3.5.4 *Nitric, Hydrofluoric, and Hydrochloric Acids Release*

The Metal Finishing Facility (Building 322) contains numerous potentially hazardous substances. The Building 322 EPHA screened 130 potentially hazardous substances and determined that three were sufficiently hazardous and present in sufficient quantities to warrant detailed analysis: nitric acid (HNO_3), hydrofluoric acid (HF), and hydrochloric acid (HCl) (LLNL 2021h). The B322 EPHA postulated a number of accident scenarios and analyzed the following five bounding scenarios.

Pressurized System Failure – The failure of a pressurized system due to structural or assembly defect in operations such as gas welding and cutting using acetylene and oxygen. The barrier breached is the pressurized system itself. The failure is assumed to breach the container and cause a spill of the total contents.

Mechanical Support System Failure – The failure of dynamic mechanical support systems in operations such as hoisting and rigging using cranes or lifting devices. The barrier breached is the container being lifted.

Containment System Failure – The failure of containment systems in operations involving the storage and/or transportation of inventoried materials in sealed containers. The barrier breached is the engineered containment system.

Building Fire – A fully involved building fire dispersing hazardous material through an opened door or through the high-flow ventilation system. The barriers breached are the containers (building inventory) and the building.

Dropped Container – A shipping container is dropped while loading on or off a flatbed trailer. The barrier breached would be the container itself. Two source terms were analyzed: 1) the largest single container, i.e., a 55-gal drum, and 2) the Administrative Limit, i.e., 134 gallons.

The results of the B322 EPHA analyses are shown in Table C-48 and Table C-49 for conservative and average meteorology, respectively. Although the Building 322 EPHA does not discuss accident frequencies, the frequencies have been included in the SWEIS based on the accident descriptions provided in the Building 322 EPHA.

Table C-48. Impacts from Accidents Involving Acids at Building 322 Under the No-Action Alternative and the Proposed Action – Conservative Meteorology (Stability Class F, and 1 m/sec.)

Accident		Frequency (per year)	Acid	MAR (gal)	Concentration (ppm)	
					Non-involved Worker	MEI
Pressurized System Failure		$\leq 1\times10^{-2}$ to 1×10^{-4}	HNO_3	9.9	1.2	0.0225
			HF	4	2.45	0.0446
			HCl	4	18.8	0.226
Mechanical Support System Failure		$\leq 1\times10^{-4}$ to 1×10^{-6}	HNO_3	137	11.4	0.264
			HF	21	10.9	0.205
Containment System Failure		$\leq 1\times10^{-4}$ to 1×10^{-6}	HNO_3	224	15.8	0.413
Building Fire		$\leq 1\times10^{-2}$ to 1×10^{-4}	HNO_3	224	0	9.7×10^{-11}
			HF	21	0	1.7×10^{-11}
			HCl	134	0	4.6×10^{-11}
Dropped Container	Single Drum	$\leq 1\times10^{-4}$ to 1×10^{-6}	HCl	55	205	2.81
	Admin. Limit	$\leq 1\times10^{-6}$ to 1×10^{-7}	HCl	134	419	6.63

Note: The nitric acid (HNO_3) PAC-1, PAC-2, and PAC-3 values are 0.16, 24, and 92 ppm, respectively; the hydrofluoric acid (HF) PAC-1, PAC-2, and PAC-3 values are 1.0, 24, and 44 ppm, respectively; the hydrochloric acid (HCl) PAC-1, PAC-2, and PAC-3 values are 1.8, 22, and 100 ppm, respectively.

As shown in Table C-48, under conservative meteorological conditions the two Dropped Container HCl accidents result in concentrations at the non-involved worker that are greater than PAC-3, and all other acid accidents result in concentrations that are below PAC-2, with some below PAC-1 at the non-involved worker location. Under conservative meteorological conditions, Table C-48 shows that all acid accidents result in concentrations at the MEI that are below PAC-2, with most below PAC-1.

Table C-49. Impacts from Accidents Involving Acids at Building 322 Under the No-Action Alternative and the Proposed Action – Average Meteorology (Stability Class D, and 3 m/sec.)

Accident		Frequency (per year)	Acid	MAR (gal)	Concentration (ppm)	
					Non-involved Worker	MEI
Pressurized System Failure		≤1×10^{-2} to 1×10^{-4}	HNO_3	9.9	0.315	0.0046
			HF	4	0.464	0
			HCl	4	2.96	0.0367
Mechanical Support System Failure		≤1×10^{-4} to 1×10^{-6}	HNO_3	137	3.62	0.056
			HF	21	2.18	0.032
Containment System Failure		≤1×10^{-4} to 1×10^{-6}	HNO_3	224	5.49	0.0882
Building Fire		≤1×10^{-2} to 1×10^{-4}	HNO_3	224	0	2.2×10^{-10}
			HF	21	0	3.8×10^{-11}
			HCl	134	0	1.0×10^{-10}
Dropped Container	Single Drum	≤1×10^{-4} to 1×10^{-6}	HCl	55	34.8	0.455
	Admin. Limit	≤1×10^{-6} to 1×10^{-7}	HCl	134	78.5	1.07

Note: The nitric acid (HNO_3) PAC-1, PAC-2, and PAC-3 values are 0.16, 24, and 92 ppm, respectively; the hydrofluoric acid (HF) PAC-1, PAC-2, and PAC-3 values are 1.0, 24, and 44 ppm, respectively; the hydrochloric acid (HCl) PAC-1, PAC-2, and PAC-3 values are 1.8, 22, and 100 ppm, respectively.

As shown in Table C-49, under average meteorological conditions the two Dropped Container HCl accidents result in concentrations at the non-involved worker that are less than PAC-3, and all other acid accidents result in concentrations that are below PAC-2, with some below PAC-1 at the non-involved worker location. Under average meteorological conditions, Table C-49 shows that all acid accidents result in concentrations at the MEI that are below PAC-1.

C.3.5.5 *Chlorine Trifluoride Release*

The High Vacuum Fluorination System (HVFS) is housed in Building 151 (B151). Chlorine trifluoride (ClF_3) is used in the HVFS for the analysis of oxygen isotope ratios of the uranium samples. ClF_3 is toxic, corrosive, and one of the most reactive oxidizing compounds known. The storage, usage, and potential release of ClF_3 at LLNL is described in the B151 Safety Basis Document (SBD) (LLNL 2019k):

> Chlorine trifluoride is stored as a pressurized gas at ambient temperature. The chlorine trifluoride inventory (≤ 3.5 kg) is spread out over two cylinders with only one cylinder connected to the HVFS reaction vessel manifold at a given time. The cylinder that is connected to the manifold is normally valved off and opened only as needed for experiments. The amount of chlorine trifluoride outside of the cylinder in the process lines is minimal. The most credible release point is from the

¼" outer diameter (3/32" inner diameter) line off of the cylinder. In the event of a line failure, the chlorine trifluoride will slowly discharge until the cylinder is emptied. The chlorine trifluoride cylinders are stored in a normally closed gas cabinet with a fan running that draws air through ducting that exhausts at the roof at a nominal height of 10 meters. (LLNL 2019k)

To minimize the ClF_3 release potential the HVFS reaction vessel manifold and the process line size from the ClF_3 cylinder are designated as Design Features. Nonetheless, the potential impacts from an accident involving ClF_3, based on information in the B151 SBD, are shown in Table C-50.

Table C-50. Impacts from an Accident Involving Chlorine Trifluoride at Building 151 Under the No-Action Alternative and the Proposed Action

Frequency (per year)	MAR (kg)	Meteorology	Concentration (mg/m^3)	
			Non-involved Worker	MEI
$\leq 1\times10^{-4}$ to 1×10^{-6}	3.5	Conservative Meteorology (Stability Class F, and 1 m/sec.)	4	0.44
		Average Meteorology (Stability Class D, and 3 m/sec.)	2	0.14

Note: The chlorine trifluoride PAC-1, PAC-2, and PAC-3 values are 0.45, 7.6, and 79 mg/m^3, respectively.

C.3.5.6 *Uranium (for chemical hazards) Release*

In addition to being radioactive, uranium is a toxic chemical, meaning that ingestion of uranium can cause kidney damage from its chemical properties. Several LLNL facilities handle uranium, including Building 231 Vault (B231V), Other Structure 232 Fenced Area (OS232FA), Building 233 Garage Vault (B233GV), Radiography Facility (B239), Plutonium Facility (B332), Building 131 High Bay (B131HB), and Hardened Engineering Test Building (B334) in quantities that have required additional analysis. The Materials Fabrication Shop (B321C) has large overall quantities of uranium but administrative controls limit the quantities of uranium in forms that pose a significant chemical hazard.

Three safety documents analyzed the toxic consequences of uranium release accidents: (1) the Superblock EPHA (LLNL 2020f), which includes B239, B332, and B334; (2) the B231 Complex EPHA (LLNL 2018l), which includes B231V, OS232FA, and B233GV; and (3) the B131HB EPHA (LLNL 2018h). These references analyzed accidents including (1) System Failure, with and without Fire, (2) Inadvertent Spill, with Fire; (3) Earthquake, with and without a Fire or Explosion; (4) 30-minute Fire; and (5) Explosive Dispersal.

The MAR for each bounding uranium release accident (i.e., the accident that results in the largest UO_2 concentration at the non-involved worker and MEI locations) for each building is shown in Table C-51 and Table C-52. Results reported in these tables are based on the DR, ARF, RF, and LPF from the facility EPHAs for each uranium release scenario (LLNL 2018h, LLNL 2018l, LLNL 2020f).

The B131HB EPHA scenarios are based on a MAR of 8,000 kg of depleted uranium. The bounding scenario is the explosive dispersal event with 25 kg of depleted uranium. Tables C-51 and C-52 assume inventories of 30,000 kg of depleted uranium, which is below the HC-3 limits of DOE-

STD-1027-2018. For explosive dispersal scenario, the source term remains the same and the consequences are unchanged. For the fire scenario, the source term increases proportionally to the MAR increase, but the consequences remain below the explosive dispersal scenario.

For each building the impacts from the bounding accidents are presented in Table C-51 for conservative meteorology and in Table C-52 for average meteorology. The impacts from all of the other uranium release accidents analyzed by the EPHAs are less than the impacts shown on Tables C-51 and C-52.

Table C-51. Impacts from Bounding Accidents Involving Uranium Under the No-Action Alternative and the Proposed Action – Conservative Meteorology (Stability Class F, and 1 m/sec.)

Building	Bounding Accident	Reference	Frequency (per year)	MAR (kg)	MEI Distance (m)	Uranium Dioxide (UO_2) Concentration (mg/m^3)[c]	
						Non-involved Worker	MEI
B231 Complex[a]	Explosive Dispersal	LLNL 2018l	$\leq 1\times10^{-4}$ to 1×10^{-6}	750	670	2.3	1.1
B131HB	Explosive Dispersal	LLNL 2018h	$\leq 1\times10^{-4}$ to 1×10^{-6}	30,000	442	2.3	1.4
B131HB[b]	Earthquake (Fire)	LLNL 2018h	$\leq 1\times10^{-4}$ to 1×10^{-6}	30,000	442	0.01	0.244
B239	Earthquake	LLNL 2020f	$\leq 1\times10^{-4}$ to 1×10^{-6}	550	800	3.8	0.19
B332	Earthquake (Explosion)	LLNL 2020f	$\leq 1\times10^{-2}$ to 1×10^{-4}	80	900	6.2×10^{-7}	6.5×10^{-9}
B334	Fire	LLNL 2020f	$\leq 1\times10^{-4}$ to 1×10^{-6}	500	860	16	0.22

a. These include B231, B232FA, and B233GV.
b. Not a bounding accident, but included for completeness.
c. The UO_2 PAC-1, PAC-2, and PAC-3 values are 0.068, 10, and 30 mg/m^3, respectively.

Table C-52. Impacts from Bounding Accidents Involving Uranium Under the No-Action Alternative and the Proposed Action – Average Meteorology (Stability Class D, and 3 m/sec.)

Building	Bounding Accident	Reference	Frequency (per year)	MAR (kg)	MEI Distance (m)	Uranium Dioxide (UO_2) Concentration (mg/m^3)[c]	
						Non-involved Worker	MEI
B231 Complex[a]	Explosive Dispersal	LLNL 2018l	$\leq 1\times10^{-4}$ to 1×10^{-6}	750	670	2.5	1.1
B131HB	Explosive Dispersal	LLNL 2018h	$\leq 1\times10^{-4}$ to 1×10^{-6}	30,000	442	2.5	1.4
B131HB[b]	Earthquake (Fire)	LLNL 2018h	$\leq 1\times10^{-4}$ to 1×10^{-6}	30,000	442	0.18	0.32
B239	Earthquake	LLNL 2020f	$\leq 1\times10^{-4}$ to 1×10^{-6}	550	800	0.63	0.034
B332	Earthquake (Explosion)	LLNL 2020f	$\leq 1\times10^{-2}$ to 1×10^{-4}	80	900	7.4×10^{-7}	1.4×10^{-7}
B334	Fire	LLNL 2020f	$\leq 1\times10^{-4}$ to 1×10^{-6}	500	860	1.4	0.031

a. These include B231, B232FA, and B233GV.
b. Not a bounding accident, but included for completeness.
c. The UO_2 PAC-1, PAC-2, and PAC-3 values are 0.068, 10, and 30 mg/m^3, respectively.

Comparing Table C-51 and Table C-52, it is observed that for the B231 Complex, B131HB, and B332 the average meteorology concentrations are greater than or equal to the conservative meteorology concentrations. This is because these three bounding accidents involve explosion scenarios. For explosion scenarios the plume is modeled as five vertical segments beginning at ground-level and including sections at 20%, 40%, 60%, and 80% of the top of the explosion's cloud. The four non-ground-level sections are then modeled as elevated releases, and as discussed in Section C.3.1.4, Stability Class F often does not result in the highest ground-level concentrations for elevated releases. Thus, it is not unusual for Stability Class D meteorology to produce concentrations that are greater than the concentrations produced under Stability Class F meteorology.

C.3.6 Accident Scenarios Involving High Explosives (HE)

As discussed in Section C.3.1.2, no facilities at the Livermore Site have been assigned an explosive hazard classification of High. Only one facility– the HEAF– has been assigned an explosive hazard classification of Moderate. All of the remaining facilities have been assigned either a Low or LSI explosive hazard classification. Facilities with explosive hazard classification of Moderate or High are analyzed for explosive accident consequences.

Similarly, as discussed in Section C.3.1.2 for Site 300, HE is pervasive at Site 300. The explosive hazard classification of the Site 300 HE facilities is driven by the toxicity of plumes from detonation of chemicals commingled with explosives. Therefore, the Site 300 HE hazard analysis does not contain an analysis of a pure explosive event, but does contain analyses of explosive events comingled with radioactive or chemical materials.

C.3.6.1 *Building 191 High Explosives Application Facility (HEAF)*

The HEAF contains two propellant storage magazines: OSM191 (for storage of propellants associated with work in HEAF) and OSM191-1 (for storage of explosives such as flash bangs, smoke grenades, and ammunition used for training by the Security Organization). As discussed in Section C.3.1.2, the HEAF is classified as a Moderate explosive hazard facility based on the inventory of explosives, because its quantity of explosives exceeds the Low hazard limits set by LLNL ES&H Manual, Document 3.1. A discussion of three potential HEAF HE accidents follows.

Accidental Detonation or Deflagration of Explosives in Storage. Personnel who are present in a magazine room or workroom where an accidental detonation occurs could be fatally injured, depending on the quantity of explosives in the room. The HEAF Facility Safety Plan (LLNL 2018i) sets limits on the quantity of explosives in the HEAF. Others in proximity to the room of occurrence could suffer severe or fatal injuries, depending on their location. Personnel outside the room of occurrence could experience eardrum rupture, but they should not suffer any major lung damage. Offsite consequences would be limited to overpressures in populated areas. The frequency of this accident is estimated to be 10^{-4} to 10^{-6} per year.

Personnel Injury Due to Failure of Controls for Remote Explosives Operations. The consequences of this accident would include property damage and severe or fatal injury to the worker. There would be no blast effects (overpressure or fragments) outside the facility. The frequency of this accident is estimated to be 10^{-4} to 10^{-6} per year.

Accidental Detonation of Explosives During Contact Operations. All personnel inside the room of occurrence (up to six people) could receive fatal injuries. The largest quantity of high explosives allowed in any HEAF room by the HEAF Facility Safety Plan (LLNL 2018i) is 10-kilograms. Although the consequences in a workroom with a 10-kilogram limit would likely be more severe than those in workrooms with lower explosives limits, it still would be possible that the consequences in these rooms could equal the consequences in a workroom with a 10-kilogram limit. Personnel outside the room of occurrence could also receive injury from overpressure effects (walls, mazes, and doors would preclude fragment hazards). Overpressure predictions outside the room of occurrence (but inside the facility) would be expected to result in some eardrum rupture. Lung damage would also be possible. There would be no blast effects (overpressure or fragments) outside the facility. The frequency of this accident is estimated to be 10^{-4} to 10^{-6} per year.

C.3.6.2 *Site 300*

The Site 300 Safety Basis Document (LLNL 2018e) presents an analysis of HE accidents. The Site 300 explosive hazard is ranked as high, not because of normal explosives safety issues, but because the explosives are comingled[6] with hazardous chemicals, namely: (1) Cobalt, (2) Beryllium, (3) Beryllium Oxide, (4) Lithium Hydride, (5) Lithium Hydroxide, and (6) Mercury. The unmitigated explosive release of these six chemicals could result in potentially lethal and potentially irreversible health effects to onsite and offsite individuals, respectively (i.e., high hazard [>PAC-2 for the public)]. The Site 300 SBD analyzed 22 other chemicals, but their consequences were

[6] Explosives that are in close proximity to or direct contact with chemical or radiological material, i.e., comingled explosives.

less (i.e., moderate hazard (<PAC-2 for the public, <PAC-3 for the non-involved worker) (LLNL 2018e).

As shown Table C-53, the Site 300 SBD analyzed 12 explosive events with the amount of equivalent TNT mass ranging from 10 grams to 300 pounds. Table C-53 also indicates the level of over-pressurization that would result in harm to the human body, and the distance over which the explosion could exceed these pressures (LLNL 2018e). Because the impact distance is affected by the type of blast, Table C-53 provides a range of distances.

Table C-53. Summary of Site 300 SBD Explosive Over Pressurization Results

Explosive TNT Mass	Maximum Impact Distance[a] (m)		
	5 psi (Eardrum Ruptures)	10 psi (Lung Damage)	25 psi (Onset of Lethality)
10 g	1.2 – 1.9	0.84 – 1.3	0.54 – 0.85
0.5 lb	3.5 – 5.5	2.4 – 3.6	1.5 – 2.4
1 lb	4.4 – 6.9	3.0 – 4.6	1.9 – 3.0
5 lb	7.5 – 12	5.1 – 7.9	3.3 – 5.2
10 lb	9.4 – 15	6.5 – 9.9	4.2 – 6.5
20 lb	12 – 19	8.1 – 12	5.3 – 8.2
50 lb	16 – 25	11 – 17	7.1 – 11
75 lb	18 – 29	13 – 19	8.2 – 13
100 lb	20 – 32	14 – 21	9.0 – 14
150 lb	23 – 37	16 – 24	10 – 16
200 lb	25 – 40	18 – 27	11 – 18
300 lb	29 – 46	20 – 31	13 – 20

a. minimum distance corresponds to side-on pressure and maximum distance corresponds to ground reflected over-pressure.
Source: LLNL 2018e.

As shown in Table C-53, a non-involved worker located 100 meters from the explosion would not be affected by the blast. The only consequence to the non-involved worker and the MEI would be if the explosion resulted in the dispersal of radiological or hazardous chemical material. To address those concerns the SBD analyzed two postulated accidents:

- Accidental detonation of explosives commingled with chemicals.
- Accidental detonation of explosives commingled with radiological materials.

Accidental detonation of explosives commingled with chemicals. The Site 300 SBD postulated that an accidental detonation of explosives commingled with chemicals could be initiated by a number of causes, including human error, fire, electrical fault, natural phenomena (e.g., seismic, wind, or lightning), vehicle accidents or other external events. The Site 300 SBD went on to state that such an accident was prevented and/or mitigated by numerous design and administrative features. The Site 300 SBD concluded that the unmitigated consequences to collocated workers and offsite public of an accidental detonation of explosives commingled with radiological materials were low, as such an accident analysis is not required (LLNL 2018e).

Nonetheless, to document the low consequences the Site 300 SBD presents the results of an accidental detonation of explosives commingled with hazardous chemicals. For Site 300 there is not a fixed maximum amount of hazardous chemical that can be stored. Rather for each hazardous chemical and for each Site 300 facility a maximum amount is determined that is a function of the chemical's Protective Action Criteria (PAC), the facility's distance to the site boundary, the position of the chemical in the assembly, the mass of the explosives in the assembly, and the chemical's LSI limit (or Q value). The Site 300 SBD identified six chemicals for which high hazard designation (i.e., >PAC-2 for the public) is made when comingled with explosives: Cobalt, Beryllium, Beryllium Oxide, Lithium Hydride, Lithium Hydroxide, and Mercury. The Site 300 SBD explains that the High hazard classification is not driven by pure explosive hazards. Instead, it is driven by the toxicity of plumes from detonation of chemicals commingled with explosives (LLNL 2018e). To mitigate the hazard, the following non-nuclear administrative control has been provided when special assemblies are at Site 300 facilities and outside of DOT or LLNL-approved packaging, or at an approved firing location; the main charge detonators shall be shorted until the assembly is ready to be expended (LLNL 2018e).

With this control the likelihood of an accidental detonation of explosives commingled with chemical materials is reduced to between 1 in 10,000 to 1 in a million (i.e., $\leq 1\times10^{-4}$ to 1×10^{-6}) per year or less, effectively precluding the event from occurring.

Accidental detonation of explosives commingled with radiological materials. The Site 300 SBD postulates that an accidental detonation of explosives commingled with radiological materials could be initiated by a number of causes, including human error, fire, electrical fault, natural phenomena (e.g., seismic, wind, or lightning), vehicle accidents or other external events. Such an accident can be prevented and/or mitigated by numerous design and administrative features. The Site 300 SBD concludes that the unmitigated consequences to collocated workers and offsite public of an accidental detonation of explosives commingled with radiological materials are Low (LLNL 2018e).

Nonetheless, to document the potential consequences, the Site 300 SBD presents the results of an accidental detonation of explosives commingled with radiological materials. Table C-54 presents the assumptions used by the Site 300 SBD to calculate the radionuclide source term. The MAR is assumed to be at the facility limit for each radionuclide, the ARF for thorium and uranium was assumed to be 0.06, and all other parameters were conservatively assumed to be equal to 1.0 (LLNL 2018e).

Table C-54. Site 300 Detonation with Radiological Materials Source Term

Radionuclide	MAR (Ci)	DR	ARF	RF	LPF	ST (Ci)
Tritium (H-3)	1.6×10^{4}	1.0	1.0	1.0	1.0	1.6×10^{4}
Th-232	1.65×10^{-3}	1.0	0.06	1.0	1.0	9.9×10^{-5}
U-234	1.02×10^{-2}	1.0	0.06	1.0	1.0	6.12×10^{-4}
U-235	7.61×10^{-4}	1.0	0.06	1.0	1.0	4.57×10^{-5}
U-238	5.87×10^{-2}	1.0	0.06	1.0	1.0	3.52×10^{-3}

Source : LLNL 2018e.

Because the smallest explosive mass would result in the highest concentrations for a given mass of radiological material, the Site 300 SBD analysis assumes an explosive mass of 0.022 lb (10 g) equivalent TNT. Consequences were determined at the six site boundary distances (i.e., 100 m, 200 m, 300 m, 400 m, 600 m, and 1,100 m) using the HotSpot computer program.

The consequences of an accidental detonation of explosives commingled with radiological materials calculated for this SWEIS are presented in Table C-55 for average meteorological conditions (i.e., stability class D and 7 m/s wind speed) and conservative meteorological conditions (i.e., stability class F and 1 m/s wind speed).

Table C-55. Site 300 Detonation with Radiological Materials Impacts

Radionuclide	Dose (rem)					
	100 m	200 m	300 m	400 m	600 m	1100 m
Average Meteorology (Stability Class D and 7 m/sec.)						
Tritium (H-3)	0.42	0.13	0.063	0.038	0.019	7.0×10^{-3}
Th-232	4.3×10^{-3}	1.3×10^{-3}	6.5×10^{-4}	3.9×10^{-4}	1.9×10^{-4}	7.1×10^{-5}
U-234	5.4×10^{-3}	1.7×10^{-3}	8.2×10^{-4}	5.0×10^{-4}	2.5×10^{-4}	8.9×10^{-5}
U-235	3.7×10^{-4}	1.1×10^{-4}	5.5×10^{-5}	3.3×10^{-5}	1.7×10^{-5}	6.0×10^{-6}
U-238	0.027	8.2×10^{-3}	4.0×10^{-3}	2.4×10^{-3}	1.2×10^{-3}	4.4×10^{-4}
Conservative Meteorology (Stability Class F and 1 m/sec.)						
Tritium (H-3)	9.8	4.1	2.2	1.4	0.73	0.27
Th-232	0.090	0.036	0.019	0.012	5.8×10^{-3}	1.9×10^{-3}
U-234	0.12	0.046	0.025	0.015	7.4×10^{-3}	2.5×10^{-3}
U-235	7.8×10^{-3}	3.1×10^{-3}	1.7×10^{-3}	1.0×10^{-3}	5.0×10^{-4}	1.7×10^{-4}
U-238	0.57	0.23	0.12	0.075	0.036	0.012

Note: The distance from each Site 300 Complex/Facility may be found in LLNL 2018e, Table D-1, and ranges from 200 to 1,100 meters.

The calculated LCF risk due to an accidental detonation of explosives commingled with radiological materials are presented in Table C-56 for average and conservative meteorological conditions. As shown in Table C-56 the LCF risks due to an accidental detonation of explosives commingled with radiological materials would be Low (i.e., less than 1 in 170 years for a non-involved worker, and less than 1 in 4,000 years for the public). Furthermore, these are conditional risk (i.e., the risks of an LCF given that an accident has occurred). Once the probability of an accident occurring is factored in, the total risk would be lower. The frequency of this event is estimated to be 10^{-4} to 10^{-6} per year, giving the total risk to a non-involved worker between 1 in 1.7 million and 1 in 170 million years (i.e., 5.9×10^{-7} to 5.9×10^{-9} per year) and the total risk to the public of between 1 in 40 million and 1 in 4 billion years (i.e., 2.5×10^{-8} to 2.5×10^{-10} per year).

Table C-56. Site 300 Detonation with Radiological Materials Latent Cancer Fatality Risk

Radionuclide	Latent Cancer Fatality Risks					
	100 m	200 m	300 m	400 m	600 m	1100 m
Average Meteorology (Stability Class D, and 7 m/sec.)						
Tritium (H-3)	2.5×10^{-4}	7.8×10^{-5}	3.8×10^{-5}	2.3×10^{-5}	1.1×10^{-5}	4.2×10^{-6}
Th-232	2.6×10^{-6}	7.8×10^{-7}	3.9×10^{-7}	2.3×10^{-7}	1.1×10^{-7}	4.3×10^{-8}
U-234	3.2×10^{-6}	1.0×10^{-6}	4.9×10^{-7}	3.0×10^{-7}	1.5×10^{-7}	5.3×10^{-8}
U-235	2.2×10^{-7}	6.6×10^{-8}	3.3×10^{-8}	2.0×10^{-8}	1.0×10^{-8}	3.6×10^{-9}
U-238	1.6×10^{-5}	4.9×10^{-6}	2.4×10^{-6}	1.4×10^{-6}	7.2×10^{-7}	2.6×10^{-7}
Conservative Meteorology (Stability Class F and 1 m/sec.)						
Tritium (H-3)	5.9×10^{-3}	2.5×10^{-3}	1.3×10^{-3}	8.4×10^{-4}	4.4×10^{-4}	1.6×10^{-4}
Th-232	5.4×10^{-5}	2.2×10^{-5}	1.1×10^{-5}	7.2×10^{-6}	3.5×10^{-6}	1.1×10^{-6}
U-234	7.2×10^{-5}	2.8×10^{-5}	1.5×10^{-5}	9.0×10^{-6}	4.4×10^{-6}	1.5×10^{-6}
U-235	4.7×10^{-6}	1.9×10^{-6}	1.0×10^{-6}	6.0×10^{-7}	3.0×10^{-7}	1.0×10^{-7}
U-238	3.4×10^{-4}	1.4×10^{-4}	7.2×10^{-5}	4.5×10^{-5}	2.2×10^{-5}	7.2×10^{-6}

C.3.7 Accident Scenarios Involving Biological Hazard

As shown in Table C-24, there are many LLNL facilities authorized to work with biohazardous materials. However, with one exception, the LLNL facilities are only authorized to work with Risk Group-1 or Risk Group-2 levels of biohazardous materials in the BSL-1 or BSL-2 facilities, for which the DOE has a NEPA categorical exclusion (10 CFR, Part 1021, Subpart D, Appendix B). The one exception is the Biosafety Level 3/Animal Biosafety Level 3 (BSL-3/ABSL-3).

The Risk Group 3 materials used in the BSL-3/ABSL-3 may include, but are not limited to:

Bacteria/(disease)

- Bacillus anthracis (Anthrax)
- Burkholderia spp. (Glanders, Meliodosis)
- Francisella tularensis (Tularemia)
- Yersinia pestis (Plague)
- Brucella spp. (Brucellosis)
- Clostridium botulinum (Botulism)

Viruses/(disease)

- Rift Valley Fever virus (RVF)
- Venezuelan Equine Encephalitis virus (VEE)
- SARS-CoV-2 (COVID-19)

Fungi/(disease)

- Coccidioides spp. (Valley Fever)

C.3.7.1 *Biosafety Level3/Animal Biosafety Level 3 (BSL-3/ABSL-3) Facility*

Microbiology laboratories are unique work environments that could pose special risks to personnel working within that environment. NNSA selected a representative facility accident that was previously analyzed by the U.S. Army in the *Final Programmatic Environmental Impact Statement Biological Defense Research Program* (Army EIS) (Army 1989). The microorganism analyzed by the Army was *Coxiella burnetii*, which is considered representative of all types of BSL-1, BSL-2, and BSL-3 laboratory microorganisms (bacteria, rickettsia, viruses, fungi, parasites, and prions) because it is highly durable, infectious, and transmissible, and has excellent environmental survivability (NNSA 2008). The Army EIS concluded that the escape of *Coxiella burnetii* from the containment laboratory, even under the worst-case meteorological conditions, does not represent a credible hazard to the non-involved worker or offsite population. NNSA continues to believe that this accident scenario bounds any potential scenarios associated with the LLNL Biosafety Level 3/Animal Biosafety Level 3 (BSL-3/ABSL-3) Facility.

In 2008 DOE published the *Final Revised Environmental Assessment for The Proposed Construction and Operation of a Biosafety Level 3 Facility at Lawrence Livermore National Laboratory, Livermore, California* (NNSA 2008). Regarding potential accidents at the BSL-3 facility, the 2008 EA states that accident scenarios usually envisioned for DOE facilities would normally be seen to exacerbate or enhance a release or spread of the hazardous materials, but for the BSL-3 facility would potentially render these materials innocuous (heat, fire, sunlight, and wind). These would be avoided when working with microorganisms and would usually result in microorganisms being killed. Consequently, catastrophic events such as earthquake, fire, explosions, and airplane crashes, normally considered as initiating events in DOE radiological or chemical accident analyses, have the potential to actually reduce the consequences of microbiological material releases (NNSA 2008).

The 2008 EA re-evaluated the Army 1989 maximum credible event and concluded that workers in the room where the *Coxiella burnetii* event occurs could potentially be exposed to 100,000 human infectious dose (HID_{50}), while workers incidentally exposed could receive 100 to 300 HID_{50}, and the public could receive a small fraction of one HID_{50}. HID_{50} is the estimated human infective dose with a 50 percent chance of causing an exposed person to contract the disease through the inhalation route. For *Coxiella burnetii*, the HID_{50} is 100 organisms (NNSA 2008).

In the 2011 Supplement Analysis (NNSA 2011), LLNL re-evaluated the consequences of the LLNL BSL-3 bounding accident. Based on that re-evaluation, NNSA estimated a dose concentration of 0.084 human infective dose (HID_{50})[7] per liter of air at 16 meters and 0.015 HID_{50} per liter of air at 38 meters from the BSL-3 facility. The re-evaluation also estimated that the dose consequence applicable to the nearest public receptor at 810 meters would be 4.5×10^{-5} HID_{50} per liter of air. Thus, the re-evaluation confirmed the consequence estimates that the potential consequences to the public would be below the minimum infectious dose of one organism.

In 2017, LLNL prepared a SBD for Building 368 (LLNL 2017j), which evaluated the following accident scenarios:

[7] HID_{50} is the estimated human infective dose with a 50 percent chance of causing an exposed person to contract the disease through the inhalation route. For *C. burnetii* the HID_{50} is 100 organisms (NNSA 2008).

- Dropping or spilling of culture container inside the biosafety cabinet (BSC),
- Dropping or spilling of culture container outside the BSC,
- Infectious aerosol inhalation,
- Rodent escapes,
- Mosquitoes as infected vector,
- Manufacturing defects or mechanical failures of the equipment, and
- Centrifuge accident.

To mitigate the effects of these or any other accident, the B368 was designed to the requirements of DOE-STD-1020 (DOE 2002b) for a low potential consequence facility. This was the current standard when this facility was constructed. This facility is operated in accordance with guidelines for BSL-3/ABSL-3 laboratories established by the Centers for Disease Control and the National Institutes of Health (CDC-NIH 2020). Therefore, the consequences from each of the above accidents were determined to be negligible (i.e., no treatment required except decontamination)[8]. Except for mosquitos as infected vectors, the frequency for each of the other accident scenarios was identified as between 1 in 100 and 1 10,000 (i.e., $\leq 1\times10^{-2}$ to 1×10^{-4}) per year (i.e., natural phenomena or events resulting from two independent failure modes [operator errors and/or equipment failures]). The frequency for mosquitos as infected vectors was identified as between 1 in 10,000 and 1 in a million (i.e., $\leq 1\times10^{-4}$ to 1×10^{-6}) per year (i.e., events resulting from more than two independent failure modes [multiple operator errors and/or equipment failures]).

Based on the analyses described above, the bounding biological accident analyses would be the escape of *Coxiella burnetii* from the containment laboratory. However, even under the worst-case meteorological conditions, that accident does not represent a credible hazard to the non-involved worker or members of the public (Army 1989, NNSA 2008, NNSA 2011).

C.3.8 Accident Scenarios Involving Onsite Transport of Material

Onsite transfers at LLNL are defined as the movement of materials by programmatic organizations on the Livermore Site. LLNL radioactive waste transfer operations begin when the vehicle leaves the boundary of RHWM's originating facility and end when the transfer vehicle enters the boundary of RHWM's receiving facility. For all other facilities, radioactive waste transfer operations begin when the transfer vehicle leaves the originating facility and ends when the transfer vehicle stops to unload the containers at the receiving facility. Onsite transportation at Site 300 is limited to activities related to materials within the geographically contiguous property of Site 300.

The hazards associated with such onsite transfers were evaluated in three transportation safety documents. Two documents, the Transportation Safety Basis Documents (TSBD) (LLNL 2017c and LLNL 2017k) cover the nonnuclear onsite transportation activities. One document, the Transportation Safety Document (TSD) (LLNL 2018j) covers the nuclear onsite transportation activities. The transportation safety documents identified the following potential hazards: chemical, explosive, biological, industrial, and radiological. Radiological hazards involved with transporting less than the DOE-STD-1027 defined HC-3 quantity of radioactive material were

[8] The SBD (LLNL 2017j) presents unmitigated and mitigated consequences and frequencies. The unmitigated results are used by LLNL to determine what design features and/or administrative controls are necessary for the safe operation of the ABSL-3/BSL-3. For this SWEIS update the mitigated results are presented, since they represent the manner in which the ABSL-3/BSL-3 was constructed and is operated.

evaluated in the TSBDs and hazards involved with transporting equal to or greater than HC-3 quantities were evaluated in the TSD. The results of these hazard evaluations are summarized in Table C-57.

Table C-57. Onsite Transportation Hazards Evaluation Results

Type of Hazard	Onsite Transportation Hazard Classification	
	LLNL	Site 300
Chemical	Light Science and Industry (LSI)	LSI
Biological	Low	No regulated biohazardous materials are authorized for research activities at Site 300
Explosives	Low	Moderate
Industrial	LSI	LSI
<HC-3 Radiological	Low	Low
≥HC-3 Radiological	See analysis below	No ≥HC-3 quantity radioactive materials are handled or transported at Site 300

Source: LLNL 2017c, LLNL 2017k, LLNL 2018j..

The LSI hazard classification is used when a facility has only standard industrial hazards, such as use of chemicals with no known or suspected toxic properties, use of materials that are commonly available and used by the public, and use of small-scale quantities of chemicals, such as in laboratories. LSI classified facilities have the potential for unmitigated release of hazards with impacts to the public that are believed to present no appreciable risk of health effects and with impacts to non-involved workers that cause no more than mild, transient adverse health effects. A facility with an LSI classification is generally less hazardous than a facility with a Low hazard classification.

No radioactive materials handled or transported at Site 300 are greater than or equal to HC-3. In addition, biohazardous materials are not authorized for research activities at Site 300. Consequently, these two types of hazards are only applicable to the Livermore Site. Consistent with the approach taken in Section C.3.1.2, hazards classified as LSI or Low are bounded by other accidents and are not further analyzed in this SWEIS. Furthermore, the Table C-57 moderate explosive hazard for onsite transport at Site 300 is bounded by the analysis presented in Section C.3.4 for high explosives at Site 300.

Therefore, the only hazard analyzed in this section is the transport of HC-3 radiological material on the Livermore Site. As described above, two types of transfers are considered: (1) the transfer of waste between RHWM facilities, and (2) the MM transfer of material within the Superblock and between the Superblock and B239. The transfer of waste between RHWM facilities is further divided into the transfer of small quantities of waste (i.e., a maximum quantity 33 PE-Ci of radioactive material) along a route that takes it within 90 meters of the site boundary and the transfer of larger quantities (i.e., a maximum quantity 108 PE-Ci of radioactive material) that takes it to within 170 meters to the site boundary. The Superblock MM transfers are limited to 5,000 grams (in solid metal form with up to 1% oxide powder) of fuel-grade plutonium. The amount of radioactive material transferred other than fuel-grade plutonium (e.g., weapons-grade plutonium, enriched uranium) must be shown to be equivalent (or less) in dose to the fuel-grade plutonium quantity limit of 5,000 grams.

The following are three types of accidents analyzed in the TSD (LLNL 2018j) for RHWM transfers, along with some example initiating events:

1. Spill/Impact — Transfer vehicle impacts with stationary object, heavy construction equipment, or another vehicle; Waste containers fall from transfer vehicle and impact with the roadway; Driver error; Vibration from bad road;
2. Fire — Fire on transfer vehicle from excessive heating of defective wiring or exhaust system; Transfer vehicle fuel fire;
3. Impact Followed by Fire — Impact of transfer vehicle with another vehicle, with more than 20 gallons of fuel resulting; Impact with hydrogen-fueled shuttle bus; Vehicle mechanical or brake failure, human error.

The following are four types of accidents analyzed in the TSD (LLNL 2018j) for MM transfers, along with some example initiating events:

1. Spill/Impact — Electric vehicle impacts with stationary object; Vehicle mechanical or brake failure; human error; Package punctured by forklift tines; Transfer package fall from electric vehicle and impacts with the roadway
2. Fire — Excessive heating of defective electric motor, wiring, or batteries
3. Impact Followed by Fire — Electric forklift or electric vehicle runs into an object; Driver error; Mechanical failure
4. Unique Sealed-Source Impact — Inadvertent discharge from a weapon; Security personnel error, equipment (firearms) malfunction.

The TSD (LLNL 2018j) analyzed a shipment impacted with a subsequent fire. There are four types of releases that could occur during a "RHWM Impact Followed by Fire" accident: (1) Impact, (2) Confined Fire, (3) Flexing in Air, and (3) Unconfined Fire. A confined fire is one that occurs within the waste container, while an unconfined fire is one that occurs with the waste spilled on the ground. Flexing in air is when material traveling through air sheds particles due to the flexing of the substrate during the transmission. The DR, ARF, RF, and LPF for each release type were developed in accordance with guidance from DOE-STD-5506, which are shown in Table C-58 along with the resulting source terms (DOE 2007).

Table C-58. RHWM Onsite Transportation: Impact Followed by Fire — Radiological Source Terms

Release Type	DR (Damage Ratio)	ARF & RF (Airborne Release Fraction & Respirable Fraction)	LPF (Leak Path Factor)	Source Term (PE-Ci) MAR = 33 PE-Ci	Source Term (PE-Ci) MAR = 108 PE-Ci
Initial Impact	0.1	1×10^{-4}	1.0	0.00033	0.00108
Confined Fire	0.9	5×10^{-4}	1.0	0.01485	0.0486
Flex Impact	0.1	1×10^{-4}	1.0	0.00033	0.00108
Unconfined Fire	0.1	0.01	1.0	0.033	0.108

Source: LLNL 2018j.

Up to 4,000 grams of weapons grade plutonium oxide powder may be transported in a Measurement Standard Assembly (MSA) container, informally described as "Bish Can." The only release type for the MM Unique Sealed-Source Impact accident is due to the bullet impacting the Bish Can. Based on DOE-HDBK-3010, the ARF & RF were assigned a value of 1×10^{-4}, while both the DR and LPF were assigned values of 1.0, resulting in a source term of 0.4 grams.

As stated above, the RHWM larger quantity material transfers (i.e., up to 108 PE-Ci) can be as close as 170 meters to the site boundary, while RHWM transfer that can be within 90 meters of the site boundary are limited to 33 PE-Ci. MM transfers occur at or near the Superblock, and would be a minimum of 800 meters from the site boundary. Although the non-involved worker is typically place 100 meters from the release, because the site boundary is only 90 meters from the release for one of the accidents, the non-involved worker was assumed to be at 90 meters for all of the onsite transportation accidents. Plume buoyancy was taken into account when calculating the dispersion from confined and unconfined fire release during the RHWM bounding accident. The fire source is assumed equivalent to 10 gallons of diesel fuel, with a sensible heat of 5 megawatts (MW). Ground level release was assumed for all other releases.

As shown in Table C-59, the calculated radiological consequences from the onsite transport of RHWM and MM are small. For example, the non-involved worker's exposure following a MM unique sealed-source impact accident has the largest exposure, but the worker's total LCF risk is only about 1 in 5.5 billion (i.e., 1.5×10^{-8}) per year. The total LCF for the MEI is also small (i.e., 3.7×10^{-10} per year).

Table C-59. Onsite Transportation Bounding Accident Under the No-Action Alternative and the Proposed Action Radiological Consequences (Stability Class F and 1 m/sec.)

Frequency (per year)	Maximally Exposed Individual				Non-involved Worker		
	Distance (m)	Dose* (rem)	Latent Cancer Fatality Risk: Conditional	Latent Cancer Fatality Risk: Total (yr^{-1})	Dose[a] (rem)	Latent Cancer Fatality Risk: Conditional	Latent Cancer Fatality Risk: Total (yr^{-1})
RHWM: Impact Followed by Fire							
6.22×10^{-7}	90	1.15	6.9×10^{-4}	4.3×10^{-10}	1.15[b]	6.9×10^{-4}	4.3×10^{-10}
	170	1.31	7.9×10^{-4}	4.9×10^{-10}	3.76	2.3×10^{-3}	1.4×10^{-9}
MM: Unique Sealed-Source Impact							
5.5×10^{-7}	800	1.13	6.8×10^{-4}	3.7×10^{-10}	45.4	0.027	1.5×10^{-8}

a. Source: LLNL 2018j.
b. Non-involved worker is assumed to be at site boundary (90 meters).

In addition to radioactive material, the RHWM transfers may contain quantities of toxicological materials within the package. These toxicological materials could include lead, acetone, toluene, trichloroethylene, Freon, carbon tetra chloride, hydroquinone, solvents, asbestos, and beryllium. Except for beryllium, these other hazardous materials are present in TRU waste in trace quantities well below the 40 CFR 302.4 reportable quantities (LLNL 2018j). An analysis of the consequences of beryllium release during the bounding RHWM accident would bound all toxicological material consequences. Smaller quantities of waste, with up to 1,800 grams of beryllium, may be transported along a route that could be within 90 meters of the site boundary. Transportation of larger quantities, with up to 3,600 grams of beryllium, could be within 170 meters of the site boundary. The beryllium source term is calculated in the same manner as the radioactive material source term, with identical DR, ARF, RF, and LPF. Table C-60 shows the calculated RHWM onsite transportation impact followed fire accident beryllium source term.

Table C-60. RHWM Onsite Transportation: Impact Followed by Fire — Toxic Chemical (Beryllium) Source Terms

Release Type	DR (Damage Ratio)	ARF & RF (Airborne Release Fraction & Respirable Fraction)	LPF (Leak Path Factor)	Source Term (g)	
				MAR = 1,800 g	MAR = 3,600 g
Initial Impact	0.1	1×10^{-4}	1.0	0.018	0.036
Confined Fire	0.9	5×10^{-4}	1.0	0.81	1.62
Flex Impact	0.1	1×10^{-4}	1.0	0.018	0.036
Unconfined Fire	0.1	0.01	1.0	1.8	3.6

Source: LLNL 2018j.

The atmospheric dispersion of the beryllium from the release point to the MEI and non-involved worker locations would be the same as the description above for the radioactive materials source term. As shown in Table C-61, the calculated toxic chemical consequences from the onsite transport of RHWM would be small (i.e., less than the PAC-1 value for the MEI and less than the PAC-2 value for the non-involved worker). These results are consistent with the classification of the LLNL chemical hazard from onsite transportation of material as Low (LLNL 2017c, LLNL 2017k), as shown in Table C-61.

Table C-61. RHWM Onsite Transportation Bounding Accident Under the No-Action Alternative and the Proposed Action Toxic Chemical (Beryllium) Consequences (Stability Class F and 1 m/sec.)

Frequency	MEI Distance (m)	Be Concentration (mg/m³)	
		MEI	Non-involved Worker
RHWM: Impact Followed by Fire			
6.22×10^{-7}	90	3.5×10^{-3}	3.5×10^{-3}
	170	2.5×10^{-3}	7.0×10^{-3}

Note: The beryllium oxide PAC-1, PAC-2, and PAC-3 values are 0.0063, 0.069, and 0.28 mg/m³, respectively.

C.3.9 Site-Wide Multiple-Building Scenarios

This section addresses the potential releases and consequences of a seismic event or wildfire affecting multiple facilities and involving multiple source terms (both radiological and chemical).

C.3.9.1 *Seismic Events*

Although the Livermore Site has numerous facilities that could be impacted during a seismic event, they are dispersed over the site's entire 821 acre. Therefore, unless the facilities are located near each other, the release from one facility is not likely to significantly increase impacts on the non-involved worker or MEI at another facility. The Superblock however contains multiple buildings in close proximity to each other, with each building housing hazardous and/or radiological materials. A single seismic event could cause releases from multiple buildings that potentially could impact the non-involved workers or MEI.

Superblock: Buildings 239, 331, 332, & 334. The four main buildings within the Superblock are: Building 239 Radiography Facility, Building 331 Tritium Facility, Building 332 Plutonium Facility, and Building 334 Hardened Engineering Test Building. The four Superblock Buildings have each been designed to withstand an evaluation basis earthquake (EBE), i.e., an earthquake with a peak ground acceleration of 0.57 g. At the Livermore site a 0.57 g earthquake has a return period of 1,000 years or a frequency of 0.001 per year.

The DSAs for each of these buildings contain a summary of the hazards that may result from seismic events. The Building 332 DSA (LLNL 2019l) contains a detailed analysis of the EBE. The results of that analysis have been included in Table C-62. The Building 331 DSA (LLNL 2018f) indicates that larger quantities of tritium in the Tritium Science Station and the Tritium Processing Station are typically stored on beds that are not susceptible to release under EBE conditions. However, the DSA also indicated that a large release could occur from Building 331 if the EBE initiated a fire in one of the increments. For this SWEIS it was conservatively assumed that Building 331 tritium releases following an EBE initiated fire would be the same as those presented in Table C-31. The Building 331 DSA estimated the frequency of an EBE initiated fire to be from $<1\times10^{-4}$ to 1×10^{-6} per year. Table C-62 presents the consequences of an EBE initiated fire at Building 331. Although the Building 239 and Building 334 DSAs (LLNL 2017f and LLNL 2017g) do not contain detailed EBE analyses, the DSAs do conclude that the consequences following a EBE to the non-involved worker and the public would be negligible due to no or minor radiological releases. The Building 239 and Building 334 DSAs define negligible consequences as <0.1 rem, but the consequences could be as low as zero if no radiological release occurs due to the EBE. This information has also been included in Table C-62.

As Table C-62 shows, the consequences from all four Superblock Buildings of an EBE occurring at the Livermore site are dominated by the consequences from Building 331.

Table C-62. Superblock Evaluation Basis Earthquake Consequences and Risks Under the No-Action Alternative and the Proposed Action

Superblock Building	Frequency (per year)	Consequence			Fatality Risks		
		MEI (rem)	Offsite Population (person-rem)	Non-involved Worker (rem)	MEI (LCF)	Offsite Population (LCF)	Non-involved Worker (LCF)
Building 239	0.001	Negligible*	Negligible	Negligible	Negligible	Negligible	Negligible
Building 331	$<1\times10^{-4}$ to 1×10^{-6}	0.97	220	38	5.8×10^{-4}	0.13	0.023
Building 332	0.001	2.6×10^{-5}	0.0059	0.0011	1.6×10^{-8}	3.5×10^{-6}	6.4×10^{-7}
Building 334	0.001	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

* The B239 and B334 DSAs (LLNL 2017f and LLNL 2017g) define negligible consequences as <0.1 rem, but the consequences could be as low as zero if no radiological release occurs due to the EBE.

Source: LLNL 2019l, LLNL 2018f, LLNL 2017f, LLNL 2017g.

C.3.9.2 *Wildfires*

As discussed in the LLNL Emergency Plan (LLNL 2016e), wildland fires are a concern at LLNL. Historically, wildland fires have not been a threat at the Livermore site because most of the site is developed, except for the North and West Buffer zones. Dry grasses from these buffer zones are cleared every spring to reduce the probability of fires. Wildland fires are a significant concern at Site 300 because of its remoteness and size. Precautions are taken to reduce the potential for a wildland fire spreading at Site 300 facilities by controlling the growth of vegetation within a buffer area inside the facility perimeter fence. Wildland fire control at Site 300 is also mitigated aggressively by annual prescribed burns. Prescribed burns confine a potential fire to within the Site 300 property boundaries, eliminating the fuel in high fire probability areas (including HE test areas), and generally break the fuel path, thereby limiting the size of potential fires in other areas. LLNL has been successfully conducting prescribed burns at Site 300 throughout its history (LLNL 2016e).

Additionally, the Alameda County Fire Department (ACFD), under contract to LLNL, maintains fire department stations at the Livermore Site (Station 20) and Site 300 (Station 21). If a wildfire were to approach either site, the ACFD would immediately act to extinguish it. The following discussion provides further details on the steps taken by LLNL to mitigate the potential impact of wildfires.

Livermore Site. The Livermore Site has a small wildland fire threat mostly concentrated on the West and North sides in the buffer zone. Vegetation at LLNL consists mostly of perennial grasses. This vegetation creates a fuel during the summer months that is generally light and flashy resulting in fast moving fires that pose little threat to permanent buildings with adequate clear space around them. To mitigate the threat of wildland fire, LLNL imposes several preventive measures, including restricting fuels within 20 feet of permanent buildings, and mowing the buffer zone grasses to a height of less than 6 inches, a height that will not sustain a fast-moving fire.

The ACFD Station 20, is located onsite in Building 323. The ACFD Station 20 provides Livermore Site with fire, rescue, hazardous material response, and emergency services. Memoranda of Understanding exist with several community agencies, including the Alameda County, Livermore/Pleasanton, and Tracy Fire Departments, Valley Care and Eden Medical Centers, and local governments. The ACFD Station 20, an 18,000 square foot facility, houses a Battalion Chief, three fire companies (two exclusively dedicated to LLNL), with nine firefighters, and the following equipment: 3–Type I Engines, 1–75 Foot Ladder Truck, 2–Type III Wildland Fire Engines, 3–Type VI apparatus (patrols), 1–Hazardous materials unit, 2–Ambulances, and 2–Incident Command Cars.

If a wildfire danger occurs offsite, crews from LLNL's Community Emergency Response Team (CERT) – staffed with LLNL employee volunteers specifically trained in light search and rescue, advance medical First Aid, and basic firefighting – are available to answer the call for help. For example, in August 2020, the SCU Lightning Complex Fire quickly grew to burn more than 390,000 acres in portions of five counties. It briefly shuttered Site 300 and advanced to within miles of the Livermore Site. Due to the massive size of the fire and its proximity to the Livermore area, Cal Fire reached out to LLNL's CERT for assistance. More than 20 LLNL volunteers provided a range of assistance to help Cal Fire bring the SCU Lightning Complex Fire under control.

Site 300. Potential risks associated with wildland fires are currently lessened at Site 300 through implementation of the annual prescribed burns. LLNL has conducted prescribed burns for wildfire control at Site 300 throughout its history. Annually approximately 2,000 acres at Site 300 are burned. For example, the 2020 burn covered about 2,200-acres, divided into 24 plots ranging from less than one acre to over 600 acres (LLNL 2020g). Annual prescribed burning typically takes place from mid-May through June when the grass has dried enough and wind conditions are typically more ideal than later in the summer. During the burn period daily prescribed burn acreage can range between approximately 10 to 1,200 acres.

In addition to prescribed burns, LLNL reduces vegetation at Site 300 by mechanical mowing and herbicide spraying. A defensible space around all buildings is well defined and maintained, and vegetation is kept clear within a 20-foot radius of all wood power poles. Finally, personal protective equipment specific to wildland fire hazards is maintained for all ACFD firefighters stationed at Site 300 and has established procedures that require mobile response apparatus and firefighters to be pre-staged in certain areas during periods of high fire danger.

Planning and coordination with the Bay Area Air Quality Management District (BAAQMD) and San Joaquin Valley Air Pollution Control District (SJVAPCD) is also critical. Each district imposes stringent review and approval requirements before allowing prescribed burn activities to take place to meet their smoke management objectives. In addition, each air district prioritizes burn activities requested within their air basin and provides daily burn allocations to the requesting facility based on air quality, weather conditions, declared burn days, and other scheduled burn activities. In addition to meeting air district requirements, LLNL conducts prescribed burns to meet DOE wild land management requirements and follows best management practices to minimize the creation of smoke and ensure safe burn conditions.

Prescribed burns conducted at Site 300 are considered a long-term benefit to air quality as they reduce the potential for destructive wildfires. In addition, fires remove potential airborne residues that accumulate, such as pollen and other respirable matter. The principal objectives of the LLNL Site 300 Explosive Test Facility Prescribed Burn/Smoke Management Plan are to:

- Minimize the occurrence of unnaturally intense fires by reducing the amount of vegetation that can fuel larger, more catastrophic fires.
- Preserve the capability to safely test explosives while protecting the environment.
- Minimize the occurrences of fires that could leave the Site 300 boundaries and impact neighbors and limit the extent of prescribed fires, which could reduce the air quality for neighbors.
- Use minimum impact prescribed burns and fire suppression techniques, and rehabilitate areas to protect natural and cultural resources from adverse impacts attributable to wildfire suppression activities (LLNL 2017l).

The prescribed burn strategically reduces the fuel load at Site 300, and prevents the uncontrolled spread of wildfire. Stationing the Fire Department at Site 300 further reduces risks associated with accidental wildfire by decreasing emergency response times and increasing personnel familiarity with the area (LLNL 2017l).

C.4 INTENTIONAL DESTRUCTIVE ACTS

C.4.1 Introduction

The Department of Energy's (DOE's) *Recommendations for Analyzing Accidents under the National Environmental Policy Act* (NEPA) (DOE 2002a) requires that EIS's include a range of accident scenarios analyzed for intentional destructive acts (IDAs). Although these IDAs (i.e., malevolent acts of sabotage or terrorism) are not accidents, their physical acts – whether caused by a fire, explosion, missile, or other impact force – may be compared to the effects of postulated accidents. These consequences, involving radioactive and hazardous materials with environmental and/or health risks, caused by an act of sabotage or terrorism, can then be compared to the accident analyses documented in this SWEIS.

NNSA has prepared an IDA appendix to support this LLNL SWEIS that analyzes the potential impacts of intentional destructive acts (e.g., sabotage, terrorism). That appendix contains Official Use Only information related to security concerns and is not publicly releasable. A publicly-releasable summary of that appendix is presented below.

The IDA analysis follows these steps:

- Identification of IDA scenarios— explain the process used to identify the potential IDA scenarios and describe the scenario(s) carried forward for further analysis (it could be several scenarios or a single bounding scenario).

- Results of IDA analysis— present the results of the IDA analysis. Depending upon how the analysis was done, this can either be a qualitative or quantitative discussion.

- Conclusion— compare the IDA impacts to the SWEIS accident impacts.

C.4.2 Identification of Intentional Destructive Act Scenarios

The development of IDA scenarios requires identification of material types, potential source terms, identification of receptors (onsite and offsite), and consequences that are specific and relative to environmental concerns (exposure, dispersal, sabotage, theft, etc.). The various sources, which may vary by material and receptor type, and other parameters analyzed are provided below.

- Theft of a material (bounded by SWEIS accident analysis)
- Radiological, chemical, or biological sabotage (analyzed for environmental concerns)
- Sabotage of a critical facility or mission (analyzed for environmental concerns)
- Theft of classified or sensitive information (not further analyzed)
- Facility seizure (not further analyzed)
- Workplace violence or hostage-taking (not further analyzed)
- Protest activities to include vandalism, destruction of property, etc. (not further analyzed)

As shown in the bullets above, not all sabotage or theft events are further analyzed in the appendix; only those that potentially could have environmental or health and safety consequences. This includes radiological materials, chemicals, biological materials and toxins, and special nuclear materials. The scenarios in the last four bullets above were not further analyzed in the IDA analysis because they do not have environmental consequences. Theft was not addressed in detail within this summary document as security mitigation efforts have been implemented which categorize the risk of materials theft as low. Therefore, the probability for environmental impacts is assumed to be low. Additionally, not all facilities with materials inventories are analyzed; only those that would have high probability and high consequence from an IDA scenario. Table C-63 presents the material types, receptors, potential sources, and consequences analyzed in this IDA, which supports the objectives stated above.

Table C-63. Material Types, Source Terms, and Consequences Analyzed in the IDA

Material Type	Receptor/Category	Potential Source	Consequences (Relative to Environmental Concerns)
Radiological Materials	Radiological Materials with Onsite Dispersal or Exposure Consequences	^{137}Cs Source	Involved Worker Radiological Exposure; no offsite consequences
		^{60}Co Source	Involved Worker Radiological Exposure; no offsite consequences
		^{238}Pu	Involved Worker Radiological Exposure; no offsite consequences
		Highly Enriched Uranium (HEU) / Plutonium (Pu)	Radiological Release; SWEIS Accident Analysis is Bounding
		Inherently Safe Subcritical. Assembly	Radiological Release; SWEIS Accident Analysis is Bounding
	Other Radiological Materials	Various	SWEIS Accident Analysis is Bounding
Hazardous Chemicals	Chemicals with onsite dispersal or exposure consequences	Various	Chemical Release/ Sabotage; SWEIS accident analyses are Bounding
Biological Agents, Biological Select Agents and Toxins	Risk Group 3	Bacteria, Virus, Fungi	Sabotage would not result in offsite consequences; Theft, low risk due to security mitigation.
	Risk Group ½	Bacteria, Virus, Fungi, Toxins	Sabotage would not result in offsite consequences; Theft, low risk due to security mitigation
SNM	CAT III SNM	Lab/Storage	Theft; low risk due to security mitigation
	CAT IV SNM	CAT IV	Theft; low risk due to security mitigation
National Critical Facilities	High Explosives Application Facility	High Explosives	Sabotage would not result in offsite consequences
	Superblock Pu Facility	Various Radiological Materials	Sabotage would not result in offsite consequences
	National Ignition Facility (NIF)	Various Radiological Materials	Sabotage would not result in offsite consequences
	Site 300 Contained Firing Facility (CFF)	High Explosives	Sabotage would not result in offsite consequences

C.4.3 Results of IDA analysis and Conclusion

The IDA analysis used a qualitative approach and compared the resulting events with consequences in the SWEIS accident analysis. In some cases, the SWEIS accident analysis did not analyze similar IDA events, so a direct comparison was not possible.

As indicated in the Table C-63 above, comparison of the IDA analysis against the SWEIS accident analysis shows that many events have similar impacts. The IDA impacts and the SWEIS accident impacts have similar consequences for radioactive materials dispersal, criticality events, chemicals, and biological events. The radioactive materials direct exposure events in the IDA analysis are comparable to the prompt dose from a criticality event in the SWEIS accident analysis. Additionally, sabotage for key chemical facilities as well as National Critical Facilities are comparable to SWEIS accident analyses. In summary, the accident analyses done in the SWEIS with details presented in the reference documentation represents the bounding accidents relative to environmental concerns for the IDA analysis.

C.5 EMERGENCY MANAGEMENT

C.5.1 Introduction

DOE requires all sites to implement a comprehensive emergency management system that considers and incorporates in its planning responses to a broad spectrum of hazards and possible consequences. The extent of emergency planning and preparedness for a particular LLNL building or facility corresponds to the type and amount of hazards and the potential effects on workers, the public, the environment and/or national security (LLNL 2021f).

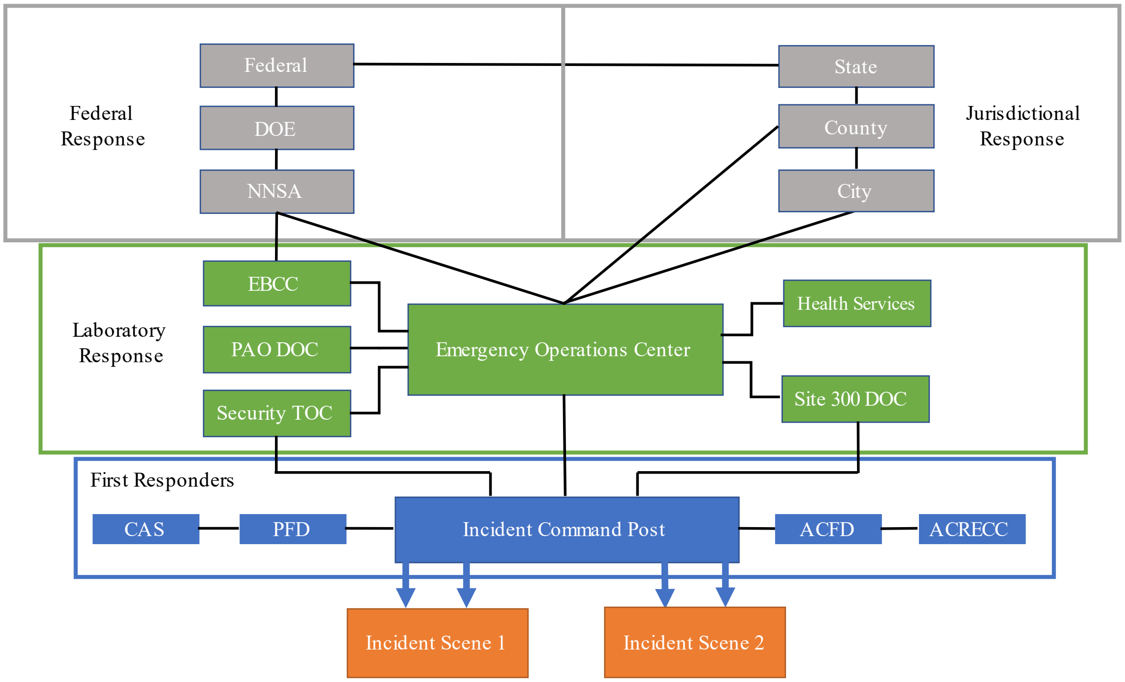
LLNL has prepared an *Emergency Management Plan* (LLNL 2021f) that documents LLNL's comprehensive emergency management program, including response to Operational Emergencies, at LLNL. The Emergency Management Plan (Emergency Plan) was prepared and structured in accordance with the DOE programmatic guidance for a standard format and content of DOE/NNSA emergency plans. It addresses the contractor applicable requirements of DOE Order 151.1D and provides an overview of the roles, responsibilities, and lines of authority for the Emergency Response Organization (ERO). The Emergency Plan also describes the interfaces and coordination with offsite agencies that provide community awareness and protection through notifications, protective action recommendations, and mutual aid. The concepts outlined in the plan provide for the protection of workers, responders, the public, the environment, and national assets (LLNL 2021f).

The Emergency Plan addresses and applies a description of emergency preparedness and response to an emergency as defined in DOE Order 151.1D, which is stated to be "Any incident, whether natural or manmade, that could endanger or adversely affect people, property, or the environment, and that requires responsive action beyond normal operations. An 'Operational Emergency' is a term used to categorize a specific type of emergency." When an emergency occurs, the plan is invoked through implementing documents for response to the emergency. Routinely designated LLNL emergency responders, such as fire, ES&H Teams, Hazardous Material (HazMat), medical/emergency medical services, and Security Organization/law enforcement, provide on-scene response. The Incident Commander (IC) through a Unified Command structure directs emergency response (LLNL 2021f).

Resources at LLNL sites from the Alameda County Fire Department (ACFD) and the LLNL Security Organization provide the first response level for dealing with emergency incidents at LLNL, and they may be supported by the ES&H Teams, Facilities Management, and Health Services Department (HSD). If an incident should escalate beyond LLNL's pre-planned initial response, additional emergency response resources can be obtained through existing local, state, and federal agreements (LLNL 2021f).

In addition to the Emergency Management Plan, LLNL has prepared a *Disaster Response Plan* (LLNL 2018k) to augment the planning found in the Emergency Plan for severe events. Because of the likelihood of a major earthquake in the region, the Disaster Response Plan (Response Plan) focuses on a response to a significant regional earthquake. LLNL would apply various portions of the earthquake response for other severe events. The Response Plan describes how LLNL and the ERO will respond to a large-scale or regional severe event (e.g., earthquake) impacting LLNL when, for a significant period of time, there may be limited or no immediate response from ACFD or other professional emergency response organizations. Disaster response is considered part of the LLNL Emergency Management Core Program because it covers all site facilities, regardless of whether significant hazards are impacted (LLNL 2021f).

The LLNL response to emergencies is based on echelons. Echelons are an organizational structure where each level above is larger, has broader responsibilities, and supports the level below. (see Figure C-5). Emergency Management Teams at each level provide command and control of the emergency response efforts. The IC is in charge of the Incident Command System (ICS) at the incident scene, and the Emergency Director (ED) in LLNL's Emergency Operations Center (EOC) is in charge of the overall site-wide response efforts and support of the IC. The Emergency Management Department has an Emergency Management Duty Officer (EMDO) is onsite or on-call at all times, and is responsible for categorizing Operational Emergencies and further potentially classifying hazardous material Operational Emergencies as Alerts, Site Area Emergencies, or General Emergencies, if required (LLNL 2021f).



Note: EBCC=Executive Business Coordination Center; PAO = Public Affairs Office; DOC=Department Operations Center; TOC=Tactical Operations Center; CAS = Central Alarm Station; PFD = Patterson Fire Department; ACFD = Alameda County Fire Department; ACRECC = Alameda County Regional Emergency Communications Center.
Source: LLNL 2021f.

Figure C-5. LLNL Emergency Response Organization

The Emergency Planning Zone (EPZ) for hazardous material accidents are described and analyzed in the individual facility Emergency Planning Hazards Assessment (EPHAs). In general, an EPZ is an area within which the results of an EPHA indicate the need for specific planning to protect people from the consequences of hazardous material releases. For the Livermore Site, it was determined that a one-mile composite EPZ was appropriate based upon a summary of the EPZs for individual facilities. The EPZ for Site 300 is the site boundary itself. It is unlikely that any offsite area would be affected by emergencies at Site 300. The primary exposure pathway from hazards at both sites is inhalation, although ingestion and absorption potential is also considered in EPHAs (LLNL 2021f).

C.5.2 Training and Drills

There are two emergency management training program categories at LLNL: Emergency Preparedness Training and Emergency Response Organization Training. They are designed to meet the following goals:

- Provide general instructions to the onsite population (including visitors and guest) regarding potential hazards based on the All-Hazards Survey, methods of alerting and protective actions that may be ordered;
- Provide training to members of the ERO, to include initial and annual refresher training;
- Provide problem solving drills to the members of the ERO to enhance their skills;

- Continually improve emergency management training incorporating new ideas and lessons learned;
- Provide appropriate offsite agencies the opportunity to participate in selected LLNL training; and
- Provide a cadre of trained evaluators and controllers for the drill and exercise program (LLNL 2021f).

LLNL is required by DOE Order 151.1D to conduct building evacuation drills at least annually. Each member of the LLNL ERO must participate at least annually in a drill. This may be accomplished by participation in a drill, exercise, or actual incident as long as it is formally documented. However, qualified field emergency response personnel (e.g., firefighters, HazMat Technicians, paramedics, security officers) that perform essentially the same functions for the LLNL ERO as they do on a day-to-day basis, demonstrate proficiency doing their everyday jobs and do not necessarily need to participate in an annual drill (LLNL 2021f).

DOE Order 151.1D requires facilities having EPHAs to conduct a drill where occupants take protective actions *and* interface with First Responders (e.g., Fire Department, ES&H Team, and Protective Forces) at an Incident Command Post. These types of drills are referred to as Protective Action Drills (LLNL 2021f).

In addition, LLNL has developed an Operational Drill program to ensure facilities are prepared to manage a variety of potential emergencies that are commensurate with the hazards present. LLNL operational procedures direct EPHA facilities to have a documented, internal facility-level operational drill and exercise program apart from the institutional level site-level exercise program. These facility-level operational drills provide supervised, hands-on training for facility occupants utilizing facility-specific response expectations inclusive of protective actions. Facility-level operational drills are developed, conducted, evaluated using objectives and associated evaluation criteria, and documented. Criteria for operational drills are developed from facility-specific policies and procedures. Fire Department and Security participation is encouraged in operational drills. Operational drills help responders develop proficiency in performing emergency activities such as notification, communication, fire control, medical planning, and hazardous materials response, which are also exercised as part of the Emergency Management Hazardous Materials Program (LLNL 2021f).

C.5.3 General Protective Actions for Emergencies

The primary objective of protective actions is to limit individual doses or exposures. In the short-term, this may be accomplished by taking action (e.g., shelter-in-place) to keep exposure levels below the thresholds for severe early health effects. In the longer term, additional actions may be required to reduce or avoid additional exposure (e.g., evacuate populations), which may cause temporary exposure to higher plume concentrations than would occur during shelter-in-place, for the purpose of avoiding a higher dose over an extended period of time, thereby producing a positive net benefit. The overall risk to workers and the public should be limited, to the extent practicable, by reducing the population or collective dose (or exposure). Protective actions, when implemented individually or in combination, accomplish this objective. The Laboratory has procedural actions for protection of onsite personnel and recommendations to offsite agencies in the event of an Operational Emergency. LLNL is required by DOE Order 151.1D to provide immediate notification and protective actions to affected employees no later than 10 minutes after the protective actions have been identified in accordance with the LLNL emergency management plan implementing procedures and notification to local, state, and federal authorities within 15 minutes of categorization of a classified hazardous material Operational Emergency. There are three basic protective actions that may be implemented to limit injury and death of the LLNL population caused by an emergency condition. These are:

- Evacuation
- Shelter-In-Place (for an airborne hazardous material release)
- Lockdown (for an active onsite security threat) (LLNL 2021f).

LLNL protective action recommendations for protection of offsite populations are developed using the same criteria as onsite protective actions. Offsite recommendations are implemented at the discretion and direction of local authorities who may implement the recommended protective actions per local jurisdictional procedures (LLNL 2021f).

C.5.4 Specific Disaster Response Plans

The *Disaster Response Plan* (LLNL 2018k) describes how LLNL and the ERO will respond to a large-scale or regional disaster, such as earthquakes, wildland fires, flooding, and thunderstorms, all of which are discussed below.

Earthquakes. A major earthquake is a credible disaster caused by a natural phenomenon that is likely to involve the entire Laboratory and the entire surrounding community. Hazard mitigation at LLNL is achieved by complying with building codes, applying good engineering and housekeeping practices, and providing training programs required for managers and workers (LLNL 2018k).

Wildland Fires. Wildland fires are a concern at LLNL. Historically, wildland fires have not been a threat at the Livermore Site. However, wildland fires are a significant concern at Site 300. Precautions are taken to reduce the potential for a wildland fire spreading at Site 300 by reducing and controlling the growth of vegetation within a buffer area inside the perimeter fence. Wildland fire control at Site 300 is also mitigated aggressively by the annual prescribed burn. The prescribed burn confines a potential fire to the property boundaries of Site 300, eliminates the fuel in high fire probability areas (high explosive test areas), and generally breaks the fuel path, thereby limiting the size of potential fires in other areas. The Fire Department has been successfully conducting prescribed burns at Site 300 for decades (LLNL 2018k).

ACFD Station 21 personnel at Site 300 are well trained and experienced with “back-fire” techniques and use that technique extensively as a fire control measure when responding to wildland fires at Site 300. Staffing at ACFD Station 21 allows a standard two-flank attack. LLNL firefighters have a history of aggressive wildland fire attack at Site 300. Wildland fires beyond the capabilities of this initial fire attack are usually held in check by the prescribed burn boundaries; however, due to the topography and remote nature of Site 300, additional ACFD equipment and personnel are automatically dispatched by Alameda County Regional Emergency Communications Center (ACRECC) as part of LLNL’s planned initial response to a wildland fire at Site 300. Through LLNL’s Mutual Threat Zone Memorandum of Understanding (MOU) with

California Division of Forestry and Fire Protection (CAL FIRE), this may include specialized resources such as firefighting helicopters and fixed-wing aircraft tankers (LLNL 2018k).

Flooding. Flooding would not occur at the Livermore Site or Site 300 from a failure of the Del Valle Reservoir dam, from loss of water from the Patterson Reservoir, or from a break in the South Bay Aqueduct near LLNL. There are no dams in the Site 300 vicinity posing threat of inundation in the event of failures. Flooding is still a possibility at both sites due to storms. According to a recent U.S. Geological Survey report, scientists believe a megastorm occurs in California once every 165 to 400 years. Called "ArkStorms" by the U.S. Geological Survey, these megastorms are caused by a long band of subtropical moisture known as the "pineapple express" that sometimes stretches across the Pacific Ocean to the California Coast. These storms are estimated to produce precipitation that in many places exceeds levels only experienced on average once every 500 to 1,000 years. The last large ArkStorm to hit California occurred in December 1861 and lasted through January 1862, turning the Sacramento valley into an inland sea and causing the state capitol to be moved temporarily to San Francisco. Geologic studies of deposits offshore of California's big rivers suggest that storms even bigger than 1861-62 have happened six times in the last 1,800 years. Smaller ArkStorms caused significant damage in northern California in 1986 and 1997. The flood hazard annual probability is 1.0×10^{-4} (i.e., a return period of 10,000 years). The estimated water level for a 10,000-year flood would be less than 1-foot above ground level (LLNL 2018k).

Thunderstorm. Thunderstorms occur fewer than five days per year on average and are not intense. There have been no recorded instances of lightning strikes within the boundaries of the Livermore Site. Livermore is in an area that experiences less than 0.1 lightning strikes/km^2/yr (LLNL 2018k).

C.5.5 Specific Earthquake Disaster Response Actions

Initial Response. An earthquake is considered the most likely disaster. During an earthquake, a person at the Laboratory is expected to drop to the ground, cover his/her head and neck and get under a desk or heavy furniture, and hold on until the shaking stops; then, when safe to do so, evacuate to the nearest Assembly Point. Employees are encouraged to assist anyone in need if it is safe to do so. Following a major earthquake, the ability to issue protective action announcements using the Emergency Voice Alarm (EVA) or other means may be partially or fully impaired. During minor or moderate earthquakes, there could be confusion on whether an evacuation is needed. To help prevent confusion, the EMDO, in consultation with the on-call Laboratory Emergency Duty Officer (LEDO), may issue a site-wide announcement knowing that some or all the EVA system may be damaged. The goal is to quickly get all people outdoors to on site Assembly Points (LLNL 2018k).

Initial First Responder Actions. Firefighters will immediately move fire vehicles out of the fire stations. The ACFD IC is expected to organize the firefighters into teams to complete a visual tour of the site. Teams may or may not be full crews. It is expected that the IC will not commit firefighters to a specific event until the windshield tour is near complete. If a number of events requiring response are identified, the IC may establish Area Command and identify an IC for each of the specific responses. Security officers, likewise, will complete a windshield tour of the site. Injury and damage information will be provided to the Central Alarm Station (CAS). The gates remain staffed and the outbound lanes of traffic remain open. The IC from Security will typically join the ACFD IC at the Incident Command Post (ICP) for unified Area Command. LLNL Community Emergency Response Team (CERT) members will report to their assigned or closest Assembly Point, check-in, identify themselves as a CERT member and then make their way to the CERT muster point at the Building 323, Fire Station 20 to await deployment. Site 300 has one deployable CERT (LLNL 2018k).

Initial Management Response. The initial management actions are dependent on the magnitude of the event:

- Minor Earthquake (acceleration up to 0.15g). The LEDO will determine the appropriate EVA announcement to make, if he/she believes an announcement is necessary. An announcement may be made indicating that an earthquake occurred, but that no action is required.

- Moderate Earthquake (Approx. 0.16g – 0.3g reading, OR other indication of strong intensity, including quake duration, tripped gas valves, boiler flame roll-out, waterflow alarms, or numerous alarms). The LEDO will determine the appropriate EVA announcement to make. Most employees should have evacuated without an announcement. The announcement may direct personnel to evacuate to their nearest Assembly Points, complete accountability, but not reenter buildings until instructed to do so. The announcement may direct ERO members to report to their assigned emergency facilities if safe to do so. The ERO is trained to automatically respond to the EOC.

- Major Earthquake (greater than 0.3g, OR other indication of disaster, such as one or more collapsed buildings). The LEDO will determine the appropriate EVA announcement to make. Nearly all employees should have evacuated without an announcement. The announcement will direct personnel to report to their Assembly Points and report injuries and damage. The message will also direct ERO members to report to their emergency facilities. The ERO is trained to automatically respond to the EOC (LLNL 2018k).

Workforce at Assembly Points. Approximately 80 Assembly Points have been pre-established at the Livermore Site, and14 at Site 300. First-aid supplies, tools, information, forms and other materials are stored at each Assembly Point in Self-Help supply boxes. There are approximately 100 Self-Help supply boxes located at Assembly Points. Each box was designed to support approximately 100 people (LLNL 2018k).

Emergency Operations Center Actions. The focal point of coordination for Laboratory-wide response is the EOC. The integrated response has the following objectives:

- Save lives.
- Reduce immediate threats to life, public safety and health, and property.
- Provide necessary care for the Laboratory population until they leave Laboratory property.
- Assess damage to infrastructure, structures, and the environment.
- Expedite restoration of utilities and begin the process of recovery.
- Restore the operations of facilities (LLNL 2018k).

The EOC has an established set of procedures to complete required tasks that can be identified prior to an event. The current procedures include:

- Activating the ERO using a cloud-based employee mass notification system
- Declaring the EOC operational
- Using the EOC Video Wall and Common Operating Picture System
- Categorizing and classifying Operational Emergencies
- Ensuring protective actions are adequate and appropriate
- Notifying offsite Agencies
- Performing accountability in the affected area
- Issuing news releases
- Communicating with offsite agencies
- Determining the consequences of the event
- Contacting the emergency contacts for injured people
- Evacuating facilities to support muster and accountability actions
- Managing Field Monitoring Teams
- Evaluating structures and infrastructure
- Initiating recovery activities
- Terminating the emergency (LLNL 2018k).

After the EOC is operational, the Liaison Officer is responsible for ensuring required communications are made to affected public and private entities, including Federal, State, and local agencies. The information on *Emergency Notification* forms (initial and each update) is vetted by the Emergency Management Team before being issued. Once approved by the Emergency Director, the information on these forms is then disseminated to offsite agencies (LLNL 2018k).

Communications with offsite law enforcement and most requests for offsite mutual aid are typically handled by ACRECC (for fire department support) and/or the Tactical Operations Center (for security). The Liaison Officer is responsible for communications with all other offsite agencies, including:

- DOE-Headquarters Watch Office
- SNL/CA
- California Office of Emergency Services
- Alameda County Office of Emergency Services
- San Joaquin County Office of Emergency Services
- City of Livermore EOC (LLNL 2018k).

If offsite agencies request permission to send liaisons to the LLNL EOC, these requests will be handled by the Liaison Officer, who will facilitate the needs of the offsite representatives, including coordination with the Security Organization for site access and escorts, if needed, as well as the provision of EOC identification, work space, and other support (LLNL 2018k).

In a response to a regional disaster, significant amounts of time sensitive information is needed to allow management decisions on the release of the Laboratory population. Status of nearby hospitals becomes important for transport of the injured. Interface with the City of Livermore EOC is required if stranded employees are in need of shelters (LLNL 2018k).

C.6 References

10 CFR Part 20 — "Standards for Protection Against Radiation." *Energy*. Nuclear Regulatory Commission. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=18fe9e19f8f2568efbf36641a600f490&mc=true&node=pt10.1.20&rgn=div5

10 CFR Part 835 — "Occupational Radiation Protection." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=bba32df19249345b2a59046010dc267a&mc=true&node=pt10.4.835&rgn=div5

10 CFR Part 850 — "Chronic Beryllium Disease Prevention Program." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=cf107416800dee5f3aee2bf0e9a52389&mc=true&node=pt10.4.850&rgn=div5

10 CFR Part 851 — "Worker Safety and Health Program." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=16254389c07c98991085c732029dae22&mc=true&node=pt10.4.851&rgn=div5

10 CFR Part 1021 — "National Environmental Policy Act Implementing Procedures." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=7badeb153b53b77d8297172e1d76d083&mc=true&node=pt10.4.1021&rgn=div5

29 CFR Part 1910 — "Occupational Safety and Health Standards." *Labor*. Occupational Safety and Health Administration, Department of Labor. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=005fb664925b2c2130760fcc3be7e2e2&mc=true&node=pt29.6.1910&rgn=div5

29 CFR Part 1926 — "Safety and Health Regulations for Construction." *Labor*. Occupational Safety and Health Administration, Department of Labor. Code of Federal Regulations. Available online: https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1926

40 CFR Part 61 — "National Emission Standards for Hazardous Air Pollutants." *Protection of Environment*. Environmental Protection Agency. *Code of Federal Regulations*. Available online:

https://www.ecfr.gov/cgi-bin/text-idx?SID=cefcdea2e5e7fe3f063ee5191daeaf5f&mc=true&node=pt40.10.61&rgn=div5

40 CFR Part 141 "National Primary Drinking Water Regulations." *Protection of Environment*. Environmental Protection Agency. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=bba32df19249345b2a59046010dc267a&mc=true&node=pt10.4.835&rgn=div5

40 CFR Part 302 "Designation, Reportable Quantities, and Notification." *Protection of Environment*. Environmental Protection Agency. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=8e5b65ce921d4925521ae510c892ab31&mc=true&node=pt40.30.302&rgn=div5

40 CFR Part 1502 "Environmental Impact Statement." *Protection of Environment*. Council on Environmental Quality. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-40/chapter-V/subchapter-A/part-1502

Army 1989 U.S. Army, "Final Programmatic Environmental Impact Statement Biological Defense Research Program," Medical Research and Development Command, April 1989.

BLS 2021 Bureau of Labor Statistics. "Injuries and Fatalities." Available at: https://www.dir.ca.gov/oprl/Injuries/Demographics/2019/PrivateIndustry/2019Table7-PrivateIndustry.html (accessed November 2021).

CDC 2021 Centers for Disease Control and Prevention. "Underlying Cause of Death, 1999-2019," https://wonder.cdc.gov/ucd-icd10.html, (accessed March 24, 2021).

CDC-NIH 2020 Centers for Disease Control and Prevention-National Institutes of Health. "Biosafety in Microbiological and Biomedical Laboratories," 6th edition, Revised June 2020. Available online: https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final-3.pdf

DOE 1994 U.S. Department of Energy. "DOE Handbook: Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, Volume I – Analysis of Experimental Data," DOE-HDBK-3010, December 1994.

DOE 1997 U.S. Department of Energy. "DOE Standard: Hazard Categorization of DOE Nuclear Facilities," DOE-STD-1027-92, Change Notice 1, September 1997.

DOE 2002a U.S. Department of Energy (DOE), "Recommendations for Analyzing Accidents Under the National Environmental Policy Act," July 2002.

DOE 2002b U.S. Department of Energy (DOE), "DOE Standard: Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities," DOE-STD-1020-2002, January 2002.

DOE 2007 U.S. Department of Energy (DOE), "DOE Standard: Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities," DOE-STD-5506-2007, April 2007.

DOE 2010 U.S. Department of Energy (DOE), "DOE Guide: Safety Software Guide for Use with 10 CFR 830 Subpart A, *Quality Assurance Requirements*, and DOE O 414.1C, *Quality Assurance*," DOE G 414.1-4, Certified November 3, 2010.

DOE 2011a DOE Order 436.1: Department Sustainability." May 2, 2011. Available at: https://www.directives.doe.gov/directives-documents/400-series/0436.1-Border/@@images/file

DOE 2014 U.S. Department of Energy. "DOE Standard: Preparation of Nonreactor Nuclear Facility Documented Safety Analysis," DOE-STD-3009, November 2014.

DOE 2018a U.S. Department of Energy. "Office of Enterprise Assessments Assessment of Occupational Injury and Illness Recordkeeping and Reporting at the Lawrence Livermore National Laboratory." June 2018. https://www.energy.gov/sites/default/files/2018/06/f52/Assessment%20of%20OII%20Recordkeeping%20and%20Reporting%20at%20LLNL.pdf.

DOE 2018c U.S. Department of Energy. "DOE Standard: Hazard Categorization of DOE Nuclear Facilities," DOE-STD-1027-2018, November 27, 2018.

DOE 2020a U.S. Department of Energy. "Computerized Accident/Incident Reporting System." Available online: https://data.doe.gov/MS/asp/Main.aspx. (accessed May 2020).

DOE 2020b U.S. Department of Energy. "DOE Order: Quality Assurance," DOE O 414.1D, Change 2, September 15, 2020.

DOE 2021	U.S. Department of Energy. "Protective Action Criteria (PAC) with AEGLs, ERPGs, & TEELs." Available online: https://www.energy.gov/ehss/protective-action-criteria-pac-aegls-erpgs-teels (accessed March 25, 2021)
DOE Order 151.1D	"Comprehensive Emergency Management System." Approved August 11, 2016. Available online: https://www.directives.doe.gov/directives-documents/100-series/0151.1-Border-d/@@images/file
DOE Order 436.1	"Departmental Sustainability." Approved May 2, 2011. Available online: https://www.directives.doe.gov/directives-documents/400-series/0436.1-Border/@@images/file
DOE Order 440.1A	"Worker Protection Management for DOE Federal and Contractor Employees." Approved March 27, 1998. Available online: https://www.directives.doe.gov/directives-documents/400-series/0440.1-Border-a/@@images/file
DOE Order 458.1	"Radiation Protection of the Public and the Environment." Approved February 11, 2011, Change 4, September 15, 2020. Available online: https://www.directives.doe.gov/directives-documents/400-series/0458.1-border-chg4-ltdchg/@@images/file
DOE Order 5400.5	"Chg 2, Radiation Protection of the Public and the Environment." Approved January 7, 1993. Available online: https://www.directives.doe.gov/directives-documents/5400-series/5400.05-Border-c2/@@images/file
DOE-STD-1212-2019	"Explosives Safety." DOE-STD-1212-2019. November. Available online: https://www.standards.doe.gov/standards-documents/1200/1212-astd-2019/@@images/file
DOE-STD-3009	"Preparation of Nonreactor Nuclear Facility Documented Safety Analysis." DOE-STD-3009-2014. November. Available online: https://www.standards.doe.gov/standards-documents/3000/3009-astd-2014/@@images/file
Homann & Aluzzi 2019	Steven G. Homann and Fernando Aluzzi, "HotSpot, Health Physics Codes, Version 3.1.1, User's Guide," National Atmospheric Release Advisory Center, Lawrence Livermore National Laboratory, LLNL-SM-636474, June 11, 2019.
Homann 2015.	Homann, S. et al., "EPIcode Version 8.0 User's Guide," LLNL-SM-672406, National Atmospheric Release Advisory Center, Lawrence Livermore National Laboratory, Livermore, CA.

ICRP 1979	International Commission on Radiological Protection (ICRP). *Limits for Intakes of Radionuclides by Workers*. ICRP Publication 30. Ann. ICRP 2 (3-4). Available online: https://www.icrp.org/publication.asp?id=ICRP%20Publication%2030%20(Part%201).
ICRP 1991	International Commission on Radiological Protection (ICRP). *1990 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 60. Ann. ICRP 21 (1-3).
ICRP 1994	International Commission on Radiological Protection (ICRP). *Dose Coefficients for Intakes of Radionuclides by Workers*. ICRP Publication 68. Ann. ICRP 24 (4).
Lawrence 2002	Lawrence, Andy. "Memorandum on the Radiation Risk Estimation From Total Effective Dose Equivalents (TEDEs)." Office of Environmental Policy and Guidance, Washington, D.C., August 9, 2002.
LLNL 2016a	Lawrence Livermore National Laboratory. *Site Annual Environmental Report 2015*. UCRL-TR-50027-15. ID 1431. Livermore, CA. October 1, 2016. Available online: https://saer.llnl.gov/saer15/saer15_home.html
LLNL 2016b	Lawrence Livermore National Laboratory. *ES&H Manual*. Volume I, Part 3: Safety Analysis and Work Plans and Procedures, Document 3.1 Nonnuclear Safety Basis Program. UCRL-AM-133867-VOL-I-PT-3.1-2015. Livermore, CA. Implementation date: March 7, 2016.
LLNL 2016c	Lawrence Livermore National Laboratory. *LLNL Site 200 Risk Management Plan Technical Supplement*. LLNL-MI-702782. ID 1036. Livermore, CA. September 2016.
LLNL 2016e	Lawrence Livermore National Laboratory. *Emergency Plan*. LLNL-MI-681599, Revision 21. Lawrence Livermore National Laboratory, Livermore, CA. January 2016.
LLNL 2017a	Lawrence Livermore National Laboratory. *Site Annual Environmental Report 2016*. UCRL-TR-50027-16. ID 1432. Livermore, CA. October 1, 2017. Available online: https://saer.llnl.gov/saer16/saer16_home.html
LLNL 2017b	Lawrence Livermore National Laboratory. *ES&H Manual*. Volume II Part 20: Ionizing Radiation, Non-Ionizing Radiation." ID 1313. Livermore, CA. April 10, 2017.

LLNL 2017c Lawrence Livermore National Laboratory. *Transportation Safety Basis Document for Nonnuclear Onsite Transfer Activities at Lawrence Livermore National Laboratory–Site 300*. UCRL-MI-234983-REV-3. ID 1082. Livermore, CA. August 2017. **OFFICIAL USE ONLY.**

LLNL 2017e Lawrence Livermore National Laboratory. *Tier-2 Safety Basis Document, High Explosives Application Facility (HEAF) Building 191*, *Revision 2*. LLNL-MI-797357. ID 1146. Livermore, CA. December 2017. **OFFICIAL USE ONLY.**

LLNL 2017f Lawrence Livermore National Laboratory. *Weapons and Complex Integration, Radiography Facility—Building 239, Documented Safety Analyses*. UCRL-AR-147501-12. ID 1005. Livermore, CA. December 2017. **OFFICIAL USE ONLY.**

LLNL 2017g Lawrence Livermore National Laboratory. *Weapons and Complex Integration, Hardened Engineering Test Building—Building 334, Documented Safety Analyses*. UCRL-AR-123109-10. ID 1014. Livermore, CA. January 2017. **OFFICIAL USE ONLY/UNCLASSIFIED UNCONTROLLED NUCLEAR INFORMATION.**

LLNL 2017j Lawrence Livermore National Laboratory. *Emergency Planning Hazards Assessment, Buildings 365/368/255, Biosafety Level 2/3 Facilities, Revision 4*. LLNL-TR-726797. ID 1646. Livermore, CA. March 2017. **OFFICIAL USE ONLY.**

LLNL 2017k Lawrence Livermore National Laboratory. *Transportation Safety Basis Document for Nonnuclear Onsite Transfer Activities at Lawrence Livermore National Laboratory–Main Site*. UCRL-TM-226938, Rev. 4. ID 1081. Livermore, CA. February 2017. **OFFICIAL USE ONLY.**

LLNL 2017l Lawrence Livermore National Laboratory. *Draft Environmental Assessment for the Proposed Increase in the Weight of Explosives Detonated at Lawrence Livermore National Laboratory Experimental Test Site, Site 300*. DOE/EA-2076. Livermore, CA. November 2017.

LLNL 2017m Lawrence Livermore National Laboratory. *Building 131 High Bay Tier-3 Safety Basis Document*. ID 1789. Livermore, CA. December 2017.

LLNL 2017n Lawrence Livermore National Laboratory. *Tier 2 Safety Basis Document (SBD) Multi-User Tandem Building 235*. ID 1717. Livermore, CA. May 19, 2017.

LLNL 2018a Lawrence Livermore National Laboratory. *LLNL Occupational Health and Safety Management System (OHSMS)*. ID 1224. Livermore, CA. April 10, 2018.

LLNL 2018b Lawrence Livermore National Laboratory. *Integrated Safety Management System*. ID 1263. Livermore, CA. March 29, 2018.

LLNL 2018c Lawrence Livermore National Laboratory. *LLNL Environmental Management System Description*. ID 1261. Livermore, CA. March 29, 2018.

LLNL 2018d Lawrence Livermore National Laboratory. *Site Annual Environmental Report 2017*. UCRL-TR-50027-17. Livermore, CA. October 1, 2018. Available online: https://saer.llnl.gov/saer17/saer17_home.html

LLNL 2018e Lawrence Livermore National Laboratory. *Site 300, Tier 3 Safety Basis Document, Revision 1*. LLNL–TM–938865, ID 1757. Livermore, CA. June 2018. **OFFICIAL USE ONLY.**

LLNL 2018f Lawrence Livermore National Laboratory. *Weapons and Complex Integration, Tritium Facility—Building 331, Documented Safety Analyse*s. UCRL-AR-114203-11. ID 1008. Livermore, CA. May 2018. **OFFICIAL USE ONLY.**

LLNL 2018g Lawrence Livermore National Laboratory. *Tier 2 Safety Basis Document for the Building 581-582 Complex*. NIF-5019666-AJ, Revision 4. ID 1276. Livermore, CA. March 19, 2018.

LLNL 2018h Lawrence Livermore National Laboratory. *Emergency Planning Hazards Assessment, Building 131 High Bay, Revision 6*. LLNL-TR-754498. ID 1643. Livermore, CA. June 2018. **OFFICIAL USE ONLY.**

LLNL 2018i Lawrence Livermore National Laboratory. *Facility Safety Plan, High Explosives Applications Facility (HEAF) Building 191*. LLNL-MI-797241. ID 1145. Livermore, CA. May 2018. **OFFICIAL USE ONLY.**

LLNL 2018j Lawrence Livermore National Laboratory. *Lawrence Livermore National Laboratory Transportation Safety Document, Packaging and Transportation Safety Program*. UCRL-MA-152462-REV-7. ID 1083. Livermore, CA. December 2018. **OFFICIAL USE ONLY.**

LLNL 2018k Lawrence Livermore National Laboratory. *LLNL Disaster Response Plan*. ID 2031. Livermore, CA. December 2018.

LLNL 2018l Lawrence Livermore National Laboratory. *Tier-3 Safety Basis Document, B231V-OS232FA-B233GV Complex*. Revision 4. ID 2009. Livermore, CA. December 2018.

LLNL 2019b Lawrence Livermore National Laboratory. *Site Annual Environmental Report 2018*. UCRL-TR-50027-18. Livermore, CA. October. Available online: https://saer.llnl.gov/report-archive/environmental-annual-2018

LLNL 2019c Lawrence Livermore National Laboratory. *LLNL Radiation Control Manual*. LLNL-TM-790740; MAN-2050. ID 1343. Livermore, CA. September 26, 2019.

LLNL 2019d Lawrence Livermore National Laboratory. Distribution of Employee Doses. ID 1475. Livermore, CA. December 3, 2019.

LLNL 2019e Lawrence Livermore National Laboratory. *Lawrence Livermore National Laboratory Main Site, Hazardous Materials Business Plan – 2019 Update*. LLNLMI-615252-19. ID 1018. Livermore, CA. March 2019.

LLNL 2019f Lawrence Livermore National Laboratory. *LLNL Facility Screening Report (SCR) for B165. Rev. 1*. B165 SCLLNL. ID 1608. Livermore, CA. March 2019.

LLNL 2019g Lawrence Livermore National Laboratory. *Environmental Safety & Health Manual.* Volume II, Part 14: Chemical, Document 14.1LLNL Chemical Safety Management Program. UCRL-AM-133867-VOL-2-PT-14.1-2017. ID 1193. Livermore, CA. Approval date: January 2019.

LLNL 2019h Lawrence Livermore National Laboratory. *Emergency Planning Hazards Assessment, Site 300*. Revision 6. LLNL-TR-795779. ID 1647. October 2019. **OFFICIAL USE ONLY.**

LLNL 2019i Lawrence Livermore National Laboratory. *LLNL NESHAPs 2018 Annual Report*. Livermore, CA.

LLNL 2019k Lawrence Livermore National Laboratory. *Tier 3 Safety Basis Document B151 Complex Building 151 Building 152 Building 154*. LLNL-MI-808089. ID 1708. Livermore, CA. February 27, 2019. **OFFICIAL USE ONLY.**

LLNL 2019l Lawrence Livermore National Laboratory. *Weapons and Complex Integration, Plutonium Facility—Building 332, Documented Safety Analyses*. UCRL-AR-119434-13. Livermore, CA. November 2019. **OFFICIAL USE ONLY/UNCLASSIFIED UNCONTROLLED NUCLEAR INFORMATION.**

LLNL 2020a Lawrence Livermore National Laboratory. *Site Annual Environmental Report 2019*. UCRL-TR-50027-19. ID 2007. Livermore, CA. October 2020.

LLNL 2020b Lawrence Livermore National Laboratory. *LLNL NESHAPs 2019 Annual Report*. UCRL-TR-113867-20. ID 1782. Livermore, CA. June 2020. Available online: https://saer.llnl.gov/sites/saer/files/2020-11/NESHAPs_Report_2019.pdf (accessed December 2020).

LLNL 2020c Lawrence Livermore National Laboratory. *2019 Annual Yearbook for the LLNL SW/SPEIS*. LLNL-AR-811785. ID 1784. Livermore, CA. June 2020.

LLNL 2020d Lawrence Livermore National Laboratory. "Accident Question." Email from George Anderson, LLNL, on September 28, 2020.

LLNL 2020e Lawrence Livermore National Laboratory. "MACCS2 Met Data." Livermore, CA. April 2020.

LLNL 2020f Lawrence Livermore National Laboratory. *Emergency Planning Hazards Assessment, Superblock: Buildings 239, 331, 332, & 334, Revision 1*. LLNL-TR-797499. ID 1648. Livermore, CA. January 2020. **OFFICIAL USE ONLY.**

LLNL 2020g Lawrence Livermore National Laboratory. *Site 300, Explosive Test Facility, Prescribed Burn/Smoke Management Plan*. UCRL-AR-154174-REV-17. Livermore, CA. April 2020.

LLNL 2021a Lawrence Livermore National Laboratory. "NIF Worker Dose." Email from Ken Kasper to Hank Khan on September 16, 2021. Project ID 2111.

LLNL 2021b Lawrence Livermore National Laboratory. *Operational Notes for No-Action and Proposed Action Facilities*. ID 1998. Livermore, CA. March 2021.

LLNL 2021c Lawrence Livermore National Laboratory. *Facilities Information Management System*. ID 1985. Livermore, CA.

LLNL 2021d Lawrence Livermore National Laboratory. *U.S. Department of Energy Occupational Radiation Exposure for CY 2019*. ID 2054. Livermore, CA. January 12, 2021.

LLNL 2021e Lawrence Livermore National Laboratory. *Accident Scenario Analyses for the National Ignition Facility*," K. Kasper, LLNL-MI-820121. ID2008. Livermore, CA. March 3, 2021.

LLNL 2021f Lawrence Livermore National Laboratory. *Lawrence Livermore National Laboratory Emergency Management Plan*. Revision 26. LLNL-MI-819776. ID 2032. Livermore, CA. January 2021.

LLNL 2021h Lawrence Livermore National Laboratory. *Emergency Planning Hazards Assessment, Building 322, Metal Finishing Facility, Revision 8*. LLNL-TR- 820393. ID 2118. Livermore, CA. January 2021. **OFFICIAL USE ONLY.**

LLNL 2021i Lawrence Livermore National Laboratory. "App C: NIF TPS Fire Scenario." Email from Hank Khan, LLNL, on November 8, 2021. Livermore, CA.

LLNL 2021j Lawrence Livermore National Laboratory. *Documented Safety Analyses for the Waste Storage Facilities*. LLNL-TM-688339 Rev 2. ID 2158. Livermore, CA December 2021.

NCRP 2009 National Council on Radiation Protection and Measurements (NCRP). *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 160. March 3, 2009. Available online: https://pubs.rsna.org/doi/pdf/10.1148/radiol.2532090494 . Accessed March 2021.

NNSA 2002 *Environmental Assessment for the Proposed Construction and Operation of a Biosafety Level 3 Facility at Lawrence Livermore National Laboratory, Livermore, California*. DOE/EA-1442. National Nuclear Security Administration. December 2002.

NNSA 2005 National Nuclear Security Administration. *Final Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement*. DOE/EIS-0348 and DOE/EIS-0236-S3. ID 2087. March 2005. Available online: https://www.energy.gov/nepa/downloads/eis-0348-and-eis-0236-s3-final-site-wide-environmental-impact-statement

NNSA 2008 National Nuclear Security Administration. *Final Revised Environmental Assessment for The Proposed Construction and Operation of a Biosafety Level 3 Facility at Lawrence Livermore National Laboratory, Livermore, California.* DOE/EA-1442R. January 2008.

NNSA 2011 — National Nuclear Security Administration. *Supplement Analysis of the 2005 Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory*. DOE/EIS-0348-SA-03. ID 20191. August 2011. Available online: https://www.energy.gov/sites/prod/files/EIS-0348-SA_03-2011.pdf

NRC 1983 — U.S. Nuclear Regulatory Commission. Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants. Regulatory Guide 1.145, Revision 1. Reissued February 1983.

NRC 2021 — U.S. Nuclear Regulatory Commission. "Glossary." U.S. Available online: https://www.nrc.gov/reading-rm/basic-ref/glossary/lethal-dose-ld.html (accessed March 24, 2021)

NRC 2003 — U.S. Nuclear Regulatory Commission. "Regulatory Guide 1.195: Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors." May 2003. Available online: https://www.nrc.gov/docs/ML0314/ML031490640.pdfhttps://www.nrc.gov/docs/ML0314/ML031490640.pdf (accessed August 2021)

ORNL 1998 — Oak Ridge National Laboratory. *An Updated Nuclear Criticality Slide Rule, Functional Slide Rule*. NUREG/CR-6504, Volume 2, ORNL/TM-13322/V2. Oak Ridge, TN. April 1998.

Pinkston 2022 — Pinkston, David. *Increased Inventory Limits for B235 in the New Sitewide Environmental Impact Statement (SWEIS)*. Memorandum To: Tom Arsenlis, Deputy Program Director for Weapons Physics and Design, From: David Pinkston, Safety Basis Division Leader, SB22-003, May 4, 2022.

PNNL 2012 — Pacific Northwest National Laboratory. RASCAL 4: Description of Models and Methods. NUREG-1940. Richland, WA. December 2012.

Ries et al. 2002 — National Council on Radiation Protection and Measurement (NCRP), Risk Estimates for Radiation Protection, NCRP Report No. 115, 1993, First Edition, First Printing. (ISBN: 0929600347), National Council on Radiation Protection, Bethesda, MD, December 31, 1993.

Sandia 1990 — "MELCOR Accident Consequence Code System (MACCS), Model Description," NUREG/CR-4691, SAND86-1562, Vol. 2. Sandia National Laboratories. February 1990.

UNECE 2019 United Nations Economic Commission for Europe (UNECE), "Globally Harmonized System of Classification and Labelling of Chemicals," ST/SG/AC.10/30/Rev.8, 2019.

USEPA 2008 U.S. Environmental Protection Agency. "Radiation Risk Assessment Software: CAP88 and CAP88 PC." Available at: http://www.epa.gov/radiation/assessment/CAP88/ index.html.

USEPA 2013 U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration, "ALOHA® (Areal Locations of Hazardous Atmospheres) 5.4.4," NOAA Technical Memorandum NOS OR&R 43, November 2013.

USEPA 2016 U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration, "ALOHA Software," Version 5.4.7, https://www.epa.gov/cameo/aloha-software (accessed: March 29, 2022), September 2016.

USEPA 2017 U.S. Environmental Protection Agency. "PAG Manual, Protective Action Guides and Planning Guidance for Radiological Incidents." EPA-400/R-17/001. Office of Radiation and Indoor Air. January. Available online: https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed July 7, 2021).

Willis 1976 Willis, Charles, "Prompt Neutron and Gamma Doses from an Accidental Criticality," U.S. Nuclear Regulatory Commission, circa 1976.

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APPENDIX D

Radiological Transportation

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D RADIOLOGICAL TRANSPORTATION

D.1 INTRODUCTION

Transportation of any commodity involves a risk to both transportation crew members and members of the public. This risk results directly from transportation-related accidents and indirectly from increased levels of pollution from vehicle emissions, regardless of the cargo. The transport of certain materials, such as radioactive waste, can pose an additional risk due to the unique nature of the material itself. To permit a complete appraisal of the environmental impacts for the two alternatives, the human health risks associated with the transportation of radioactive materials to and from LLNL and wastes from LLNL on public highways were assessed.

This appendix provides an overview of the approach used to assess the human health risks that could result from transportation of radiological materials and wastes between LLNL and several potential destinations across the United States' DOE/NNSA complex. The topics in this appendix include the scope of the subject transportation impact evaluation, packaging and determination of potential shipping routes, the analytical methods used for the impact evaluation (e.g., computer models, scaling, etc.), as well as other key supporting assumptions that were employed. In addition, to aid in understanding and interpreting the evaluation results, specific areas of uncertainty are described with an emphasis on how those uncertainties may affect comparisons between the alternatives.

The impact evaluation results are presented in this appendix in terms of "per-shipment risk factors," as well as the annualized risks for a given alternative. Per-shipment risk factors provide an estimate of the risk from a single shipment. The annualized risks for a given alternative are estimated by multiplying the expected number of shipments in a year by the appropriate per-shipment risk factor. These risk factors were developed with the intention of estimating the impact of transporting one shipment of radioactive material or waste cargo over a unit-distance of travel in any given population-density zone. The risk factors were combined with routing information, such as shipment distances through various population-density zones, to determine the overall risk for a single shipment between a given origin and destination. Derived risk factors were fundamentally based upon the initial assessment of travel on interstate highways and freeways, as required by 49 CFR Parts 171 to 178 for highway-route-controlled quantities of radioactive material and waste cargo within rural, suburban, and urban population zones, via the use of the Radioactive Material Transportation Risk Assessment (RADTRAN) model (discussed below).

D.2 SCOPE OF ASSESSMENT

The scope of the transportation human health risk evaluation, including transportation activities, applicable packaging and transportation regulations, transportation modes, emergency response, applied assessment methodology, and derived radiological impacts, are described in the sections below. The scope of this analysis only includes programmatic shipments between LLNL and other DOE/NNSA sites. Additionally, radioactive waste shipments from LLNL are sent directly to commercial and/or DOE/NNSA sites.

D.2.1 Transportation-related Activities

The transportation risk evaluation is limited to estimating the human health risks related to transportation for each alternative. This includes incident-free risks related to being in the vicinity of a shipment during transport or at stops, as well as accident risks. The impacts of increased transportation levels on local traffic flow or infrastructure are addressed in Chapter 5, Section 5.11 of this SWEIS.

D.2.2 Packaging and Transportation Regulations

This section provides a high-level summary of radioactive materials and waste packaging and transportation regulations. The packaging and transportation of radioactive materials and waste are highly regulated. The U.S. Department of Transportation (USDOT) and the U.S. Nuclear Regulatory Commission (NRC) have primary responsibility for federal regulations governing commercial radioactive materials and waste transportation. In addition, the U.S. Department of Energy (DOE) works with DOT and NRC in developing requirements and standards for radioactive materials and waste transportation. DOE, including NNSA, has broad authority under the Atomic Energy Act of 1954, as amended, to regulate all aspects of activities involving radioactive materials and /waste that are undertaken by DOE or on its behalf, including the transportation of radioactive materials and waste. While DOE can regulate under AEA, the vast majority of shipments are performed by approved commercial carriers operating under DOT and NRC rules.

The regulatory standards for packaging and transporting radioactive materials and waste cargo are designed to achieve the following four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation by specific limitations on allowable radiation levels.
- Contain radioactive material and /waste in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria).
- Prevent nuclear criticality (an unplanned nuclear chain reaction that could occur as a result of concentrating too much fissile material in one place).
- Provide physical protection against theft and sabotage during transit.

The CFR details regulations pertaining to the ground transportation of radioactive materials and waste cargo published by DOT at 49 CFR Parts 106, 107, and 171–178; and NRC at 10 CFR Parts 20, 61, 71, and 73. International Air Transport Association (IATA) regulations for shipment via aircraft can be found in IATA-published criteria regarding hazardous cargo protocols. For the U.S. Postal Service, Publication 52, "Hazardous, Restricted, or Perishable Mail," specifies the quantities of radioactive material and waste prohibited in surface mail. Interested readers are encouraged to visit the cited resources for the most current regulations, review DOT's *Radioactive Material Regulations Review* (DOT 2008) for a comprehensive discussion on radioactive material and waste cargo regulations, or review DOT's Radioactive Materials Branch website at https://www.phmsa.dot.gov/research-and-development/hazmat/radioactive-materials (DOT-PHMSA 2021).

Packaging Regulation Specifics

Packaging represents the primary barrier between the radioactive material and waste cargo being transported and radiation exposure to the public, workers, and the environment. Transportation packaging for radioactive materials and waste such cargo must be designed, constructed, and maintained to contain and shield its contents during normal transport conditions. For radioactive material and waste, such as special nuclear material (SNM), packaging must contain and shield the contents in the event of severe accident conditions. The type of packaging used is determined by the total radioactive hazard presented by the material or waste within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Specific requirements for these packages are detailed in 49 CFR 173, Subpart I, Class 7 ([Radioactive] Materials). All packages are designed to protect and retain their content under normal operations.

Excepted packaging is limited to transporting materials and waste that present a limited hazard to the public and the environment, because of their extremely low levels of radioactivity and low external radiation dose (e.g., depleted uranium).

Type A packaging, typically a 55-gallon (0.21-cubic-meter) drum or metal boxes, are commonly used to transport radioactive materials or waste with higher concentrations or amounts of radioactivity than that transported in Excepted packages. Type A packaging is designed to protect and retain its contents under normal transport conditions. Furthermore, it must maintain sufficient shielding to limit radiation exposure to handling personnel.

Type B packaging is used to transport material or waste with the highest radioactivity levels and is designed to protect and retain its contents under transportation accident conditions (described in more detail in the following sections). In addition, it must maintain sufficient shielding to limit radiation exposure to handling personnel. There are numerous designs of Type B packages that DOE uses for transporting radioactive materials or waste. Packages are selected based on the purpose and contents for which they will be used. DOE typically uses the TRU Package Transporter-II (TRUPACT II) for contact-handled TRU waste shipments. The TRUPACT-II is a large cask that can contain multiple smaller packages. It includes armor, impact limiters, and thermal insulation. Other similarly robust transporters, such as the HalfPACT, may also be used. For SNM transport the Model BTSP-1 (Bulk Tritium Shipping Package), Model, 9975 and Model 9977 containers are also regularly used Type B packages.

Compliance with packaging requirements is demonstrated by using a combination of simple calculation methods, computer simulation techniques, scale-modeling, or full-scale testing of transportation packages or casks.

Transportation Regulation Specifics

DOT regulates the transportation of hazardous materials in interstate commerce by land, air, and water. DOT specifically regulates the carriers of radioactive materials and waste cargo and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. DOT also regulates the labeling, classification, and marking of radioactive material and waste packaging.

NRC regulates the packaging and transportation of radioactive material and waste for its licensees, including commercial shippers of radioactive materials and waste. In addition, under an agreement with DOT, NRC sets the standards for packages containing fissile materials and Type B packaging.

DOE, through its management directives, Orders, and contractual agreements, ensures the protection of public health and safety by imposing on its transportation activities standards that meet those of DOT and NRC. DOT recognizes in 49 CFR 173.7(d) that packaging made by or under the direction of DOE may be used for transporting Class-7 materials (radioactive materials and radioactive waste) when the packages are evaluated, approved, and certified by DOE against packaging standards equivalent to those specified in 10 CFR Part 71.

DOT also has requirements that help reduce transportation impacts. Some requirements affect drivers, packaging, labeling, marking, and placarding. Other requirements specify requirements specify the maximum dose rate of radioactive material and or waste shipments to limit doses during incident-free transportation. The dose rate requirements for shipments are stated under 49 CFR 173.441.

In general, the number of shipping containers per shipment was estimated on the basis of the dimensions and weight of the shipping containers, the Transport Index[1] (which is the dose rate at 3.3 feet (1 meter) from the container),), and the transport vehicle dimensions and weight limits. The various materials were assumed to be shipped in a single stack aboard their transport vehicle.

D.2.3 Transportation Modes

Radioactive Materials Transportation. For radioactive material transportation scenarios evaluated in this SWEIS, shipments take place in LLNL vehicles, commercial vehicles, by air, or in National Nuclear Security Administration's (NNSA's) Office of Secure Transportation (OST) which consists of Safeguards Transporter (SGT). Shipments involving transport of special nuclear material[2] such as plutonium oxide or metal also use SGTs (NNSA 2020).

Radioactive Waste Transportation. For radioactive waste transportation scenarios evaluated in this SWEIS, shipments take place in LLNL vehicles, commercial vehicles, or by train for large DD&D campaigns. Small waste samples for characterization purposes are shipped by air.

D.2.4 Emergency Response

The Department of Homeland Security (DHS) is responsible for establishing policies for, and coordinating civil emergency management, planning, and interaction with, federal executive agencies that have emergency response functions in the event of a transportation incident. In the event a transportation incident involving nuclear material or waste occurs, guidelines for response actions have been outlined in the National Response Framework (NRF) (DHS 2019).

The Federal Emergency Management Agency (FEMA), an organization within DHS, coordinates federal and state participation in developing emergency response plans and is responsible for the

[1] The Transport Index is a dimensionless number (rounded up to the next tenth) placed on label of a package, to designate the degree of control to be exercised by the carrier. Its value is equivalent to the maximum radiation level in millirem per hour at 1 meter (3.3 feet) from the package, and is dependent on the distribution and quantities of radionuclides, waste density, shielding provided by the packaging, and self-shielding provided by the waste mixture (10 CFR 71.4 and 49 CFR 173.403).

development and the maintenance of the Nuclear/Radiological Incident Annex (NRIA) to the NRF (DHS 2016). NRIA/NRF describes the policies, situations, concepts of operations, and responsibilities of the federal departments and agencies governing the immediate response and short-term recovery activities for incidents involving release of radioactivity to address the consequences of the event.

DHS has the authority to activate Nuclear Incident Response Teams, which include DOE Radiological Assistance Program Teams that can be dispatched from regional DOE Offices in response to a radiological incident. These teams provide first-responder radiological assistance to protect the health and safety of the general public, responders, and the environment and to assist in the detection, identification and analysis, and response to events involving radiological/nuclear material or waste. Deployed teams provide traditional field monitoring and assessment support, as well as a search capability.

DOE uses DOE Order 151.1D, Comprehensive Emergency Management System, as a basis to establish a comprehensive emergency management program that provides detailed, hazard-specific planning and preparedness measures to minimize the health impacts of accidents involving loss of control over radioactive material and chemicals/biologicals. DOE provides technical assistance to other federal agencies and to state and local governments. Contractors are responsible for maintaining emergency plans and response procedures for all facilities, operations, and activities under their jurisdiction and for implementing those plans and procedures during emergencies. Contractor and state and local government plans are fully coordinated and integrated. In addition, DOE established the Transportation Emergency Preparedness Program (http://teppinfo.com/) to ensure its operating contractors and state, tribal, and local emergency responders are prepared to respond promptly, efficiently, and effectively to accidents involving DOE shipments of radioactive material. This program is a component of the overall emergency management system established by DOE Order 151.1D.

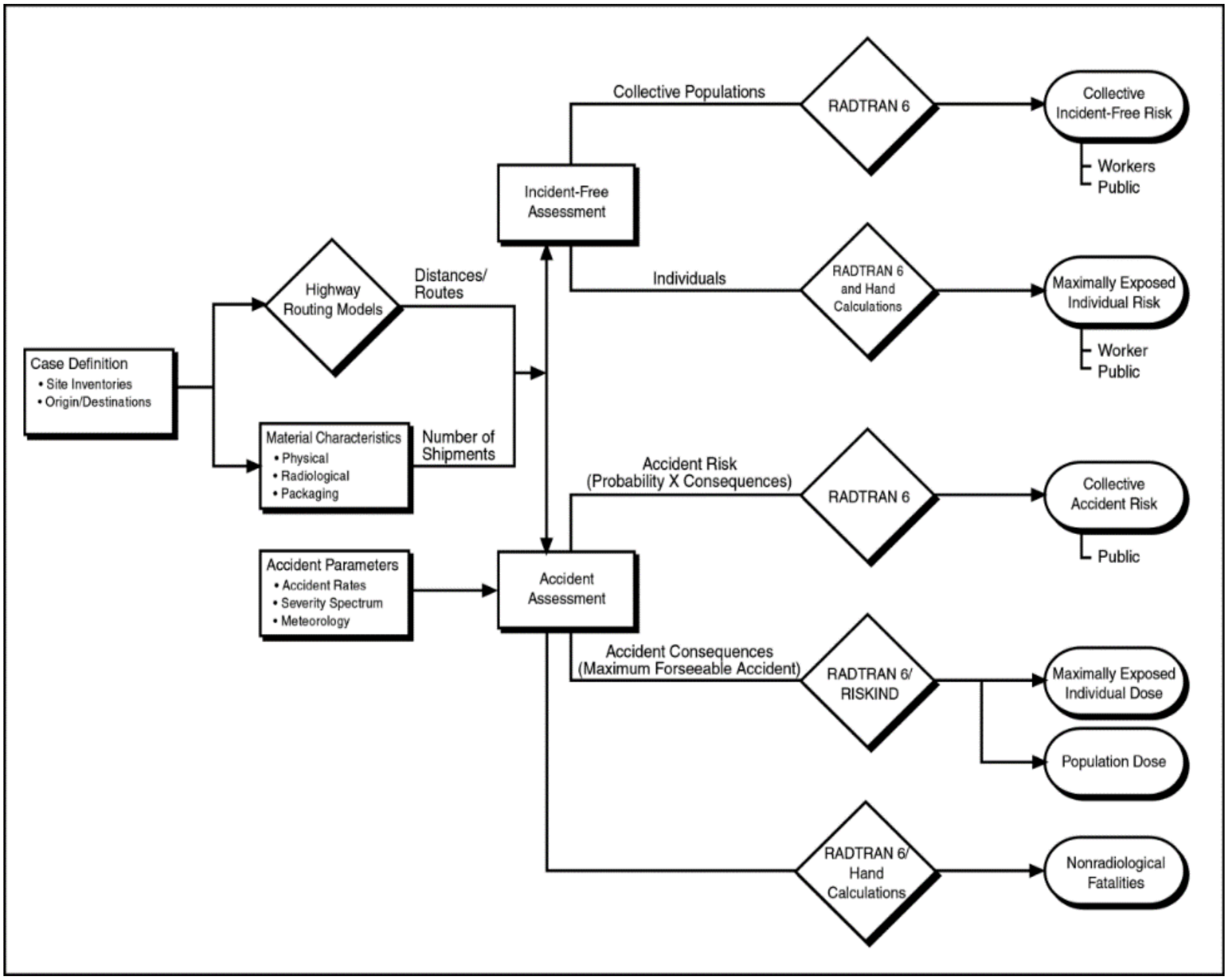
In the event of a release of radiological cargo from a shipment along a route, local emergency response personnel would be first to arrive at the accident scene. It is expected that response actions would be taken in context of the *Nuclear/Radiological Incident Annex*. Based on an initial assessment at the scene, their training, and available equipment, first responders would involve state and Federal resources as necessary. First responders and/or state and Federal responders would initiate actions in accordance with the DOT *Emergency Response Guidebook* (available at https://www.phmsa.dot.gov/hazmat/erg/emergency-response-guidebook-erg) to isolate the incident and perform any actions necessary to protect human health and the environment (such as evacuations or other means to reduce or prevent impacts to the public) (DOT-PHMSA 2021a). Cleanup actions are the responsibility of the carrier. DOE would partner with the carrier, shipper, and applicable state and local jurisdictions to ensure cleanup actions meet regulatory requirements.

To mitigate the possibility of an accident, DOE issued DOE Manual 460.2-1A, *Radioactive Material Transportation Practices Manual for Use with DOE O 460.2A* (DOE 2008b). As specified in this manual, carriers are expected to exercise due caution and care in dispatching shipments. According to the manual, the carrier determines the acceptability of weather and road conditions, whether a shipment should be held before departure, and when actions should be taken while en-route. The manual emphasizes that shipments should not be dispatched if severe weather or bad road conditions make travel hazardous. Current weather conditions, the weather forecast, and road conditions would be considered before dispatching a shipment. Conditions at the point of origin and along the entire route would be considered.

D.3 ASSESSMENT METHODOLOGY

The transportation risk assessment is based on the two SWEIS alternatives, the No Action Alternative and the Proposed Action. Figure D-1 summarizes the transportation risk assessment methodology (SNL 2016). After the alternatives were identified and the requirements of the associated shipping campaigns/activities were understood, data were collected on material characteristics, shipment quantities and frequencies, transportation routes, and accident parameters.

Transportation impacts calculated for this LLNL SWEIS are presented in two parts: impacts from incident-free or routine transportation, and impacts from transportation accidents. Impacts of incident-free transportation and transportation accidents are further divided into non-radiological and radiological impacts. Non-radiological impacts could result from transportation accidents in terms of assessed traffic fatalities. Radiological impacts of incident-free transportation include impacts on members of the public and crew from radiation emanating from materials in the shipment. Radiological impacts from accident conditions consider all foreseeable scenarios that could damage transportation packages, leading to releases of radioactive materials (including waste) to the environment; or from an accident where there is no release of radioactive material but there is external radiation exposure to unbreached packages. Incident-free risks and accident risks are expressed in terms of additional latent cancer fatalities (LCFs) to all applicable receptors, and non-radiological accident risks are expressed in terms of additional traffic fatalities. Consistent with recommendations of the Interagency Steering Committee on Radiation Standards, DOE uses a factor of 6×10^{-4} LCFs per person-rem to convert collective dose to numbers of LCFs (DOE 2003a). Hence, all radiological impacts are calculated in terms of both radiation dose and associated health effects (LCFs) in exposed public and worker populations. Calculated radiation doses are in terms of the total effective dose (see Title 10 of the *Code of Federal Regulations* [CFR], Part 20 [10 CFR Part 20]), which is the sum of the effective dose equivalent from external radiation exposure and the 50-year committed effective dose equivalent from internal radiation exposure. Radiation doses are unitized in terms of person-rem for all populations (public and worker) evaluated in this LLNL SWEIS.



Source: SNL 2016.

Figure D-1. Transportation Risk Assessment – Generalized Approach

Transportation impacts calculated for this LLNL SWEIS are presented in two parts: impacts from incident-free or routine transportation, and impacts from transportation accidents.

The impact of transportation accidents is expressed in terms of probabilistic risk, which is the probability of an accident multiplied by the consequences of that accident and summed over all reasonably conceivable accident conditions. Hypothetical transportation accident conditions ranging from low-speed "fender-bender" collisions to high-speed collisions with or without fires were analyzed. The frequencies of accidents and consequences were evaluated using a method developed by NRC and originally published in the *Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes*, NUREG-0170 (NRC 1977); *Shipping Container Response to Severe Highway and Railway Accident Conditions*, NUREG/CR-4829 (NRC 1987); and *Reexamination of Spent Fuel Shipping Risk Estimates*, NUREG/CR-6672 (NRC 2000). These reports are collectively known (i.e., compiled) as the *Radioactive Material Transport Study,* NUREG-0170; *Modal Study*, NUREG/CR-4829; and *Reexamination Study*, NUREG/CR-6672.

Transportation-related risks are calculated and presented separately for workers and members of the general public. The workers considered in the evaluation are truck crew members involved in the actual transportation. The general public includes all persons who could be exposed to a shipment while it is moving or stopped during transit.

The preponderance of the ground transportation evaluation was performed via an approach whereby previously determined impact data for numerous comparable shipping scenarios (i.e., various materials in various containers to various destinations) were applicably adapted/scaled to determine best likely impact estimates for the multitude of shipment cases analyzed for the two alternatives of this SWEIS. Previous subject data were primarily referenced from the *Final Sitewide Environmental Impact Statement for the Continued Operation of the DOE/NNSA Nevada National Security Site and Offsite Locations in the State of Nevada* (DOE/EIS-0426); the *Final Complex Transformation Supplemental Programmatic Environmental Impact Statement* (DOE/EIS-0236-S4); and the *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (DOE/EIS-0283-S2). The data/results from these original sources were in large part initially derived via the use of the Transportation Routing Analysis Geographic Information System (TRAGIS) computer program, which was used to identify candidate routes and associated distances/populations along those routes (Johnson and Michelhaugh 2003). Such information, along with the properties of the material forms/streams being shipped, along with route-specific accident frequencies, were then entered into the Radioactive Material Transportation Risk Assessment (RADTRAN) 6 computer code (SNL 2016) (or possibly earlier version such as RADTRAN 5), which calculates incident-free transport and accident risks to the public and workers (incident-free only) on a per-shipment basis. Total doses/risks to these receptors for this LLNL SWEIS were then appropriately scaled and subsequently determined by summing the products of the per-shipment risks for each radioactive material/stream shipment type by the total number of shipments for that specific material/stream projected for the year 2030 under each alternative.

RADTRAN 6 was developed by Sandia National Laboratories to calculate individual and population risks associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge. The code's population risk calculations include both the consequences and probabilities of potential exposure events, and include the following potential exposure pathways: cloud shine, ground shine, direct radiation (from loss of shielding), inhalation (from dispersed materials), and resuspension (inhalation of resuspended materials) (SNL 2016). The collective population risk output value is a measure of the total radiological risk posed to an/the exposed population as a whole.

The Risks and Consequences of Radioactive Material Transport (RISKIND) computer code (Yuan et al. 1995) was also employed in the utilized EIS sources referenced above for estimating potential impacts to populations resulting from worst-case maximum reasonably foreseeable transportation accidents. The RISKIND computer code was originally developed for DOE's Office of Civilian Radioactive Waste Management to estimate potential radiological consequences and health risks to individuals and the collective population from exposures associated with the transportation of spent nuclear fuel; however, this code is also applicable to transportation of other cargo types, as the code can model complex atmospheric dispersion and estimate radiation doses to receptors near an accident. RISKIND results discretionarily served as a supplement to the collective risk results calculated with RADTRAN 6, as provided within the referenced EIS's.

Shipment crew members typically consist of a driver and a backup driver for each shipment vehicle. For the public dose analysis, the potentially exposed general population is defined as any persons residing within 0.50 mile of a transport vehicle's projected route (off-link), persons sharing the road with the vehicle (on-link), and nearby persons at the vehicle's rest-stops. It is also conventionally assumed that 10 percent of the time travel through suburban and urban zones would encounter rush-hour conditions, leading to lower average speeds and higher traffic densities. As discussed above, the dose/LCF risks to the exposed population(s) under both alternatives are adjusted to represent the projected population(s) anticipated along all potential routes in the year 2030.

Low-level radioactive waste (LLW) and mixed LLW (MLLW) are primarily transported from LLNL to two individual disposal sites: the Nevada National Security Site (NNSS) in southern Nevada and Energy*Solutions* in Clive, Utah. LLNL estimates that about 85 percent of the LLW and MLLW generated at LLNL will be sent to the NNSS and 15 percent will be sent to Energy*Solutions*. In addition, approximately one to five shipments per year will be expected to be made to permitted/licensed treatment, storage and disposal facilities such as Perma-Fix Environmental Services in Oak Ridge, Tennessee; Perma-Fix in Richland, Washington; and/or Waste Control Specialists (WCS) in Andrews, Texas.[2] Table D-1 below conveys a total expected range of 4,200-7,560 LLW/MLLW shipments over a 15-year period from LLNL to the candidate destinations discussed above. The 4,200 shipments are based on a projected 120 routine shipments/year along with 160 (possibly up to 186) nonroutine shipments/year under the No-Action Alternative, and the 7,560 shipments is based on a projected 120 routine shipments/year along with 384 nonroutine shipments/year under the Proposed Action (*see* Table 3-8).

As for other materials/streams:

- 4 to 8 TRU waste shipments per year are estimated from LLNL to the Waste Isolation Pilot Plant (WIPP) in New Mexico.
- SNM, in the form of Pu oxide or metal (i.e., targets, fuel, pit components, etc.), as well as HEU, are expected to be shipped between LLNL and NNSS and LANL.
- Tritium is anticipated to be shipped up to seven (7) times per year from SRS to LLNL.
- Sealed Cs-137 sources and depleted-uranium (DU) will likely be shipped between the Livermore Site and Site 300 throughout the year.
- Sealed Am-241 sources will be transported between LLNL and other locations across the United States.

For the Am-241 shipments, as well as HEU-metal, in which the origin/destination site may potentially be at a multitude of locations throughout the DOE-complex (or other locations) SRS was conservatively chosen as a bounding case for its long-distance location as well as its route from LLNL going through the heart of several of the country's major population-centers. In a parallel fashion, cross-country transportation from SRS was likewise chosen as the bounding shipment case for the movement of radioactive isotopes and sealed sources to LLNL, with a

[2] NNSA bounded the potential transportation impacts by modelling shipments to Perma-Fix Environmental Services in Oak Ridge, Tennessee. Shipments from LLNL to Oak Ridge, Tennessee would be more than 1,000 miles longer and would transit through more heavily populated areas than shipments to WCS in Andrews, Texas.

representative payload conservatively depicted by one equally comprised of Am-241 and Cs-137 sources.

Table D-1 and Table D-2 below respectively provide the complete listing of expected shipments of all radiological materials/streams to/from LLNL over the next fifteen (15) year period as well as the resulting Year-2030 annualized estimated number of shipments (per alternative) for each material type after scaling factors are applied.

Table D-1. Shipments per Material Category (2020–2035)

Origin-Destination	Material Shipped	Bounding Quantity per Package	Transport Mode	Transport Index	Package	Number of Shipments Projections for Next 15 years
LLNL-LANL	Pu metal or oxide	199 g max	Dedicated commercial truck	< 1.0	9975	30
LANL-LLNL	Pu metal or oxide	199 g max	Dedicated commercial truck	< 1.0	9975	30
LLNL-LANL	Pu metal or oxide	190 g max	Dedicated commercial truck	< 1.0	9977	45
LANL-LLNL	Pu metal or oxide	190 g max	Dedicated commercial truck	< 1.0	9977	30
LLNL-LANL	HEU metal or oxide	13.5 kg max	Dedicated commercial truck	< 1.0	9975	15
LANL-LLNL	HEU metal or oxide	13.5 kg max	Dedicated commercial truck	< 1.0	9975	15
LLNL-LANL	HEU metal or oxide	500 g max	Dedicated commercial truck	< 1.0	9977	15
LANL-LLNL	HEU metal or oxide	500 g max	Dedicated commercial truck	< 1.0	9977	15
LLNL-NNSS	Pu metal or oxide	199 g max	Dedicated commercial truck	< 1.0	9975	15
NNSS-LLNL	Pu metal or oxide	199 g max	Dedicated commercial truck	< 1.0	9975	15
LLNL-NNSS	Pu metal or oxide	190 g max	Dedicated commercial truck	< 1.0	9977	120
NNSS-LLNL	Pu metal or oxide	190 g max	Dedicated commercial truck	< 1.0	9977	120
LLNL-NNSS	HEU metal or oxide	13.5 kg max	Dedicated commercial truck	< 1.0	9975	15
NNSS-LLNL	HEU metal or oxide	13.5 kg max	Dedicated commercial truck	< 1.0	9975	15
LLNL-NNSS	HEU metal or oxide	13.5 kg max	Dedicated commercial truck	< 1.0	9977	15
NNSS-LLNL	HEU metal or oxide	13.5 kg max	Dedicated commercial truck	< 1.0	9977	15
LLNL-SRS	Tritium - gas	2.75 g	Dedicated commercial truck	NA	BTSP-1	75
SRS-LLNL	Tritium - gas	2.75 g	Dedicated commercial truck	NA	BTSP-1	105
Livermore Site-Site 300	U-(Dep) Metal	500 kg max	LLNL truck	< 1.0	Type A package 5-55 gal	225

Origin-Destination	Material Shipped	Bounding Quantity per Package	Transport Mode	Transport Index	Package	Number of Shipments Projections for Next 15 years
Site 300-Livermore Site	U-(Dep) Metal	500 kg max	LLNL truck	< 1.0	Type A package 5-55 gal	75
LLNL-Multiple locations	HEU-Metal	100 g max	Non-dedicated commercial truck	< 1.0	Type A package	1,425
Multiple locations to LLNL	HEU-Metal	100 g max	Non-dedicated commercial truck	< 1.0	Type A package	1,425
Livermore Site-Site 300	Cs-137-Class IV Sealed Source metal	96 mCi 0.00111 g	LLNL Truck	0.3	Type A Cart	15
Site 300-Livermore Site	Cs-137-Class IV Sealed Source oxide	96 mCi 0.00111 g	LLNL Truck	0.3	Type A Cart	15
LLNL-Multiple locations	Am-241 Class IV Sealed Source oxide	100 mCi max 0.0295 g	LLNL truck, Non-dedicated commercial truck, and FedEx Air	0.5	Type A Drum	30
Multiple locations-LLNL	Am-241 Class IV Sealed Source oxide	100 mCi max 0.0295 g	LLNL truck, Non-dedicated commercial truck, and FedEx Air	0.5	Type A Drum	30
LLNL-Multiple locations	LLW/MLLW (expected to include misc. isotopes and sealed sources - metal, oxide, liquid, & gas)	Misc. activities including Type A Quantities	LLNL truck, Non-dedicated commercial truck, dedicated commercial truck	0.5	Excepted packages to Type A packages	4,200-7,560[a]
LLNL-WIPP	TRU/MTRU	Various	Dedicated Commercial Truck	< 1.0	TRUPACT	60
Multiple locations-LLNL	Misc. Isotopes and sealed Sources - metal, oxide, liquid, & gas	Misc. activities including Type A Quantities	LLNL truck, Non-dedicated commercial truck, and FedEx Air	0.5	Excepted packages to Type A packages	3,000-3,225

Note: The estimate of 4,200 shipments over a 15-year period is based on 120 routine shipments/year and 160 (possibly up to 186) – 384 nonroutine shipments/year for the No-Action Alternative. The estimate of 7,560 shipments over a 15-year period is based on 120 routine shipments/year and 384 nonroutine shipments/year for the Proposed Action.
Source: LLNL 2021.

Table D-2a. Annualized Shipments – No-Action Alternative

Material or Wastes	Origin	Destination	Shipments per Year
LLW/MLLW - routine	LLNL	NNSS	102
LLW/MLLW - nonroutine	LLNL	NNSS	16
LLW/MLLW - routine	LLNL	Energy*Solutions*	18
LLW/MLLW - nonroutine	LLNL	Energy*Solutions*	144
LLW/MLLW -routine/nonroutine	LLNL	Perma-Fix or WCS	1 - 5
Pu target material	LLNL or NNSS	NNSS or LLNL	4
Pu target material	LLNL	LANL	2
Pu target material	LANL	LLNL	2
HEU	LLNL or NNSS	NNSS or LLNL	2
HEU	LLNL or LANL	LANL or LLNL	2
Other Pu metal or oxide	LLNL or NNSS	NNSS or LLNL	5
Other Pu metal or oxide	LLNL	LANL	3
Other Pu metal or oxide	LANL	LLNL	2
TRU	LLNL	WIPP	4 – 8[a]
Tritium	LLNL	SRS	5
Tritium	SRS	LLNL	7
Depleted U	Livermore Site	Site 300	15
Depleted U	Site 300	Livermore Site	5
HEU Metal	LLNL or SRS (bounding)	SRS (bounding) or LLNL	95
Cs-137 Sealed Source	Livermore Site or Site 300	Site 300 or Livermore Site	1
Am-241 Sealed Source	LLNL or SRS (bounding)	SRS (bounding) or LLNL	2
Miscellaneous Isotopes and Sealed Sources	SRS (bounding)	LLNL	200
		Total	**645**

a. Could potentially be upwards of 8 shipments per year depending on the scale of TRU processing over the upcoming interim. NNSA analyzed 8 shipments per year.
Source: LLNL 2021.

Table D-2b. Annualized Shipments – Proposed Action

Material or Wastes	Origin	Destination	Shipments per Year
LLW/MLLW - routine	LLNL	NNSS	102
LLW/MLLW - nonroutine	LLNL	NNSS	38
LLW/MLLW - routine	LLNL	EnergySolutions	18
LLW/MLLW - nonroutine	LLNL	EnergySolutions	346
LLW/MLLW -routine/nonroutine	LLNL	Perma-Fix or WCS	1 - 5
Pu target material	LLNL or NNSS	NNSS or LLNL	4
Pu target material	LLNL	LANL	2
Pu target material	LANL	LLNL	2
HEU	LLNL or NNSS	NNSS or LLNL	2
HEU	LLNL or LANL	LANL or LLNL	2
Other Pu metal or oxide	LLNL or NNSS	NNSS or LLNL	5

Material or Wastes	Origin	Destination	Shipments per Year
Other Pu metal or oxide	LLNL	LANL	3
Other Pu metal or oxide	LANL	LLNL	5-6
TRU	LLNL	WIPP	4 - 8[a]
Tritium	LLNL	SRS	5
Tritium	SRS	LLNL	7
Depleted U	Livermore Site	Site 300	15
Depleted U	Site 300	Livermore Site	5
HEU Metal	LLNL or SRS (bounding)	SRS (bounding) or LLNL	95
Cs-137 Sealed Source	Livermore Site or Site 300	Site 300 or Livermore Site	1
Am-241 Sealed Source	LLNL or SRS (bounding)	SRS (bounding) or LLNL	2
Miscellaneous Isotopes and Sealed Sources	SRS (bounding)	LLNL	215
		Total	**888**

a. Could potentially be upwards of 8 shipments per year depending on the scale of TRU processing over the upcoming interim. NNSA analyzed 8 shipments per year.
Source: LLNL 2021.

In summary, planned transportation-related activities for radiological materials and waste under the alternatives evaluated in this SWEIS would predominantly support the following overarching milestones:

- Packaging and Unpackaging Security Category III SNM at LLNL.
- Transporting Security Category III SNM between LLNL and Receiver Sites.
- Storage of Security Category III SNM at LLNL and Receiver Sites.

Of note, LLNL previously completed its packaging, unpackaging, transporting, storage, and phase-out of Security Category I/II SNM in 2012. As discussed before, the LLNL SWEIS transportation evaluation for SNM movement was performed using historical impact data (associated primarily with Security Category I/II SNM shipments) under numerous comparable shipping scenarios, which were examined, adapted, and scaled to determine the best likely impact estimates for the shipping cases in this SWEIS. As such, the previous subject Category I/II shipment dose and risk data referenced from the previous NEPA documents (DOE/EIS-0426; DOE/EIS-0236-S4; and DOE/EIS-0283-S2) serves as a bounding envelope for the radiological impacts that would likely result from the shipment of Security Category III SNM.

In accordance with the above missions, the following shipment/packaging parameters would be routinely implemented:

- All oxide and non-weapon component metal would be packaged to meet the DOT 9975 or 9977 Type B shipping container requirements.
- All enriched uranium oxide would be packaged to meet 9975 or 9977 Type B shipping container requirements.
- All tritium would be packaged to meet the Bulk Tritium Shipping Package (BTSP-1) Type B shipping container requirements.

- Enriched uranium excess metal would be packaged to meet Type A shipping container requirements.
- All TRU would be shipped in TRUPACT-II containers.
- All TRU shipped to WIPP would meet the WIPP waste acceptance criteria (WAC).
- Packaging used by DOE/NNSA for hazardous materials and material/waste shipments are either certified to meet specific performance requirements or built to specifications described in DOT hazardous materials regulations (49 CFR Subchapter C). Plutonium and HEU are unique hazardous materials that require special protection. In addition to meeting the stringent Type B containment and confinement requirements of the NRC's 10 CFR Part 71 and DOT's 49 CFR, packaging for nuclear material components must be certified separately by DOE/NNSA. DOE/NNSA employs a closed Transportation Safeguards System for the inter-site transport of nuclear material components, including Pu and HEU. Specially designed SGTs are utilized to ensure high levels of safety and physical protection.

In essence, the various materials would be placed into packages for shipment. These packages would be loaded at LLNL or elsewhere, shipped to the receiving site, unpacked, and then subsequently placed into storage. The collective bounding dose due to normal operational exposure to cargo handlers and other workers for each loading or unloading operation is estimated to be less than 0.06 person-rem and less than 0.004 person-rem, respectively (DOE/EIS-0236-S4).

D.3.1 Routing Assumptions

As presented in Tables D-1 and D-2 above, to assess incident-free and transportation accident impacts under the alternatives, route characteristics were determined for the following offsite shipment scenarios that would occur as part of LLNL's continuing and future missions:

- Low-level and mixed low-level radioactive waste to the NNSS); the Energy*Solutions* facility in Clive, Utah; and Perma-Fix in Oak Ridge, TN, and Perma-Fix in Richland, Washington, and WCS in Andrews, Texas.
- Pu oxide or metal to/from LANL or NNSS
- Contact-handled transuranic (CH-TRU) waste to WIPP.
- Tritium gas to/from SRS.
- Depleted Uranium to/from Site 300.
- HEU-metal to/from numerous offsite locations (SRS modeled as bounding location).
- Cesium-137 sealed sources to/from Site 300.
- Americium-241 sealed sources to/from numerous offsite locations (SRS modeled as bounding location).
- Other miscellaneous isotopes and sealed sources from numerous offsite locations (SRS modeled as bounding origination point) to LLNL.

Original (pre-scaled) population doses (both for incident-free and accidents) per shipment for each of the above cases that were cited from the previous NEPA references (DOE/EIS-0426; DOE/EIS-0236-S4; and DOE/EIS-0283-S2) were based upon census population data for Year-2000 and Year-2010 used in respective TRAGIS iterations. For this LLNL SWEIS, these data were projected forward to the Year-2030 in the effort of appropriately scaling the subject doses and associated risks applicable to the material transportation scenarios applicable to the two alternatives in this SWEIS. Statewide projections were accordingly obtained via the University of Virginia Weldon Cooper Center's Demographics Research Group (UVA 2018).**Error! Hyperlink reference not valid.**

- The employed population scaling factors (State-weighted-average per route) as well as the total driving distances between LLNL and the candidate shipping sites (which were also scaled/ratioed within the evaluation for determination of impact estimates as needed) are provided in Table D-3

Table D- below. As a general rule, route characteristics that are important to the radiological risk evaluation include the total shipment distance and population distribution along a route. The specific route selected determines both the total potentially exposed population and the expected frequency of transportation-related accidents. Although transparent to the analytical approaches employed in the transportation impact evaluation in this SWEIS, referenced characteristics for shipment routes are conventionally assumed to consist of the following:

- Rural population densities range from 0 to 54 persons per square kilometer (0 to 139 persons per square mile).
- Suburban population densities range from 55 to 1,284 persons per square kilometer (140 to 3,326 persons per square mile).
- Urban population densities include all population densities greater than 1,284 persons per square kilometer (3,326 persons per square mile).

Table D-3. Scaling Values for Year-2030 Population Projections and Route Distances

Origin or Destination to/from LLNL	Material or Stream	States Traversed	Total Distance (mi)	2030 State-Weighted Population Adjustment Scaling Factor(s)
NNSS	LLW/MLLW; Pu oxide/metal (fuel, targets, HEU)	CA, NV	604	1.14 / 1.20
Energy*Solutions*	LLW/MLLW	CA, NV, UT	668	1.18
Perma-Fix, TN [a]	LLW/MLLW	CA, AZ, NM, TX, OK, AR, TN	2,449	1.17
Perma-Fix, WA	LLW/MLLW	CA, OR, WA	766	1.18
LANL	Pu oxide/metal (fuel, targets, HEU)	CA, AZ, NM	1,147	1.18
SRS	Tritium; HEU metal (bounding); Am-241 sources (bounding); other miscellaneous isotopes and sealed sources (bounding)	CA, AZ, NM, TX, OK, AR, TN, MS, AL, GA, SC	2,614	1.16
WIPP	TRU	CA, AZ, NM(1), TX, NM(2)	1,333 or	1.20 or

Origin or Destination to/from LLNL	Material or Stream	States Traversed	Total Distance (mi)	2030 State-Weighted Population Adjustment Scaling Factor(s)
		or CA, NV, ID, UT, CO, NM	1,938	1.23
Site 300	Cs-137 sources; DU	CA	18	1.12

a. NNSA bounded the potential transportation impacts by modelling shipments to Perma-Fix Environmental Services in Oak Ridge, Tennessee. Shipments from LLNL to Oak Ridge, Tennessee would be more than 1,000 miles longer and would transit through more heavily populated areas than shipments to WCS in Andrews, Texas.

D.3.2 Receptors

Transportation-related risks are calculated and presented separately for workers and members of the general public. The workers considered are truck crew members involved in transportation and inspection of the packages. The general public includes all persons who could be exposed to a shipment while it is moving or stopped during transit. For incident-free operation, the affected population includes individuals living within 0.5 miles (800 meters) of each side of the road. For accident conditions, the affected population includes individuals residing within 50 miles (80 kilometers) of the accident. The risk to the affected population is a measure of the radiological risk posed to society as a whole by the alternative being considered. As such, the impact on the affected population is conventionally used as the primary means of comparing alternatives.

D.4 IMPACT RESULTS

Tables D-4 and D-5 below present the potential incident-free and accident impacts associated with transporting radiological materials and wastes for the No-Action Alternative and Proposed Action, respectively, on an annualized basis (representative Year-2030). Accident risk values represent a broad spectrum of accident severities and radioactive release conditions, with accident analyses based on the previous EISs (DOE/EIS-0426; DOE/EIS-0236-S4; DOE/EIS-0283-S2) with normalized probabilities and consequences from similar set of scenarios. The final risk values for the alternatives in this SWEIS represent the LCF risks to the public population within a 50 mile-radius of the hypothetical accident release location. Non-radiological risks are likewise provided for comparison, and are expressed in terms of estimated traffic fatalities. A maximum hypothetical annual dose to a nearest situated resident along the trucking route(s) (i.e., a hypothetical MEI who is consistently present at the same closest location to the roadway for exposure to all potential shipments over a one-year period) is also discussed.

Table D-4. Annualized Transportation Impacts of Radiological Material/Waste– No-Action Alternative

				Incident-Free Dose				Accident	
Material or Waste Form	**Origin**	**Destination**	**Shipments per Year**	**Crew Dose (person-rem)[a]**	**Crew Risk (LCF)**	**Population Dose (person-rem)**	**Population Risk (LCF)**	**Rad Risk (LCF)**	**Non-rad Risk (traffic fatalities)**
LLW/MLLW - routine	LLNL	NNSS	102	1.8	1.1×10^{-3}	0.86	5.2×10^{-4}	4.8×10^{-7}	4.7×10^{-3}
LLW/MLLW - nonroutine	LLNL	NNSS	16	0.29	1.7×10^{-4}	0.14	8.1×10^{-5}	7.6×10^{-8}	7.4×10^{-4}
LLW/MLLW - routine	LLNL	Energy*Solutions*	18	0.25	1.5×10^{-4}	0.14	8.3×10^{-5}	8.1×0^{-8}	1.0×10^{-3}
LLW/MLLW - nonroutine	LLNL	Energy*Solutions*	144	2.0	1.2×10^{-3}	1.10	6.6×10^{-4}	6.5×10^{-7}	8.4×10^{-3}
LLW/MLLW - routine/nonroutine	LLNL	Perma-Fix / WCS	5	0.33	2.0×10^{-4}	0.17	1.0×10^{-4}	9.5×10^{-8}	9.0×10^{-4}
Pu target material	LLNL or NNSS	NNSS or LLNL	4	0.027	1.6×10^{-5}	0.010	5.8×10^{-6}	2.9×10^{-9}	1.5×10^{-4}
Pu target material	LLNL	LANL	2	0.014	8.4×10^{-6}	1.6×10^{-3}	9.6×10^{-7}	1.5×10^{-9}	8.3×10^{-5}
Pu target material	LANL	LLNL	2	0.014	8.4×10^{-6}	1.6×10^{-3}	9.6×10^{-7}	1.5×10^{-9}	8.3×10^{-5}
HEU	LLNL or NNSS	NNSS or LLNL	2	0.038	2.3×10^{-5}	0.031	1.9×10^{-5}	3.6×10^{-10}	6.6×10^{-6}
HEU	LLNL or LANL	LANL or LLNL	2	0.040	2.4×10^{-5}	0.010	6.2×10^{-6}	3.8×10^{-10}	8.3×10^{-5}
Other Pu (metal/oxide)	LLNL or NNSS	NNSS or LLNL	5	0.47	2.8×10^{-4}	0.39	2.3×10^{-4}	1.1×10^{-9}	1.7×10^{-5}
Other Pu (metal/oxide)	LLNL	LANL	3	0.29	1.8×10^{-4}	0.078	4.7×10^{-5}	7.1×10^{-10}	1.2×10^{-4}
Other Pu (metal/oxide)	LANL	LLNL	2	0.20	1.2×10^{-4}	0.052	3.1×10^{-5}	4.7×10^{-10}	8.3×10^{-5}
TRU	LLNL	WIPP	8	0.88	5.3×10^{-4}	1.1	6.5×10^{-4}	4.9×10^{-8}	2.4×10^{-4}
Tritium	LLNL	SRS	5	NA	NA	NA	NA	3.0×10^{-10}	1.2×10^{-4}
Tritium	SRS	LLNL	7	NA	NA	NA	NA	4.1×10^{-10}	1.7×10^{-4}
Depleted U	Livermore Site	Site 300	15	NA	NA	NA	NA	NA	5.6×10^{-4}
Depleted U	Site 300	Livermore Site	5	NA	NA	NA	NA	NA	1.9×10^{-4}
HEU Metal	LLNL or SRS (bounding distance)	SRS (bounding distance) or LLNL	95	1.2	7.2×10^{-4}	1.8	1.1×10^{-3}	8.1×10^{-8}	2.3×10^{-3}
Cs-137 Sealed Source	Livermore Site or Site 300	Site 300 or Livermore Site	1	1.8×10^{-3}	1.1×10^{-6}	5.2×10^{-4}	3.1×10^{-7}	1.2×10^{-11}	3.7×10^{-5}
Am-241 Sealed Source	LLNL or SRS (bounding distance)	SRS (bounding distance) or LLNL	2	0.53	3.2×10^{-4}	0.16	9.4×10^{-5}	3.6×10^{-9}	4.8×10^{-5}
Miscellaneous Isotopes and Sealed Sources	SRS (bounding distance)	LLNL	200	53	0.032	16	9.4×10^{-3}	3.6×10^{-7}	4.8×10^{-3}
		Totals	**645**	**61.6**	**0.037**	**21.6**	**0.013**	**1.9×10^{-6}**	**0.025**

HEU = highly enriched uranium; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NNSS = Nevada National Security Site; SRS = Savannah River Site; WIPP = Waste Isolation Pilot Plant; TRU = transuranic waste; LCF = latent cancer fatality; NA = *de minimis* dose or LCF risk; "(bounding distance)" = transport to/from SRS was evaluated as the bounding case for transport of HEU-metal, Am-241 sources, and other miscellaneous isotopes and sealed sources to/from LLNL.

a. A DOE employee would also need to comply with DOE regulations at 10 CFR Part 835 ("Occupational Radiation Protection"), which limits worker radiation doses to 5 rem/year. At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval. This limit/guideline would apply to any non-TRU waste shipment conducted by DOE personnel. Drivers of TRU waste shipments to WIPP have an administrative exposure guideline of 1 rem/year. Commercial (i.e., non-DOE-employed) drivers are subject to OSHA regulations, which limit the whole-body dose to 5 rem/year (29 CFR 1910.1096), and to the USDOT requirement of 2 millirem/hour inside the truck cab (49 CFR 173.411).

Note: A potential does exist for an occasional shipment (≤1/yr) of mission-related material to be shipped from SRS to NNSS to support LLNL operations at the DAF. The additional annual public/crew radiological impacts from such shipments would add a negligible contribution to the totals shown above.

Table D-5. Annualized Transportation Impacts of Radiological Material/Waste – Proposed Action

				Incident-Free Dose				Accident	
Material or Waste Form	**Origin**	**Destination**	**Shipments per Year**	**Crew Dose (person-rem)[a]**	**Crew Risk (LCF)**	**Population Dose (person-rem)**	**Population Risk (LCF)**	**Rad Risk (LCF)**	**Non-rad Risk (traffic fatalities)**
LLW/MLLW - routine	LLNL	NNSS	102	1.8	1.1×10^{-3}	0.86	5.2×10^{-4}	4.8×10^{-7}	4.7×10^{-3}
LLW/MLLW - nonroutine (max)	LLNL	NNSS	38	0.68	4.1×10^{-4}	0.32	1.9×10^{-4}	1.8×10^{-7}	1.7×10^{-3}
LLW/MLLW - routine	LLNL	Energy*Solutions*	18	0.25	1.5×10^{-4}	0.14	8.3×10^{-5}	8.1×10^{-8}	1.0×10^{-3}
LLW/MLLW - nonroutine (max)	LLNL	Energy*Solutions*	346	4.83	2.9×10^{-3}	2.7	1.6×10^{-3}	1.6×10^{-6}	2.0×10^{-2}
LLW/MLLW - routine/nonroutine (max)	LLNL	Perma-Fix / WCS	5	0.33	2.0×10^{-4}	0.17	1.0×10^{-4}	9.5×10^{-8}	9.0×10^{-4}
Pu target material	LLNL or NNSS	NNSS or LLNL	4	0.027	1.6×10^{-5}	0.010	5.8×10^{-6}	2.9×10^{-9}	1.5×10^{-4}
Pu target material	LLNL	LANL	2	0.014	8.4×10^{-6}	1.6×10^{-3}	9.6×10^{-7}	1.5×10^{-9}	8.3×10^{-5}
Pu target material	LANL	LLNL	2	0.014	8.4×10^{-6}	1.6×10^{-3}	9.6×10^{-7}	1.5×10^{-9}	8.3×10^{-5}
HEU	LLNL or NNSS	NNSS or LLNL	2	0.038	2.3×10^{-5}	0.031	1.9×10^{-5}	3.6×10^{-10}	6.6×10^{-6}
HEU	LLNL or LANL	LANL or LLNL	2	0.040	2.4×10^{-5}	0.010	6.2×10^{-6}	3.8×10^{-10}	8.3×10^{-5}
Other Pu (metal/oxide)	LLNL or NNSS	NNSS or LLNL	5	0.47	2.8×10^{-4}	0.39	2.3×10^{-4}	1.1×10^{-9}	1.7×10^{-5}
Other Pu (metal/oxide)	LLNL	LANL	3	0.29	1.8×10^{-4}	0.078	4.7×10^{-5}	7.1×10^{-10}	1.2×10^{-4}
Other Pu (metal/oxide)[b]	LANL	LLNL	5-6	0.60	3.6×10^{-4}	0.156	9.3×10^{-5}	1.4×10^{-9}	2.5×10^{-4}
TRU	LLNL	WIPP	8	0.88	5.3×10^{-4}	1.1	6.5×10^{-4}	4.9×10^{-8}	2.4×10^{-4}
Tritium	LLNL	SRS	5	NA	NA	NA	NA	3.0×10^{-10}	1.2×10^{-4}
Tritium	SRS	LLNL	7	NA	NA	NA	NA	4.1×10^{-10}	1.7×10^{-4}
Depleted U	Livermore Site	Site 300	15	NA	NA	NA	NA	NA	5.6×10^{-4}
Depleted U	Site 300	Livermore Site	5	NA	NA	NA	NA	NA	1.9×10^{-4}
HEU Metal	LLNL or SRS (bounding distance)	SRS (bounding distance) or LLNL	95	1.2	7.2×10^{-4}	1.8	1.1×10^{-3}	8.1×10^{-8}	2.3×10^{-3}
Cs-137 Sealed Source	Livermore Site or Site 300	Site 300 or Livermore Site	1	1.8×10^{-3}	1.1×10^{-6}	5.2×10^{-4}	3.1×10^{-7}	1.2×10^{-11}	3.7×10^{-5}
Am-241 Sealed Source	LLNL or SRS (bounding distance)	SRS (bounding distance) or LLNL	2	0.53	3.2×10^{-4}	0.16	9.4×10^{-5}	3.6×10^{-9}	4.8×10^{-5}
Miscellaneous Isotopes and Sealed Sources	SRS (bounding distance)	LLNL	215	57	3.4×10^{-2}	17.2	1.0×10^{-2}	3.9×10^{-7}	5.2×10^{-3}
		Totals	**888**	**69.2**	**0.042**	**24.7**	**0.015**	**2.9×10^{-6}**	**0.038**

Acronyms are the same as in Table D-4.

a. A DOE employee would also need to comply with DOE regulations at 10 CFR Part 835 ("Occupational Radiation Protection"), which limits worker radiation doses to 5 rem/year. At LLNL, administrative control levels are multi-tiered, meaning they can vary between 500 millirem/year and up to 5,000 millirem/year with appropriate management approval. This limit/guideline would apply to any non-TRU waste shipment conducted by DOE personnel. Drivers of TRU waste shipments to WIPP have an administrative exposure guideline of 1 rem/year. Commercial (i.e., non-DOE-employed) drivers are subject to OSHA regulations, which limit the whole-body dose to 5 rem/year (29 CFR 1910.1096), and to the USDOT requirement of 2 millirem/hour inside the truck cab (49 CFR 173.411).

b. Bounding value for 2023. Most years would have 2 shipments. Shipments expected to use Type B 0-160B cask loaded with pipe overpack containers that would contain some plutonium metals, oxides, and residues.

Note: A potential does exist for an occasional shipment (≤1/yr) of mission-related material to be shipped from SRS to NNSS to support LLNL operations at the DAF. The additional annual public/crew radiological impacts from such shipments would add a negligible contribution to the totals shown above.

As shown in Table D-4 for the No-Action Alternative, modeling of all 645 potential offsite shipments would yield a bounding collective (i.e., cumulative) incident-free dose to transport-crews of 61.6 person-rem per year, with an associated increased risk of 0.037 LCF; a bounding collective incident-free dose to the general public of 21.6 person-rem, with an associated increased risk of 0.013 LCF; and a bounding cumulative increased risk of 1.9×10^{-6} LCF to the general public from accidents that result in a container breach/release. As a point of comparison, the bounding cumulative increased risk of 0.025 additional traffic fatalities (due to traffic accidents) would result from all shipments conducted under the No-Action Alternative; this would be a factor of roughly 10,000 higher than the bounding incremental increase of 2.0×10^{-6} LCF estimated to the public from potential radiological impacts associated with such shipment accidents.

As shown in Table D-5 for the Proposed Action, modeling of all 888 potential offsite shipments would yield a bounding collective (i.e., cumulative) incident-free dose to transport-crews of 69.2 person-rem per year, with an associated increased risk of 0.042 LCF; a bounding collective incident-free dose to the general public of 24.7 person-rem, with an associated increased risk of 0.015 LCF.

The only notable quantifiable differences in radiological transportation characteristics between the No-Action Alternative and Proposed Action are: (1) the number of shipments (per year) of nonroutine LLW/MLLW to NNSS and Energy*Solutions* from LLNL; and (2) the number of shipments (per year) of miscellaneous isotopes and sealed sources between LLNL and other sites around the U.S.[3] Because these two types of shipments only account for a small fraction of the total radiological transportation impacts, as shown in D-5, the total radiological impacts for the Proposed Action would be only slightly higher across all categories as compared to the No-Action Alternative.

With regard to a potential annual bounding dose to a hypothetical MEI from incident-free transportation, a dose of 1.8×10^{-4} rem/year is estimated for both the No-Action Alternative and the Proposed Action, with an associated increased LCF risk to that individual of 1.1×10^{-7}/year (DOE/EIS-0283-S2). Moreover, as discussed in footnote "a" of Tables D-4 and D-5, a maximally exposed crew member may receive up to 2 rem/year per DOE's administrative control level (assuming the same individual is responsible for driving the majority/entirety of shipments over a full-year [e.g., 1,000 hours driving-time per year at the maximum allowable dose rate of 2 millirem/hour]) and a maximally exposed inspector would be expected to receive 0.019 rem per hour of inspection duty performed.

An accident consequence assessment was previously performed for estimating a maximum reasonably foreseeable hypothetical transportation accident with a likelihood of occurrence greater than 1 in 10 million per year (DOE/EIS-0426; DOE/EIS-0236-S4; DOE/EIS-0283-S2). This assessment provides bounding cases for scenarios that could be transported under this LLNL SWEIS.

The following assumptions were originally used to estimate the consequences of a maximum reasonably foreseeable offsite transportation accident:

[3] For this SWEIS, NNSA evaluated the impacts of transporting miscellaneous isotopes and sealed sources between LLNL and SRS, as that pairing bounded any potential impacts.

- The accident is the most severe with the highest release fraction (high-impact and high-temperature fire accident [highest severity category]).
- The individual is 100 meters (330 feet) downwind from a ground release accident.
- The individual is exposed to airborne contamination for 2 hours and ground contamination for 24 hours with no interdiction or cleanup. A moderately stable weather scenario (Pasquill Stability Class F – "moderately stable conditions") with a wind speed of 1 meter per second (2.2 miles per hour) is assumed.
- The population is assumed to have a uniform density to a radius 80 kilometers (50 miles) and to be exposed to the entire plume passage and 7 days of ground exposure without interdiction and cleanup. A neutral weather scenario (Pasquill Stability Class D) – "neutral conditions") with a wind speed in the range of 3-4 meters per second (6.6 to 8.8 miles per hour) is assumed. Because the consequence is proportional to the population density, the accident is assumed to occur in an urban area with the highest potential density.

Table D-6 provides the bounding doses and potential LCFs that could result for an individual and population from a worst-case truck transportation accident with the highest consequences, under either of the alternatives. The accidents are assumed to involve a severe impact (collision) in conjunction with a long fire duration. Based on prior results, the highest consequences for a worst-case accident are projected to be from an event occurring in a suburban area involving the transport of plutonium oxide powder to/from LANL or NNSS, and would be less than 4.3 rem (<0.003 LCF) to an MEI and less than 6,300 person-rem (<4 LCFs) to nearby populations. These consequence values, coupled with the extremely low probability (1 x10^{-7}yr) of occurrence for this accident, would result in total cancer risks far lower than that expected to naturally manifest in these populations due to other causes.

Table D-6. Estimated Dose to the Population and to the Maximally Exposed Individual Under a Postulated Worst-Case Accident

Transport Mode	Material or Waste in the Accident with the Highest Consequences	Applicable Alternatives	Range of Likelihood of the Accident (per year) [a]	Population Zone [a]	Population [b]		MEI [c]	
					Dose (person-rem)	LCF	Dose (rem)	LCF
Transport to LANL or NNSS[d]	Plutonium oxide powder in a Type B package	No-Action and Proposed Action	4.3×10^{-8} to 2.0×10^{-7}	suburban	<6,300	<4	<4.3	$<3\times10^{-3}$
Transport to WIPP[d]	TRU waste via direct disposition	No-Action and Proposed Action	1.1×10^{-6}	urban	<1,890	<3	<1.4	$<9\times10^{-4}$

LCF = latent cancer fatality; MEI = maximally exposed individual; NNSS = Nevada National Security Site; LANL = Los Alamos National Laboratory (NM); STA = safeguards transporter; TRU = transuranic; WIPP = Waste Isolation Pilot Plant (NM).

a. The likelihood shown is the range of probabilities estimated among the alternatives given the numbers of shipments expected over a specific time period. If the likelihood of an accident is equal to or greater than 1 in 10 million per year for both suburban and urban population zones, then the consequences are provided for the urban population zone.

b. Population extends at a uniform density to a radius of 80 kilometers (50 miles). The weather condition was assumed to be Pasquill Stability Class D with a wind speed of 3-4 meters per second (6.6 to 8.8 miles per hour).

c. The MEI is assumed to be 100 meters (330 feet) downwind from the accident and exposed to the entire plume of the radioactive release. The weather condition is assumed to be Pasquill Stability Class F with a wind speed of 1 meter per second (2.2 miles per hour).

d. All presented dose/LCF estimates are representative of those previously evaluated for transport between SRS and LANL and SRS to WIPP, and are theoretically bounding due to a greater distance (and hence, a greater number of population centers) being traversed between SRS and New Mexico versus LLNL and New Mexico. The analysis also assumes all transport is conducted via STA as opposed to commercial truck; however, any potential higher accident frequency associated with the latter mode for LLNL-related operations would be expected to be offset by the much greater distance travelled between SRS/New Mexico compared to LLNL/New Mexico (DOE/EIS-0283-S2).

As indicated in Tables D-4 and D-5, all annualized risk factors are less than one. This means that no LCFs or traffic fatalities are expected to occur during each individual transportation activity or throughout an entire year of collective transport. For example, the incident-free annualized risk factors to truck crews and the population for transporting one year of shipments of routine LLW/MLLW from LLNL to NNSS under either the No-Action Alternative or the Proposed Action are 1.1×10^{-3} and 5.2×10^{-4} LCFs, respectively. This risk can also be interpreted as meaning that there is a chance of approximately 1 in 900 that an additional LCF could be experienced among the exposed crew(s) from exposure to radiation during 102 shipments of this waste over a year. Similarly, there is an approximate chance of 1 in 1,900 that an additional LCF could be experienced among the exposed population residing along the transport route due to 102 shipments per year. These present a small risk, especially when normalized down to a “per-shipment” basis.

Tables D-4, D-5, and D-6 present the potential impacts associated with offsite shipments of radiological material/waste for the No-Action Alternative and the Proposed Action. As discussed in Section 4.11.4.1, LLNL also transports radiological material/waste onsite. Onsite transfers at LLNL are defined as the movement of materials by Radioactive and Hazardous Waste Management (RHWM) Program and Materials Management Vaults and Transportation Group (MM) transfer vehicles on the Livermore Site. LLNL radioactive waste transfer operations begin when the vehicle leaves the boundary of RHWM’s originating facility and end when the transfer vehicle enters the boundary of RHWM’s receiving facility. For all other facilities, radioactive waste transfer operations begin when the transfer vehicle leaves the originating facility and ends when the transfer vehicle stops to unload the containers at the receiving facility. MM transfers include fuel-grade plutonium, weapons-grade plutonium, and enriched uranium within the Superblock (i.e., between B331, B332, and B334) and between the Superblock and B239. Onsite transportation at Site 300 is limited to activities related to materials within the geographically contiguous property of Site 300. The potential impacts associated with onsite shipments of radiological material/waste are presented in Section C.3.6.

D.5 ADDITIONAL ASSUMPTIONS AND UNCERTAINTIES

Non-Radiological Accident Rates

Whenever material is shipped, the possibility exists of a traffic accident that could result in vehicular damage, injury, or death. Even when drivers are trained in defensive driving and take great care, there is a risk of a traffic accident. Despite this potentiality, DOE has had a successful 50-year history of transporting radioactive and hazardous materials and has not experienced a single transportation-related fatality (DOE 2009; Kunjeer 2020).

To calculate accident risks, unit vehicle accident and fatality rates were taken from data provided NEPA documents (DOE/EIS-0426; DOE/EIS-0236-S4; and DOE/EIS-0283-S2). Accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel in that same year. Therefore, the rate is a fractional value, with accident count per total travel distance represented. For comparative assessment purposes under each Alternative, the total number of expected accidents or fatalities was calculated by multiplying the total number of estimated shipments over a given year (i.e., Year-2030 as the representative year) for a specific material-transport case by the appropriate unit (i.e., single-shipment) accident or fatality rate. No reductions/credits in unit accident or fatality rates were assumed in the evaluation, even though radioactive material carrier drivers are well trained and have better-than-average maintained equipment. A fatality caused by an accident is officially defined (by USDOT) as the death of a member of the public who is killed instantly or passes away within 30 days directly due to injuries sustained in an accident. DOE operational experience has determined that an accident rate of roughly 3×10^{-7} accidents per kilometer (5×10^{-7} accidents per mile; or 1 in 2,000,000 per mile) is representative of a modern-day probability for such occurrences involving heavy transport vehicles on major roadways (DOE 2002a).

Accident Severity Categories and Conditional Probabilities

Accident severity categories for potential radioactive waste transportation accidents are described in the Radioactive Material Transportation Study (NRC 1977) for radioactive waste in general, and the Modal Study (NRC 1987) and Reexamination Study (NRC 2000) for SNM. The methods described in the Modal Study and the Reexamination Study are applicable to transportation of radioactive materials in a Type B container.

The Radioactive Material Transportation Study was originally used to estimate conditional probabilities associated with accidents involving transportation of radioactive materials (NRC 1977). The Modal Study and the Reexamination Study were initiatives taken by NRC to refine more precisely the analysis presented in the Radioactive Material Transportation Study, particularly for nuclear fuel shipment casks (NRC 1987, 2000).

Whereas the Radioactive Material Transportation Study analysis was primarily performed using best engineering judgments and presumptions concerning cask response, the later studies rely on sophisticated structural and thermal engineering analysis and a probabilistic assessment of the conditions that could be experienced in severe transportation accidents (NRC 1977). The latter results were based on representative nuclear fuel casks assumed to have been designed, manufactured, operated, and maintained according to national codes and standards. Design parameters of the representative casks were chosen to meet the minimum test criteria specified in 10 CFR Part 71, *Packaging and Transportation of Radioactive Material* (10 CFR 71). The study is believed to provide realistic, yet conservative results for radiological releases under transport accident conditions.

In the Modal Study and the Reexamination Study, potential accident damage to a cask is categorized according to the magnitude of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a cask is subjected to forces within a certain range of values is assigned to the accident severity region associated with that range. The accident severity scheme is designed to take into account all potential foreseeable transportation accidents, including accidents with low probabilities but high consequences, and those with high probabilities but low consequences.

The accident consequence assessment considers the potential impacts of severe transportation accidents. In terms of risk, the severity of an accident must be viewed in terms of potential radiological consequences, which are directly proportional to the fraction of the radioactive material within a cask that is released to the environment during the accident. Although accident severity regions span the entire range of mechanical and thermal accident loads, they are grouped into accident categories that can be characterized by a single set of release fractions and are, therefore, considered together in an accident consequence assessment. The accident category severity fraction is the sum of all conditional probabilities in that accident category.

For the accident risk assessment, accident "dose risk" was generically defined as the product of the consequences of an accident and the probability of occurrence of that accident, an approach consistent with the methodology used by the RADTRAN 6 computer code. The RADTRAN code sums the product of consequences and probabilities over all accident categories to obtain a probability-weighted risk value referred to in this appendix as "dose risk," which is expressed in units of person-rem. It should be emphasized that although persons are residing within an 80-kilometer (50-mile) radius along the transportation routes, they are generally situated quite far from the route. Because RADTRAN uses an assumption of homogeneous population, actual doses are often significantly overestimated because this assumption theoretically places people directly adjacent to the route where the highest doses would be present. Nonetheless, as discussed earlier, these "conservative" unit dose risk values for accident conditions were then multiplied by the estimated numbers of annual shipments for each material/stream type and ultimately presented in the summary of impacts tables in Section D-4 above.

Atmospheric Conditions

Because it is not possible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were originally selected for the risk and consequence assessments conducted in the referenced EIS documents (DOE/EIS-0426; DOE/EIS-0236-S4; and DOE/EIS-0283-S2). On the basis of observations from National Weather Service surface meteorological stations at over 177 locations in the United States, on an annual average, neutral conditions (Pasquill Stability Classes C and D) occur 58.5 percent of the time, and stable (Pasquill Stability Classes E, F, and G) and unstable (Pasquill Stability Classes A and B) conditions occur 33.5 percent and 8 percent of the time, respectively (DOE 2002a). The neutral weather conditions predominate in each season, but most frequently in the winter (nearly 60 percent of the observations).

Neutral weather conditions (Pasquill Stability Class D) compose the most frequently occurring atmospheric stability condition in the United States and are thus most likely to be present in the event of an accident involving a radioactive waste shipment. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Stable weather conditions are typified by low windspeeds, little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. The atmospheric condition conventionally employed in RADTRAN modelling is an average weather condition that corresponds to a stability class spread between Class D (for near-in distances) and Class E (for farther-out distances).

Accident consequences for a maximum reasonably foreseeable accident (an accident with a likelihood of occurrence greater than 1 in 10 million per year) are typically assessed for both stable (Class F with a wind speed of 1 meter [3.3 feet] per second) and neutral (Class D with a wind speed in the range of 3-4 meters [10-13 feet] per second) atmospheric conditions. Accordingly, population doses from such an accident are conventionally evaluated under neutral atmospheric conditions, and the MEI dose under stable atmospheric conditions. The MEI dose would thus typify an accident under weather conditions that result in a conservative dose (i.e., a stable weather condition, with minimum diffusion and dilution), whereas population doses are usually associated with average weather conditions.

Radioactive Release Characteristics

Radiological consequences are typically calculated by assigning radionuclide release fractions on the basis of the type of waste, the type of shipping container, and the accident severity category. The release fraction is defined as the fraction of the radioactivity in the container that could be released to the atmosphere in a given severity of accident. Release fractions vary according to the waste type and the physical or chemical properties of the radioisotopes. Most solid radionuclides are nonvolatile and are, therefore, relatively non-dispersible. It is noteworthy to emphasize that such is likely the case for the majority of material types/streams evaluated in this SWEIS, with the primary exception of tritium gas that is to be transported between SRS and LLNL.

Representative release fractions in the previous referenced EIS analyses were developed for each waste and container type on the basis of DOE and NRC reports (DOE 1994, 2002b, 2003b; NRC 1977, 2000, 2009). The severity categories and corresponding release fractions provided in these documents cover a range of accidents from no impact (zero speed) to impacts with speed in excess of 193 kilometers (120 miles) per hour onto an unyielding surface.

For radioactive wastes/materials transported in containers, particulate release fractions were originally developed consistent with the models in the Reexamination Study, as well as recommended values from the Radioactive Material Transportation Study and DOE Handbook on Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities (NRC 1977, NRC 2000, DOE 1994). For TRU shipments, the release fractions corresponding to the Radioactive Material Transportation Study severity categories as adapted in the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement were used (DOE 1997).

For those accidents where the waste container or cask shielding was undamaged and no radioactive material or waste was released, it was assumed that it would take 12 hours to recover from the accident and resume shipments. During this period, no individual would remain close to a cask. A first responder is conservatively assumed to stay at a location 2 to 10 meters (6.6 to 33 feet) from a/the container(s) for 1 hour (DOE 2002b).

Acts of Sabotage or Terrorism

Since the events of September 11, 2001, DOE is continuing to assess measures to minimize the risk or potential consequences of radiological sabotage. While it is not possible to determine terrorists' motives and targets with certainty, DOE considers the threat of terrorist attack to be real, and makes all efforts to reduce any vulnerability to this threat.

As such, DOE regularly evaluates potential impacts that could result from acts of sabotage or terrorism during transportation of SNM and radioactive waste shipments (DOE 1996, 2002a). The sabotage event evaluated in the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain EIS) is considered as the enveloping event/analysis for this analysis (DOE 2008c). The quantity of radioactive materials or waste transported under both alternatives considered in this LLNL SWEIS would be significantly less than that considered in the Yucca Mountain EIS analysis. Therefore, estimates of risk in the Yucca Mountain EIS substantially bound the risks from an act of sabotage or terrorism involving the radioactive materials or waste transported under both alternatives considered in this LLNL SWEIS.

Uncertainty and Conservatism in Estimated Impacts

The sequence of analyses performed to generate the estimates of radiological risk for transportation typically includes: (1) determination of the inventory and characteristics; (2) estimation of shipment requirements; (3) determination of route characteristics; (4) calculation of radiation doses to exposed individuals (including estimating of environmental transport and uptake of radionuclides); and (5) estimation of health effects. Uncertainties are inherently associated with each of these steps. Uncertainties exist in the way that the physical systems being analyzed are represented by the computational models; in the data required to exercise the models (due to measurement errors, sampling errors, natural variability, or unknowns caused simply by the future nature of the actions being analyzed); and in the calculations themselves (e.g., approximate algorithms used within the computer codes).

In principle, one can estimate the uncertainty associated with each input or computational source and predict the resultant uncertainty in each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result; however, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible, especially for actions to be initiated at an unspecified time in the future. Instead, transportation risk analysis was designed to ensure through uniform, judicious, and conservative selection of scenarios, models, and input parameters, that relative comparisons of risk among the two candidate alternatives are meaningful. In the transportation risk assessment, this design is accomplished by uniformly applying common input parameters and assumptions to both alternatives. Therefore, uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative.

In the following sections, areas of uncertainty are discussed for the assessment steps enumerated above. Special emphasis is placed on identifying whether the uncertainties affect relative or absolute measures of risk. The reality and conservatism of the assumptions are addressed. Where practical, the parameters that most significantly affect the risk assessment results are identified.

Uncertainties in Material Inventory and Characterization

The inventories and the physical and radiological characteristics are important input parameters to the transportation risk assessment. The potential number of shipments for both alternatives is primarily based on the projected dimensions of package contents, the strength of the radiation field, and assumptions concerning shipment capacities. The physical and radiological characteristics are important in determining the material released during accidents and the subsequent doses to exposed individuals through multiple environmental exposure pathways.

Uncertainties in the inventory and characterization are reflected in the transportation risk results. If the inventory is overestimated (or underestimated), the resulting transportation risk estimates are also overestimated (or underestimated) by roughly the same factor. However, the same inventory estimates are used to analyze the transportation impacts for both alternatives. Therefore, for comparative purposes, the observed differences in transportation risks between the alternatives are believed to represent unbiased, reasonably accurate estimates based on the most current assessment information available.

Uncertainties in Containers, Shipment Capacities, and Number of Shipments

The transportation required for each alternative is based in part on assumptions concerning the packaging characteristics and shipment capacities for transport vehicles. Representative shipment capacities have been defined for assessment purposes based on probable future shipment capacities. In reality, the actual shipment capacities may differ from the predicted capacities such that the projected number of shipments and, consequently, the total transportation risk, would change. However, although the predicted transportation risks would increase or decrease accordingly, the relative differences in risks within the alternatives would remain about the same (which is moreover demonstrated by the consistency in total annual impact results between the two alternatives in Tables D-4 and D-5). Moreover, estimates of accident rates from TRU shipments are expected to be conservative as shipments occasionally contain non-radioactive dunnage, rather than the "full radioactive" loads assumed within the modelling assessments from which the rate values were derived.

Uncertainties in Route Determination

TRAGIS-analyzed routes were initially determined between all origin and destination locations considered in the referenced EIS transportation analyses (DOE/EIS-0426; DOE/EIS-0236-S4; and DOE/EIS-0283-S2) from which unit dose/risk factors (per shipment) were cited and scaled. The routes were determined to be consistent with current guidelines, regulations, and practices, but may not be the actual routes that would be used for many future shipments. In reality, these actual routes that were previously assessed, as well as any new potential routes specifically evaluated, could differ from the ones that are eventually utilized with regard to distances and total populations along the routes. Moreover, because materials could be transported over an extended period starting at some time in the future, highway infrastructure and demographics along routes could change. These effects have not been accounted for in the transportation evaluation; however, it is not anticipated that these changes would significantly affect relative comparisons of risk between the alternatives considered in this SWEIS.

Uncertainties in the Calculation of Radiation Doses

The models originally used to calculate radiation doses from transportation activities introduce a further uncertainty in the risk assessment process. Estimating the accuracy or absolute uncertainty of the risk assessment results is generally difficult. The accuracy of the calculated results is closely related to the limitations of the computational models and to the uncertainties in each of the input parameters that the model requires. The single greatest limitation facing users of RADTRAN, or any computer code of this type, is the scarcity of data for certain input parameters. Populations (off-link and on-link) along the transportation routes, shipment surface dose rates, and individuals residing near the routes are the most uncertain data in dose calculations. In preparing these data, one makes assumptions that the off-link population is uniformly distributed; the on-link population is proportional to the traffic density, with an assumed occupancy of two persons per car; the shipment surface dose rate is the maximum allowed dose rate per DOT standards; and a potential exists for an individual to be residing at the edge of a highway. It is clear that not all assumptions are accurate. For example, the off-link population is mostly heterogeneous, and the on-link traffic density varies widely within a geographic zone (i.e., urban, suburban, or rural). Finally, added to this complexity are the assumptions regarding the expected distance between the public and the shipment at a traffic stop, rest stop, or during stalled traffic, and the afforded degree of shielding that may be in play at that time.

Uncertainties associated with the computational models are reduced by using state-of-the-art computer codes that have undergone extensive review. Because many uncertainties are recognized but difficult to quantify, assumptions are made at each step of the risk assessment process which are intended to ultimately produce conservative results (i.e., overestimations of calculated dose and radiological risk). Because parameters and assumptions are applied consistently to both alternatives, such model bias is not expected to affect the meaningfulness of relative comparisons of risk; however, the final results may not represent risks in an absolute sense.

Uncertainties in Traffic Fatality Rates

A large proportion of the estimated vehicle accident and fatality rates in this SWEIS are based on original data provided in State-Level Accident Rates for Surface Freight Transportation: A Reexamination, ANL/ESD/TM-150 (Saricks and Tompkins 1999). Truck accident rates were computed for each state based on statistics at the time compiled by the Federal Highway Administration with results provided per unit car-kilometer for each state, as well as national average and mean values. A subsequent review of the above report by the Federal Carrier Safety Administration (UMTRI 2003), however, indicated that a portion of state-level accident and fatality data which fed into the results of the report may have inadvertently been underreported within a range of 36-39 percent. Consequently, several of the rate-values cited from the recently published EIS references (DOE/EIS-0426; DOE/EIS-0236-S4; and DOE/EIS-0283-S2) have been adjusted upward by a factor of approximately 1.6 to compensate for the underreporting.

It should moreover be noted that future accident and fatality rates may change as a result of vehicle and highway improvements. More current U.S. DOT national accident and fatality statistics for large trucks and buses (DOT 2009) indicate lower trends for accident and fatality rates over recent years.

D.6 References

10 CFR Part 20 — "Standards for Protection Against Radiation." *Energy*. Nuclear Regulatory Commission. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=18fe9e19f8f2568efbf36641a600f490&mc=true&node=pt10.1.20&rgn=div5

10 CFR Part 61 — "Licensing Requirements for Land Disposal of Radioactive Waste." *Energy.* Nuclear Regulatory Commission. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-10/chapter-I/part-61.

10 CFR Part 71 — "Packaging and Transportation of Radioactive Material." *Energy.* Nuclear Regulatory Commission. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-10/chapter-I/part-71.

10 CFR 71.4 — "Packaging and Transportation of Radioactive Material: Definitions." ." *Energy.* Nuclear Regulatory Commission. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-10/chapter-I/part-71.

10 CFR Part 73 — "Physical Protection of Plants and Materials." *Energy.* Nuclear Regulatory Commission. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-10/chapter-I/part-73.

10 CFR Part 835 — "Occupational Radiation Protection." *Energy.* Department of Energy. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-10/chapter-III/part-835.

29 CFR 1910.1096 — "Occupational Safety and Health Standards: Ionizing Radiation." *Labor*. Occupational Safety and Health Administration. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-Z/section-1910.1096.

49 CFR Part 106 — "Rulemaking Procedures." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I.

49 CFR Part 107 — "Hazardous Materials Program Procedures." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-A/part-107.

49 CFR Part 171 "General Information, Regulations, and Definitions." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-171.

49 CFR Part 172 "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-172.

49 CFR Part 173 "Shippers – General Requirements for Shipments and Packagings." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173#subpart-I.

49 CFR 173.401 "Shippers – General Requirements for Shipments and Packagings: Class 7 (Radioactive) Materials." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-I/section-173.401.

49 CFR 173.403 "Shippers – General Requirements for Shipments and Packagings: Definitions." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-I/section-173.403.

49 CFR 173.411 "Shippers – General Requirements for Shipments and Packagings: Industrial Packages." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-I/section-173.411.

49 CFR 173.427 "Shippers – General Requirements for Shipments and Packagings: Transport Requirements for Low Specific Activity (LSA) Class 7 (Radioactive) Materials and Surface Contaminated Objects (SCO)." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-

49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-I/section-173.427.

49 CFR 173.435 "Shippers – General Requirements for Shipments and Packagings: Table of A1 and A2 Values for Radionuclides." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-I/section-173.435.

49 CFR 173.441 "Shippers – General Requirements for Shipments and Packagings: Radiation Level Limitations and Exclusive Use Provisions." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-I/section-173.441.

49 CFR 173.7(d) "Shippers – General Requirements for Shipments and Packagings: Government Operations and Materials." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173/subpart-A/section-173.7#p-173.7(d).

49 CFR Part 174 "Carriage by Rail." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-174.

49 CFR Part 175 "Carriage by Aircraft." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-175.

49 CFR Part 176 "Carriage by Vessel." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-176.

49 CFR Part 177 "Carriage by Public Highway." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online:

https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-177.

49 CFR Part 178 — "Specifications for Packagings." *Transportation.* Pipeline and Hazardous Materials Safety Administration, Department of Transportation. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-178.

AEA 1954 — *Atomic Energy Act*, 42 U.S.C. §§ 2011-2021, 2022-2286i, 2296a-2297h-13, as amended in NUREG-0980. Available online: *Atomic Energy Act of 1954*. Available online: https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter23/divisionA&edition=prelim.

DHS 2016 — U.S. Department of Homeland Security. *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans-FINAL* (accessed September 22, 2020) at https://www.fema.gov/media-library-data/1488825883577-fb52b6b7fd784dfb64aaee1fd886393a/NRIA_FINAL_110216.pdf), Federal Emergency Management Agency, Washington, DC, October 2016.

DHS 2019 — DHS. *National Response Framework. Fourth Edition.* , Federal Emergency Management Agency, Washington, DC. October 28, 2019. Available online: https://www.fema.gov/sites/default/files/2020-04/NRF_FINALApproved_2011028.pdf (accessed September 17, 2020).

DOE Order 151.1D — "Comprehensive Emergency Management System" Approved August 11, 2016. Available online: https://www.directives.doe.gov/directives-documents/100-series/0151.1-BOrder-d.

DOE-STD-1098-2017 — Radiological Control. DOE-STD-1098-2017. January 2017. Available online: https://www.standards.doe.gov/standards-documents/1000/1098-AStd-2017/@@images/file

DOE 1994 — U.S. Department of Energy. *DOE Handbook – Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facility*, DOE-HDBK-3010-94 (Change Notice No. 1, March 2000). Washington, DC, December 1994.

DOE 1996 — U.S. Department of Energy. *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.* DOE/EIS-0218. Office of Environmental Management, Washington, DC. February 1996. Available online: https://www.energy.gov/nepa/downloads/eis-0026-s2-final-supplemental-environmental-impact-statement) (accessed September 22, 2020.

DOE 1997 U.S. Department of Energy. *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*. DOE/EIS-0026-S-2. Carlsbad Area Office, Carlsbad, New Mexico, September 1997. Available online: https://www.energy.gov/nepa/downloads/eis-0026-s2-final-supplemental-environmental-impact-statement (accessed September 22, 2020).

DOE 2002a U.S. Department of Energy. *Final Environmental Impact Statement for a Geological Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250. Office of Civilian Radioactive Waste Management, Washington, DC, February 2002. Available online: https://www.energy.gov/nepa/downloads/eis-0250-final-environmental-impact-statement (accessed September 22, 2020).

DOE 2002b U.S. Department of Energy. *A Resource Handbook on DOE Transportation Risk Assessment*. DOE/EM/NTP/HB-01. Office of Environmental Management, National Transportation Program, Albuquerque, New Mexico, July 2002. Available online: https://ramp.nrc-gateway.gov/system/files/edf67e1973fbf0ab9f93f80e4f0d5af2/DOE-EM-NTP-HB-01.pdf (accessed September 22, 2020)

DOE 2003a U.S. Department of Energy. *Recommended Radiation Risk Factors Updated*. National Environmental Policy Act Lessons Learned. Office of NEPA Policy and Compliance, Quarterly Report, Issue No. 34, Washington, DC, March 3, 2003.Available online: https://www.energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/LLQR-2003-Q1.pdf (accessed on September 22, 2020)

DOE 2003b U.S. Department of Energy. *West Valley Demonstration Project Waste Management Environmental Impact Statement*. DOE/EIS-0337F. West Valley Area Office, West Valley, New York. December 2003.

DOE 2008b U.S. Department of Energy. *Radioactive Material Transportation Practices Manual for Use with DOE O 460.2A*. DOE Manual 460.2-1A. Office of Environmental Management, Washington, DC, June 4, 2008.

DOE 2008c U.S. Department of Energy. *Final Supplemental Environmental Impact Statement for a Geological Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250-S1. Office of Civilian Radioactive Waste Management, Washington, DC, June 2008.

DOE 2009 U.S. Department of Energy. *Packaging and Transportation.* Office of Environmental Management, Washington, DC, May 15, 2009. Available online: http://www.em.doe.gov/Pages/Transportation.aspx (accessed September 22, 2020).

DOE/EIS-0236-S4 *Final Complex Transformation Supplemental Programmatic Environmental Impact Statement*. DOE/EIS-0236-S4. ID 1062. October 24, 2008. Available online: https://www.energy.gov/nepa/downloads/eis-0236-s4-final-supplemental-programmatic-environmental-impact-statement

DOE/EIS-0283-S2 *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement*. U.S. Department of Energy, Office of Material Management and Minimization *and* Office of Environmental Management, Washington, DC. April 2015.

DOE/EIS-0426 *Final Sitewide Environmental Impact Statement for the Continued Operation of the DOE/NNSA Nevada National Security Site and Offsite Locations in the State of Nevada*. DOE/EIS-0426. National Nuclear Security Administration. February 2013. Available online: https://www.energy.gov/nepa/downloads/eis-0426-final-environmental-impact-statement

DOT 2008 U.S. Department of Transportation. *Radioactive Material Regulations Review*, RAMREG-12-2008. Pipeline and Hazardous Materials Safety Administration, Washington, DC, December 2008. Available online: https://rampac.energy.gov/docs/default-source/dotinfo/dot_ramreg1.pdf?sfvrsn=2 (accessed September 22, 2020).

DOT 2009 U.S. Department of Transportation. *Large Truck and Bus Crash Facts 2007*. FMCSA-RRA-09-029. Analysis Division, Federal Motor Carrier Safety Administration, Washington, DC. January 2009.

DOT-PHMSA 2021 "Pipeline and Hazardous Materials Safety Administration, Radioactive Materials Branch website". Available online: https://www.phmsa.dot.gov/research-and-development/hazmat/radioactive-materials.

DOT-PHMSA 2021a	*Emergency Response Guidebook.* Pipeline and Hazardous Materials Safety Administration. Available online: https://www.phmsa.dot.gov/hazmat/erg/emergency-response-guidebook-erg
Johnson and Michelhaugh 2003	Johnson, P. E., and R. D. Michelhaugh. *Transportation Routing Analysis Geographic Information System (TRAGIS) – User's Manual*. ORNL/NTRC-006, Rev. 0, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tennessee, June 2003.
Kunjeer 2020	Kunjeer, Prakash. *Traffic accident and fatalities associated with transport of hazardous and radioactive cargo*. Email, U.S. Department of Energy, Office of Environmental Management, Office of Packaging and Transportation, September 21, 2020.
LLNL 2021	Lawrence Livermore National Laboratory. "Special Nuclear Material Transport Information." ID1999. Lawrence Livermore National Laboratory, Livermore, CA.
NNSA 2020	National Nuclear Security Administration. "Office of Secure Transportation website." Available online: https://www.energy.gov/nnsa/office-secure-transportation (accessed 9/17/2020).
NRC 1977	U.S. Nuclear Regulatory Commission. *Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes*. NUREG-0170. Washington, DC. December 1977.
NRC 1987	U.S. Nuclear Regulatory Commission. *Shipping Container Response to Severe Highway and Railway Accident Conditions*. NUREG/CR-4829 (UCID-20733). February 1987. Washington, DC Available online: http://ttd.sandia.gov/nrc/docs.htm.
NRC 2000	U.S. Nuclear Regulatory Commission. *Reexamination of Spent Fuel Shipping Risk Estimates*. NUREG/CR-6672 (SAND2000-0234). Washington, DC. March 2000.
NRC 2009	U.S. Nuclear Regulatory Commission. Certificate of Compliance No. 9218 for the Model No. TRUPACT-II Package, Rev. 20. 2009.
Saricks and Tompkins 1999	Saricks, C, and M.M. Tompkins. *State-Level Accident Rates for Surface Freight Transportation: A Reexamination*,. ANL/ESD/TM-150. Center for Transportation Research, Argonne National Laboratory, U.S. Department of Energy, Argonne, Illinois. April 1999.

SNL 2016 Sandia National Laboratories. RADTRAN 6/*RadCat 6 User Guide*. SAND2013-8095, September 2016.

UMTRI 2003 University of Michigan Transportation Research Institute. "Evaluation of the Motor Carrier Management Information System Crash File, Phase One." UMTRI-2003-06. Center for National Truck Statistics, Ann Arbor, Michigan. March 2003.

UVA 2018 University of Virginia. Weldon Cooper Center's Demographics Research Group. Projected Population Data for Years 2020-2040. https://demographics.coopercenter.org.

Yuan et al. 1995 Yuan, Y. C., S. Y. Chen, B. M. Biwer, and D. J. LePoire. *RISKIND - A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel*, ANL/EAD-1. Argonne National Laboratory, Argonne, Illinois. November 1995.

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APPENDIX E

Floodplain and Wetlands Assessment

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E FLOODPLAIN AND WETLANDS ASSESSMENT

E.1 INTRODUCTION

The U.S. Department of Energy (DOE)/National Nuclear Security Administration (NNSA) prepared this appendix to provide an analysis of the potential impacts on floodplains and wetlands from the No-Action Alternative and Proposed Action presented in Chapter 3 of this *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory* (LLNL SWEIS). This assessment demonstrates DOE/NNSA efforts to avoid, as much as possible, adverse impacts to floodplains and wetlands located at its facilities as directed by Executive Order (EO) 11988, "Floodplain Management," and EO 11990, "Protection of Wetlands" and meets DOE *Floodplain and Wetland Environmental Review Requirements* (10 CFR 1022). Chapter 1 of this SWEIS provides the purpose and need for action, including a figure showing the location of the Livermore Site, Site 300, and the Arroyo Mocho Pumping Station.

EO 11988 directs Federal agencies to evaluate the potential effects of any actions that may be taken in a floodplain. When conducting activities in a floodplain, Federal agencies are required to take actions to reduce the risk of flood damage; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. EO 11990 directs Federal agencies to ensure consideration of wetlands protection in decision-making and to evaluate the potential impacts of any new construction proposed in a wetland. Federal agencies shall avoid the destruction or modification of wetlands and avoid direct or indirect support of new construction in wetlands if a practicable alternative exists. DOE requirements for compliance with these EOs are set forth in 10 Code of Federal Regulations (CFR) Part 1022, "Compliance with Floodplain and Wetland Environmental Review Requirements." Routine maintenance and minor modifications are exempt from the DOE Floodplain and Wetland Environmental Review Requirements (10 CFR 1022.5).

E.2 FLOODPLAIN EFFECTS

DOE Floodplain and Wetland Environmental Review Requirements define a floodplain as the lowlands adjoining inland and coastal waters and relatively flat areas and flood prone areas of offshore islands. A *base floodplain* is defined as the 100-year floodplain, that is, a floodplain with a 1.0 percent chance of flooding in any given year (10 CFR 1022.4). A *critical action floodplain* is defined as the 500-year floodplain, that is, a floodplain with a 0.2 percent chance of flooding in any given year (10 CFR 1022.4). DOE Floodplain and Wetland Environmental Review Requirements state that DOE shall prepare a floodplain assessment for any proposed floodplain action in the base floodplain or for any proposed floodplain action that is a critical action located in the critical action floodplain. A c*ritical action* means any DOE action for which even a slight chance of flooding would be too great (10 CFR 1022.4). Such actions may include, but are not limited to, the storage of highly volatile, toxic, or water reactive materials. The Federal Emergency Management Agency (FEMA) National Flood Hazard Map was used as the source of the base and critical action floodplains at LLNL Sites (FEMA 2021).

E.2.1 Livermore Site

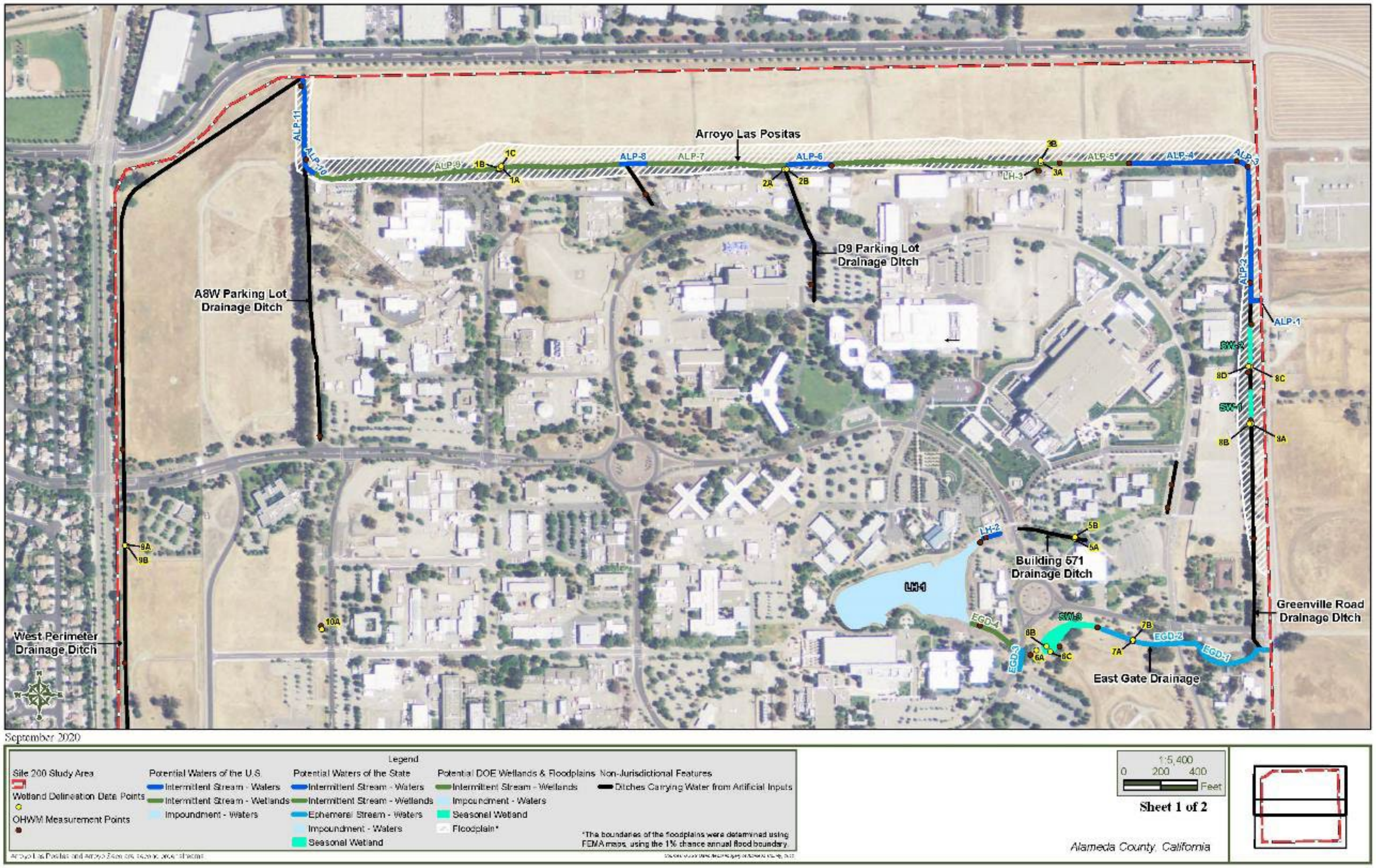
The 100-year floodplain, as defined by the FEMA, at the Livermore Site is presented in the 2020 Wetland/Aquatic Resources Delineation (Nomad Ecology 2020). The FEMA floodplain maps show a total of 25.9 acres of 100-year floodplain on the Livermore Site (Nomad Ecology 2020). Floodplains are associated with the Arroyo Las Positas (23.5 acres) and the Arroyo Seco (2.4 acres). The locations of the 100-year floodplain at the Livermore Site are shown in Figures E-1 and E-2. The FEMA Flood Insurance Rate Maps (FEMA 2009a, FEMA 2020) depict the 100-year and 500-year floodplains for the Livermore Site (Figure E-3 and Figure E-4). The 100-year (base floodplain) and 500-year floodplain (critical action floodplain) surrounding Arroyo Las Positas include the northeastern perimeter of the site near Greenville Road, a large portion of the North Buffer Zone, and the area immediately north and south of Arroyo Las Positas. The Arroyo Seco floodplain is narrower incorporating the area immediately north and south of Arroyo Seco and a small area within the southwest buffer zone.

Arroyo Las Positas and the associated floodplain approaches the Livermore Site from the east, flows north along the eastern boundary for approximately 1,000 feet, then turns west and flows adjacent to the northern boundary until it exits the Livermore Site in the far northwest corner. Arroyo Seco and the associated floodplain flows across the southwest corner of the Livermore Site and continues flowing northwesterly beyond the Livermore Site. The north buffer zone is nearly level but slopes from east to west and the direction of floodwater flow is east to west.

No-Action Alternative. There are no projects under the No-Action Alternative that would affect the floodplains at the Livermore Site.

Proposed Action. Two proposed projects under the Proposed Action (the New North Entry and the alternate location of the new Fire Station) would be located in the north buffer zone and could potentially affect floodplains (Figures E-5 and E-6). The north buffer zone is an undeveloped area located north of Arroyo Las Positas and south of Patterson Pass Road. The entire north buffer zone is within the 500-year flood plain of Arroyo Las Positas and the 100-year flood plain occurs immediately north and south of Arroyo Las Positas. The area has been previously used for soil storage, so the elevation is not uniform. The north buffer zone is vegetated by non-native annual grassland and annual maintenance includes mowing.

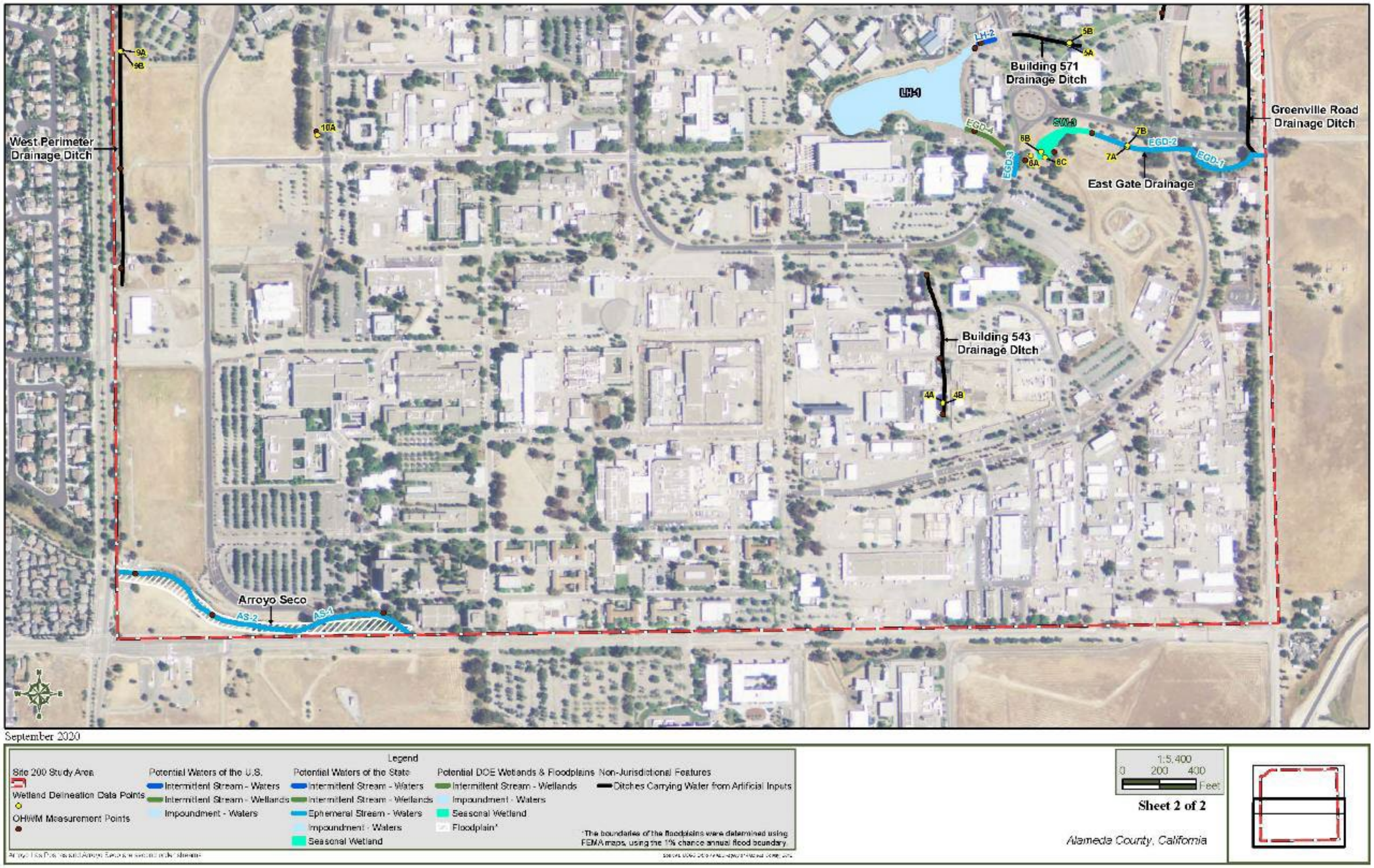
For the New North Entry, approximately 1,500 linear feet and approximately four acres of land would be disturbed for the roadway construction. This site entry would provide quick employee access to the center of the laboratory where several new facilities and office buildings are being proposed under both the No-Action Alternative and the Proposed Action. The roadway for the New North Entry would cross approximately 0.9 acres (approximately 2 percent) of the 500-year floodplain (critical action floodplain) (Figures E-5 and E-6) in the north buffer zone and approximately 0.1 acres (approximately 0.4 percent) of the 100-year floodplain (base floodplain) along Arroyo Las Positas. The proposed bridge would span the Arroyo Las Positas and the roadway would continue through previously developed land onto the Livermore Site. The alternate location of the new Fire Station could disturb approximately 0.7 acres (approximately 1.6 percent) of the 500-year floodplain (critical action floodplain) but would not disturb any acres of the 100-year floodplain (base floodplain).



Source: Nomad Ecology 2020.

Note: Jurisdictional status may not be current for Water of the U.S. Jurisdictional assessment are based on the 2020 Navigable Waters Protection Rule which was vacated by the U.S. District Court and is no longer being implemented by the USEPA and the USACE.

Figure E-1. Wetland and Aquatic Resources Delineation at the Livermore Site (Sheet 1 of 2)



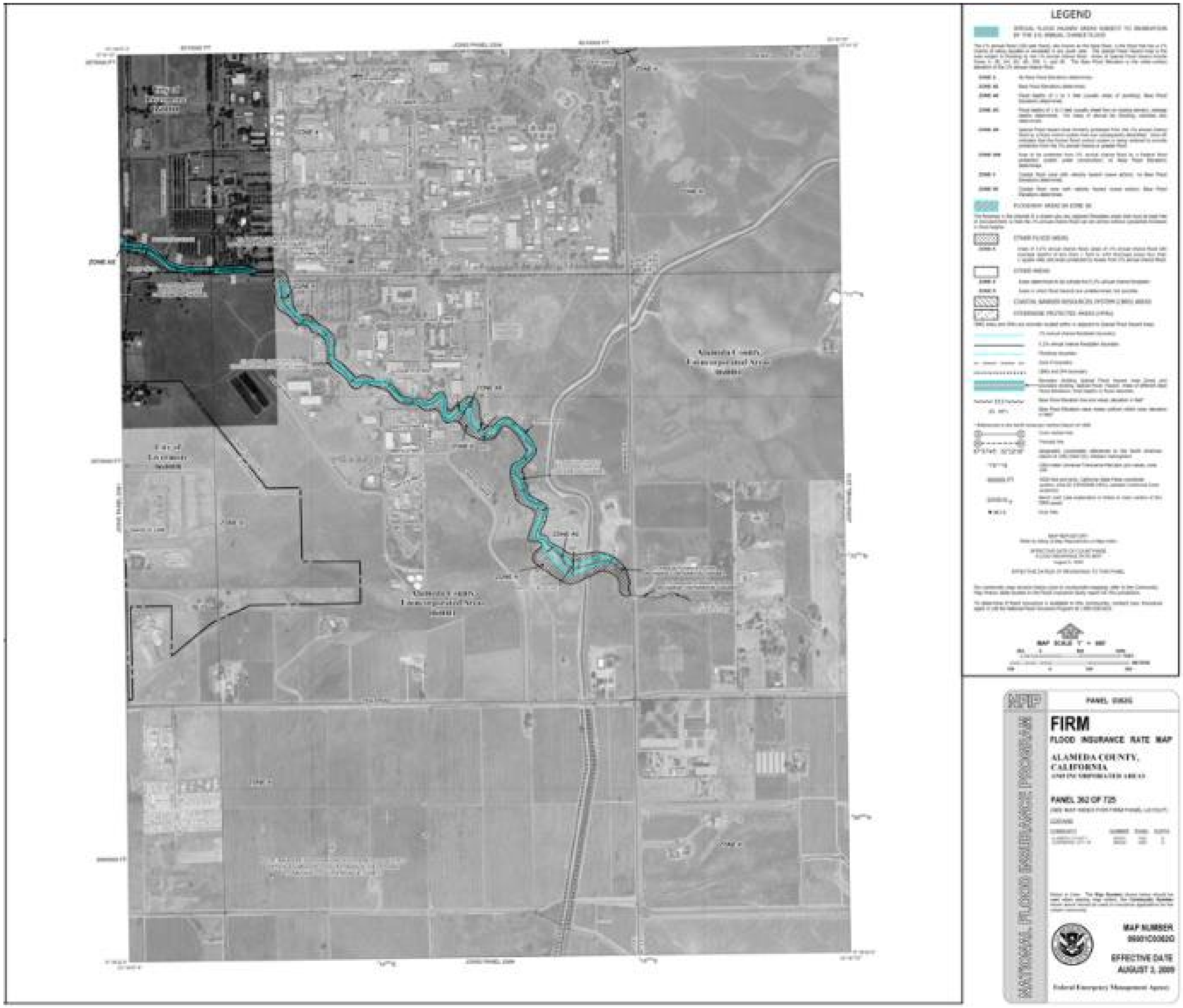
Source: Nomad Ecology 2020.

Note: Jurisdictional status may not be current for Water of the U.S. Jurisdictional assessment are based on the 2020 Navigable Waters Protection Rule which was vacated by the U.S. District Court and is no longer being implemented by the USEPA and the USACE.

Figure E-2. Wetland and Aquatic Resources Delineation at the Livermore Site (Sheet 2 of 2)

Source: FEMA 2009a, FEMA 2020.

Figure E-3. 100- and 500-Year Floodplains in the Northern Part of the Livermore Site

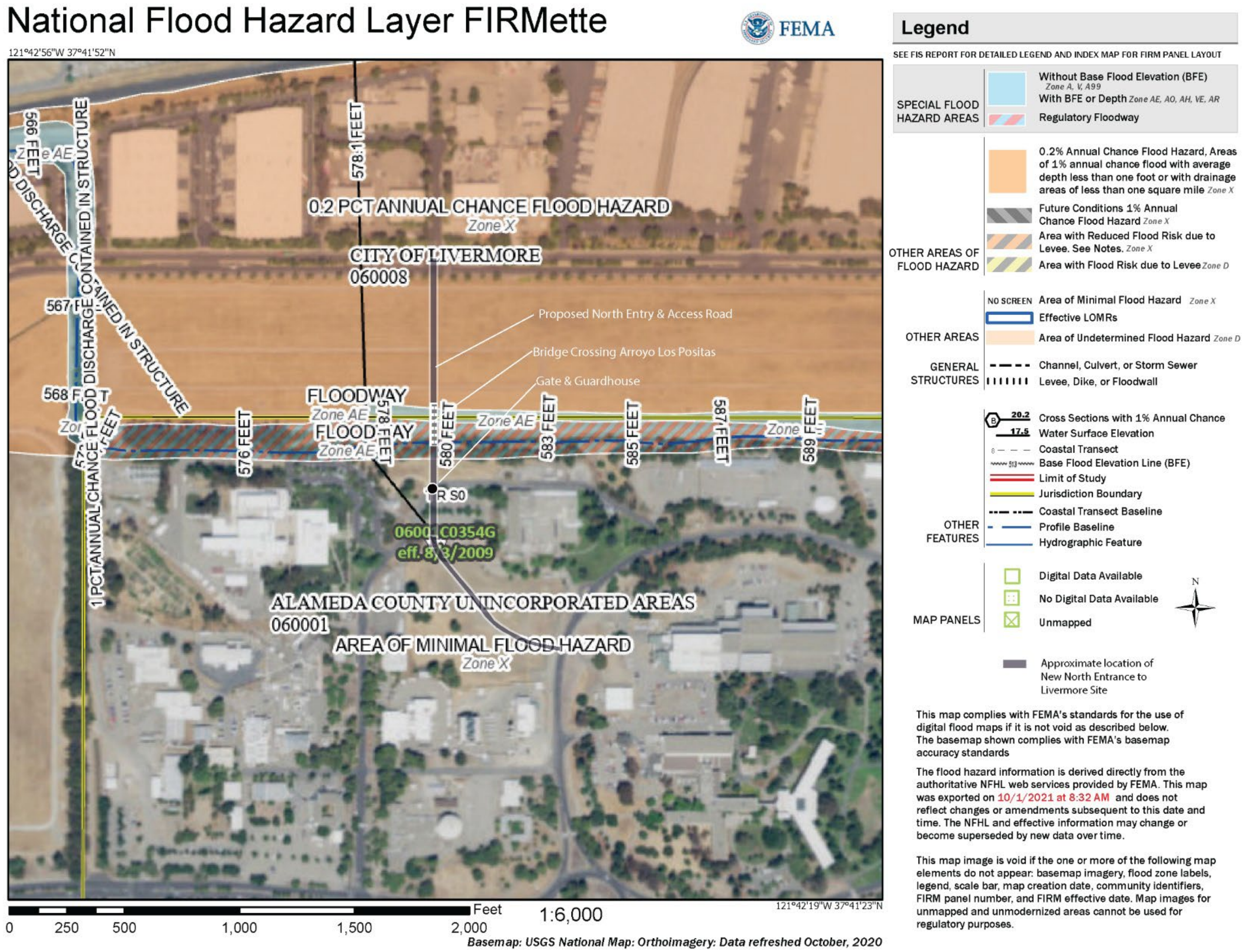


Source: FEMA 2009a, FEMA 2020.

Figure E-4. 100- and 500-Year Floodplains in the Southwestern Part of the Livermore Site

Source: modified from LLNL 2021.

Figure E-5. Details of New North Entry to Livermore Site



Source: modified from FEMA 2020.

Figure E-6. 100- and 500-Year Floodplains in the Vicinity of the New North Entry at the Livermore Site

The proposed projects would be consistent with the requirements in EO 11988. Specifically, the proposed projects would not: (1) cause a risk of flood damage; (2) affect the impact of floods on human safety, health, and welfare; or (3) adversely affect the natural and beneficial values served by floodplains. The New North Entry is not considered a critical action because a small chance of flooding would not be significant for this new roadway. With regard to ingress and egress, the Livermore Site has three alternative entrances that can be used in the event of flooding. However, because the New North Entry would be located within the 100-year floodplain (base floodplain) along Arroyo Las Positas, this floodplain analysis includes the New North Entry.

The preferred location of the new Fire Station would be in the southwest area of the Livermore Site. An alternate location is also analyzed in this SWEIS. For the alternate location, the Fire Station would be located in the north buffer zone which is located outside the 100-year floodplain, but within the 500-year floodplain, a floodplain analysis would only be required if the new Fire Station is considered a critical action. At this time, NNSA has not determined whether the Fire Station would be a critical action or not because additional analysis of surface elevations and hydrology is required to determine the potential for flooding at the location of the new Fire Station. The facility would not store materials that are highly volatile, toxic, or water reactive that could cause significant adverse impacts in the event of a flood, which is indicative of a non-critical action. However, a flooding event has the potential to render the Fire Station inoperable for some period of time. If that were to occur, emergency services to the Livermore Site would need to be provided by the Alameda County Fire Department, which could delay response time to the Livermore Site.

If the alternate location is selected, an analysis would be conducted prior to construction to determine the potential of flooding at the location of the new Fire Station. That analysis would be based on hydrological modeling of potential surface flow and an analysis of historic flood data for this location. Based on the results of that analysis, the design of the new Fire Station would include features to prevent flooding, if necessary, to ensure it would not be impacted by a flood event. Design considerations could include raising the elevation of the Fire Station construction site.

Potential impacts to floodplain values that could be impacted by both projects include the addition of sediment to storm water runoff, the loss of a small volume of flood storage capacity within the floodplain, potential impacts to California red-legged frogs and California tiger salamanders and their upland habitat. These potential impacts would be avoided or minimized through the avoidance measures described below. The small percentages of the 500-year (3.5 percent) and 100-year (0.4 percent) floodplains at the Livermore Site potentially affected by the proposed projects would result in negligible effects on the floodplain storage capacity, stormwater quality, and aquatic resources for the California red-legged frog and California tiger salamander. Consultation with the U.S. Fish and Wildlife Service would be conducted to evaluate the potential effects of the action on listed species and develop measures to avoid, minimize, or offset effects of the action.

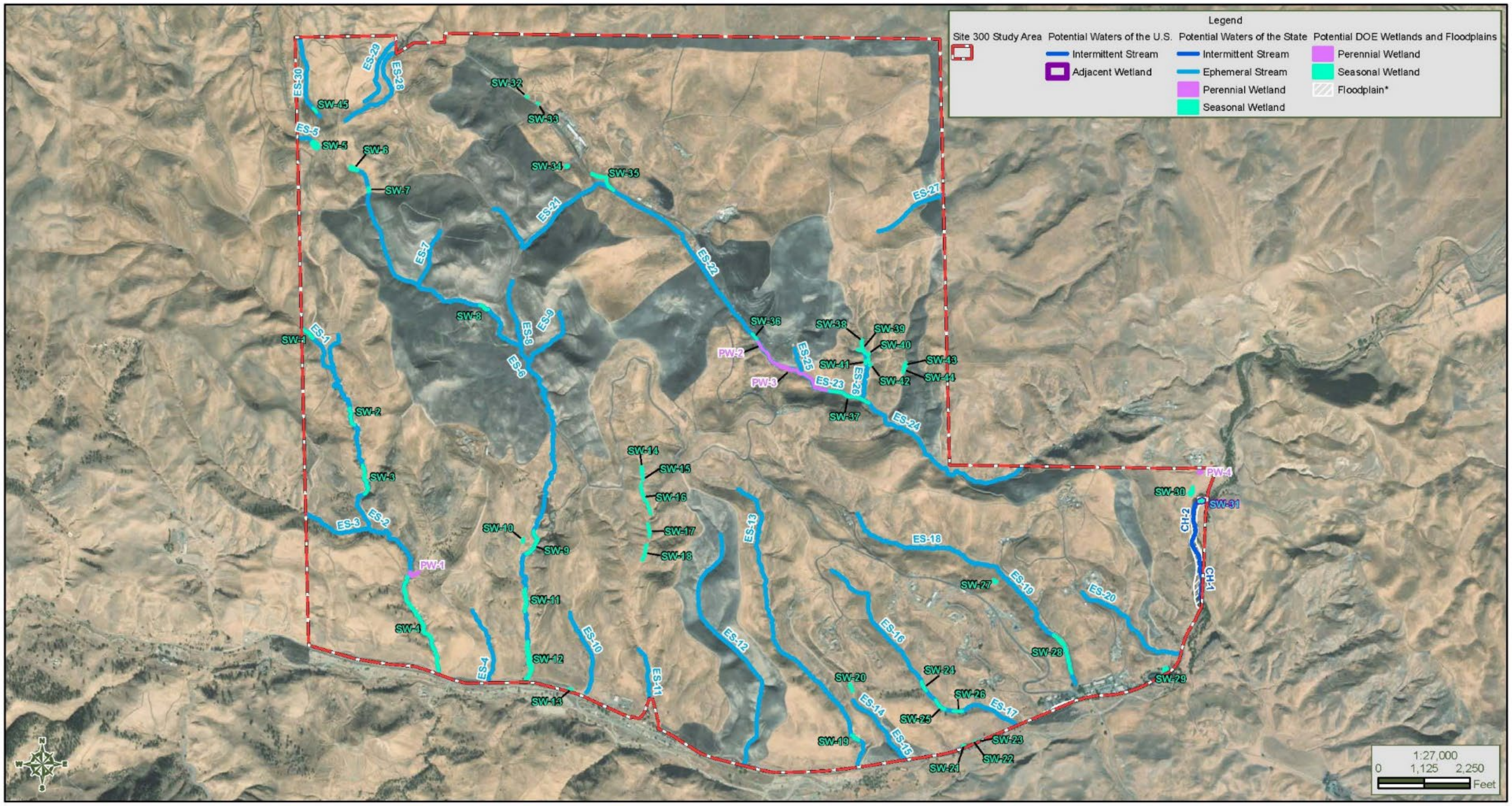
LLNL meets storm water pollution prevention requirements of the California National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction Activity (2009-0009-DWQ). Best Management Practices (BMPs) would be implemented to minimize or eliminate impacts to storm water runoff. Storm water protection activities, including implementation of BMPs, would be described in a project-specific Storm

Water Pollution Prevention Plan (SWPPP) prior to commencing construction or land disturbance activities.

DOE would implement best management practices for constructing the New North Entry and Fire Station, such as incorporating culverts under the roadway to maintain the flow of flood waters across the buffer zone and use a clear span bridge across the Arroyo Las Positas to minimize potential harm to, or within the floodplain. Measures would be implemented to ensure the proposed projects would not affect the east to west direction of floodwater flow in the north buffer zone or Arroyo Las Positas or increase the chance of flooding to LLNL buildings located south of Arroyo Las Positas. Areas of disturbance will be revegetated with native grass species to control erosion. In addition, restoration of disturbed areas using native grasses to replace the non-native annual grasses may increase native plant species diversity and promote native pollinators. Incorporation of best management practices for the proposed projects would minimize any potential effects on flooding to LLNL facilities. For the New North Entry, no alternatives were identified that would avoid the north buffer area floodplain and the Arroyo Las Positas floodplain; therefore, no practicable alternative is required.

E.2.2 Site 300

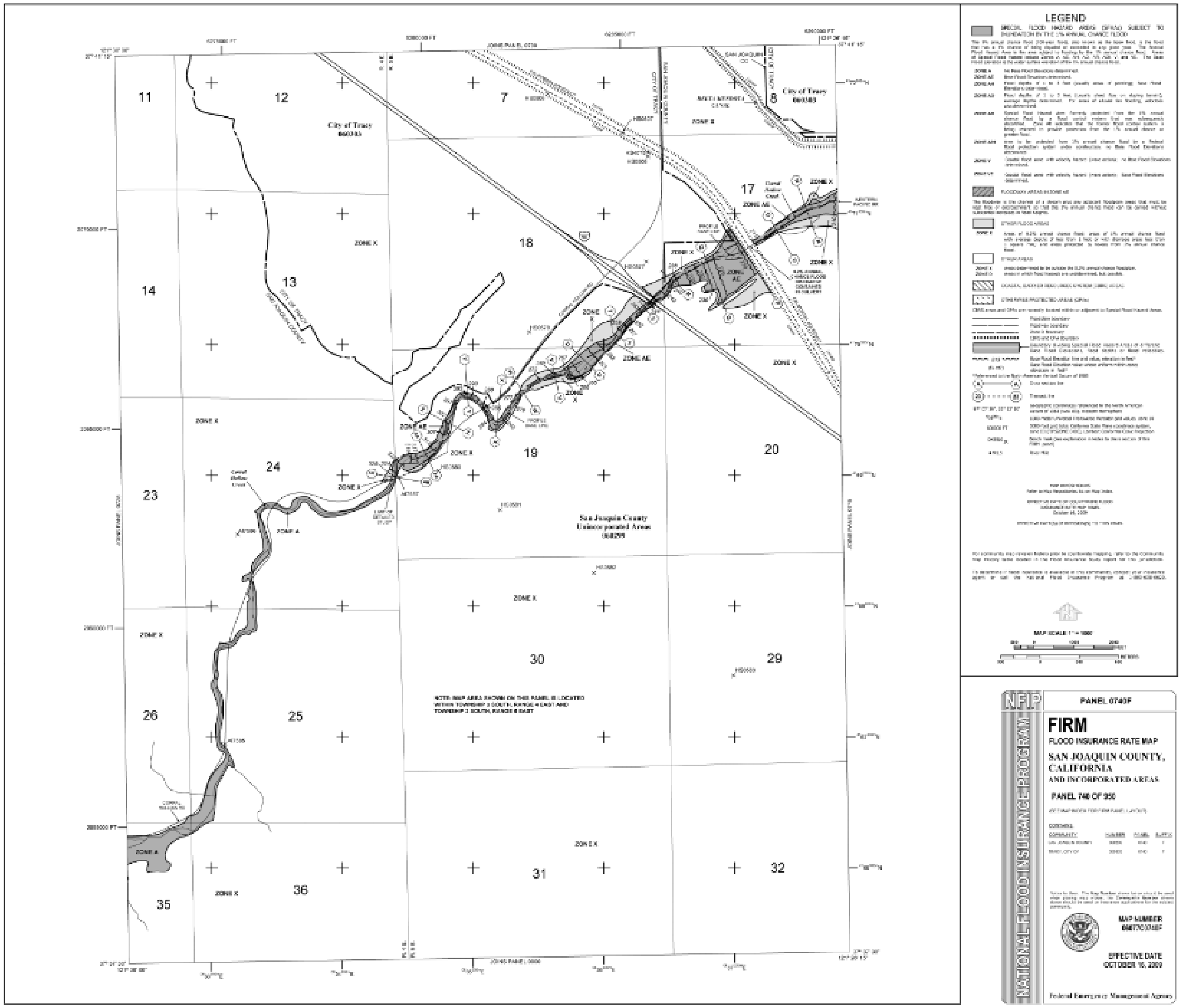
The FEMA 100-year floodplain at Site 300 is presented in the 2020 Wetland/Aquatic Resources Delineation (Nomad Ecology 2020). The FEMA floodplain map shows that the floodplain associated with the Corral Hollow intermittent stream in the southeast corner of Site 300 is 9.6 acres (FEMA 2009b, Nomad Ecology 2020). The locations of wetlands and waters are shown in Figure E-7. The FEMA Flood Insurance Rate Maps for San Joaquin County (FEMA 2020) depict the 100-year and 500-year floodplains in the southeast corner of Site 300 (Figure E-8). There are no projects proposed under the No-Action Alternative or the Proposed Action that would affect the floodplain at Site 300.



Source: Nomad Ecology 2020.

Note: Jurisdictional status may not be current for Water of the U.S. Jurisdictional assessment are based on the 2020 Navigable Waters Protection Rule which was vacated by the U.S. District Court and is no longer being implemented by the USEPA and the USACE

Figure E-7. Wetland and Aquatic Resources Delineation (Including Floodplains) at Site 300



Source: FEMA 2009b.

Figure E-8. 100- and 500-Year Floodplains in the Southeastern Corner at Site 300

E.2.3 Arroyo Mocho Pumping Station

FEMA has not mapped floodplains at the Arroyo Mocho Pumping Station (FEMA 2020, Nomad Ecology 2020). Although floodplains have not been mapped by FEMA in this remote area, floodplains are expected to occur adjacent to Arroyo Mocho. The Arroyo Mocho has been observed to receive flood flows by LLNL staff (Figure 9). If a geographic area is being considered for construction and that area has not been assessed, by FEMA or anyone else, yet floodplain evidence has been detected, floodplain delineation would be required in accordance with DOE requirements for compliance with 10 CFR Part 1022, *Compliance with Floodplain and Wetland Environmental Review Requirements*. Routine maintenance and minor modifications are exempt from the DOE Floodplain and Wetland Environmental Review Requirements (10 CFR 1022.5).

Figure E-9. Flooding Event at Arroyo Mocho

In addition, the USGS maintained a stream gage (USGS No. 11176000, Latitude 37°37'35", Longitude 121°42'13" NAD27) downstream of the Arroyo Mocho Pumping Station until January 16, 2002. Review of the annual hydrograph for the preceding 12 years shows consistent patterns of flashy, precipitation-driven flows during the winter (November-April/May) with retreat to base, or no, flow between June and October (Sequoia 2021). The elevation of the Arroyo Mocho Pumping Station is approximately 1,130 feet above mean sea level and the Arroyo Mocho stream is approximately 1,040 feet above mean sea level. The upgrades that would occur under No-Action alternatives for Arroyo Mocho Pumping Station entail interior renovations (pump replacements and pump control system). Therefore, the projects proposed under the No-Action Alternative would not affect floodplains. Proposed Action upgrades include the refurbishment of the approximately seven mile pipeline which delivers water from the Arroyo Mocho Pumping Station to the Livermore Site. Needed assessments will be conducted as part of the design process and prior to construction.

E.3 WETLAND EFFECTS

DOE Floodplain and Wetland Environmental Review Requirements define wetlands as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, and similar areas. A wetland action means any DOE action related to new construction that takes place in a wetland not located in a floodplain.

E.3.1 Livermore Site

Potential wetlands and waters of the U.S. at the Livermore Site are presented in the 2020 Wetland/Aquatic Resources Delineation (Nomad Ecology 2020). Wetlands include seasonal wetlands and freshwater marsh wetlands in intermittent streams which total 1.85 acres and 4,332 linear feet. Livermore site waters that are potentially under state or federal jurisdiction include intermittent and ephemeral streams and the Lake Haussmann impoundment which total 5.288 acres and 5,353 linear feet (Figures E-1 and E-2). The 2020 surveys (Nomad Ecology 2020) provide *preliminary* jurisdictional determinations of wetlands and waters; therefore, wetlands and waters that have been mapped may be considered potentially jurisdictional by the U.S. Army Corps of Engineers and State Water Resources Control Board.

Intermittent streams include Arroyo Las Positas, two outlet segments of Lake Haussmann, and the channel immediately upstream of Lake Haussmann. Ephemeral streams include Arroyo Seco and the East Gate Drainage. Impoundment waters are limited to Lake Haussmann. Seasonal wetlands occur in the Greenville Road Drainage Ditch. All the drainage ditches that receive only artificial water input were determined to be non-regulated wetland/aquatic resources.

No-Action Alternative. There are no projects under the No-Action Alternative that would affect the wetlands at the Livermore Site. The ongoing Arroyo Las Positas Flood Control project does affect wetlands, but is not included because it is routine maintenance.

Proposed Action. Two projects under the Proposed Action (the New North Entry and the enhancement of Lake Haussmann) would potentially affect wetlands or waters at the Livermore Site (Figures E-1 and E-2). With regard to the New North Entry (Figures E-5 and E-6), the proposed bridge across the Arroyo Las Positas would span the Arroyo and would not impact the associated intermittent stream-wetlands. The proposed project would be consistent with the requirements in EO 11990. The proposed project would avoid the destruction or modification of wetlands and new construction in wetlands. DOE would implement best management practices for constructing the roadway and use a clear span bridge across the Arroyo Las Positas to avoid potential impacts to wetlands. No alternatives were identified for a New North Entry to the Livermore Site that would avoid crossing the Arroyo Las Positas floodplain and to avoid adverse impacts; therefore, no practicable alternative is required.

NNSA is proposing additional landscaping around Lake Haussmann to facilitate a collaborative environment while retaining the lake's mission as a conveyance channel. The proposed project would not involve planting additional landscaping within wetlands or waters of the U.S. Wetlands are present that meet the wetland definition included in the DOE Floodplain and Wetland Review

Requirements (10 CFR 1022.4). The additional landscaping around Lake Haussmann would not affect DOE wetlands or intermittent stream waters adjacent to the lake. No alternatives were identified for Lake Haussmann enhancements to avoid adverse impacts; therefore, no practicable alternative is required.

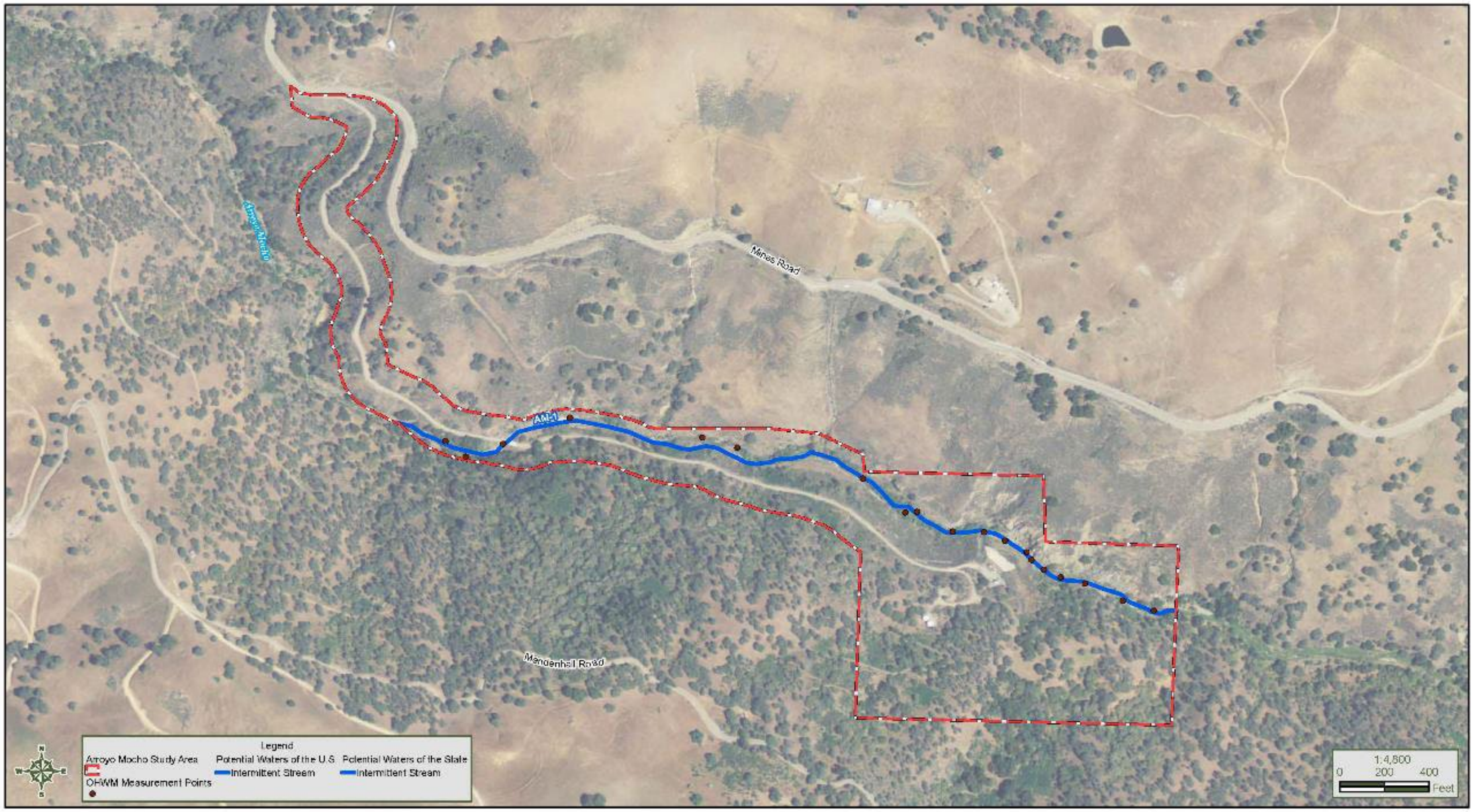
E.3.2 Site 300

Potential wetlands and waters of the U.S. at Site 300 are presented in the 2020 Wetland/Aquatic Resources Delineation (Nomad Ecology 2020). Perennial and seasonal wetlands total 8.4 acres. Waters include intermittent and ephemeral streams which total 10.54 acres and 108,066 linear feet (Figure E-7).

Corral Hollow is the only intermittent stream on Site 300. There were 30 ephemeral stream segments, four perennial wetlands, and 45 seasonal wetlands mapped on Site 300 (Nomad Ecology 2020). There are no projects proposed under the No-Action Alternative or the Proposed Action that would affect wetlands or waters at Site 300.

E.3.3 Arroyo Mocho Pump Station

Potential wetlands and waters of the U.S. at the Arroyo Mocho Pump Station are presented in the 2020 Wetland/Aquatic Resources Delineation (Nomad Ecology 2020). Although there were no wetlands at the Arroyo Mocho Pump Station that meet the California or federal definition of wetlands, wetlands are present that meet the wetland definition included in the DOE Floodplain and Wetland Review Requirements (10 CFR 1022.4). Waters include open water of Arroyo Mocho which totals 3.5 acres and 3,865 linear feet (Figure E-10). The projects proposed under the No-Action Alternative and the Proposed Action would not affect wetlands or waters at the Arroyo Mocho Pump Station.



Source: Nomad Ecology 2020.
Note: Jurisdictional status may not be current for Water of the U.S. Jurisdictional assessment are based on the 2020 Navigable Waters Protection Rule which was vacated by the U.S. District Court and is no longer being implemented by the USEPA and the USACE.

Figure E-10. Wetland and Aquatic Resources Delineation at the Arroyo Mocho Pumping Station

E.4 References

10 CFR Part 1022 — "Compliance with Floodplain and Wetland Environmental Review Requirements." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=16254389c07c98991085c732029dae22&mc=true&node=pt10.4.1022&rgn=div5

10 CFR Part 1022.4 — "Definitions." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/current/title-10/chapter-X/part-1022#1022.4

10 CFR Part 1022.5 — "Applicability." *Energy*. U.S. Department of Energy. *Code of Federal Regulations.* Available online: https://www.ecfr.gov/current/title-10/chapter-X/part-1022/subpart-A/section-1022.5

EO 11988 — "Floodplain Management." May 24, 1977; 42 FR 26951. Available online:https://www.archives.gov/federal-register/codification/executive-order/11988.html

EO 11990 — "Protection of Wetlands." May 24, 1977; 42 FR 26961. Available online: https://www.energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/Req-EO11990wetlands.pdf

FEMA 2009a — Federal Emergency Management Agency (FEMA). Flood Insurance Rate Map (FIRM), Alameda County California and Incorporated Area, Map Numbers 06001C0354G and 06001C0362G. 2009. Accessed from the FEMA National Flood Hazard Viewer at: https://www.fema.gov/flood-maps/national-flood-hazard-layer (accessed October 22, 2021).

FEMA 2009b — Federal Emergency Management Agency (FEMA). Flood Insurance Rate Map (FIRM), San Joaquin County, California, Map Number 06077C0725F. 2009. Accessed from the FEMA National Flood Hazard Viewer at: https://www.fema.gov/flood-maps/national-flood-hazard-layer (accessed March 11, 2021).

FEMA 2020 — Federal Emergency Management Agency (FEMA). "FEMA's National Flood Hazard Layer Viewer." Available online: https://hazards-fema.maps.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd&extent=-121.71084748416098,37.68433136174484,-

121.70170651583902,37.688576590991126 (accessed October 1, 2021)

LLNL 2021 — *A New Site Development Plan for Lawrence Livermore National Laboratory 2021*. ID 1997. Lawrence Livermore National Laboratory, Livermore, CA. January 2021.

Nomad Ecology 2020 — Nomad Ecology. *Wetland/Aquatic Resources Delineation for the 2021 Sitewide Environmental Impact Statement. Lawrence Livermore National Laboratory Facilities, Alameda and San Joaquin Counties, California*. LLNL-TR-816689. ID 1883. Prepared for Lawrence Livermore National Laboratory by Nomad Ecology, Martinez, CA. September 2020.

Sequoia 2021 — Sequoia Ecological Consulting, Inc. *Arroyo Mocho Habitat Suitability Assessment for Sensitive Reptiles, Amphibians, and Fish for the 2021 Sitewide Environmental Impact Statement*, *Lawrence Livermore National Laboratory, California*. LLNL-SR-826592. ID 2104. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Sequoia Ecological Consulting. September 2021.

APPENDIX F

NEPA and CEQA CROSSWALK

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LIST OF TABLES

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F NEPA AND CEQA CROSSWALK

F.1 INTRODUCTION

The *National Environmental Policy Act* (NEPA) was one of the first U.S. environmental laws and established the broad national framework for protecting our environment. NEPA was passed in the Senate and House in 1969 and signed into law on January 1, 1970 (Title 42 of the United States Code, 4371-4347, as amended). NEPA was enacted to ensure that all federal agencies consider the environmental effects of their proposed actions prior to making decisions. The range of actions covered by NEPA is broad and includes decisions on permit applications, adopting federal land management actions, and construction of highways and other publicly owned facilities.

Nine months after Congress passed NEPA, California passed a similar measure entitled the *California Environmental Quality Act* (CEQA) (California Public Resource Code 21000 *et sq*). NEPA and CEQA are similar, both in intent and in the review processes they require. CEQA incorporated many of the same stated goals and provisions of NEPA, but differs in a few respects. CEQA requires state and local government agencies to inform decision makers and the public about the potential environmental impacts of proposed projects, to mitigate significant environmental impacts to the extent feasible. NEPA does not require that the lead agency implement mitigation measures to reduce environmental impacts caused by the proposed project or legislation. Instead, NEPA only requires that the lead agency show that mitigation measures were considered.

Under NEPA, an Environmental Impact Statement (EIS) is required if the project or action as a whole will produce significant environmental impacts based on context and intensity. CEQA requires each significant effect on the environment resulting from a project to be identified and mitigated if feasible and an Environmental Impact Report (EIR) is required if a proposed project will result in a significant environmental effect that cannot be mitigated to a less-than-significant level. A significant effect under CEQA may not have great enough magnitude to be considered a significant impact under NEPA, thus CEQA has a much narrower scope and a lower threshold to trigger the need for an EIR.

Both NEPA and CEQA require agencies to determine whether a proposed action or project may have a significant impact on the environment, and to determine the appropriate level of environmental review. When NEPA and CEQA apply, agencies must therefore first determine what level of review is required. The agency has the following three NEPA and CEQA options: (1) Categorical Exclusion/Categorical Exemption; (2) Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) (or Mitigated FONSI)/Initial Study (IS)) and Negative Declaration (ND) (or Mitigated Negative Declaration (MND)); or (3) EIS/EIR. Table F-1 compares the NEPA and CEQA processes.

Table F-2. Comparison of NEPA and CEQA Processes (EIS Process versus EIR Process)

NEPA (EIS Process)	CEQA (EIR Process)
Notice of Intent	Notice of Preparation
Scoping	Scoping
Draft EIS	Draft EIR
Filing with EPA which publishes a Notice of Availability in the Federal Register	State Clearinghouse Distribution for State Agency Review (if required)
Public and Agency Review and Comment	Public and Agency Review and Comment
Final EIS	Final EIR
-	Provide proposed responses to public agency comments at least 10 days prior to certification of the EIR
Filing and EPA Notice of Availability in the Federal Register, and, if necessary, Mitigation Action Plan	Certify EIR, adopt Findings on Project' Significant Environmental Impacts and Alternatives, Mitigation Monitoring and Reporting Program, and, if necessary, a Statement of Overriding Considerations
30-day wait period	-
Agency Decision: Record of Decision	Agency Decision: Notice of Determination

While there is substantial overlap between NEPA and CEQA, there are some key terminology distinctions between the two laws. For example, NEPA refers to the evaluated activity in an EIS as a proposed action by a federal entity, whereas CEQA refers to the activity as a proposed project undertaken, supported, or permitted by a public agency. Table F-2 outlines and correlates the terminology between the two laws.

Table F-3. Correlation of NEPA and CEQA Terminology

NEPA Terminology	CEQA Terminology
Existing Environment	Environmental Setting
Cooperating Agency	Responsible Agency
Environmental Consequences	Environmental Impacts
Environmental Impact Statement	Environmental Impact Report
EPA Filing/Federal Register Notice and Agency/ Public Review (also known as a Notice of Availability)	Notice of Completion/Notice of Availability
No Action Alternative	No Project Alternative
Notice of Intent	Notice of Preparation
Purpose and Need	Project Objectives
Proposed Action and Alternatives	Proposed Project and Alternatives
Record of Decision	Notice of Determination/Findings/Statement of Overriding Considerations
Although none are specified in NEPA, CEQ regulations require an EIS to identify the direct and indirect effects "and their significance" (40 CFR 1502.16)	Threshold of Significance/Significant Impacts

The CEQA Guidelines allow a state or local agency to use an EIS or EA and FONSI if completed before an EIR or ND would otherwise be prepared for the project, if the NEPA review meets CEQA requirements. Section 15221 of the CEQA Guidelines sets forth rules governing use of a NEPA document to satisfy CEQA. It states:

1) When a project will require compliance with both CEQA and NEPA, State or local agencies should use the EIS or Finding of No Significant Impact rather than preparing an EIR or Negative Declaration if the following two conditions occur:

   a) An EIS or Finding of No Significant Impact will be prepared before an EIR or Negative Declaration would otherwise be completed for the project; and
   b) The EIS or Finding of No Significant Impact complies with the provisions of these Guidelines.
2) Because NEPA does not require separate discussion of mitigation measures or growth inducing impacts, these points of analysis will need to be added, supplemented, or identified before the EIS can be used as an EIR.

To complete the CEQA analysis, four descriptive categories are used to discuss environmental impacts: Potentially Significant Impact, Less Than Significant With Mitigation, Less Than Significant Impact, and No Impact. These categories have been created and assigned to individual impacts only for the purposes of supporting CEQA requirements and are used here only in a CEQA context. Under NEPA, the significance of environmental impacts determines the need for the NEPA document. Once that decision has been made, specific impacts are not categorized according to level of impact in an EIS. The following describes the environmental impact categories used in this document:

- **Potentially Significant Impact**—There is substantial evidence that the impact of the proposed project may be significant and cannot be avoided or reduced to a less-than-significant level.
- **Less than Significant with Mitigation**—Absent mitigation measures or project revisions, the impact of the proposed project would be considered significant.
- **Less Than Significant Impact**—The proposed project would result in an impact, but at a level that is not considered significant.
- **No Impact**—The proposed project would not result in an impact.

For this SWEIS, NNSA has prepared Table F-3, which identifies/categorizes the potential CEQA impacts based on the analysis in this SWEIS. Table F-3 correlates the NEPA impacts to one of the four descriptive categories discussed above (i.e., (1) Potentially Significant Impact; (2) Less than Significant with Mitigation; (3) Less Than Significant Impact; and (4) No Impact). As shown in Table F-3, all of the potential CEQA impacts are categorized as either "less than significant" or "no impact."

Table F-4. Potential CEQA Impacts Based on Analysis in this SWEIS

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).

Environmental Factors Potentially Affected per CEQA Guidelines	No-Action Alternative	Proposed Action	Notes/Relevant Section in SWEIS
1. Aesthetics			
a. Have a substantial adverse effect on a scenic vista.	○	○	5.3.1, 5.3.2
b. Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings and historic buildings within a state scenic highway.	○	○	5.3.1, 5.3.2
c. Substantially degrade the existing visual character or quality of public views of the site and its surroundings.	○	○	5.3.1, 5.3.2
d. Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area.	○	○	5.3.1, 5.3.2
2. Agricultural Resources			
a. Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland) as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to nonagricultural use.	○	○	5.4.1, 5.4.2
b. Conflict with existing zoning or agriculture use, or Williamson Act contract.	○	○	5.2.1, 5.2.2
c. Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural uses.	○	○	5.4.1, 5.4.2
3. Air Quality			
a. Conflict with or obstruct implementation of the applicable air quality plan.	○	○	5.6.1, 5.6.2
b. Violate any air quality standard or contribute substantially to an existing or projected air quality violation.	△	△	5.6.1, 5.6.2
c. Result in cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors).	△	△	5.6.1, 5.6.2
d. Expose sensitive receptors to substantial pollutant concentrations.	○	○	5.6.1, 5.6.2
e. Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people.	○	○	5.6.1, 5.6.2
4. Biological Resources			
a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the	△	△	5.8.1, 5.8.2

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).			
Environmental Factors Potentially Affected per CEQA Guidelines	**No-Action Alternative**	**Proposed Action**	**Notes/Relevant Section in SWEIS**
California Department of Fish and Wildlife or U.S. Fish and Wildlife Service.			
b. Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service.	△	△	5.8.1, 5.8.2
c. Have a substantial adverse effect on state or federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means.	○	△	5.8.1, 5.8.2
d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.	△	△	5.8.1, 5.8.2
e. Conflict with local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance.	○	○	5.8.1, 5.8.2
f. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.	○	○	5.8.1, 5.8.2
5. Cultural Resources			
a. Cause a substantial adverse change in the significance of a historical resource as defined in § 15064.5.	△	◇[a]	5.9.1, 5.9.2
b. Cause a substantial adverse change in the significance of an archeological resource pursuant to § 15064.5.	○	○	5.9.1, 5.9.2
c. Disturb any human remains, including those interred outside of formal cemeteries.	○	○	5.9.1, 5.9.2
6. **Energy**			
a. Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation.	○	○	5.12.1, 5.12.2
b. Conflict with or obstruct a state or local plan for renewable energy or energy efficiency.	○	○	5.12.1, 5.12.2
7. Geology and Soils			
a. Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:	△	△	5.4.1, 5.4.2

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).			
Environmental Factors Potentially Affected per CEQA Guidelines	**No-Action Alternative**	**Proposed Action**	**Notes/Relevant Section in SWEIS**
○ Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. (Refer to Division of Mines and Geology Special Publication 42.) ○ Strong seismic ground shaking. ○ Seismic-related ground failure, including liquefaction. ○ Landslides.			
b. Result in substantial soil erosion or the loss of topsoil.	△	△	5.4.1, 5.4.2
c. Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.	○	○	5.4.1, 5.4.2
d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property.	N/A	N/A	
e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of water.	N/A	N/A	
f. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.	△	△	5.9.1, 5.9.2
8. Greenhouse Gas Emissions			
a. Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment.	△	△	5.6.1, 5.6.2
b. Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases.	△	△	5.6.1, 5.6.2
9. Hazards and Hazardous Materials			
a. Create a significant hazard to the public or the environment throughout the routine transport, use or disposal of hazardous materials.	△	△	5.13.1.1, 5.13.1.2, 5.13.2.2, 5.13.2.3, 5.11.3
b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.	△	△	5.13.1.1, 5.13.1.2, 5.13.2.2, 5.13.2.3, 5.16
c. Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances or waste within one-quarter mile of an existing or proposed school.	○	○	5.10.1, 5.10.2, 5.13.1.1, 5.13.1.2 5.13.2.2, 5.13.2.3

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).

Environmental Factors Potentially Affected per CEQA Guidelines	No-Action Alternative	Proposed Action	Notes/Relevant Section in SWEIS
d. Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to public or the environment.	○	○	5.13.1.1, 5.13.1.2, 5.13.2.2, 5.13.2.3 Neither the Livermore Site nor Site 300 are on the Cortese List
e. Impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan.	△	△	5.13.1.1, 5.13.1.2, 5.13.2.2, 5.13.2.3, 5.16, Appendix C (Section C.5) Plans will have to be updated to incorporate new quantities of hazardous materials, but otherwise implementation should not be adversely impacted
f. Expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving wildland fires.	○ ◇	○ ◇	5.16.2, Appendix C (Section C.3.6.2) Livermore Site is ○ Site 300 is ◇
10. Hydrology and Water Quality			
a. Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality.	○	○	5.5.1, 5.5.2
b. Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin.	○	○	5.5.1, 5.5.2
c. Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would: o Result in substantial erosion or siltation on- or off-site; o Substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site; o Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or o Impede or redirect flood flows.	○	○	5.5.1, 5.5.2
d. In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation.	○	○	5.5.1, 5.5.2
e. Conflict or obstruct implementation of a water quality control plan or sustainable groundwater management plan.	○	○	5.5.1, 5.5.2
11. Land Use and Planning			
a. Physically divide an established community.	○	○	5.2.1, 5.2.2

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).			
Environmental Factors Potentially Affected per CEQA Guidelines	**No-Action Alternative**	**Proposed Action**	**Notes/Relevant Section in SWEIS**
b. Cause a significant environmental impact due to a conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect.	○	○	5.2.1, 5.2.2
12. Mineral Resources			
a. Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.	○	○	5.4.1, 5.4.2
b. Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.	○	○	5.41, 5.4.2
13. Noise			
a. Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.	△	△	5.7.1, 5.7.2
b. Generation of excessive groundbourne vibration or groundbourne noise levels.	○	○	5.7.1, 5.7.2
14. Population and Housing			
a. Induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure).	○	○	5.10.1, 5.10.2
b. Displace substantial numbers of existing people or housing, necessitating the construction of replacement housing elsewhere.	○	○	5.10.1, 5.10.2
15. Public Services			
a. Result in substantial adverse physical impacts associated with the provision of new or physically altered government facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the following public services: fire protection, police protection, schools, parks, other public facilities.	○	○	5.10.1, 5.10.2
16. Recreation			
a. Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated.	○	○	5.10.1, 5.10.2

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).			
Environmental Factors Potentially Affected per CEQA Guidelines	**No-Action Alternative**	**Proposed Action**	**Notes/Relevant Section in SWEIS**
b. Include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment.	○	○	5.10.1, 5.10.2
17. Transportation and Traffic			
a. Conflict with a program, plan, ordinance or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities.	△	△	5.11.1, 5.11.2
b. Conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b) (Criteria for Analyzing Transportation Impacts).	△	△	5.11.1, 5.11.2
c. Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment).	○	○	3.2, 5.11.1, 5.11.2
d. Result in inadequate emergency access.	○	○	3.3, 5.11.1, 5.11.2
18. Tribal Cultural Resources. Cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code section 21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:			
a. Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code section 5020.1(k), or	○	○	5.9.1, 5.9.2
b. A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code Section 5024.1. In applying the criteria set forth in subdivision (c) of Public Resources Code Section 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe.	○	○	5.9.1, 5.9.2
19. Utility and Service Systems			
a. Require or result in the relocation or construction of new or expanded water, wastewater treatment or storm water drainage, electric power, natural gas, or telecommunications facilities, the construction or relocation of which could cause significant environmental effects.	△	△	5.12.1, 5.12.2
b. Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years.	△	△	5.12.1, 5.12.2
c. Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the providers existing commitments.	○	△	5.12.1, 5.12.2

CEQA: (○-No Impact, △-Less than Significant Impact, ◇-Less than Significant with Mitigation, and ◆-Potentially Significant Impact).			
Environmental Factors Potentially Affected per CEQA Guidelines	**No-Action Alternative**	**Proposed Action**	**Notes/Relevant Section in SWEIS**
d. Generate solid waste in excess or State or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals.	△	△	5.13.1.1, 5.13.1.2, 5.13.2.2, 5.13.2.3, 5.11.3
e. Comply with federal, state, and local management and reduction statutes and regulations related to solid waste.	○	○	5.13.1.1, 5.13.1.2, 5.13.2.2, 5.13.2.3, 5.11.3

Source: AEP 2021.

[a] If facilities are identified as NRHP-eligible under the Proposed Action appropriate mitigation would be implemented.

F.2 REFERENCES

AEP 2021 Association of Environmental Professional (AEP). "2021 California Environmental Quality Act (CEQA) Statute and Guidelines." Available online: https://www.califaep.org/docs/CEQA_Handbook_2021.pdf (accessed January 2022).

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APPENDIX G

Public Notices

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DOE/FE ORDERS GRANTING IMPORT/EXPORT AUTHORIZATIONS—Continued

4556	06/22/20	20–62–NG	Producción de Energía Mexicana, S. de R.L. de C.V.	Order 4556 granting blanket authority to export natural gas to Mexico.
4557; 4211–A	06/24/20	20–64–NG; 18–77–NG	J. Aron & Company LLC	Order 4557 granting blanket authority to import/export natural gas from/to Canada/Mexico, and vacating prior authority (Order 4211).

[FR Doc. 2020–17068 Filed 8–4–20; 8:45 am]

BILLING CODE 6450–01–P

DEPARTMENT OF ENERGY

National Nuclear Security Administration

Notice of Intent To Prepare a Site-Wide Environmental Impact Statement for Continued Operation of the Lawrence Livermore National Laboratory

AGENCY: National Nuclear Security Administration, Department of Energy.

ACTION: Notice of intent.

SUMMARY: The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the United States (U.S.) Department of Energy (DOE), announces its intent to prepare a Site-Wide Environmental Impact Statement (SWEIS) for the Lawrence Livermore National Laboratory (LLNL or Laboratory) in Livermore, California (LLNL SWEIS). The LLNL SWEIS will be prepared by NNSA's Livermore Field Office (LFO) and analyze the potential environmental impacts of the Proposed Action, other reasonable alternatives that may be identified, and the No Action Alternative for continuing operations of LLNL for approximately the next 15 years. The continued operation of LLNL is critical to NNSA's Stockpile Stewardship Program, to preventing the spread and use of nuclear weapons worldwide, and to many other areas that may impact national security and global stability. The Proposed Action Alternative will include continued operations and foreseeable new and/or modified operations/facilities to address aging infrastructure concerns at LLNL. The purpose of this Notice is to invite public participation in the process and to encourage public involvement on the scope and alternatives that should be considered.

DATES: The public scoping period begins with the publication of this Notice in the **Federal Register** and continues until September 21, 2020. Comments received after this date will be considered to the extent practicable. NNSA will hold one public scoping meeting for the proposed LLNL SWEIS as follows:

In light of recent public health concerns, NNSA will be hosting an internet-based, virtual public scoping meeting in place of an in-person meeting. The date of the meeting will be provided in a future notice posted on the following website: *https://www.energy.gov/nnsa/nnsa-nepa-reading-room.* NNSA will hold the meeting no earlier than 15 days from the posting of the notice. Public scoping meeting details will also be announced in local media outlets.

ADDRESSES: NNSA invites other Federal and state agencies, state and local governments, Native American tribes, industry, other organizations, and members of the public to submit comments to assist in identifying environmental issues and in determining the appropriate scope of the LLNL SWEIS. Written and oral comments will be given equal weight and NNSA will consider all comments received or postmarked by the end of the comment period in preparing the Draft LLNL SWEIS. Comments received or postmarked after the comment period will be considered to the extent practicable. Written comments on the scope of the LLNL SWEIS or requests for information related to the LLNL SWEIS should be sent to: Ms. Fana Gebeyehu-Houston, NEPA Document Manager, National Nuclear Security Administration, Livermore Field Office, 7000 East Avenue, L–293, Livermore, CA 94550–9234 or email to: *LLNLSWEIS@NNSA.DOE.GOV.* Before including your address, phone number, email address, or other personally identifiable information in your comment, please be advised that your entire comment—including your personally identifiable information—may be made publicly available. If you wish for NNSA to withhold your name and/or other personally identifiable information, please state this prominently at the beginning of your comment. You may also submit comments anonymously.

Information related to the online scoping meeting, including internet and telephone access details, and instructions on how to participate will be available at the following website: *https://www.energy.gov/nnsa/nnsa-nepa-reading-room* and announced in local media outlets.

FOR FURTHER INFORMATION CONTACT: For further information about this Notice, please contact Ms. Fana Gebeyehu-Houston, NEPA Document Manager, National Nuclear Security Administration, Livermore Field Office, 7000 East Avenue, L–293, Livermore, CA 94550–9234; phone: 833–778–0508; or email to: *LLNLSWEIS@NNSA.DOE.GOV.*

SUPPLEMENTARY INFORMATION:

Background

LLNL has been in existence for 68 years, has an annual budget of approximately $2.2 billion and employs approximately 8,000 people. LLNL consists of two federally-owned sites: A 770-acre site in Livermore, California (Livermore Site) and a 7,000-acre experimental test site (Site 300) southeast of the Livermore Site between Livermore and Tracy, California. Most LLNL operations are located at the Livermore Site, which is situated about 50 miles east of San Francisco in southeastern Alameda County. Site 300 is primarily a test site for explosives and non-nuclear weapons components; it is located about 15 miles southeast of Livermore in the hills of the Diablo Range. Most of Site 300 is located in San Joaquin County; the western edge of the site is in Alameda County.

Missions

The 21st century presents a growing set of challenges that are the focus of the Laboratory's mission as a DOE/NNSA national security laboratory. LLNL's defining responsibility is ensuring the safety, security, and reliability of the nation's nuclear deterrent. LLNL's mission is broader than stockpile stewardship and also includes missions that respond to national security and global security concerns that range from nuclear proliferation and terrorism to energy shortages and climate change. The Laboratory's science and engineering capabilities are applied to these challenges. Programs at LLNL support DOE, NNSA, Department of Defense (DoD), Department of Homeland Security (DHS), and other federal sponsor missions. LLNL also conducts work to collaborate with and

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support state and local agencies, private and academic sponsors, and other scientific collaborators.

Basic science is the engine that drives national security research at LLNL. Funded by a broad contingent of the scientific community—including the Office of Science, academic partners, and Laboratory Directed Research and Development investments—basic science ensures that LLNL research capabilities remain at the cutting edge and that LLNL's scientists and engineers are prepared to solve critical challenges across national security missions. This basic science supports the LLNL missions.

Weapons

The Weapons Program works to ensure that the nation's nuclear deterrent remains safe, secure, and reliable. The program accomplishes this through the Stockpile Stewardship Program—an ongoing effort to apply a science-based fundamental understanding of nuclear weapons performance—from the development of enhanced warhead surveillance tools that detect the onset of problems to manufacturing capabilities that produce critical components. High performance computational capabilities used for physics computer simulations and code development are conducted on some of the world's most capable supercomputers, located at LLNL.

Lasers

The National Ignition program is an important national scientific resource that uses advanced lasers to research materials at temperatures and pressures that otherwise would only exist in the cores of stars and giant planets and inside nuclear weapons. The National Ignition Facility's (NIF) primary purpose is assuring viability of the nation's nuclear deterrent as part of the Stockpile Stewardship Program. This includes a variety of scientific studies from the DOE national laboratories, high energy density science research centers, academia, and other national and international scientific programs.

Biosecurity

To keep the world safe from ever-changing biological threats, revolutionary advances in detection, characterization and mitigation are essential to safeguard against disease. High performance computational capabilities are used to enhance bioinformatics and to develop novel drug development strategies and point-of-care public health monitoring and detection.

Counterterrorism

In a world where threats are continuously changing, the Laboratory is working diligently to help the nation prevent and mitigate catastrophic incidents arising from biological, chemical, radiological, or high explosive materials. This broad scope of capabilities has resulted in collaborations with sponsors such as DHS, the Department of Agriculture, the Department of Justice, the Department of Commerce, state and local governments, and non-governmental organizations.

Defense

LLNL supports DoD as a preeminent innovative science and technology contributor. For 68 years the Laboratory has answered the call to help defend this nation, fielding products and providing services that strengthen the ability of the DoD to achieve precision effects and enhance situational awareness.

Energy

LLNL advances the nation's security through innovative science and technology solutions to improve national energy security and surety while reducing environmental impact. LLNL is developing technologies that enable expanded use of renewable energy, improved efficiency, new resources, systems integration, and reduced costs.

Intelligence

The Laboratory's Intelligence Program delivers comprehensive analysis, policy and operational support in areas where technology research and development are critical to national strategic priorities, from combating weapons of mass destruction and cyber security, to space and other emerging and disruptive technologies.

Nonproliferation

With globalization and the spreading availability of technologies, proliferation challenges continue to grow and evolve. LLNL works to stem chemical, biological, radiological, and nuclear proliferation by providing scientific and technological solutions and sound advice to counter emerging threats.

Purpose and Need for Agency Action

National security policies require DOE, through NNSA, to maintain the U.S. nuclear weapons stockpile and the nation's core competencies in nuclear weapons. NNSA has the mission to maintain and enhance the safety, security, and effectiveness of the nuclear weapons stockpile. The 2018 Nuclear Posture Review (NPR) states that an effective, responsive, and resilient nuclear weapons infrastructure is essential to the U.S. capacity to adapt flexibly to shifting requirements and support the sustainment of its nuclear forces to protect the homeland, assure allies, deter adversaries, and hedge against adverse developments.

The U.S. nuclear weapons infrastructure is aging and historically underfunded. Over half of NNSA's infrastructure is over 40 years old, and a quarter dates back to the early 1950s. Previous NPRs have highlighted the need to maintain a modern nuclear weapons infrastructure, but the U.S. has fallen short in sustaining a modern infrastructure that is resilient and has the capacity to respond to unforeseen developments. The 2018 NPR places a high priority on recapitalizing the physical infrastructure needed to produce strategic materials and components for U.S. nuclear weapons.

The 2018 NPR affirms the U.S. will have the ability to maintain and certify a safe, secure, and effective nuclear arsenal. Synchronized with DoD replacement programs, the U.S. will sustain and deliver on-time the warheads needed to support both strategic and non-strategic nuclear capabilities by completing several Life Extension Programs (LEPs) as part of the Stockpile Stewardship Program. LLNL will complete some of the LEPs by conducting testing and maintenance of weapons components without nuclear testing. LLNL will also continue its basic science to support biosecurity, counterterrorism, defense, weapons technology, energy, intelligence, nonproliferation, space programs, climate security, and cybersecurity.

LLNL is in need of facilities and infrastructure investments. Half of the operating buildings at LLNL are assessed as being inadequate or in substandard condition. This deterioration of assets presents program and operational risks in executing mission needs, attracting and maintaining a high-quality workforce, and meeting regulatory requirements.

Requirements To Fulfill DOE NEPA Compliance

The LLNL SWEIS will be prepared pursuant to the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 *et seq.*), the Council on Environmental Quality's NEPA regulations (40 CFR parts 1500–1508) and the DOE NEPA Implementing Procedures (10 CFR part 1021). The DOE regulations (10 CFR 1021.330) require preparation of site-wide documents for certain large, multiple facility sites, such as LLNL. The purpose of a SWEIS is to provide the public with an analysis of the potential environmental impacts from ongoing and reasonably foreseeable new and modified operations and facilities, and reasonable alternatives at a DOE site, to provide a basis for site-wide decision making, and to improve and coordinate agency plans, functions, programs, and resource utilization. The SWEIS provides an overall NEPA baseline so that the environmental effects of proposed future changes in programs and activities can be compared to the baseline. A SWEIS also enables DOE to "tier" its later NEPA project-specific reviews at a site to eliminate repetitive discussion of the same issues in future project-specific NEPA studies, and to focus on the actual issues ready for decisions at each level of environmental review.

The NEPA process allows for all interested agencies (federal, state and local), public interest groups, Native American Tribes, local businesses, and members of the general public to participate in the environmental review process. The new SWEIS will utilize the baseline information from the previous LLNL SWEIS (2005 LLNL SWEIS), to the extent possible, as well as current information contained in annual site environmental reports and other technical reports.

Preliminary Alternatives

The scoping process is an opportunity for the public to assist NNSA in determining the alternatives and issues for analysis. NNSA welcomes specific comments or suggestions on the content of these alternatives, or on other alternatives that could be considered. A preliminary set of alternatives and issues for evaluation in the LLNL SWEIS is identified below. Additionally, during the development of the LLNL SWEIS, NNSA may consider other alternatives judged to be reasonable.

No Action Alternative: Continuing Present Operations

The No Action Alternative would continue current facility operations throughout LLNL in support of assigned missions. NEPA regulations require analysis of the No Action Alternative to provide a benchmark for comparison with environmental effects of the other alternatives. This alternative includes the programs and activities described above in the LLNL Mission and those activities for which NEPA review is already done or underway.

Proposed Action Alternative

The programmatic context for this alternative is the continued support of existing programs and development of additional missions or projects that would be needed to meet DOE/NNSA mission requirements and sustain science, technology, and engineering excellence to respond to future national security challenges. This alternative would include the scope of the No Action Alternative, as described above, and an increase in current facility operations or enhanced operations that may require new or modified facilities and are reasonably foreseeable over the next 15 years. NNSA has identified four categories of actions associated with the Proposed Action: (1) New Facility Construction Projects; (2) Modernization/Upgrades of Existing Facilities and Infrastructure; (3) Operational Changes; and (4) Decontamination, Decommissioning, and Demolition Projects. Each of these categories of actions is discussed below.

NNSA has identified approximately 35 new facility construction projects, including laboratory facilities related to materials engineering, exascale computing, laser-explosives applications, and high explosives research and development; general office buildings; maintenance facilities; science centers for both nuclear security and forensics; and a new fire station. New facility projects would be proposed at both the Livermore Site and Site 300.

With regard to modernization/upgrades of existing facilities and infrastructure, NNSA has identified approximately 65 discrete projects, including upgrades to basic infrastructure (*e.g.,* domestic water systems, electrical systems, fire protection systems, communication systems, and security systems); modernization of firing and control systems at Site 300; NIF laser power upgrades and utility system replacements; biosecurity and bioscience facility upgrades; modernization of high performance computing capabilities; seismic risk reduction initiatives; and waste management facility enhancements. Modernization/upgrades will extend facility lifetimes, improve work environments, and enhance operational capabilities.

Proposed operational changes are expected to include: Changes to material-at-risk (MAR), administrative limits, and radiological bounding accident scenarios as a result of the deinventory of Security Category I and II special nuclear materials from LLNL, which was completed in 2012; and changes in various facility operations, which would be defined in the LLNL SWEIS, and may result in changes in generated wastes and shipments to disposal sites. All proposed operational changes would be described in detail and analyzed in the Draft LLNL SWEIS.

Decontamination, decommissioning, and demolition of older facilities would be conducted on a continuing basis to eliminate excess facilities and reduce costs and risks. Over the 15-year LLNL SWEIS planning horizon, NNSA has identified more than 110 excess facilities, totaling more than 1.1 million square feet, to be decontaminated, decommissioned, and demolished.

The net effect of new facility construction, existing facility modernization/upgrades, and demolition of excess facilities is expected to reduce LLNL's footprint and improve the efficiency of operations. The LLNL SWEIS will identify the specific projects and facilities that are potentially affected by the Proposed Action, and will assess the potential impacts associated with implementation of the Proposed Action.

Other Potential Reasonable Alternatives

The timeframe for the LLNL SWEIS analysis is approximately 15 years into the future. NNSA recognizes that requirements, needs, opportunities, and vision may change over such a long planning horizon. Consequently, NNSA is exploring the possibility of including additional alternatives in the LLNL SWEIS—such as reduced operations or expanded operations—that could be reasonable and responsive to that planning horizon. NNSA welcomes input on alternatives that the public thinks are reasonable and should be analyzed in the LLNL SWEIS.

Alternatives that NNSA will not consider as reasonable are: The complete closure and decontamination and decommissioning of the Livermore Site or Site 300, and transfer of current missions/operations from LLNL to other sites, as those actions would be inconsistent with the LLNL mission defined by NNSA. Such a possibility was considered in 2008 when NNSA prepared the Complex Transformation Supplemental Programmatic EIS. In that document, NNSA concluded that, "as a result of the continuing challenges of certification [of nuclear weapons] without underground testing, the need for robust peer review, benefits of intellectual diversity from competing physics design laboratories, and uncertainty over the details [of] future stockpiles, NNSA does not consider it reasonable to evaluate laboratory

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consolidation [or elimination] at this time.'' That conclusion has not changed today. In addition, as one of only three nuclear weapons laboratories, LLNL contributes significantly to the core intellectual and technical competencies of the United States related to nuclear weapons. These competencies embody more than 50 years of weapons knowledge and experience. The laboratories perform the basic research, design, system engineering, development testing, reliability and assessment, and certification of nuclear weapon safety, reliability, and performance. From a broader national security perspective, the core intellectual and technical competencies of LLNL (and Los Alamos National Laboratory and Sandia National Laboratories [NNSA's other nuclear weapons laboratories]) provide the technical basis for the pursuit of U.S. arms control and nuclear nonproliferation objectives.

The Complex Transformation Supplemental Programmatic EIS also considered and evaluated the transfer of missions/operations to/from LLNL, and NNSA has implemented, as appropriate, decisions that followed preparation of that document. NNSA has not identified any new proposals for current missions/operations that are reasonable for transfer to/from LLNL.

Preliminary Environmental Analysis

The following issues have been identified for analysis in the LLNL SWEIS. The list is tentative and intended to facilitate public comment on the scope of the LLNL SWEIS. It is not intended to be all-inclusive, nor does it imply any predetermination of potential impacts. The NNSA specifically invites suggestions for the addition or deletion of items on this list.

1. Potential effects on the public and workers from exposures to radiological and hazardous materials during normal operations, construction, reasonably foreseeable accidents, and intentional destructive acts.
2. Impacts on surface and groundwater, floodplains and wetlands, and on water use and quality.
3. Impacts on air quality.
4. Impacts to plants and animals and their habitat, including species which are federally- or state-listed as threatened or endangered, or of special concern.
5. Impacts on physiography, topography, geology, and soil characteristics including vadose zone.
6. Impacts to cultural resources such as those that are historic, prehistoric, archaeological, scientific, or paleontological.
7. Socioeconomic impacts to affected communities.
8. Environmental Justice, particularly whether or not activities at LLNL have a disproportionately high and adverse effect on minority and/or low-income populations.
9. Potential impacts on land use and applicable plans and policies.
10. Impacts from traffic and transportation of radiological and hazardous materials and waste on and off the LLNL sites.
11. Pollution prevention and materials and waste management practices and activities.
12. Impacts on visual aesthetics and noise levels of the LLNL facilities on the surrounding communities and ambient environment.
13. Impacts to community services, including fire protection, police protection, schools, and solid waste disposal in landfills.
14. Impacts from use of utilities, including water and electricity consumption, fuel use, sewer discharges, and resource conservation.
15. Impacts from site contamination, characterization and remediation.
16. Unavoidable adverse impacts due to natural phenomena (*e.g.,* floods, earthquakes, etc.).
17. Environmental compliance and inadvertent releases.
18. Short term uses and long-term productivity.
19. Irreversible and irretrievable commitment of resources.
20. Cumulative effects of past, present, and future operations.
21. Reasonably foreseeable impacts associated with the shutdown or demolition of excess facilities.
22. Mitigation commitments.

Site Specific LLNL SWEIS Process

The scoping process is intended to involve all interested agencies (federal, state, and local), public interest groups, Native American Tribes, local businesses, and members of the general public. Interested parties are invited to participate in the LLNL SWEIS process, to refine the preliminary alternatives and environmental issues that are not reasonable or pertinent. Input from the scoping meeting will assist NNSA in formulating the proposed action, refining the alternatives, and defining the scope of the LLNL SWEIS analyses.

Following the scoping process announced in this Notice, and after consideration of comments received during scoping, NNSA will prepare a Draft LLNL SWEIS for the continued operation of the LLNL. NNSA will announce the availability of the Draft LLNL SWEIS in the **Federal Register** and local media outlets. NNSA will hold one or more public hearings for the Draft LLNL SWEIS. Any comments received on the Draft LLNL SWEIS will be considered and addressed in the Final LLNL SWEIS. NNSA will then issue a Record of Decision no sooner than 30 days after publication by the Environmental Protection Agency of a Notice of Availability of the Final LLNL SWEIS.

Relationship to Existing and Other NEPA Analyses

NNSA is responsible for management and implementation of the requirements of NEPA and the regulations and policies promulgated thereunder, including but not limited to the Council of Environmental Quality NEPA regulations (40 CFR parts 1500–1508), the DOE NEPA implementing procedures (10 CFR part 1021), and NNSA Policy (NAP) 451.1. In addition to compliance with NEPA, the LLNL SWEIS will address requirements in the California Environmental Quality Act (CEQA), Public Resources Code Sec 21000 *et seq.* Because requirements for NEPA and CEQA are somewhat different, the document would be prepared to comply with whichever requirements are more stringent.

The current SWEIS for Continued Operation of LLNL (2005 LLNL SWEIS) was completed in 2005. This was the conclusion of a process involving roughly 42 months of analysis, public meetings, and document preparation. Previously, a SWEIS was issued in 1992. While there is no specific ''lifespan'' for a SWEIS, historically, NNSA has performed new SWEIS analyses for national laboratories on an average of every 10 years.

In 2008, the NNSA completed the Complex Transformation Supplemental Programmatic EIS which included further analysis for LLNL programs/facilities. Some facilities identified for closure in that document remain operational due to programmatic requirements.

In 2011, NNSA prepared a Supplement Analysis (SA) to the 2005 LLNL SWEIS which included new information that was not available for consideration when the 2005 LLNL SWEIS was prepared. It concluded that the 2005 LLNL SWEIS remained adequate for LLNL for the next five years. A team of LFO and Lawrence Livermore National Security, LLC subject matter experts then began working on a new SA in 2016. Although this more recent SA process was not completed, the team reached a consensus that a new SWEIS would provide numerous programmatic and

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operational benefits for the LLNL national security mission.

EIS Preparation and Schedule

NNSA expects to issue the Draft LLNL SWEIS in early 2021.

Signing Authority

This document of the Department of Energy was signed on this 21st day of July, 2020, by Lisa E. Gordon-Hagerty, Under Secretary for Nuclear Security and Administrator, NNSA, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the **Federal Register**.

Signed in Washington, DC, on July 31, 2020.

Treena V. Garrett,

Federal Register Liaison Officer, U.S. Department of Energy.

[FR Doc. 2020–17054 Filed 8–4–20; 8:45 am]

BILLING CODE 6450–01–P

DEPARTMENT OF ENERGY

Federal Energy Regulatory Commission

[Project No. 13652–001]

Gary and Rita Hall; Notice of Revocation of Exemption and Soliciting Comments, Motions to Intervene, and Protests

Take notice that the following hydroelectric proceeding has been initiated by the Commission:

a. *Type of Proceeding:* Revocation of exemption pursuant to Article 14.

b. *Project No.:* 13652–001.

c. *Date Initiated:* May 9, 2018.

d. *Exemptee:* Gary and Rita Hall.

e. *Name of Project:* Potter Creek Hydroelectric Project.

f. *Location:* The project was located on Potter Creek, in Flathead County, Montana, and occupied lands within the Flathead National Forest managed by the U.S. Forest Service (Forest Service).

g. *Pursuant to:* Article 14 and section 31(a) of the Federal Power Act.

h. *Exemptee Contact:* Rita Hall, P.O. Box 133, Olney, Montana 59927.

i. *FERC Contact:* Diana Shannon, (202) 502–6136 or *diana.shannon@ferc.gov.*

j. Deadline for filing comments, interventions, and protests is August 31, 2020.

The Commission strongly encourages electronic filing. Please file motions to intervene, protests and comments using the Commission's eFiling system at *http://www.ferc.gov/docs-filing/efiling.asp.* Commenters can submit brief comments up to 6,000 characters, without prior registration, using the eComment system at *http://www.ferc.gov/docs-filing/ecomment.asp.* You must include your name and contact information at the end of your comments. For assistance, please contact FERC Online Support at *FERCOnlineSupport@ferc.gov,* (866) 208–3676 (toll free), or (202) 502–8659 (TTY). In lieu of electronic filing, please send a paper copy to: Secretary, Federal Energy Regulatory Commission, 888 First Street NE, Washington, DC 20426 if you are using the United States Postal Service, and to Secretary, Federal Energy Regulatory Commission, 12225 Wilkins Avenue, Rockville, Maryland 20852 if you are using any other carriers/couriers. The first page of any filing should include docket number P–13652–001.

k. *Description of Proceeding:* Article 14 of the exemption provides, in part, for the Commission to revoke the exemption if essential project property is removed or destroyed or becomes unfit for use without adequate replacement. On May 9, 2018, the Forest Service filed a report with the Commission indicating that project features, including the dam, were removed on October 20, 2017 by the Forest Service. Sediments were excavated, the historic channel was reshaped, erosion control measures were implemented, and the area was replanted with native shrubs. The exemptee did not file an application to surrender the exemption and neither the exemptee nor the Forest Service contacted the Commission before the project was removed and restoration work completed. Because essential project property was removed, and the area has been restored, we are providing notice of revocation pursuant to Article 14 of the exemption.

l. Filings may be viewed on the Commission's website at *http://www.ferc.gov/docs-filing/elibrary.asp.* Enter the docket number (P–13652–001) excluding the last three digits in the docket number field to access the documents. You may also register online at *http://www.ferc.gov/docs-filing/esubscription.asp* to be notified via email of new filings and issuances related to this or other pending projects. For assistance, call 1–866–208–3676 or email *FERCOnlineSupport@ferc.gov,* for TTY, call (202) 502–8659. Agencies may obtain copies of the application directly from the applicant.

m. Individuals desiring to be included on the Commission's mailing list should so indicate by writing to the Secretary of the Commission.

n. *Comments, Protests, or Motions to Intervene:* Anyone may submit comments, a protest, or a motion to intervene in accordance with the requirements of Rules of Practice and Procedure, 18 CFR 385.210, .211, .212 and .214. In determining the appropriate action to take, the Commission will consider all protests or other comments filed, but only those who file a motion to intervene in accordance with the Commission's Rules may become a party to the proceeding. Any comments, protests, or motions to intervene must be received on or before the specified comment date for the particular application.

o. *Filing and Service of Documents:* Any filing must (1) bear in all capital letters the title COMMENTS, PROTEST, or MOTION TO INTERVENE as applicable; (2) set forth in the heading the name of the applicant and the project number of the application to which the filing responds; (3) furnish the name, address, and telephone number of the person protesting or intervening; and (4) otherwise comply with the requirements of 18 CFR 385.2001 through 385.2005. All comments, motions to intervene, or protests should relate to the surrender application that is the subject of this notice. Agencies may obtain copies of the application directly from the applicant. A copy of any protest or motion to intervene must be served upon each representative of the applicant specified in the particular application. If an intervener files comments or documents with the Commission relating to the merits of an issue that may affect the responsibilities of a particular resource agency, they must also serve a copy of the document on that resource agency.

Dated: July 30, 2020.

Nathaniel J. Davis, Sr.,

Deputy Secretary.

[FR Doc. 2020–17076 Filed 8–4–20; 8:45 am]

BILLING CODE 6717–01–P

APPENDIX H

NEPA Disclosure Statements

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE *SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR THE CONTINUED OPERATION OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY*

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981 guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 8026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)." 46 FR 18026-18038 at 18031.

In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows: (check either (a) or (b) to assure consideration of your proposal).

(a) __X__ Offeror and any proposed subcontractor have no financial or other interest in the outcome of the project.

(b) _____ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests

1.

2.

3.

Certified by

[signature]

Signature

Maher Itani, Director

Printed Name and Title

Tetra Tech, Inc.

Company

April 28, 2021

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE *SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR THE CONTINUED OPERATION OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY*

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(b) _____ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests

1.

2.

3.

Certified by

[signature]

Signature

DONALD G. TROST, OCI OFFICER

Printed Name and Title

TECH SOURCE, INC.

Company

4/28/21

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE *SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR THE CONTINUED OPERATION OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY*

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(b) _____ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests

1.

2.

3.

Certified by

____
Signature

Abe Zeitoun, Senior Vice President
Printed Name and Title

SC&A, Inc..
Company

04/28/2021
Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE *SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR THE CONTINUED OPERATION OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY*

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981 guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 8026-18038 at Question 17a and b.

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In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows: (check either (a) or (b) to assure consideration of your proposal).

(a) __X__ Offeror and any proposed subcontractor have no financial or other interest in the outcome of the project.

(b) _____ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests

1.

2.

3.

Certified by

[signature]

Signature

Joseph W. Rivers, Jr., President

Printed Name and Title

Rivers Consulting, Inc.

Company

April 28, 2021

Date

APPENDIX I

2018 - 2021 Biological Resources Surveys

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LIST OF FIGURES

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I 2018 – 2021 BIOLOGICAL RESOURCES SURVEYS

I.1 INTRODUCTION: BIOLOGICAL SURVEYS

Nineteen biological resources studies and reports were prepared in 2018 to 2021 in support of this *Lawrence Livermore National Laboratory Site-wide Environmental Impact Statement* (LLNL SWEIS). The objectives of the specialized species surveys and reports were to determine and document species presence/absence, location, shelter, foraging, roosting, nesting, migration, emergent habitat use, and behavioral observations as appropriate for each species or target group.

The following biological resources studies and reports are summarized in Section I.2:

- Passerine Bird Surveys for the Lawrence Livermore National Laboratory Site 200. LLNL-SR-826650 (ECORP 2021e)
- 2019-2021 Nesting Bird Survey Summary Report for the Lawrence Livermore National Laboratory Site 200. LLNL-AR-826687 (LLNL 2021a)
- California Red-legged Frog USFWS Protocol Survey Report for Lawrence Livermore National Laboratory, Site 200 – Livermore Campus, Livermore, CA. 2021. LLNL-SR-824306 (Sequoia 2021a)
- Avian Surveys Report for the Lawrence Livermore National Laboratory Arroyo Mocho Pumping Station. 2021f. LLNL-SR-826648 (ECORP 2021f)
- Botanical Resource Survey Report, Arroyo Mocho. LLNL-SR-824961 (Nomad Ecology 2021a)
- Arroyo Mocho Habitat Suitability Assessment for Sensitive Reptiles, Amphibians, and Fish. 2021. LLNL-SR-826592 (Sequoia 2021b)
- Carnivore Survey Results for the Lawrence Livermore National Laboratory Site 300. LLNL-SR-826543 (ECORP 2021c)
- Bat Survey for the Lawrence Livermore National Laboratory Experimental Test Site 300. LLNL-SR-826544 (ECORP 2021b)
- Small Mammal Trapping Survey for the Lawrence Livermore National Laboratory Site 300. LLNL-SR-826653 (ECORP 2021d)
- Herpetological Survey for the Lawrence Livermore National Laboratory Site 300. LLNL-SR-826640 (ECORP 2021a)
- Final Site 300 Sensitive Botanical Resource Report. 2021b. LLNL-SR-825226 (Nomad Ecology 2021b)
- FY19 and FY20 Report for the Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Natural Resources Management Plan. LLNL-AR-826662 (LLNL 2021b)
- Valley Elderberry Longhorn Beetle Surveys at the Lawrence Livermore National Laboratory - Site 300. 2020. LLNL-SR-817701 (Shepard 2020)
- Valley Elderberry Longhorn Beetle Surveys at the Lawrence Livermore National Laboratory - Site 300. 2021. LLNL-SR-824027 (Shepard 2021)
- Results of a 20-Day Trapping Survey for Alameda Whipsnake (*Masticophis lateralis euryxanthus*), Lawrence Livermore National Laboratory, Site 300 Experimental Test Site, Alameda and San Joaquin Counties, California. LLNL-AR-827444 (LLNL 2021c)

- 2020 Mitigation and Monitoring Report for the Arroyo Las Positas Management Project. Lawrence Livermore National Laboratory, Livermore, CA. LLNL-TR-820238 (LLNL 2021d)
- Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve: 2020 Deployment. Alameda and San Joaquin Counties, California. LLNL- SR-768323 (Woollett 2019)
- Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve: 2020 Deployment. Alameda and San Joaquin Counties, California. LLNL-TR-818743 (Woollett 2021).
- Wetland/Aquatic Resources Lawrence Livermore National Laboratory Facilities, Alameda and San Joaquin Counties, California. 2020. LLNL-TR-816689 (Nomad Ecology 2020)

I.1.1 Livermore Site: Biological Surveys

Four studies and reports were conducted at the Livermore Site and included passerine bird and waterfowl surveys, nesting bird surveys, and California red-legged frog surveys.

(1) Passerine bird surveys were conducted to detect presence/absence of any protected passerine birds at focused sites within the Livermore Site according to habitat delineations (i.e., riparian, lacustrine, grassland as example habitat classes). The target species was loggerhead shrike.

(2) A summary report was prepared for the 2019-2021 nesting bird surveys; target species included all raptor species expected to occur at the Livermore Site in addition to common raven and American crow.

(3) A U.S. Fish and Wildlife Service (USFWS) Protocol Survey Report for the California red-legged frog was prepared based on surveys at focused areas within the Livermore Site. All aquatic features surveyed were assessed for habitat suitability.

(4) A report was prepared that describes maintenance, monitoring, and mitigation (the project) conducted in 2020 as part of the Arroyo Las Positas Management Project at the Livermore Site. The purpose of the project is to enhance habitat value for the California red-legged frog within the LLNL reach of Arroyo Las Positas and protect LLNL facilities from flooding.

I.1.2 SITE 300: BIOLOGICAL SURVEYS

Eleven studies and reports were conducted at the Site 300 and included carnivore surveys, bat surveys, small mammal surveys, herpetological (reptiles) surveys, sensitive botanical resources surveys, fiscal year (FY) 2019 and FY 2020 summary report for the natural resources management plan, 2020 and 2021 surveys for valley elderberry longhorn beetles, and Alameda whipsnake surveys.

(1) A mesocarnivore/large carnivore study was conducted to primarily detect three target species, including the San Joaquin kit fox, American badger, and mountain lion at Site 300.

(2) Bat surveys were conducted to determine bat species present, where they occur, and their apparent seasonal use patterns. The two focal species included western red bat and pallid bat. An acoustic unit was used to record bat acoustics at 36 sites and external structure surveys adjacent to the acoustic sites were conducted to determine if bats were using the structural elements for day roosting and/or night roosting.

(3) A small mammal trapping survey was conducted to determine woodrat species present and if riparian woodrats were present on Site 300 or the adjacent California Department of Fish and Wildlife (CDFW) Corral Hollow Ecological Reserve.

(4) Reptile surveys were conducted to detect presence/absence of two target species at Site 300, including Northern California legless lizard and coast horned lizard.

(5) Sensitive botanical resource surveys and vegetation mapping and classification were conducted to identify, locate, and map special status plant species and vegetation communities within Site 300. In addition, LLNL data were compiled from past monitoring and environmental impact evaluations on existing rare plant and vegetation data.

(6) Special status wildlife population studies were conducted between October 1, 2018 and September 30, 2020 to fulfil management recommendations described in the Site 300 Natural Resources Management Plan and ensure compliance with the federal *Endangered Species Act* (ESA), California ESA, *Migratory Bird Treaty Act* (MBTA), Department of Energy (DOE) policies, and additional state laws protecting wildlife. The FY 2019 and 2020 summary report included avian monitoring for burrowing owls, tri-colored blackbirds, and nesting raptors and ravens; amphibian monitoring for three special status species, California red-legged frog, California tiger salamander, and western spadefoot; and surveys of fire trails that traverse protected habitat onsite including California red-legged frog critical habitat, Alameda whipsnake critical habitat, large-flowered fiddleneck critical habitat, and nesting bird habitat.

Surveys were conducted in 2020 (7) and 2021 (8) to map the locations of blue elderberry plants at Site 300 and the Corral Hollow Ecological Reserve. In addition, observations of valley elderberry longhorn beetle emergence holes on elderberry plants were also mapped. The 2020 and 2021 reports provide information on the potential presence of the valley elderberry longhorn beetle and the quantity and quality of its host plant, blue elderberry.

(9) The Alameda whipsnake surveys conducted in 2021 and observations of Alameda whipsnakes during reptile and rare plant surveys conducted in 2019 and 2020 show that Alameda whipsnakes are still present in and near the coast scrub habitat found in the southwestern quadrant of Site 300.

Scat detection dog surveys were conducted in 2018 (10) and 2020 (11). Subsequent DNA analysis of scats do not support the presence of kit foxes at Site 300 or the Corral Hollow Ecological Reserve.

I.1.3 Arroyo Mocho Pumping Station: Biological Surveys

Three studies and reports were conducted at the LLNL Arroyo Mocho Pumping Station (Arroyo Mocho) and included avian surveys; botanical resources surveys; and a habitat suitability assessment for reptiles, amphibians, and fish.

(1) Avian surveys were conducted to document the presence and abundance of all avian species within the survey area near the Arroyo Mocho Pumping Station. As part of the avian surveys, nesting bird surveys were conducted to provide the first environmental baseline for raptors at Arroyo Mocho.

(2) A sensitive botanical resource survey and vegetation mapping and classification were conducted to identify, locate, and map special status plant species and vegetation communities within the 17 acres surrounding Arroyo Mocho and the access road to the pumping station.

(3) A habitat suitability assessment was conducted to assess current habitat suitability and evaluate the potential presence of special-status species at and near Arroyo Mocho. The habitat assessment focused on special status species including the California tiger salamander, California red-legged frog, foothill yellow-legged frog, western pond turtle, Alameda whipsnake, Coast horned lizard, and central California coast distinct population segment steelhead.

Wetland and Aquatic Resources Delineation

A wetland and aquatic resources delineation was conducted in 2020 on the Livermore Site, Site 300, and Arroyo Mocho Pumping Station. The report presents the results of the field evaluations and provides a preliminary determination of jurisdictional waters of the United States (including wetlands) regulated by the U.S. Army Corps of Engineers (USACE), jurisdictional waters of California (including wetlands), regulated by the Regional Water Quality Control Board, and wetlands and floodplains defined in DOE Floodplain and Wetland Environmental Review Requirements (10 CFR 1022).

I.1.4 Species Lists

Plant and animal species list for the Livermore Site, Site 300, and the Arroyo Mocho Pumping Station presented in this appendix were compiled from onsite surveys, historical records of plant and animal occurrences, and January 2022 California Natural Diversity Databases (CNDDB) (CNDDB 2022a, 2022b). The plant and animal lists include species that are known to occur based on observations and expected to occur based on habitat availability at the site. Plant and animal lists are included in Section I.3.

I.2 SUMMARY OF BIOLOGICAL SURVEYS

I.2.1 Passerine Bird Surveys for the Lawrence Livermore National Laboratory Site 200

Passerine bird and waterfowl surveys were conducted in 2021 at the Livermore Site (ECORP 2021e). The survey encompassed portions of the land bird wintering season, migration, and breeding season. Avian point-count surveys were conducted at seven stations along the perimeter of the Livermore Site. There were 81 species recorded at the point-count stations. The most common species by number of occurrences were American robin, bushtit, cedar waxwing, cliff swallow, European starling, and yellow-rumped warbler. Bird species observed nesting or exhibiting nesting behavior included American kestrel, Anna's hummingbird, bushtit, chestnut-backed chickadee, California scrub-jay, oak titmouse, red-shouldered hawk, song sparrow, western bluebird, and western kingbird.

In addition to the point-count surveys, focal point surveys were conducted at Lake Haussmann with a specific focus on waterfowl identification. Canada geese and mallards, as expected, successfully nested at Lake Haussmann. During waterfowl surveys, a total of 53 species, including 15 aquatic bird species, were observed. Species observed during every month of surveying included Canada goose, American coot, mallard, and pied-billed grebe. Other aquatic bird species observed less frequently included black-crowned night-heron, bufflehead, double-crested cormorant, great blue heron, great egret, green heron, killdeer, ring-necked duck, snowy egret, sora, and spotted sandpiper. Other, non-waterfowl species included barn swallow, northern rough-winged swallow, tree swallow, marsh wren, common yellowthroat, belted kingfisher, Swainson's hawk and white-tailed kite. Waterfowl species observed nesting or exhibiting nesting behavior included Canada goose, pied-billed grebe, and mallard.

Special status species observed at the Livermore Site included Bullock's oriole, Nuttall's woodpecker, oak titmouse, yellow warbler, Swainson's hawk, and white-tailed kite. Evidence of recent nesting was documented for Bullock's oriole. Species likely nesting on the Livermore Site or exhibiting nesting behavior included Nuttall's woodpecker, oak titmouse, white-breasted nuthatch, Cooper's hawks (California watch list species), and white-tailed kite.

The cumulative list of birds identified within the LLNL Site 200 Survey Area is presented in Table I.3-1 in Section I.3. This list is taken from Attachment B of the 2021 passerine bird survey report.

I.2.2 2019-2021 Nesting Bird Survey Summary Report for the Lawrence Livermore National Laboratory Site

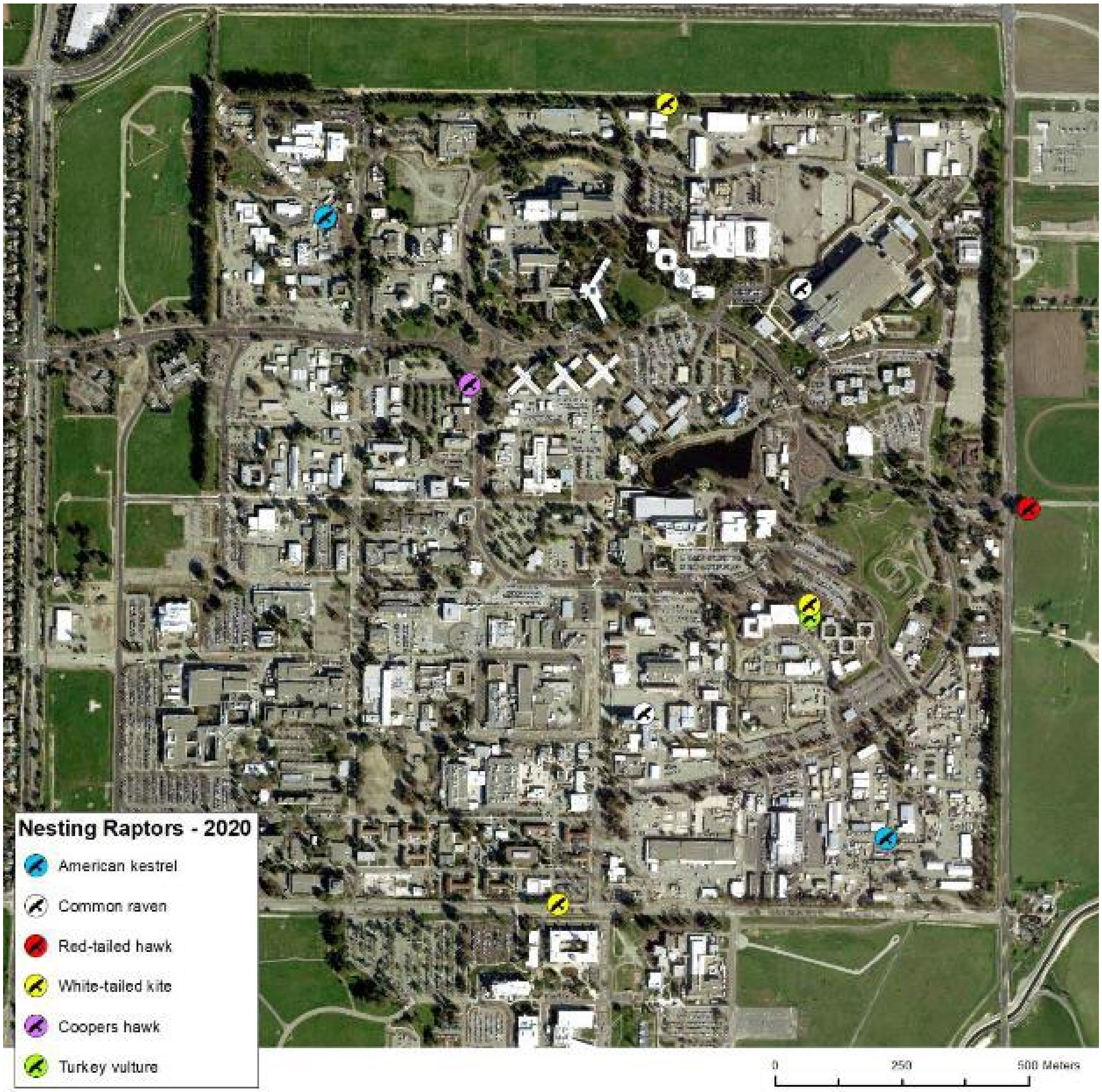
Lawrence Livermore National Security wildlife biologists, in conjunction with subcontract biologists from Sequoia Environmental Consulting, conducted annual nesting bird surveys at the Livermore Site from 2019 to 2021 (LLNL 2021a). Nesting bird locations were monitored to ensure compliance with the federal Migratory Bird Treaty Act. In addition, some raptor species that occur at the Livermore Site are considered rare or endangered and receive additional protections under state and federal law. The purpose of this summary is to detail historic nesting raptor locations and to report on the raptor species known to nest at the Livermore Site which are protected under the federal MBTA, the *Bald and Golden Eagle Protection Act* (BGEPA), and the CESA.

Target species for these surveys included red-tailed hawk, white-tailed kite, Swainson's hawk, American kestrel, Cooper's hawk, burrowing owl, turkey vulture, common raven, and American crow. Special status raptor species that have been observed at the Livermore Site include golden eagle (2021 incidental observation), bald eagle (2015 incidental observation), and species observed during the current surveys (Swainson's hawk, white-tailed kite, and peregrine falcon). The total number of nesting raptor pairs monitored in 2019, 2020, and 2021 was seven, 10, and eight, respectively. Nesting species included, American kestrel, Cooper's hawk, common raven, red-tailed hawk, turkey vulture, white-tailed kite, Swainson's hawk, and American crow. No sign of burrowing owl presence was observed during the surveys.

In summary, the Livermore Site is used by a variety of protected raptor species during the nesting bird season including two special status species: the white-tailed kite and Swainson's hawk. Figures I-1 through I-3 provide locations of target species nest sites observed in 2019, 2020, and 2021, respectively.

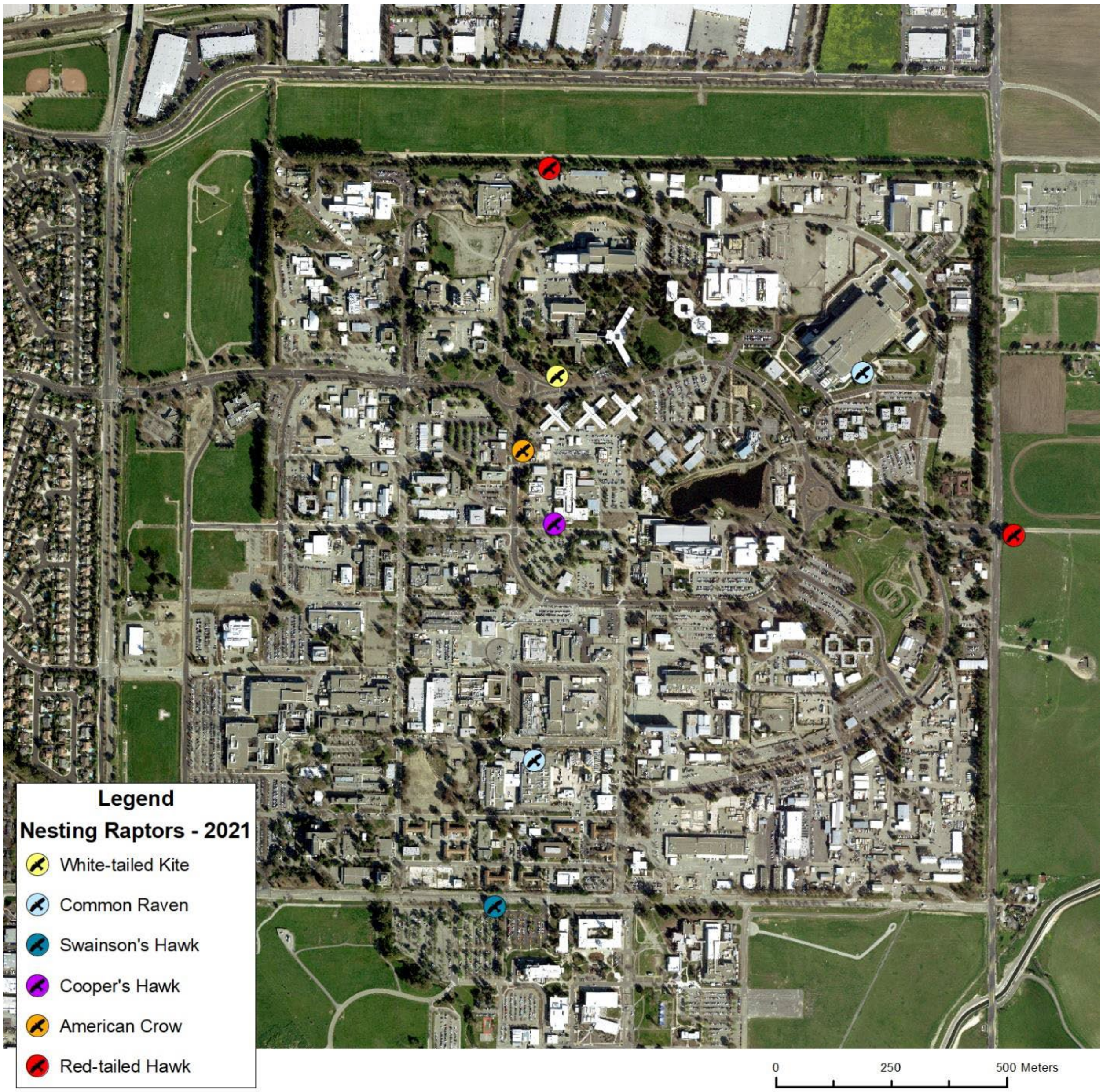
Source: Sequoia 2021a.

Figure I-1. Target species nest sites observed at the LLNL Livermore Site during 2019 Nesting Bird Surveys



Source: Sequoia 2021a.

Figure I-2. Target species nest sites observed at the LLNL Livermore Site during 2020 Nesting Bird Surveys



Source: Sequoia 2021a.

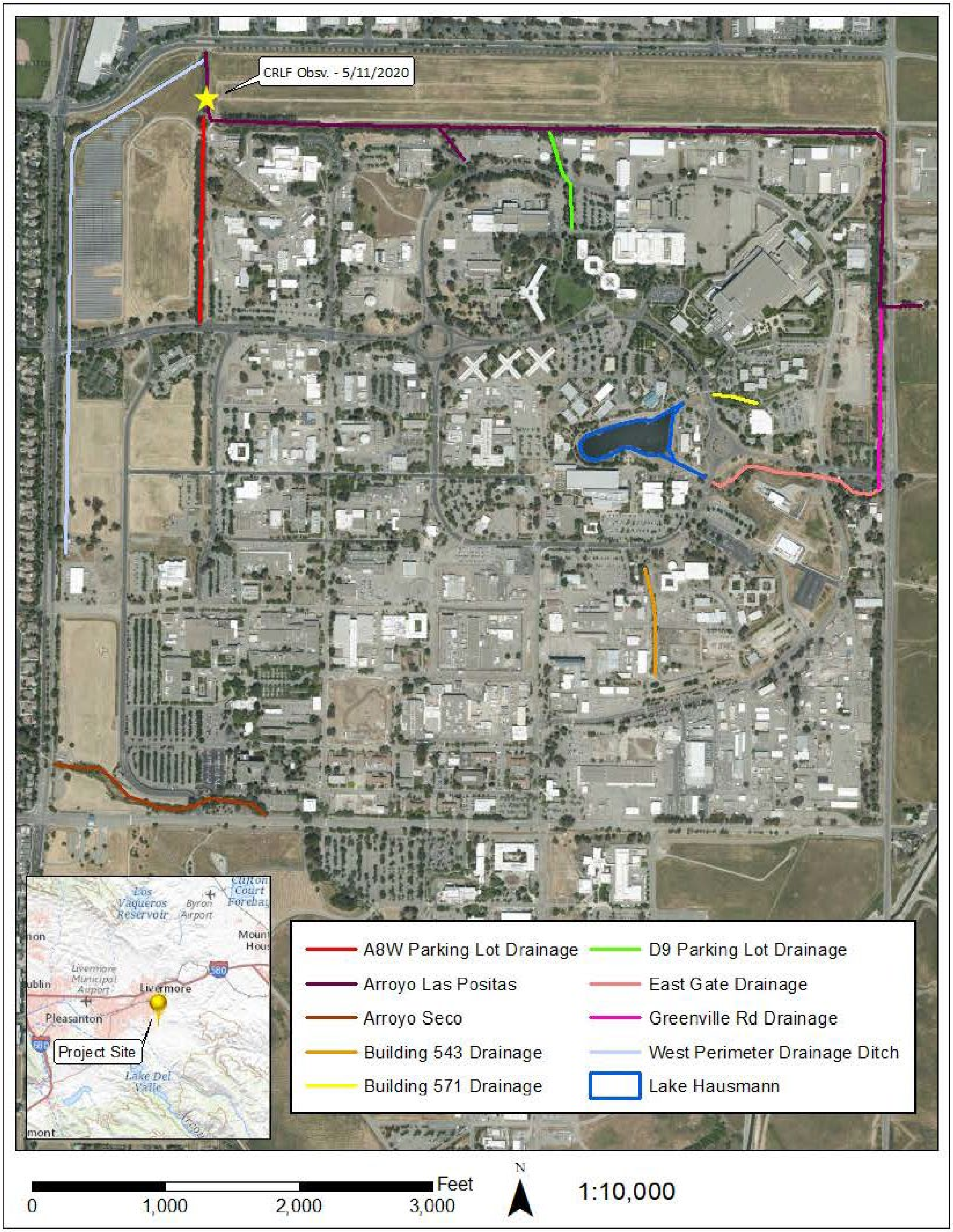
Figure I-3. Target species nest sites observed at the LLNL Livermore Site during 2021 Nesting Bird Surveys

I.2.3 California Red-legged Frog USFWS Protocol Survey Report for Lawrence Livermore National Laboratory, Site 200 – Livermore Campus, Livermore, CA 2021

Surveys for the California red-legged frog using standard visual encounter survey techniques were conducted during the non-breeding season between 1 July and 30 September 2020 and during the breeding season between 1 January and 28 February 2021 in accordance with methods provided in the USFWS Revised Guidance on Site Assessments and Field Surveys for the California Red-Legged Frog (Sequoia 2021a).

The survey areas (Figure I-4) included Arroyo Las Positas, Arroyo Seco, Lake Hausmann, and several drainages (east gate, west perimeter, A8W Parking Lot, D9 Parking Lot, Greenville Road, Building 571, and Building 543). One California red-legged frog was observed in the northeastern-most corner of Arroyo Las Positas in May 2020. Although only one individual was observed, there is suitable habitat for this species on Site 200. The study concluded that the lack of observed individuals or any signs of presence (e.g., egg masses, larvae, vocalizations, etc.) suggests that California red-legged frog are likely not abundant on Site 200 and may not have reproduced onsite in 2020 or 2021.

Years 2020 and 2021 were both dry years in terms of total rainfall, with rain events few and far between in the 2020-2021 winter. Given that rain events generally trigger long distance California red-legged frog movements (including subadult dispersal away from breeding areas) the likelihood of additional California red-legged frog dispersing to, or moving across, the site when no breeding was detected in the spring or summer of 2020 would presumably be lower during a dry year.



Source: Sequoia 2021a.

Figure I-4. Map of Aquatic Features Surveyed and Location of California red-legged frog Individual Observed in 2020 Surveys

I.2.4 Avian Surveys Report for the Lawrence Livermore National Laboratory Arroyo Mocho Pumping Station

Passerine bird and raptor surveys were conducted in the spring and summer of 2021 at six point-count stations to document the presence and abundance of avian species at the Arroyo Mocho Pumping Station (ECORP 2021f). Particular focus of the survey was on special status bird species.

Avian point-count surveys were conducted at six stations, spaced at least 250 m apart, along the access road and near the pump station. Surveys included the area extending 100 meters horizontally from the observer and 100 meters vertically for 30 minutes at each of the six stations. Nesting raptor surveys were conducted at the Arroyo Mocho Pumping Station, the access road, and areas adjacent to the pumping station, and included areas within a one-mile radius around the pumping station that were visible from the pumping station. The surveys focused on appropriate habitat (e.g., woodlands, areas with larger trees suitable for nesting).

A total of 59 species were recorded during the avian point counts and raptor nesting surveys. Species observed every month during the survey period included bushtit, California scrub-jay, California towhee, common raven, oak titmouse, red-tailed hawk, spotted towhee, turkey vulture, white-breasted nuthatch, and wrentit. The most common species by number of occurrences were California quail, spotted towhee, oak titmouse, and turkey vulture. Non-raptor bird species observed nesting or exhibiting nesting behavior at point count stations included black-headed grosbeak, black phoebe, Bullock’s oriole, California scrub-jay, California towhee, common raven, house finch, house wren, oak titmouse, and phainopepla. Special-status bird species observed at point count stations included Nuttall’s woodpecker, Bullock’s oriole, California thrasher, olive-sided flycatcher, wrentit, oak titmouse, and willow flycatcher. Raptors observed on point count stations included Cooper’s hawk, golden eagle, and sharp-shinned hawk. One golden eagle nest was observed 0.25 miles south of the pump station. Other raptors observed during nesting surveys included sharp-shinned hawk, Cooper’s hawk, red-tailed hawk, turkey vulture and American kestrel.

The cumulative list of birds identified within the Arroyo Mocho Survey Area is presented in Table I.3-2 in Section I.3. This list is taken from Attachment B of the 2021 avian survey report.

I.2.5 Botanical Resource Survey Report, Arroyo Mocho

Based on a review of available databases and literature, familiarity with the regional flora, and presence of specific vegetation types, four California Native Plant Society special status (rare and watch list) species were determined to be targets of the 2020 and 2021 rare plant surveys at The Arroyo Mocho Pumping Station (Table I-1). Targets were based on probability of occurrence, as well as LLNL staff input.

Table I-1. Target Arroyo Mocho Special Status Plant Species

Species Name / Common Name	Status[a]	Peak Blooming Period
California Native Plant Society Listed Species (Rank 1 & 2)		
Balsamorhiza macrolepis big-scale balsamroot	1B.2	April
Delphinium californicum subsp. *interius* Hospital Canyon larkspur	1B.2	May
California Native Plant Society Listed Species (Rank 3 & 4)		
Acanthomintha lanceolata Santa Clara thorn-mint	4.2	May
Clarkia concinna subsp. automixa Santa Clara red	4.3	May

a. Explanation of Status Codes:
California Native Plant Society codes: 1B=Rare, threatened, or endangered in California and elsewhere; 4=Plants of limited distribution - Watch list
California Native Plant Society Threat Codes: .2 =Moderately threatened in California (20-80% occurrences threatened); .3= Not very threatened in California (<20% of occurrences threatened / low degree and immediacy of threat or no current threats known)
Source: Nomad Ecology 2021a.

Previous rare plant surveys have not been conducted by LLNL at the Arroyo Mocho Pumping Station. Sensitive botanical resource surveys, and vegetation mapping and classification were conducted in April and May 2020 and March 2021 on the 17 acres surrounding the pump station and the access road to the pump station (Nomad Ecology 2021a). No federal or state listed threatened or endangered plant species were observed during the surveys.

A total of 26 sensitive natural communities (Table I-2) were identified as targets for vegetation mapping at Site 300 (Figure I-5). The list of target sensitive natural communities was based on a map-based search of the Manual of California Vegetation, as well as input from LLNL staff.

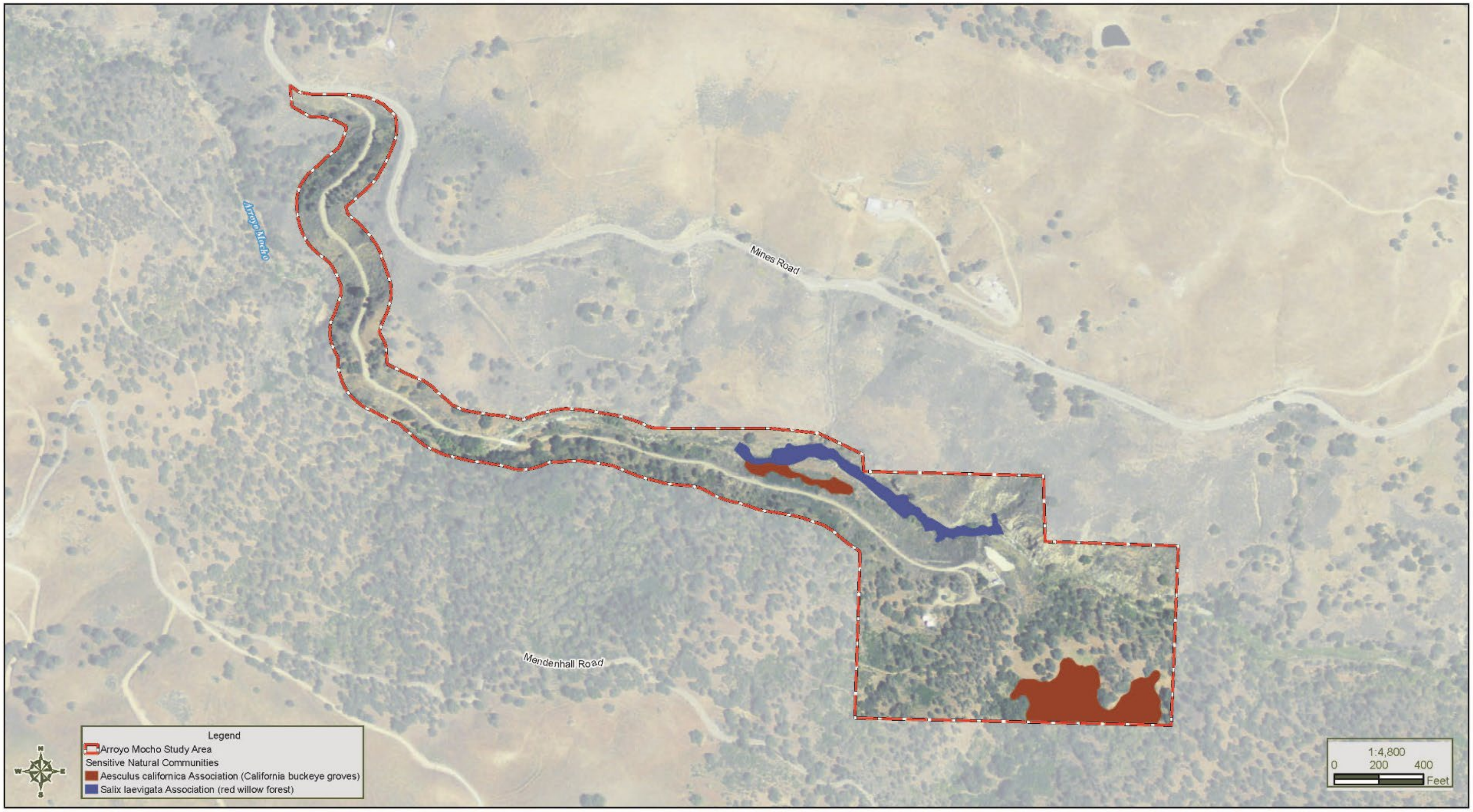
Table I-2. Target Arroyo Mocho Sensitive Natural Communities

Common Name	Scientific Name*	Lifeform	Status[1]
California buckeye groves	*Aesculus californica* Alliance	Tree	S3
Iodine bush scrub	*Allenrolfea occidentalis*	Shrub	S3.2
Yerba mansa – Nuttall's sunflower – Nevada goldenrod alkaline wet meadows	*Anemopsis californica – Helianthella nuttallii – Solidago spectabilis*	Herb	S2
Bush monkeyflower scrub	*Diplacus aurantiacus* Alliance	Shrub	S3?
Wright's buckwheat – Heermann's buckwheat – Utah butterfly bush	*Eriogonum wrightii – Eriogonum heermannii – Buddleja utahensis*	Shrub	S3
Alkali heath marsh	*Frankenia salina* Alliance	Herb	S3
California match weed patches	*Gutierrezia californica*	Shrub	S3?
Goldenaster patches	*Heterotheca* (*oregana, sessiliflora*)	Herb	S3
Iris-leaf rush seeps	*Juncus (oxymeris, xiphioides)* Alliance	Herb	S

Common Name	Scientific Name*	Lifeform	Status[1]
Scale broom scrub	*Lepidospartum squamatum*	Shrub	S3
Common monkey flower seeps	*Mimulus* (*guttatus*) Alliance	Herb	S
Monolopia – leafy-stemmed tickseed fields	*Monolopia* (*lanceolata*) – *Coreopsis* (*calliopsidea*)	Herb	S3
Deer grass beds	*Muhlenbergia rigens*	Herb	S2?
California sycamore woodlands	*Platanus racemosa* Alliance	Tree	S3
Fremont cottonwood forest	*Populus fremontii – Fraxinus velutina – Salix gooddingii*	Tree	S3.2
Valley oak woodland	*Quercus lobata* Alliance	Tree	S3
Basket bush – river hawthorn – desert olive patches	*Rhus trilobata – Crataegus rivularis – Forestiera pubescens*	Shrub	S3.2?
Oak gooseberry thickets	*Ribes quercetorum*	Shrub	S2?
California rose briar patches	*Rosa californica*	Shrub	S3
Black willow thickets	*Salix gooddingii – Salix laevigata*	Tree	S3
Blue elderberry stands	*Sambucus nigra ssp. cerulea*	Shrub	S3
Hardstem and California bulrush marshes	*Schoenoplectus (acutus, californicus)*	Herb	S3
Bushy spikemoss mats	*Selaginella bigelovii*	Herb	S3
Alkali sacaton – scratchgrass – alkali cordgrass alkaline wet meadow	*Sporobolus airoides – Muhlengergia asperifolia – Spartina gracilis*	Herb	S2
Bush seepweed scrub	*Suaeda moquinii*	Shrub	S3
White-tip clover swales	*Trifolium variegatum*	Herb	S3?

State Codes: S1=Critically Imperiled; S2=Imperiled; S3=Vulnerable; ?=A question mark (?) denotes an inexact numeric rank because there are insufficient samples over the full expected range of the type, but existing information points to this rank
Source: Nomad Ecology 2021a.

Two California sensitive natural communities, California buckeye groves and red willow forest, covering 4.6 acres were observed in the study area. Two of the target species, Santa Clara thorn-mint and Santa Clara red ribbons, were not observed in the 2020-2021 surveys. Three California Native Plant Society special status (one rare and two watch list) plant species, three occurrences, and 50 individuals were recorded during the surveys. Rare species included one occurrence and 42 individuals of Hospital Canyon larkspur. Watch list species, not originally considered target species for the 2020-2021 surveys, included one occurrence each for Jepson's woolly sunflower (seven individuals) and Michael's rein orchid (one individual). These species were not previously recorded within the study area at Arroyo Mocho. Special status species observations were distributed throughout the study area. No threats were noted for the two sensitive natural communities at the Arroyo Mocho Pumping Station. Jepson's woolly sunflower and Michael's rein orchid were observed to be threatened with potential species decline by road, trail, or infrastructure maintenance activities, which should be considered for management action. The study concluded that maintenance activities at specific locations for these species should be restricted to a specific time of year, before germination and after seed set, to improve the long-term survivability of populations.



Source: Nomad Ecology 2021a.

Figure I-5. Sensitive natural Communities at Arroyo Mocho

The 2020 vegetation classifications for vegetation types identified at the pumping station are presented in Table I-3. In addition, 2.2 acres were mapped as developed land. The most frequently mapped vegetation communities were California sagebrush scrub (approximately 17 acres, or 32 percent of the survey area) and blue oak – grass woodland (approximately 13 acres or 24 percent of the area). The next highest acreage was coast live oak – poison oak woodland (approximately 6 acres and 12 percent of the area). The herbaceous vegetation type accounted for approximately four acres or 8 percent of the area. The other vegetation classifications accounted each for less than three acres or five percent of the area.

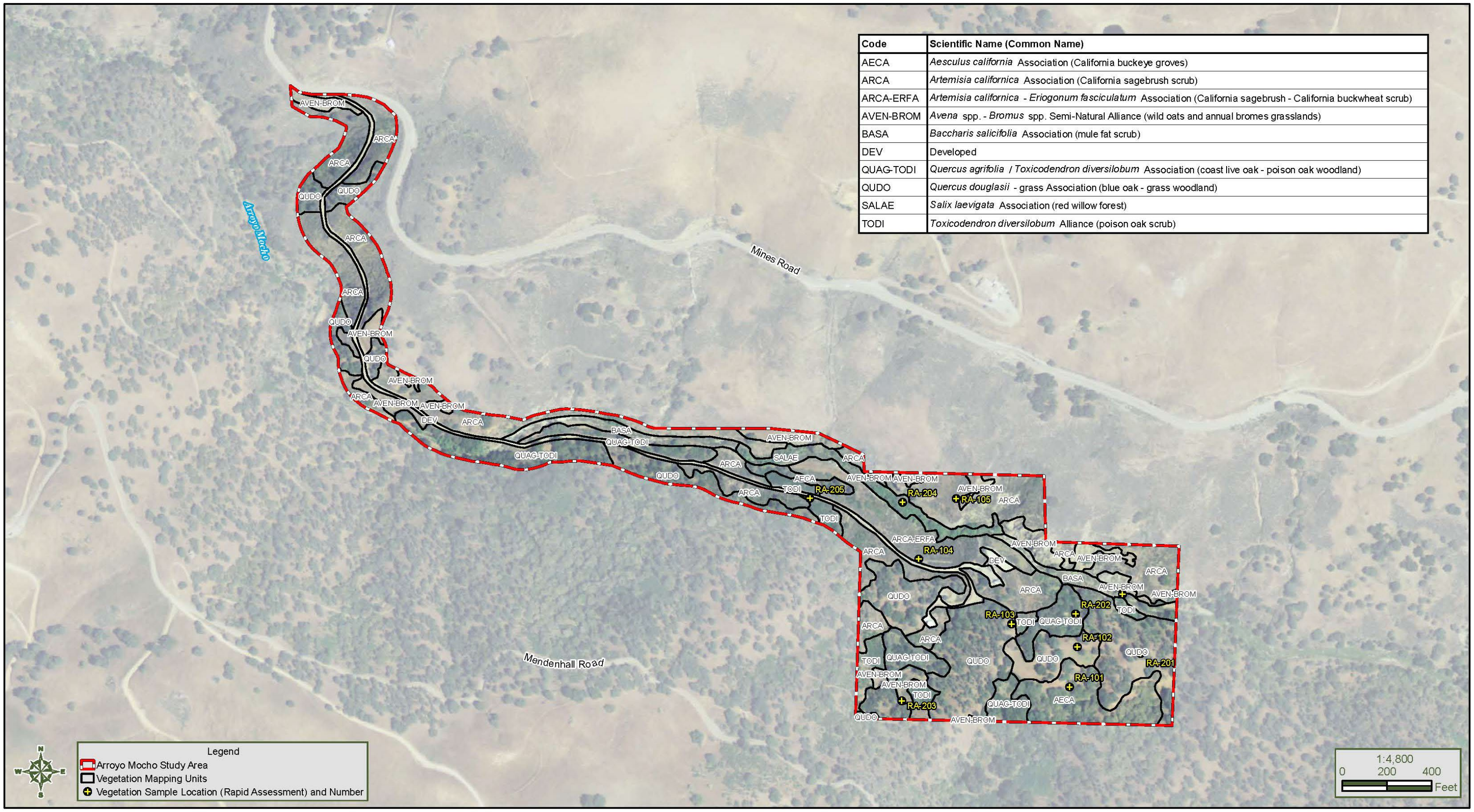
Table I-3. Vegetation Classifications from the 2020 Surveys at the Arroyo Mocho Pumping Station

Alliance	Association
California buckeye groves	California buckeye groves
Coast live oak woodland	Coast live oak – poison oak woodland
Blue oak woodland and forest	Blue oak – grass woodland
Goodding's willow – red willow riparian woodland and forest	Red willow forest
Mule fat thickets	Mule fat thickets
California sagebrush scrub	California sagebrush scrub California sagebrush – California buckwheat scrub
Poison oak scrub	Poison oak scrub – (coyote brush) scrub
Wild oats – annual brome grasslands	None designated

Source: Nomad Ecology 2021a.

Vegetation classification and mapping efforts conducted in 2020 at the Arroyo Mocho Pumping Station resulted in four tree, three shrub, and one herbaceous alliance. Most were assigned further into associations resulting in four tree and four shrub associations. The vegetation mapping units are depicted in Figure I-6.

One of the objectives of conducting the rare plant surveys was to create a plant list for the Arroyo Mocho Pumping Station. Table I.3-3 in Section I.3 presents the plant list from Appendix A of the 2021 Botanical Resource Survey Report, Arroyo Mocho.



Code	Scientific Name (Common Name)
AECA	*Aesculus california* Association (California buckeye groves)
ARCA	*Artemisia californica* Association (California sagebrush scrub)
ARCA-ERFA	*Artemisia californica* - *Eriogonum fasciculatum* Association (California sagebrush - California buckwheat scrub)
AVEN-BROM	*Avena* spp. - *Bromus* spp. Semi-Natural Alliance (wild oats and annual bromes grasslands)
BASA	*Baccharis salicifolia* Association (mule fat scrub)
DEV	Developed
QUAG-TODI	*Quercus agrifolia* / *Toxicodendron diversilobum* Association (coast live oak - poison oak woodland)
QUDO	*Quercus douglasii* - grass Association (blue oak - grass woodland)
SALAE	*Salix laevigata* Association (red willow forest)
TODI	*Toxicodendron diversilobum* Alliance (poison oak scrub)

Source Nomad Ecology 2021a.

Figure I-6. Vegetation classifications from the 2020 surveys for the Arroyo Mocho Pumping Station

I.2.6 Arroyo Mocho Habitat Suitability Assessment for Sensitive Reptiles, Amphibians, and Fish

A habitat suitability assessment was conducted in 2021 for special-status reptiles, amphibians, and fish that may occur at or adjacent to the Arroyo Mocho Pumping Station and the access road to the pumping station (study area) (Sequoia 2021b). The study focused on providing a description of presence and habitat suitability for California tiger salamander, California red-legged frog, foothill yellow-legged frog, western pond turtle, Alameda whipsnake, Blainville's (coast) horned lizard, and central California coast distinct population segment steelhead. A desktop review and onsite surveys were conducted.

Vegetation communities were previously identified in 2020 by Nomad Ecology in Wetland/Aquatic Resources Delineation, for the 2021 Sitewide Environmental Impact Statement, Lawrence Livermore National Laboratory Facilities, Alameda and San Joaquin Counties (Nomad Ecology 2020). Vegetation communities consist primarily of blue oak woodland, California buckeye groves, and Diablan sage scrub. White alder riparian forest and central coast riparian scrub are present along Arroyo Mocho Creek. Small amounts of coast live oak woodland and non-native annual grassland are present in the upland communities.

The study concluded that there is low potential for California tiger salamander to occur within the Arroyo Mocho study area. The area does not contain suitable breeding habitat due to water flow in Arroyo Mocho and a lack of pools. Although the area is close to known breeding populations (approximately 1.1 miles southwest of the area) and lacks dispersal barriers (i.e., roadways, residential neighborhoods, etc.), the pump station has only marginal quality as upland habitat for the California tiger salamander.

Highly suitable breeding and non-breeding habitat occurs within the pump station study area and supports the presence of foothill yellow-legged frogs. California red-legged frogs have a high potential of occurring because of occurrences within and nearby the pump station. The area provides low suitability as breeding habitat but provides high quality non-breeding aquatic and upland dispersal habitats for California red-legged frogs. The western pond turtle has high potential to occur within the Arroyo Mocho Pumping Station study area because of suitable habitat and known observations within and nearby the area.

The Alameda whipsnake has high potential to occur within the pump station study area because high-quality suitable habitat is present onsite and adjacent to the area, and the nearest known record is approximately 1.2 miles east-southeast of the area. Blainville's (coast) horned lizards have moderate potential to occur because of nearby known occurrences (approximately 0.43 miles northwest of the area) and moderate habitat suitability within the pump station study area. Steelhead is not expected to occur because of no known occurrences within 3 miles of the pump station, downstream blockage, and Arroyo Mocho is considered outside the range of the species.

A summary of the special status wildlife species assessed for habitat suitability is presented in Table I.3-4 in Section I.3. This information is taken from Appendix A, Table 1 in the report on the Arroyo Mocho Habitat Suitability Assessment for Sensitive Reptiles, Amphibians, and Fish.

I.2.7 Carnivore Survey Results for the Lawrence Livermore National Laboratory Site 300

Carnivore surveys using camera stations and spotlighting were conducted at Site 300 in the spring of 2021 (ECORP 2021c). The surveys were designed to document carnivores and other animals present on Site 300, with a focus on documenting the presence of three special status species, San Joaquin kit fox, American badger, and mountain lion, on Site 300. American badgers are known to occur on Site 300 and there have been a few sporadic sightings of mountain lions, but San Joaquin kit fox have not been documented on Site 300.

An expansive array of remote infrared camera stations was deployed to detect the target species. The camera station survey was conducted over the course of three five-day sessions, with each session consisting of 12-13 unique camera locations. The spotlighting survey was one session consisting of two unique routes surveyed for two nights over the course of a four-night period.

The surveys indicated that Site 300 supports a robust population of wildlife, with coyote, black-tailed deer, and wild pigs being the three most detected species. American badger was detected at three different camera stations. San Joaquin kit fox and mountain lion were not detected.

Camera station surveys detected coyote, bobcat, striped skunk, Heermann's kangaroo rat, black-tailed deer, California ground squirrel, raccoon, wild pig, desert cottontail, side-blotched lizard, and various birds. Observations from the spotlighting surveys were consistent with results from the camera surveys, including coyote, black-tailed deer, bobcat, and wild pig. However, San Joaquin kit fox, mountain lion, and American badger were not observed during the spotlighting surveys.

In summary, the 2021 carnivore surveys detected one California Species of Special Concern (American badger); however, San Joaquin kit fox, and mountain lion were not detected on Site 300. The survey techniques employed were effective in detecting carnivore and mesocarnivore species and if San Joaquin kit fox and/or mountain lion were present on the site in any density at the time of the surveys they should have been detectable. Mountain lions are a mobile predator that is known to occur in the vicinity of Site 300, and the habitat on Site is certainly suitable for the species. Although mountain lions have been sporadically documented on Site 300 in the past, the 2021 carnivore survey was not able to detect this species. However, the survey effort only represents a snapshot of the species that were on the Site at the time of the survey, and it's possible that mountain lions may be sporadically present in low densities, making detection extremely difficult and there is a possibility that they could have gone undetected. The San Joaquin kit fox is also a mobile predator species with a historic range that includes most of California's Central Valley. Although San Joaquin kit fox have historically occurred in Alameda and San Joaquin Counties, there has been a marked decline in density and abundance in the last four decades. Additionally, the habitat and topography on Site 300 is considered marginally suitable for the San Joaquin kit fox. Based on the absence of high-quality habitat on Site 300, the lack of recent San Joaquin kit fox records in the vicinity, and the negative findings of surveys conducted with scent detection dogs in 2018 and 2020 (Woollett 2019 and Woollett 2021), San Joaquin kit fox is not expected to occur on Site 300.

I.2.8 Bat Survey for the Lawrence Livermore National Laboratory Experimental Test Site 300

Bat surveys using acoustic detectors/recorders for passive monitoring were conducted at Site 300 in the spring of 2021 (ECORP 2021b). The surveys targeted two focal species that are designated as California Species of Special Concern, including the western red bat and pallid bat.

A Wildlife Acoustics SM4BAT-FS unit using the SMM-U2 Microphone in multiple locations was used to record bat acoustics as full-spectrum WAV files. The SM4BAT-FS units were distributed at 36 sites with a standard deployment period of seven nights for each unit at each site. The availability of multiple acoustic detector units allowed for all 36 sites to have one-week acoustic detector deployments within a four-week period in 2021.

External structure surveys were also conducted at a few locations with structures adjacent to acoustic detector deployments. A visual survey of the exteriors of some buildings were conducted to determine if bats were using the structural elements for day roosting and/or night roosting. Presence of bat guano, bat urine staining, or culled insect parts were used as indicators of bat use of a structure. Spotlights and/or strong flashlights were also used to illuminate areas to see potential features and potential evidence of bat use.

The 2004 LLNL Site 300 Bat Survey provided excellent background information regarding the natural history of bat populations in general as well as specific life histories for bat species expected to be found at Site 300. Most importantly, the site selection process in 2004 for passive acoustic detectors provided an excellent template for deployment locations of acoustic detectors for the 2021 study.

Acoustic analysis of the recorded data identified 14 species (Table I.3-5 in Section I.3) of bats at Site 300, including the two focal species targeted for the survey and two other California Species of Special Concern (Townsend's big-eared bat and western mastiff bat).

The acoustic surveys indicated that there was a high degree of bat activity in two areas of Site 300. One area is the southeastern portion of the site along Corral Hollow Road in the CDFW Corral Hollow Ecological Reserve and also along the main cluster of buildings at LLNL near the entrance to Site 300 from Corral Hollow Road. The other area with high bat activity levels recorded in the surveys was mid-site along the eastern edge of Site 300. The geological features and a small riparian zone associated with freshwater springs in the area were attractive to bats.

A few pieces of bat guano were found during the structure surveys of six buildings adjacent to acoustic detector deployments, but there were no observations indicating day- or night-roosting of bats. The buildings that were surveyed were immediately adjacent to the following Acoustic Detector locations: Site 11 – West CP, Site 46 – East CP Parking Utility Platform, Site 28 – East O.P., Site 47 – Building 865 Wetland, Site 41 – West O.P., and Site 50 – Near Building W6.

In summary, Site 300 habitats have a good diversity of bat species (14 species). While some are likely transiting species (i.e., Western Mastiff Bat) the others are likely more resident in the area. Two particular areas of Site 300 (i.e., southeastern portion of the Corral Hollow Ecological Preserve and near the entrance to Site 300 from Corral Hollow Road) have high levels of bat activity and were observed to have both roosting and foraging habitats present at both sites. The two focal bat species occur in many of the survey locations (i.e., Pallid Bat detected in 75 percent of the survey locations (27/36 sites) and Western Red Bat detected in 64 percent of the survey locations (23/36 sites). Two other special status species (Townsend's Big-eared Bat and Western Mastiff Bat) were detected.

I.2.9 Small Mammal Trapping Survey for the Lawrence Livermore National Laboratory Site 300

Small mammal (rodents) trapping surveys were conducted in the spring of 2021 to document small mammal occurrence at Site 300 and the adjacent Corral Hollow Ecological Reserve (ECORP 2021d). The surveys were conducted in two three-night trapping sessions. One trapping session was conducted on Site 300 and the second trapping session was conducted at Corral Hollow. Due to the large size of the sites, trap placement was focused on locations with definite or likely woodrat sign (e.g., middens) within areas of suitable riparian habitat. Areas that represented suitable habitat but lacked woodrat sign were also trapped. Twelve-inch collapsible Sherman live-traps were used during this survey.

The surveys resulted in the capture of four rodent species typically found throughout Alameda and San Joaquin counties, including Bryant's woodrat, California pocket mouse, brush mouse, and western harvest mouse. One Bryant's woodrat (*Neotoma bryanti*) was captured on Site 300. Nine woodrats were captured at Corral Hollow; these woodrats exhibited morphological characteristics that were consistent with that of the Diablo Range (Dusky-footed) woodrat (*Neotoma fuscipes*). The surveys did not document the presence of the federally listed (endangered) riparian woodrat (*Neotoma fuscipes riparia*) at Site 300 or the adjacent Corral Hollow Ecological Reserve.

In summary, small mammal surveys conducted in 2003 did not positively identify woodrats captured during the survey, but biologists postulated that the woodrats could be a disjunct population of the of the federally endangered riparian woodrat. The 2003 small mammal study recommended further study to determine whether the woodrats captured are the riparian woodrat, the Diablo Range woodrat, or both. The 2021 surveys on Site 300 resulted in the capture of four rodent species typically found throughout Alameda County, including Bryant's woodrat, California pocket mouse, brush mouse, and western harvest mouse. The trapping survey at Corral Hollow resulted in capture of two rodent species typically found throughout Alameda and San Joaquin counties, including Diablo Range woodrat and brush mouse. No federally endangered riparian woodrats were captured in the 2021 surveys, and this species is not expected to occur on Site 300 or the Corral Hollow Ecological Reserve.

I.2.10 Herpetological Survey for the Lawrence Livermore National Laboratory Site 300

Herpetological (reptiles and amphibians) surveys using visual observations and cover boards were conducted at Site 300 in 2021 (ECORP 2021a). The surveys targeted three California Species of Special Concern reptile species, including Blainville's (coast) Horned Lizard (*Phrynosoma blainvillii*), Northern California Legless Lizard (*Anniella pulchra*), and San Joaquin Coachwhip (*Masticophis flagellum ruddocki*). Special-status amphibian species were not targets of this survey effort. All three reptile target species were documented, as well as 14 other species, including California toad, coast range fence lizard, western side-blotch lizard, California (southern) alligator lizard, pacific gopher snake, and northern pacific rattlesnake.

Surveys for special-status herpetofauna were previously conducted in 2002. The 2002 surveys documented the presence of targeted species, including San Joaquin Coachwhip, Alameda Whipsnake (*Masticophis lateralis euryxanthus*), and Northern California Legless Lizard.

Several methods were employed during the 2021 survey, including Quadrat Surveys, Microhabitat Surveys, Coverboard Sampling, Road-driving Surveys, and Dirt Road/Firebreak Surveys. In addition to the target species, a running species list (Table I.3-6 in Section I.3) of all reptiles and amphibians was compiled during the survey and during routine Site 300 herpetofauna surveys. General locations were recorded for commonly encountered species. A series of 100' X 100' survey grids was developed in geographic information system and overlain across a map of Site 300. Primary grids were placed in areas thought to represent suitable habitat for the three target herpetofauna species. Secondary grids were located in presumed lesser-quality, potential habitat. All sign of target and non-target reptile and amphibian species were documented during surveys including live or dead animals, shed skin, and scat. Microhabitats including rock outcrops, dry drainages, and basins with unique vegetation assemblages were surveyed within the quadrats. Sixteen arrays of six coverboards (2' x 2' pieces of 3/8" plywood) were deployed in representative habitats across Site 300. Every mobilization to and from a survey site or repositioning within Site 300 was treated as a Road Survey. An additional technique used to target Blainville's (coast) Horned Lizard was Dirt Road/Firebreak Surveys. Surveys were conducted by slowly walking a section of dirt road or firebreak and searching for horned lizards and sign (scat).

In summary, a combination of survey methods including Coverboards, Quadrat Surveys, Road Transects, Walking Dirt Road/Firebreak Transects, and Microhabitat Surveys, were used to document three focal herpetofauna species and other species as encountered. All three target species were documented, as well as 14 other species (Table I-10 in Section I.3).

I.2.11 Final Site 300 Sensitive Botanical Resource Report

Sensitive botanical resource surveys, and vegetation mapping and classification were conducted in April-June, and August 2020, and February and March 2021 on Site 300 (Nomad Ecology 2021b). In addition, existing rare plant and vegetation data provided by LLNL from past monitoring and environmental impact evaluations were compiled to produce a Site 300 plant list. Seven special status plant species were recorded, and 35 vegetation communities, of which 20 communities are considered sensitive natural communities, were mapped at Site 300.

Background information on potentially occurring endangered, threatened, and rare plant and sensitive natural communities was compiled through a review of project specific sources, USFWS listed species, California Native Plant Society (CNPS)/CDFW datasets, and other sources (e.g., Manual of California Vegetation). Twelve species (Table I-4) were identified as targets for the 2020 and 2021 rare plant survey and vegetation mapping efforts. Targets were based on probability of occurrence, as well as LLNL staff input.

Table I-4. Target Site 300 Special Status Plant Species

Species Name / Common Name	Status	Peak Blooming Period
Federal/State Listed Species		
**Amsinckia grandiflora* large-flowered fiddleneck	FE, SE, 1B.1	April
California Native Plant Society Listed Species (Rank 1 & 2)		
**Blepharizonia plumosa* big tarplant	1B.1	September
Caulanthus lemmonii Lemmon's jewelflower	1B.2	March
**Eschscholzia rhombipetala* diamond-petaled poppy	1B.1	February / March
Madia radiata showy golden madia	1B.1	March / April
Navarretia nigeliformis subsp. *radians* *shining navarretia	1B.2	May
Senecio aphanactis chaparral ragwort	2B.2	March
Tropidocarpum capparideum caper-fruited tropidocarpum	1B.1	March / April
California Native Plant Society Listed Species (Rank 3 & 4)		
**Androsace elongata* subsp. *acuta* California androsace	4.2	March
Convolvulus simulans small-flowered morning-glory	4.2	April
**Fritillaria agrestis* stinkbells	4.2	February
Hesperevax caulescens hogwallow starfish	4.2	April

Key to status: FE=Federally endangered; SE=State endangered; California Native Plant Society codes: 1B=Rare, threatened, or endangered in California and elsewhere; 4=Plants of limited distribution - Watch list; California Native Plant Society Threat Codes: .1=Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat); .2=Moderately threatened in California (20-80% occurrences threatened)
* Observed in the 2020-21 surveys.
Source: Nomad Ecology 2021b.

A total of 26 sensitive natural communities were identified as targets for vegetation mapping at Site 300 (Table I-5). The list of target sensitive natural communities was based on a map-based search of the Manual of California Vegetation, as well as input from LLNL staff.

Table I-5. Target Site 300 Sensitive Natural Communities

Common Name	Scientific Name*	Lifeform	Status
California buckeye groves	*Aesculus californica* Alliance	Tree	S3
Iodine bush scrub	*Allenrolfea occidentalis*	Shrub	S3.2
Yerba mansa – Nuttall's sunflower – Nevada goldenrod alkaline wet meadows	*Anemopsis californica – Helianthella nuttallii – Solidago spectabilis*	Herb	S2
Bush monkeyflower scrub	*Diplacus aurantiacus* Alliance	Shrub	S3?
Wright's buckwheat – Heermann's buckwheat – Utah butterfly bush scrub	*Eriogonum wrightii – Eriogonum heermannii – Buddleja utahensis*	Shrub	S3
Alkali heath marsh	*Frankenia salina* Alliance	Herb	S3
California match weed patches	*Gutierrezia californica*	Shrub	S3?
Goldenaster patches	*Heterotheca* (*oregana, sessiliflora*)	Herb	S3
Iris-leaf rush seeps	*Juncus (oxymeris, xiphioides)* Alliance	Herb	S4?
Scale broom scrub	*Lepidospartum squamatum*	Shrub	S3
Common monkey flower seeps	*Mimulus* (*guttatus*) Alliance	Herb	S5?
Monolopia – leafy-stemmed tickseed fields	*Monolopia* (*lanceolata*) – *Coreopsis* (*calliopsidea*)	Herb	S3
Deer grass beds	*Muhlenbergia rigens*	Herb	S2?
California sycamore woodlands	*Platanus racemosa* Alliance	Tree	S3
Fremont cottonwood forest	*Populus fremontii – Fraxinus velutina – Salix gooddingii*	Tree	S3.2
Valley oak woodland	*Quercus lobata* Alliance	Tree	S3
Basket bush – river hawthorn – desert olive patches	*Rhus trilobata – Crataegus rivularis – Forestiera pubescens*	Shrub	S3.2?
Oak gooseberry thickets	*Ribes quercetorum*	Shrub	S2?
California rose briar patches	*Rosa californica*	Shrub	S3
Black willow thickets	*Salix gooddingii – Salix laevigata*	Tree	S3
Blue elderberry stands	*Sambucus nigra ssp. cerulea*	Shrub	S3
Hardstem and California bulrush	*Schoenoplectus (acutus, californicus)*	Herb	S3
Bushy spikemoss mats	*Selaginella bigelovii*	Herb	S3
Alkali sacaton – scratchgrass – alkali cordgrass alkaline wet meadow	*Sporobolus airoides – Muhlengergia asperifolia – Spartina gracilis*	Herb	S2
Bush seepweed scrub	*Suaeda moquinii*	Shrub	S3
White-tip clover swales	*Trifolium variegatum*	Herb	S3?

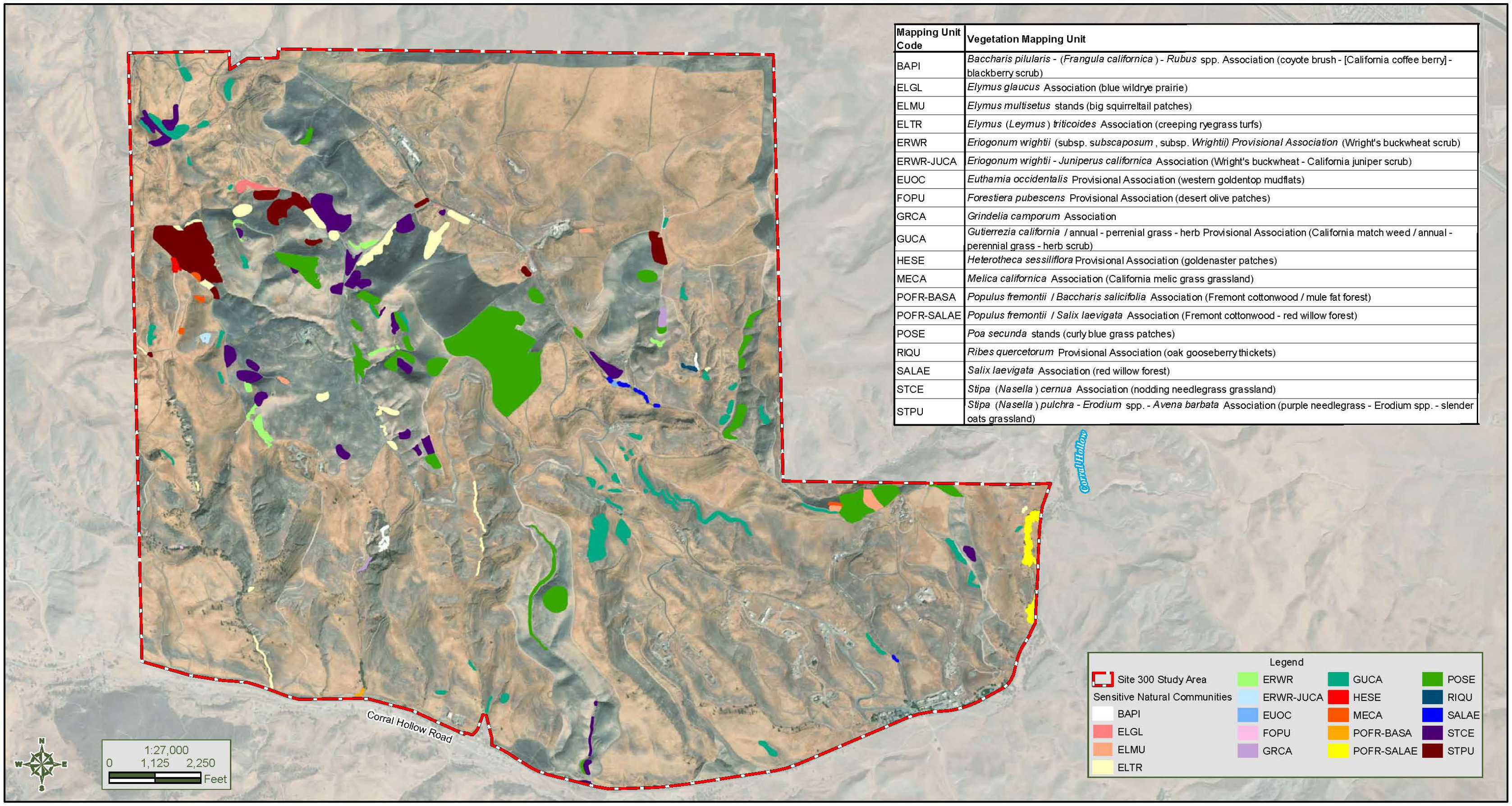
Special Status Codes: State Codes: S1=Critically Imperiled; S2=Imperiled; S3=Vulnerable; ?=A question mark (?) denotes an inexact numeric rank because there are insufficient samples over the full expected range of the type, but existing information points to this rank

Source: Nomad Ecology 2021b.

The large-flowered fiddleneck is the only federal and state listed endangered species known to occur at Site 300. No new populations of large-flowered fiddleneck were recorded in 2020 or 2021. According to annual monitoring reports by LLNL, the two native populations at Site 300 have not supported any large-flowered fiddleneck for over a decade, but the introduced subpopulations are still extant, largely due to occasional planting of large-flowered fiddleneck seeds and seedlings. Only one extant population of large-flowered fiddleneck was recorded within Site 300.

There were 20 California sensitive natural communities observed scattered throughout Site 300 (Figure I-7). Six California Native Plant Society special status (4 rare and 3 watch list) plant species, 26 rare plant occurrences, and 14,077 individuals were recorded at Site 300. Observations included 98 individuals and one occurrence for the federal and state endangered large-flowered fiddleneck. Rare plant species observations included one metapopulation (i.e., patch) and more than 10,000 big tarplants, three occurrences and 17 individuals of diamond-petaled poppy, and one occurrence and 1,536 individuals of shining navarretia. Watchlist plant species observations included 16 occurrences and 593 individuals of California androsace, three occurrences and 1,837 individuals of stinkbells, and one occurrence and an unknown (population not estimated) number of hogwallow starfish plants.

Threats of potential species decline were associated with 11 sensitive natural communities and all seven of the special status species. Threats included invasive weeds and exotic annual grass competition, small population size, pig damage, and changes in fire regime. Invasive weed (primarily non-native annual grasses) threat of potential species decline was recorded for five special status species. The threats to sensitive natural communities and special status species should be considered for management action. Management considerations for special status species in grassland habitat should include prescribed fire, flash grazing, or mechanical removal to slow the growth of exotic annual grasses, and the resulting build-up of thatch, thereby increasing the long-term survivability of special status plants occupying grassland habitat within Site 300. Management considerations for prescribed burns should weigh both benefits and negative impacts of fire on special status plant populations. Management considerations for small populations of special status species should include continued monitoring of large-flowered fiddleneck and diamond-petaled poppy and increasing population size and genetic diversity through direct seeding or out-planting.



Mapping Unit Code	Vegetation Mapping Unit
BAPI	*Baccharis pilularis* - (*Frangula californica*) - *Rubus* spp. Association (coyote brush - [California coffee berry] - blackberry scrub)
ELGL	*Elymus glaucus* Association (blue wildrye prairie)
ELMU	*Elymus multisetus* stands (big squirreltail patches)
ELTR	*Elymus* (*Leymus*) *triticoides* Association (creeping ryegrass turfs)
ERWR	*Eriogonum wrightii* (subsp. *subscaposum*, subsp. *Wrightii) Provisional Association* (Wright's buckwheat scrub)
ERWR-JUCA	*Eriogonum wrightii* - *Juniperus californica* Association (Wright's buckwheat - California juniper scrub)
EUOC	*Euthamia occidentalis* Provisional Association (western goldentop mudflats)
FOPU	*Forestiera pubescens* Provisional Association (desert olive patches)
GRCA	*Grindelia camporum* Association
GUCA	*Gutierrezia california* / annual - perrenial grass - herb Provisional Association (California match weed / annual - perennial grass - herb scrub)
HESE	*Heterotheca sessiliflora* Provisional Association (goldenaster patches)
MECA	*Melica californica* Association (California melic grass grassland)
POFR-BASA	*Populus fremontii* / *Baccharis salicifolia* Association (Fremont cottonwood / mule fat forest)
POFR-SALAE	*Populus fremontii* / *Salix laevigata* Association (Fremont cottonwood - red willow forest)
POSE	*Poa secunda* stands (curly blue grass patches)
RIQU	*Ribes quercetorum* Provisional Association (oak gooseberry thickets)
SALAE	*Salix laevigata* Association (red willow forest)
STCE	*Stipa* (*Nasella*) *cernua* Association (nodding needlegrass grassland)
STPU	*Stipa* (*Nasella*) *pulchra* - *Erodium* spp. - *Avena barbata* Association (purple needlegrass - Erodium spp. - slender oats grassland)

Source: Nomad Ecology 2021b.

Figure I-7. Sensitive Natural Communities Observed at Site 300

The 2020-21 vegetation classifications for Site 300 are presented in Table I-6. In addition to the vegetation mapping units, developed and unvegetated -disturbed areas were mapped as non-vegetated types. The most mapped vegetation community was wild oats and annual brome grasslands, occupying approximately 5,908 acres, or 86 percent of Site 300. The next highest acreages were unvegetated – disturbed areas (urban) (163 acres, or 2.4 percent), developed areas (154 acres, or 2.2 percent), California sagebrush scrub (146 acres, or 2.1 percent), curly blue grass patches (143 acres, or 2.1 percent), and California sagebrush – black sage scrub) (97 acres, or 1.4 percent).

Table I-6. Vegetation Classifications from the 2020-21 Surveys for Site 300

Alliance	Association
California juniper woodland	California juniper / annual herb woodland
Blue oak woodland and forest	blue oak – grass woodland
Fremont cottonwood forest and woodland	Fremont cottonwood / mule fat forest Fremont cottonwood – red willow forest
Goodding's willow – red willow riparian woodland and forest	red willow forest
Mule fat thickets	Mule fat thickets
Goldenaster patches	Goldenaster patches
Basket bush – river hawthorn – desert olive patches	Desert olive patches
Arroyo willow thickets	Arroyo willow – mule fat thickets
California sagebrush – (purple sage) scrub	California sagebrush scrub California sagebrush – California buckwheat scrub
California sagebrush – black sage scrub	None assigned
California buckwheat scrub	California buckwheat scrub
California match weed patches	California match weed / annual – perennial grass – herb scrub
Silver bush lupine scrub	Silver bush lupine scrub
Poison oak scrub	Poison oak – (coyote brush) scrub
Coyote brush scrub	coyote brush – (California coffee berry) – blackberry scrub
Wright's buckwheat – Heermann's buckwheat – Utah butterfly-bush scrub	Wright's buckwheat – California juniper scrub Wright's buckwheat scrub
Purple three-awn – squirreltail – curly blue grass patches	Big squirreltail patches Curly blue grass patches
California brome – blue wildrye prairie	Blue wildrye prairie
Wild oats and annual bromes grasslands	None assigned
Sand-aster and perennial buckwheat fields	Naked buckwheat fields
Needle grass – melic grass grassland	California melic grass grassland Nodding needlegrass grassland Purple needlegrass – slender oats grassland
Ashy ryegrass – creeping ryegrass turfs	Creeping ryegrass turfs
Salt grass flats	Salt grass – annual grass sinks
Cattail marshes	Cattail marsh
Choke cherry thickets	Choke cherry thickets
Oak gooseberry thickets	Oak gooseberry thickets
Nodding beggarticks – western goldentop – marsh seedbox mudflats	Western goldentop mudflats
Gum plant patches	Gum plant patches
Stinging nettle thickets	None assigned

Source: Nomad Ecology 2021b.

Comparison of the Site 300 2002 vegetation classifications with the 2020-2021 vegetation classifications indicated that the 2002 native grassland mapping unit was refined into 11 native grassland, and herbaceous associations and stands in the 2020-2021 vegetation classifications. The acreage of native grasslands decreased from the 2002 vegetation classifications (Table I-7). In 2002 approximately 480 acres of native grasslands were identified at Site 300, and in 2020 approximately 285 acres of native grasslands were mapped in 2020. The former coastal scrub mapping unit was refined into seven native shrub alliances and associations. The acreage of coastal scrub habitat increased in 2020 compared to 2002. This is likely because communities dominated by sub-shrubs, such as California matchweed and Wright's buckwheat, were mapped in 2020 that were not identified in 2002. The areas on Site 300 that were previously mapped as Valley oak woodland were found to be scattered valley oak trees within another vegetation type, mule fat scrub and arroyo willow – mule fat thickets. The previously mapped areas of Mexican elderberry were determined to be scattered blue elderberry shrubs within another vegetation type, choke cherry scrub and oak gooseberry scrub. Scattered Mexican elderberry shrubs were observed in the 2020-2021 surveys in stands of stinging nettle thickets and coyote brush – California coffee berry – blackberry scrub stands.

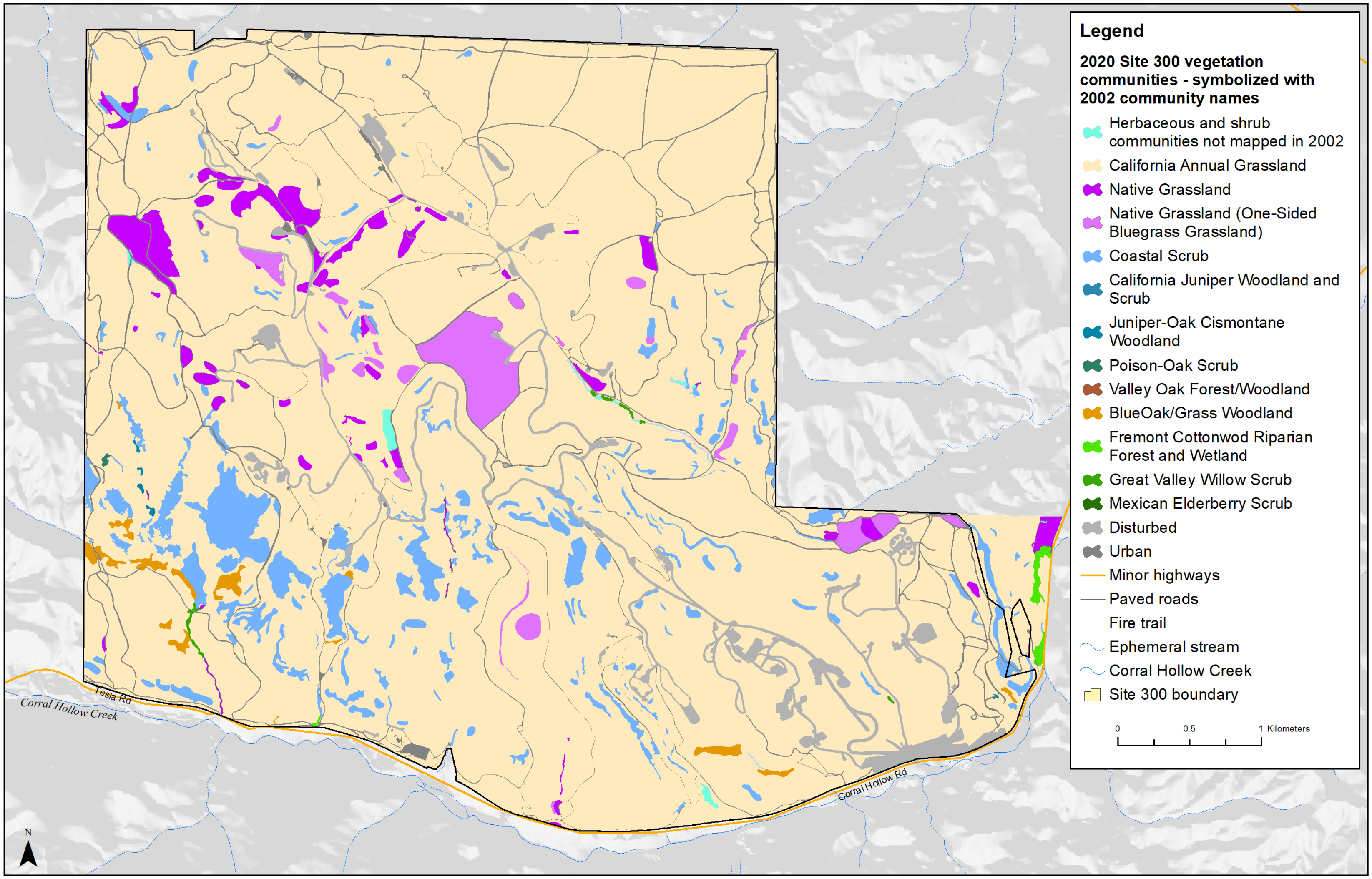
Table I-7. Comparison of Vegetation Classifications in 2001 and 2020 at Site 300

2002 Vegetation Community Classification	2002 Area (acres)	2002 Percentage of Area	2020 Area (acres)	2020 Percentage of Area
BlueOak/Grass Woodland	56.2	0.8	28.6	0.4
California Annual Grassland	5533.7	80.2	5908.4	85.6
California Juniper Woodland and Scrub & Juniper-Oak Woodland	36.4	0.3	1.6	0.0
Coastal Scrub	234.7	3.4	334.3	4.8
Fremont Cottonwood Riparian Forest and Wetland	12.8	0.2	8.7	0.1
Great Valley Willow Scrub	0.9	0.0	3.5	0.1
Mexican Elderberry Scrub	2.0	0.0	0.0	0.0
Native Grassland/One-Sided Bluegrass Grassland	480.2	7.0	285.8	4.1
Poison-Oak Scrub	0.9	0.0	0.7	0.0
Valley Oak Forest/Woodland	4.5	0.1	0.0	0.0
Emergent Wetland Communities Not Included in 2002	0.0	0.0	2.9	0.0
Herbaceous Communities Not Included in 2002	0.0	0.0	7.6	0.1
Shrub Dominated Communities Not Included in 2002	0.0	0.0	0.9	0.0

Source: LLNL GIS Database Analysis.

Vegetation classification and mapping efforts conducted in 2020 and 2021 on Site 300 resulted in four tree-overstory, 14 shrubland, and 11 herbaceous alliances (i.e., uniform group of plant associations). The vegetation mapping units are depicted in Figure I-8.

One of the objectives of conducting the rare plant surveys was to create a plant list for Site 300. Table I.3-8 in Section I.3 presents the plant list taken from Appendix B of the 2021 Botanical Resource Survey Report, Site 300.



Source: Nomad Ecology 2021b.

Figure I-8. Vegetation Communities Mapped in 2020 on Site 300

I.2.12 FY19 and FY20 Report for the Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Natural Resources Management Plan

Special status avian and amphibian monitoring were conducted between October 2018 and September 2020 to fulfill management recommendations described in the Site 300 Natural Resources Management Plan (NRMP) (LLNL 2021b). Focused monitoring was conducted for red-tailed hawk, great horned owl barn owl and common raven.

Surveys for nesting burrowing owls included fire trail surveys, transect surveys conducted for development projects, and monitoring of nesting burrowing owls during spring and summer. In 2019, 18 potential nesting burrowing owl pairs were observed. Fledglings were observed with 13 of these 18 potential nesting pairs. These 13 nesting pairs produced 39 fledglings. The number of nesting burrowing owl pairs decreased in 2019 compared to 2018. In 2018, 25 potential nesting burrowing owl pairs were identified using the three survey methodologies. In 2020, 10 potential nesting burrowing owl pairs were observed, and eight nesting pairs produces 28 fledglings.

Annual tracking of the nesting tricolored blackbird colony at Site 300 was conducted in the riparian corridor of Elk Ravine. In 2019, approximately 425 tricolored blackbirds were observed in Elk Ravine through May 10, 2019. In 2020, biologists were not allowed onsite for surveys because of the COVID-19 pandemic shelter in place order. During this time, Site 300 facility managers first reported tricolored blackbirds in Elk Ravine on March 25 and observed 20 or fewer tricolored blackbirds from April 29 through May 6. In 2019 and 2020, no fledglings were observed.

Nesting raptors and raven locations were monitored in 2019 and 2020 to ensure compliance with the federal Migratory Bird Treaty Act. Other common raptor species expected to nest onsite (i.e., American kestrel, Coopers hawk, sharp shinned hawk and red-shouldered hawk) were not observed nesting near LLNL facilities or project sites in 2019 or 2020, thus were not included in focused monitoring. Two additional special status raptors have historically been observed nesting or attempting to nest at Site 300. In 2009 there was an unsuccessful Swainson’s hawk nesting attempt at Site 300, and in 2011 a pair of white-tailed kites successfully nested at Site 300. No subsequent Swainson’s hawk or white-tailed kite nesting attempts have been observed Site 300. Although the golden eagle is known to nest within 10 miles, there have been no nesting attempts observed at Site 300. The northern harrier is regularly observed and expected to nest onsite. Monitoring for nesting northern harriers is not conducted. Raptors observed in the 2019 surveys included Swainson’s hawk, red-tailed hawk, northern harrier, American kestrel, golden eagle, barn owl, red-shouldered hawk and great horned owl. The 2019 surveys documented 13 red-tailed hawk nests, two great horned owl nests, and 11 common raven nests. In 2020, surveys were restricted due to the COVID-19 pandemic. Species observed included red-tailed hawk, loggerhead shrike, American kestrel, golden eagle, turkey vulture, barn owl, and great horned owl. The 2020 surveys documented 13 red-tailed hawk nests, two great horned owl nests, one barn owl fledgling, and six common raven nests.

Monitoring for California red-legged frog and California tiger salamander was conducted in 2019 and 2020 (LLNL 2021b). Diurnal egg mass surveys were conducted each rainy season to record California red-legged frog breeding at pools throughout Site 300. California red-legged frogs reproduced in Pool M1a and M1b in Elk Ravine in 2019 and 2020. Evidence of California red-legged frog reproduction was also observed at Pool CR in Elk Ravine (2019 and 2020) and in Corral Hollow Creek in the Corral Hollow Ecological Reserve (2020). Adult California red-legged frogs were occasionally observed in 2019 at several wetlands including Pool M1a and M1b, Pool CR, and the Corral Hollow Ecological Reserve. During the 2020 surveys subadult and adult California red-legged frogs were observed in Pool M1a and b, Pool CR, Pool J, Pool O, and the Corral Hollow Ecological Reserve. In addition, the western spadefoot successfully reproduced in Pool OS and western spadefoot larvae were observed at the Corral Hollow Ecological Reserve in 2019.

Nine seasonal pools that support California tiger salamander breeding were monitored in 2019 and 2020. In 2019, California tiger salamander eggs were observed at Pools OS, A, H, M2, and HC1, which were inundated long enough for California tiger salamander metamorphosis. Less than average rainfall in 2020 resulted in one seasonal pool (OS) filling and supporting California tiger salamander eggs; however, the pool was not inundated long enough to allow for California tiger salamander larvae metamorphosis.

Fire trail surveys were conducted in 2019 and 2020 for approximately 85 miles of dirt fire trails on Site 300 in preparation for annual fire trail grading. These fire trails traverse California red-legged frog critical habitat, Alameda whipsnake critical habitat, large-flowered fiddleneck critical habitat, and nesting bird habitat. Annual fire trail monitoring is a requirement of the ESA consultation for Site 300 fire trail grading. Fire trail surveys resulted in observations of Blainville's (coast) Horned Lizards and American badger (both species are California Special Status Species) in several areas throughout Site 300 in 2019 and 2020.

In summary, the distribution and abundance of special status species observed in 2019 and 2020 at Site 300 remain similar to previous annual observations. The special status species observed at Site 300 in 2020, had fewer successful breeding attempts for which reproductive success was monitored (burrowing owl, California red-legged frog, and California tiger salamander). Common raptor species monitored at Site 300, including the red-tailed hawk, maintained a similar level of reproductive success in 2019 and 2020. Site 300 avian monitoring occurred to ensure compliance with the federal MBTA and the Memorandum of Understanding between DOE and USFWS Regarding Implementation of Executive Order 13186, was successfully implemented. Common raptor species, including the red-tailed hawk, great-horned owl, and barn owl, continued to successfully utilize nesting sites at Site 300 in 2019 and 2020. Red-tailed hawks were observed to have similar nesting success in 2019 and 2020. Great horned owls and barn owls were included in focused monitoring efforts where these species nested at or near Site 300 facilities. Both owl species were observed to successfully rear fledglings. Burrowing owl surveys identified 18 potential nesting pairs in 2019 and ten potential nesting pairs in 2020. Site 300 tricolored blackbird monitoring was conducted to ensure compliance with the California ESA and the federal MBTA. Fire trail surveys were conducted to meet the requirements of the 2002 Site 300 Biological Opinion. Incidental observations of Blainville's (coast) Horned Lizards and American badger show that these two California Special Status Species occurred in several areas throughout Site 300 in 2019 and 2020. The diurnal surveys for California tiger salamanders indicated that nine pools surveyed regularly support California tiger salamander breeding in years with average or above average rainfall. California red-legged frogs were able to successfully reproduce in Elk Ravine in 2019 and 2020 although only one California red-legged frog egg mass was observed in pools in 2020. The western spadefoot, a California Species of Special Concern, successfully reproduced at the Corral Hollow Ecological Reserve in 2019.

I.2.13 Valley Elderberry Longhorn Beetle Surveys at the Lawrence Livermore National Laboratory - Site 300

In 1980, the USFWS listed the valley elderberry longhorn beetle as a threatened species. A visual survey was conducted in October and November of 2020 to determine the potential presence of the valley elderberry longhorn beetle and the quantity and quality of its host plant, blue elderberry on Site 300 and CDFW land southeast of Site 300 (Shepard 2020). The 2020 survey included mapped locations of elderberry plants that were observed using a sub-meter global positioning system to obtain positional coordinates for every elderberry plant at Site 300 and the CDFW site. In addition, observations of valley elderberry longhorn beetle emergence holes on elderberry plants were also mapped using global positioning system. This study updated earlier information that had been collected in 1991 and 2002. The discovery of valley elderberry longhorn beetle at Site 300 and the CDFW site became a range extension for the valley elderberry longhorn beetle.

In 2020, all elderberry plants that were known to occur at the LLNL Site 300 and CDFW site were surveyed by inspecting elderberry plants for signs of past infestation as evidenced by exit holes and collecting data at each elderberry plant inspected. Presence-absence surveys were not conducted in 2020 due to the timing of the surveys and were planned for Spring 2021.

The presence of valley elderberry longhorn beetle was first discovered on Site 300 in 2002. No confirmed valley elderberry longhorn beetles were observed in 2020 or 2021. A total of 45 emergence holes in 39 elderberry plants in three areas on Site 300 and the CDFW site were mapped. Four hundred and ninety-eight elderberry plants were located along intermittent drainages or seeps in canyon bottoms, in riparian habitat, in association with rock outcrops, and on slopes and ledges of canyon walls.

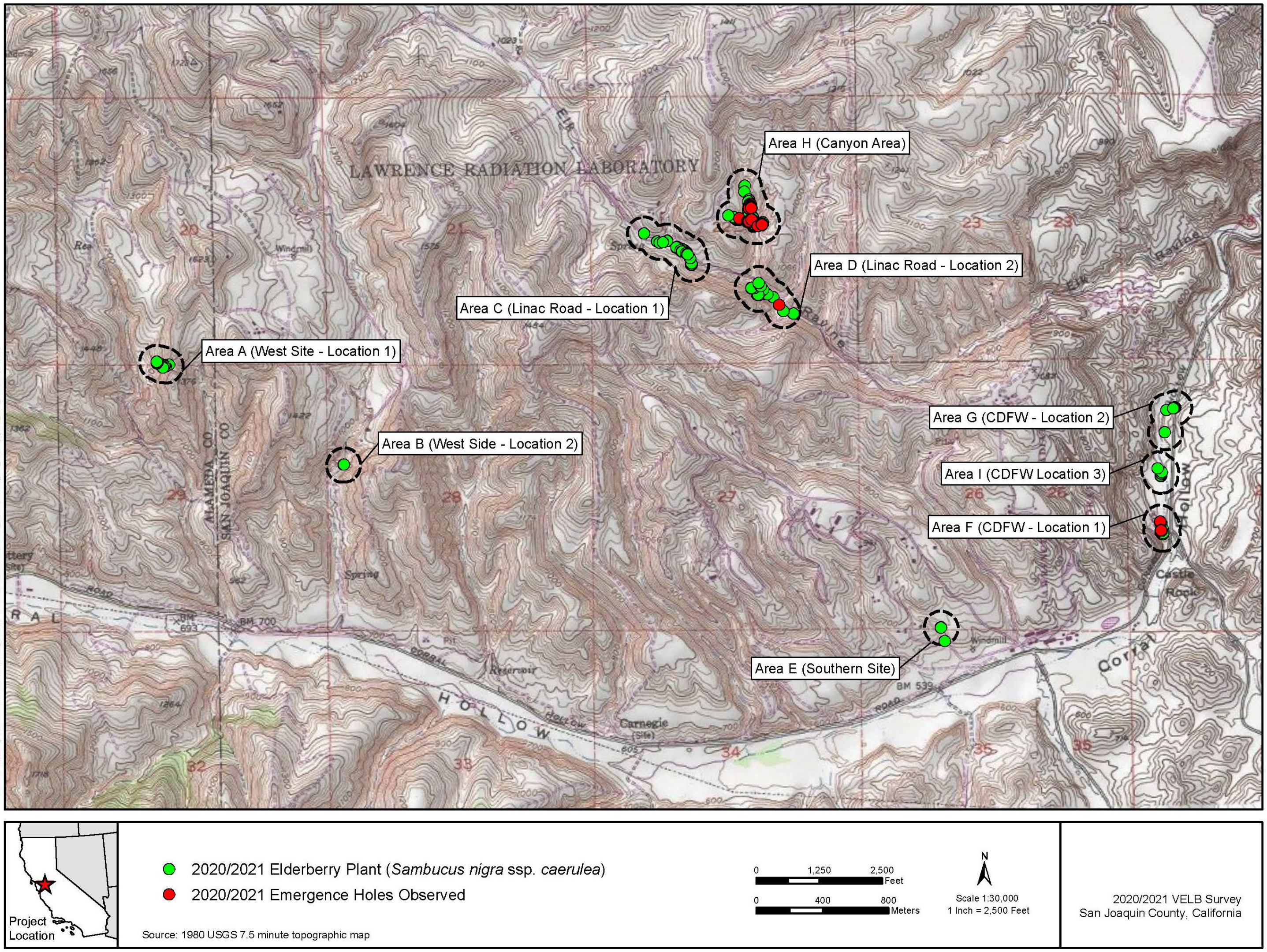
As concluded in the 2002 survey, none of the elderberry areas surveyed in 2020 were located near active construction sites. The primary activity at Site 300 that may adversely impact the elderberry plants is maintenance of dirt roads and fire breaks. As noted in the 2020 surveys, rubbing and stripping of elderberry plants by wild pigs may negatively impact valley elderberry longhorn beetle emergence or egg laying. If current or future activities at Site 300 are likely to impact any elderberries, the plants must be inventoried in the manner described by the USFWS conservation guidelines.

I.2.14 Valley Elderberry Longhorn Beetle Surveys at the Lawrence Livermore National Laboratory – Site 300

Presence-absence surveys were conducted, along with inspections of elderberry plants, at Site 300 and CDFW land southeast of Site 300 for signs of past infestation as evidenced by exit holes in April and May 2021 (Shepard 2021). The surveys included elderberry plants that were known from the 2020 surveys to be suitable habitat (riparian) for valley elderberry longhorn beetles. Suitable riparian habitat for the valley elderberry longhorn beetle exists within Elk ravine, although was not surveyed in 2021 due to the active nesting tricolored blackbird colony.

The 2021 surveys confirmed the presence of the elderberry plants mapped during the 2002 survey at all previously mapped locations but one, where the plant had died and was no longer present. No new emergence holes were observed during the 2021 surveys. As noted in the 2002 survey for valley elderberry longhorn beetle at Site 300, the 2020 and 2021 surveys noted that none of the elderberry areas are located near active construction sites. Similarly, the studies noted that maintenance of dirt roads and fire breaks are the primary activities at Site 300 that may result in potential adverse impacts on elderberry plants. In addition, impacts to elderberry plants by wild pigs were noted in the 2020 and 2021 surveys. Evidence of pigs rubbing against elderberry trunks and causing bark stripping at approximately the same height as valley elderberry longhorn beetle exit holes was observed in the field. An increase in the wild boar population may negatively impact the emergence or egg laying of valley elderberry longhorn beetles at Site 300.

A total of 498 elderberry plants were located; 422 plants were found in six areas at Site 300 and 76 plants were found in three areas at the CDFW site. The findings are depicted in Figure I-9.



Source: Shepard 2021.

Figure I-9. Results of the 2021 Valley Elderberry Longhorn Beetle Survey at Site 300

I.2.15 2021 Alameda Whipsnake Surveys for the Lawrence Livermore National Laboratory Site 300

This report presents the results of a 20-day trapping survey for the Alameda whipsnake (*Masticophis lateralis euryxanthus*) conducted at Site 300 (LLNL 2021c). The study site is within the northwest corner of Alameda whipsnake Critical Habitat Unit 5A. The survey was conducted under the authority of federal recovery permit TE-053672-3. The Alameda whipsnake, one of two subspecies of the California whipsnake (*Masticophis lateralis*), is a state (1971) and federal (1997) listed threatened subspecies.

The study area was within the southwestern quadrant of Site 300 (approximately 145 acres). The study site is within the two largest uninterrupted shrubland patches of California sagebrush – black sage scrub on Site 300. Twenty trap units were installed at the study site in May of 2021. Traps were activated on May 26, 2021 and checked daily between May 27 and June 25 for a total of 20 trap-days. Trap units were placed in approximately the same locations as traplines used in a 2002 study and a follow up five-year study investigating impacts of fire on whipsnakes.

Two individual Alameda whipsnakes were captured during this study. A total of 21 individual snakes representing nine species were captured during this study (Table I.3-9 in Section I.3). A total of 45 individual lizards representing five species were captured and eight individual small mammals representing 3 species were captured. No amphibians were captured during the study. All snakes were scanned for PIT tags from previous studies, but no PIT tags or indications of capture during previous studies were detected. During the spring and summer of 2020/2021 multiple surveys were conducted for special status species throughout Site 300 in support of data collection for this SWEIS. Incidental observation of Alameda whipsnakes in 2020 and 2021 indicate that Alameda whipsnakes within the southwest quadrant of Site 300 are still present.

I.2.16 2020 Mitigation and Monitoring Report for the Arroyo Las Positas Management Project

This report describes maintenance, monitoring, and mitigation conducted in 2020 as part of the Arroyo Las Positas Management Project (the project) at the Livermore Site (LLNL 2021d). The purpose of this project is to enhance habitat value for the California red-legged frog (*Rana draytonii*) within the LLNL reach of Arroyo Las Positas and protect LLNL facilities from flooding. The project description, in addition to the monitoring and mitigation requirements for this project are described in the October 2015 Revised Mitigation and Monitoring Plan (MMP) for the Arroyo Las Positas Management Project and the USFWS Formal Consultation on the Proposed Arroyo Maintenance Project on Arroyo Las Positas at Lawrence Livermore National Laboratory (biological opinion; Service File Numbers 1-1-97-F-173 and 1-1-98-I-1562).

The MMP requires 12 photo stations at each vegetation removal location. Photographs are to be taken at these locations prior to vegetation removal work and twice a year for five years following vegetation removal (at each section). All monitoring photographs are provided in the 2020 MMP report.

The MMP requires that the percent cover of emergent wetland vegetation, woody riparian canopy, and open water be recorded each summer. Vegetation community measurements were monitored and recorded on August 25, 2020. Five community or substrate types were identified within the arroyo: areas dominated by the invasive ornamental tree *Casuarina* sp.; emergent wetland vegetation dominated by *Nasturtium officinale*, *Typha latifolia* and *Typha angustifolia*; willow dominated areas which include *Salix lasiolepis*, *Salix exigua*, and *Salix gooddingii*; open water areas with greater than 50 percent open water; and concrete lined channels. In 2020, the channel (excluding the concrete lined section) of Arroyo Las Positas was predominantly (approximately 50 percent) vegetated by emergent wetland vegetation prior to maintenance. Project goals include decreasing the cover of the invasive ornamental tree *Casuarina* sp. and increase native willow and cottonwood species cover. In 2020, 3.5 percent of the project site was dominated by *Casuarina* sp. Willows planted during the first two years of this project (2014 and 2015) have sufficiently grown to be considered the dominant vegetation type in some areas. In 2020, 31.6 percent of the native willow and cottonwood species cover the project site.

The MMP requirement for willow survivorship includes annually recording the survivorship of willow cuttings for the first five years after planting. If the survivorship of a planted reach of the arroyo drops below 70 percent during the first five years after planting, additional willow cuttings are required to be planted to achieve the required numbers. The survivorship of willow cuttings in all locations was measured on August 25, 2020. The 2019 maintenance required the planting of 120 cuttings; 211 willows were observed within the two 2019 maintenance reaches. The 2018 maintenance required the planting of 160 cuttings; 264 plantings from the previous year were observed in three reaches of the project site. No willow planting was conducted in 2017. In 2016, 180 willow and cottonwood cuttings were planted; 149 willows and cottonwoods have survived four years after planting. In 2015, the first year of required planting for this project, 180 willow cuttings were planted in three locations. The 70 percent willow survivorship requirement was met in 2020, the fifth year after planting, with approximately 150 willows and cottonwoods surviving from the 2015 plantings.

The MMP requirement includes conducting at least three California red-legged frog egg mass surveys by a Service-approved biologist in each open water reach of Arroyo Las Positas in which vegetation removal had been previously conducted. At least two nocturnal amphibian surveys will be conducted throughout the project site each summer. In 2020, four California red-legged frog surveys were conducted along Arroyo Las Positas. Two surveys were performed during the California red-legged frog breeding season on April 21, 2020 (diurnal survey) and April 28, 2020 (nocturnal survey). Two summer surveys were performed on July 21, 2020 and September 23, 2020. California red-legged frogs were not observed during the diurnal or nocturnal surveys.

The MMP requirement for maintenance specifies that vegetation will only be removed in 100 to 300-foot sections of the arroyo alternating with 100 to 300-foot sections that are left undisturbed. Vegetation removal will be conducted in no more than 20 percent (900 linear feet) of the project site each year. This will enhance California red-legged frog habitat by creating open water pools that provide potential California red-legged frog breeding habitat alternating with sections of emergent and riparian vegetation that provide cover for red-legged frogs. Flood control maintenance was conducted in Arroyo Las Positas between 2014 and 2020. No California red-legged frogs were harmed or discovered during the maintenance work. The 2019 and 2020 vegetation management activities included vegetation and sediment removal in two sections of the arroyo, including invasive *Casuarina* sp. removal. Vegetation and sediment removal activities in 2018 maintenance activities were conducted in three sections of the arroyo. Riparian vegetation was trimmed and removed with an excavator, and invasive tree species were removed and trimmed with chainsaws and hand tools. Vegetation management activities in 2017 were conducted in one 60-foot section of the arroyo. Removal of cattails, sediment, and invasive trees from the channel in 2016 was conducted in three sections of Arroyo Las Positas. Two California red-legged frogs were found and safely relocated prior to work in these areas. Sediment and vegetation were removed in 2015 from two 300-foot reaches of the arroyo. No California red-legged frogs were observed during the 2015 work.

The MMP requirements for mitigation include vegetation management (removal of no more than 20 percent or 900 linear feet of the project site each year), vegetation community cover (maintain minimum of 30 percent cover of emergent wetland vegetation and woody riparian canopy), and willow planting (minimum of 20 willow or cottonwood cuttings will be planted for every 100 linear feet of unshaded habitat where cattails or other wetland vegetation are removed from the arroyo). In 2020, the vegetation management requirement was met; flood control maintenance conducted within two 300-foot reaches of the arroyo were separated by over 900 feet. The requirement to maintain 30 percent cover before and after flood control maintenance was surpassed by more than double in 2020.

The MMP requirement for invasive species control is focused on reducing bullfrog reproduction in Arroyo Las Positas. During years that vegetation removal is conducted in the Arroyo Las Positas, a bullfrog control program shall be implemented through dewatering the arroyo by temporarily terminating *Comprehensive Environmental Response, Compensation, and Liability Act* discharges for a minimum of 7 days to control bullfrog reproduction. Bullfrog tadpoles remaining after dewatering shall be removed and dispatched. Bullfrogs encountered during vegetation removal shall be dispatched according to the requirements of the CDFW. One bullfrog subadult and 2 bullfrog tadpoles and were removed from the arroyo pools and dispatched by a Service-approved biologist during the 2020 dewatering activities.

The MMP requirement for invasive trees is focused on removing *Casuarina* sp. Eight non-native, invasive *Casuarina* sp. trees were removed during the 2020 maintenance work.

The MMP requirement for bank stabilization specifies that if the banks of the Arroyo Las Positas are disturbed during vegetation removal, they will be seeded with a native grass seed mix or stabilized with erosion control fabric. Impacts to the northern bank of the arroyo were minimal in 2020, and stabilization with native grass seed and erosion control fabric were not warranted.

In summary, the MMP and Service mitigation and monitoring requirements for the Arroyo Las Positas management project were met in 2020.

I.2.17 Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve: 2020 Deployment. Alameda and San Joaquin Counties, California

The San Joaquin kit fox (*Vulpes macrotis mutica*) historically occupied an extensive range in the San Joaquin Valley, California; however, their populations and habitat have since been significantly reduced. More than 95 percent of the potential habitat for kit foxes on the San Joaquin

Valley floor has been converted to irrigated agriculture, urbanized, or industrialized lands. The USFWS listed the San Joaquin kit fox as endangered in 1967 and was listed as threatened by the State of California in 1971.

Prior surveys to determine kit fox status have been conducted on and adjacent to Site 300. Surveys in 1986 and 1990 were not able to find definitive evidence of kit foxes on the site or on immediately southeast of Site 300. A separate survey in 1986 reported two confirmed sightings and a kit fox carcass approximately 1.5 and 2 miles, respectively north of Site 300. More recent surveys conducted in 2002 and 2018 (Woollett 2019) found no evidence of kit foxes.

Scat detection dog surveys at Site 300 were conducted in November 2020 (Woollett 2021). Because dogs can detect both fresh and old scats, data on current presence as well as recent past in an area can be determined. Follow-up genetic analysis of DNA extracted from scat collected during the survey was carried out by the Mammalian Ecology and Conservation Unit of the Veterinary Genetics Laboratory at the University of California, Davis to identify kit fox presence in the study areas. One scat that was alerted to by a dog during surveys on Site 300 was collected for genetic analysis. Subsequent DNA analysis indicated the scat was from a coyote.

Results of scat detection dog surveys conducted in 2020, and subsequent DNA analysis, do not support the presence of kit foxes at Site 300 or the Corral Hollow Ecological Reserve. These are consistent with previous surveys, as well as with conclusions from other researchers and managers working in this region.

I.2.18 Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve, Alameda and San Joaquin Counties, California. 2018 Surveys

San Joaquin kit fox scat surveys were conducted on 12-13 November 2018 on Site 300 and the Corral Hollow Ecological Reserve. The purpose of the surveys was to obtain updated information on kit fox presence on these properties. Follow-up genetic analysis of DNA extracted from any scat collected during the survey effort was to be carried out by the Smithsonian Conservation Biology Institute Center for Conservation & Evolutionary Genetics Laboratory in Washington, D.C. to confirm kit fox presence in the study areas. Surveys were systematically conducted on transect routes through defined search areas based on suitable kit fox habitat present on site.

Approximately 810 acres on Site 300 and the Corral Hollow Ecological Reserve were searched for San Joaquin kit fox scat. One scat was alerted to by a dog during surveys on Site 300 and collected for genetic analysis. Subsequent DNA analysis indicated the scat was deposited by a feral domestic dog. Results of the scat detection dog surveys, and subsequent DNA analysis, do not support the presence of kit foxes on Site 300 and the Corral Hollow Ecological Reserve.

I.2.19 Wetland/Aquatic Resources Lawrence Livermore National Laboratory Facilities, Alameda and San Joaquin Counties, California

This Wetland/Aquatic Resource Delineation report presents the results for three LLNL locations: Livermore (Site 200), Site 300, and the Arroyo Mocho Pumping Station (Arroyo Mocho) (Nomad Ecology 2020). Field evaluations were conducted in June 2020 and provide a preliminary determination of Jurisdictional Waters of the United States (including wetlands), regulated by the USACE, Jurisdictional Waters of the State (including wetlands), regulated by the Regional Water Quality Control Board, and Wetlands and Floodplains as defined by 10 CFR Part 1022 [DOE Floodplain and Wetland Environmental Review Requirements].

Fieldwork was conducted in accordance with the USACE Wetlands Delineation Manual (USACE 1987), Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (2008), Field Guide to the Identification of the Ordinary High Water Mark (OHWM) in the Arid West Region of the Western United States (USACE 2008), DOE Floodplain and Wetland Environmental Review Requirements (10 CFR 1022), and State Wetland Definition and Dredge and Fill Procedures (CWB 2019).

Hydrologic Features – Livermore Site. The study area is in the San Joaquin Valley Subregion of the California Floristic Province in the Alameda Creek Watershed. The Livermore Site is in the Fremont-Livermore Hills and Valleys subsection of the Central California Coast Ranges. Two creeks are present in the study area: Arroyo Seco and Arroyo Las Positas. Both arroyos have been artificially modified because of historic use of the site.

Arroyo Seco. The headwaters of Arroyo Secco are approximately 4.5 miles east-southeast of the study area. The arroyo enters and exits the southwest corner of the study area. Arroyo Seco is typically only flows during rain events. In 2005, an extensive erosion control and restoration project repaired existing erosion damage and restored the Arroyo Seco banks to a more natural topography. During this project, this area was also restored with native vegetation. Arroyo Seco has an ephemeral flow and becomes dry during the summer months.

Arroyo Las Positas. The headwaters of Arroyo Las Positas are approximately 3 miles east of the study area. Arroyo Las Positas enters the study area on the east side of the property under Greenville Road, flows north along the eastern perimeter of the property, and then turns west along the northern perimeter of the property. When it reaches the northwest corner of the property, it turns north to flow off site. Arroyo Las Positas in the study area is in a trapezoidal ditch. A few portions have a concrete channel, but the majority is earthen. The release of treated ground water from surface ditches has resulted in wetland development in the arroyo and the downstream portion flows year-round. Upstream of the ditches, Arroyo Las Positas is dry during the summer months. Without the addition of treated ground water, Arroyo Las Positas is expected to have an intermittent flow.

Drainage Ditches and Lake Haussmann. Numerous artificial drainage ditches cross the study area. They all drain north and connect to Arroyo Las Positas either above ground or through underground culverts. Many of them are perennial due to continuous inputs from LLNL groundwater treatment facilities and contain cattails (*Typha latifolia*) and other freshwater marsh vegetation. Lake Haussmann is present in the middle of the study area. It is fed by natural runoff from the hills east of Greenville Road as well as the artificial drainage ditches.

Hydrologic Features – Site 300. Site 300 is situated on the foothills of the Diablo Range in the northwestern end of the San Joaquin Valley. It is in the Corral Hollow Watershed.

Streams. Site 300 is characterized by ephemeral drainages in steep grassland canyons that drain from north to south and into Corral Hollow Creek, an intermittent stream, through multiple culverts along Corral Hollow Road. Many of these ephemeral drainages average only a few feet wide and have well-defined bed and banks, while others have obscured or lack bed and banks. These drainages carry flow only during and immediately following precipitation. Corral Hollow Creek enters Site 300 at its southeastern corner and flows north before exiting the study area. It is the only intermittent stream present in the study area.

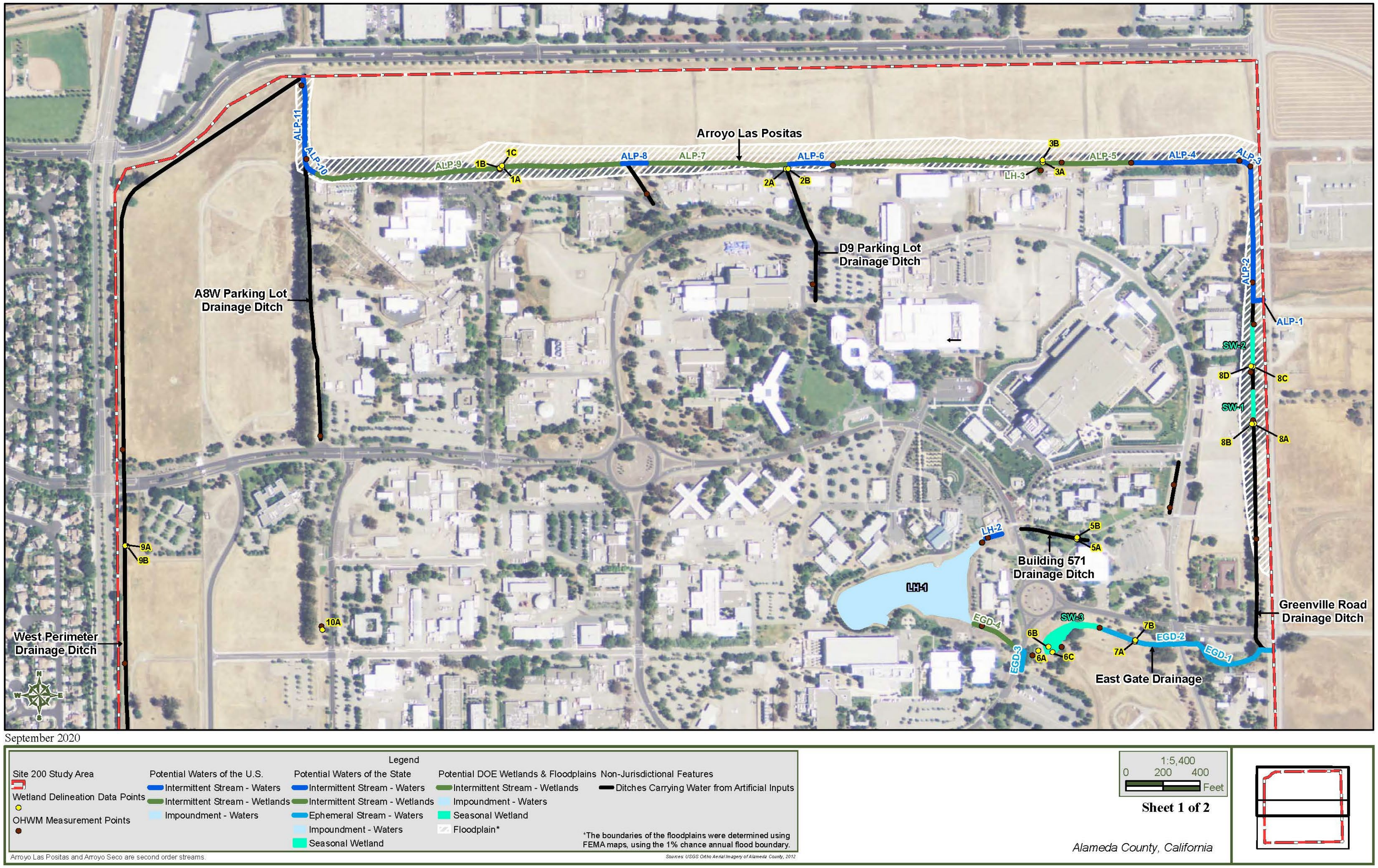
Wetlands. There are scattered seasonal wetlands throughout Site 300, many of which are fed by groundwater seeps. These seasonal wetlands are often in the bottoms of ephemeral drainages. Other seasonal wetlands on site are fed by direct precipitation. Two perennial wetland features are present on site which support species such as cattails and duck weed (*Lemna* sp.).

Hydrologic Features – Arroyo Mocho Pumping Station. Arroyo Mocho is in the Diablo Range subsection of the Central California Coast Ranges Section. This subsection consists of the steep mountains and hills. Arroyo Mocho drains the Arroyo Mocho Watershed which ultimately flows into the Alameda Creek Watershed. Arroyo Mocho has its headwaters at Mount Mocho approximately 13 miles south of the study area. It is fed by multiple small tributaries as it follows Mines Road from Mount Mocho and through Arroyo Mocho Canyon. From the study area Arroyo Mocho Creek flows approximately 6 miles northwest to the city of Livermore. Near the pumping station, Arroyo Mocho has a perennial flow except during the driest years.

Aquatic Resources Delineation Results – Livermore Site. Waters in the study area include intermittent and ephemeral streams and an impoundment which total 5.3 acres and 5,353 linear feet. Wetlands in the study area include seasonal wetlands and freshwater marsh wetlands in intermittent streams which total 1.8 acres and 4,332 linear feet. Wetlands and waters in the study area total 7.1 acres and 9,685 linear feet. The Federal Emergency Management Agency (FEMA) Floodplain maps show a total of 25.9 acres of floodplain in the study area. The locations of mapped features are shown in Figure I-10 and Figure I-11.

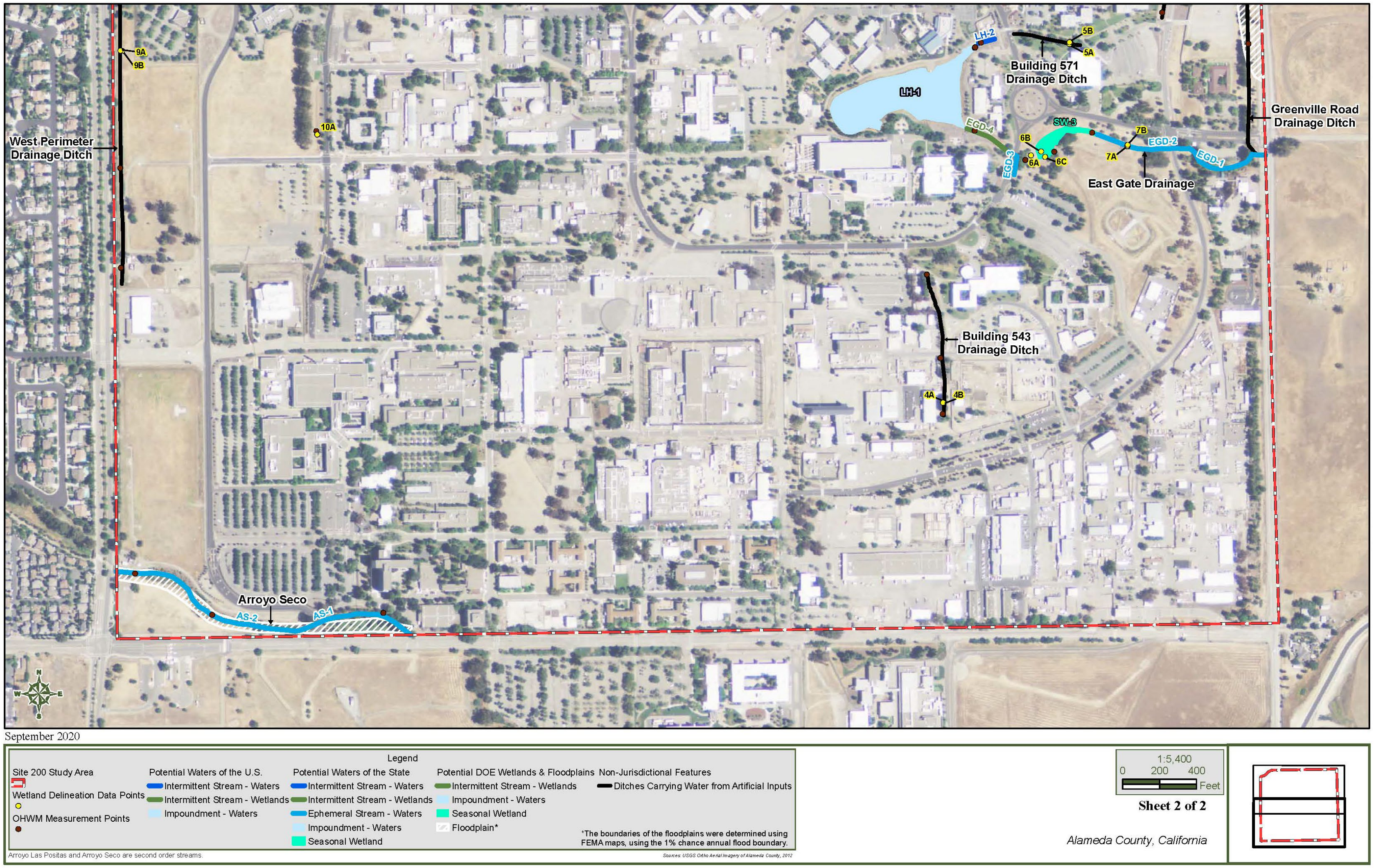
Aquatic Resources Delineation Results – Site 300. Waters in the study area include intermittent and ephemeral streams which total 10.5 acres and 108,066 linear feet. Wetlands in the study area include perennial wetlands and seasonal wetlands, which total 8.4 acres. Wetlands and waters in the study area total 18.9 acres and 108,066 linear feet. The FEMA Floodplain maps show the Corral Hollow floodplain in the study area is 9.6 acres. The locations of mapped features are shown in Figure I-12.

Aquatic Resources Delineation Results – Arroyo Mocho Pumping Station. Wetlands and waters in the Arroyo Mocho study area include open water which totals 3.5 acres and 3,865 linear feet. There were no wetlands in the study area. The locations of mapped features are shown in Figure I-13.



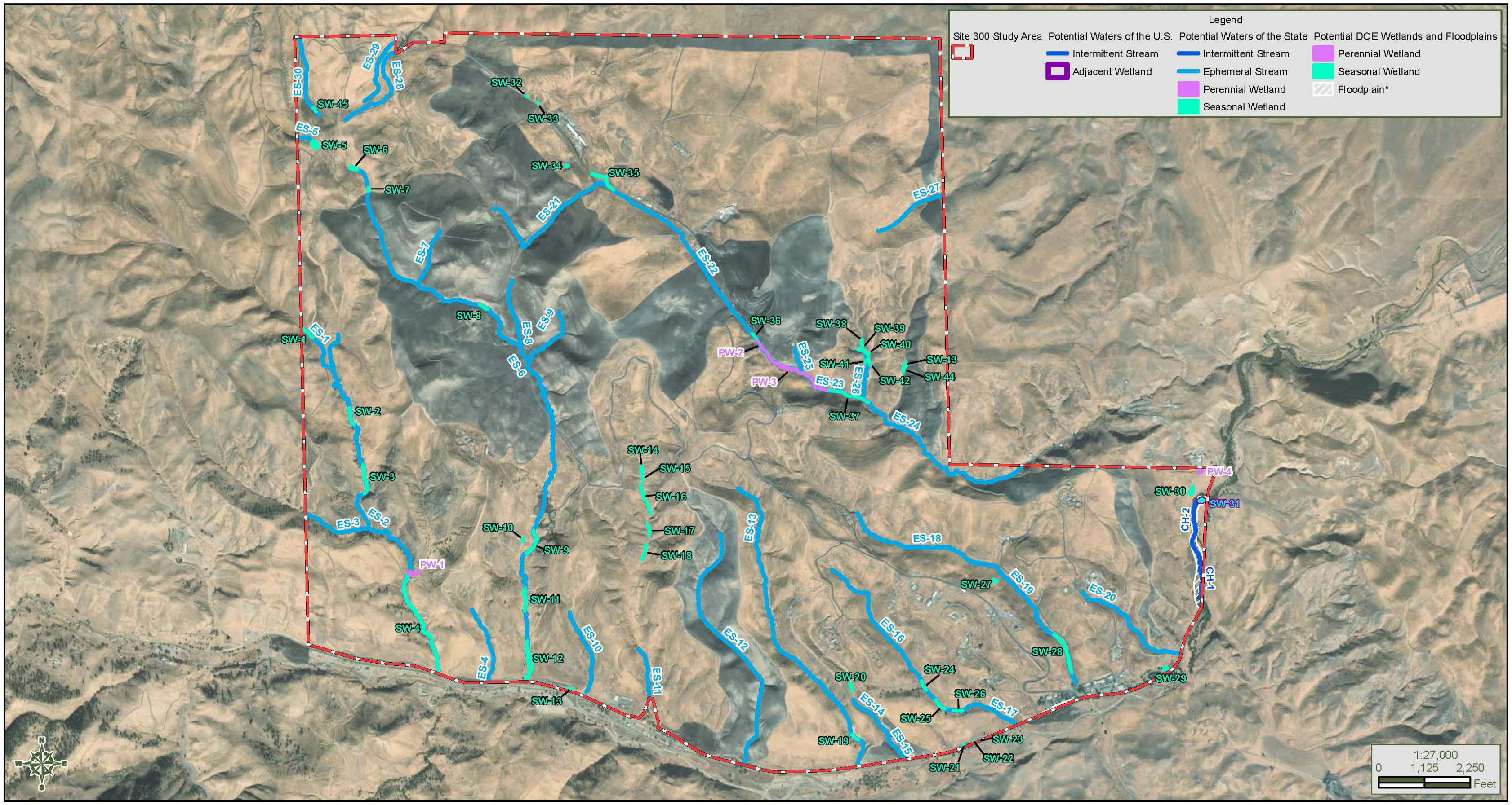
Source: Nomad Ecology 2020.

Figure I-10. Wetland and Aquatic Resources Delineation at the Livermore Site (sheet 1 of 2)



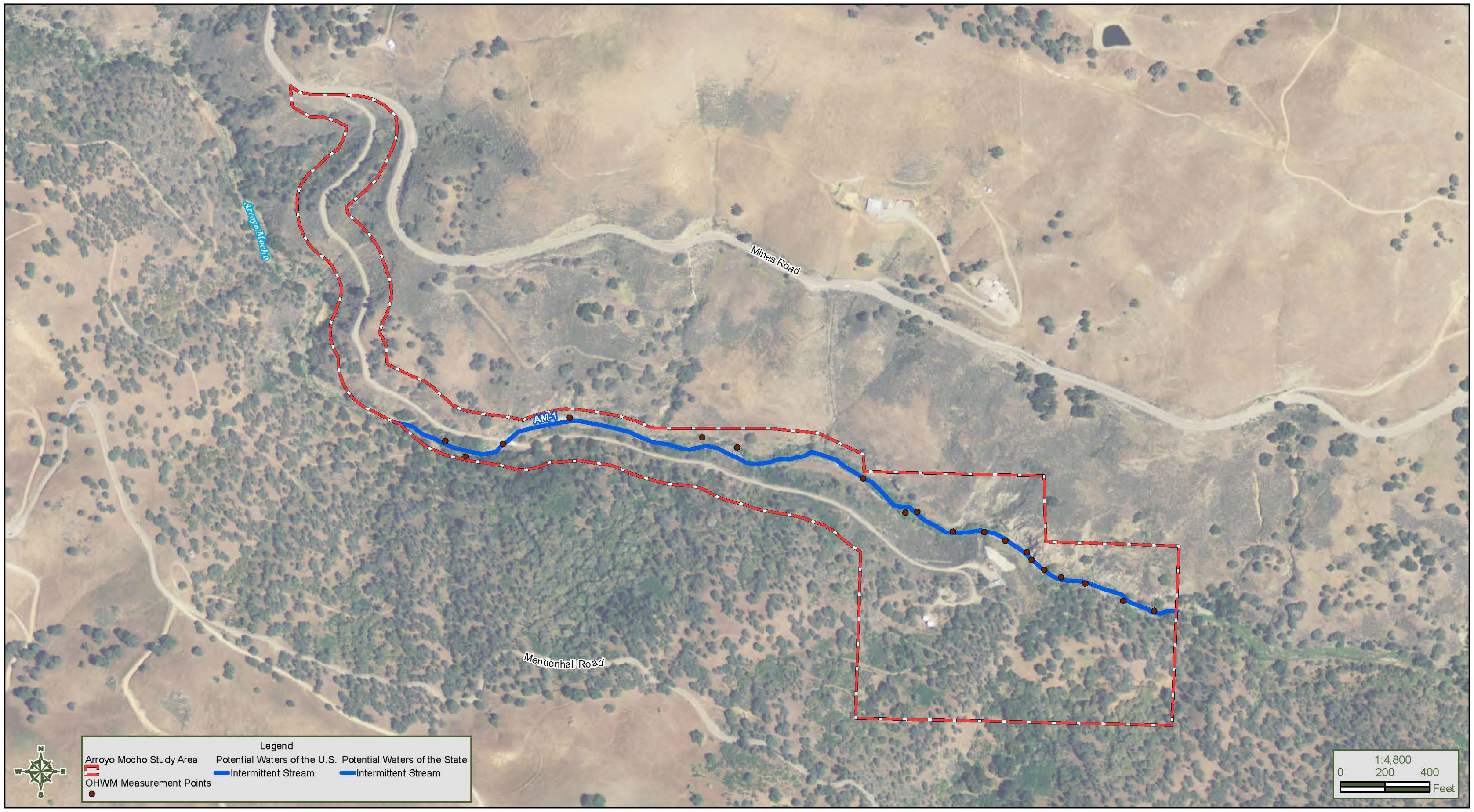
Source: Nomad Ecology 2020.

Figure I-11. Wetland and Aquatic Resources Delineation at the Livermore Site (sheet 2 of 2)



Source: Nomad Ecology 2020.

Figure I-12. Wetland and Aquatic Resources Delineation at Site 300



Source: Nomad Ecology 2020.

Figure I-13. Wetland and Aquatic Resources Delineation at the Arroyo Mocho Pumping Station

I.3 SPECIES LISTS

Tables I.3-1 through I.3-15 present plant and animal species lists for the Livermore Site, Site 300, and the Arroyo Mocho Pumping Station. Species tables were compiled from onsite surveys, historical records of plant and animal occurrences, and the January 2022 CNDDB. Plant and animal lists include:

- Table I.3-1. Cumulative List of Birds Identified Within the LLNL Livermore Site Survey Area (February - July 2021)
- Table I.3-2. Cumulative List of Birds Identified at Arroyo Mocho Survey Area (February - July 2021)
- Table I.3-3. Arroyo Mocho Plant List
- Table I.3-4. Special-Status Amphibians, Reptiles, and Fish Species with Potential to Occur on the Arroyo Mocho Site
- Table I.3-5. Bat Species Detected at Site 300 in the 2021 Bat Survey Report
- Table I.3-6. Special-Status Herpetofauna Species with Potential for Occurrence at Lawrence Livermore's Site 300
- Table I.3-7. Species Documented During Herpetofauna Surveys at Lawrence Livermore's Site 300
- Table I.3-8. Site 300 Plant List Compiled from 2020-2021 Botanical Surveys and Prior Species Reports
- Table I.3-9. Species Captured During 2021 Alameda Whipsnake Surveys At Site 300
- Table I.3-10. Livermore Site Plant List
- Table I.3-11. Amphibians and Reptile Species Observed at the Livermore Site and Site 300 in 1986, 1991, and 2001 Surveys
- Table I.3-12. Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys
- Table I.3-13. Federally and State-Listed Threatened, Endangered, and Other Special Status Animal Species with Potential to Occur at the Livermore Site in 2001 and 2002
- Table I.3-14. Mammal Species Observed at the Livermore Site in 1986 and 2002 Surveys
- Table I.3-15. Site 300 Wildlife Species List

Table I.3-1. Cumulative List of Birds Identified within the LLNL Livermore Site Survey Area (February - July 2021)

Common Name	Scientific Name	Status[a]
American Coot	*Fulica americana*	MBTA
American Crow	*Corvus brachyrhynchos*	MBTA
American Goldfinch	*Spinus tristis*	MBTA
American Kestrel	*Falco sparverius*	MBTA
American Robin	*Turdus migratorius*	MBTA
Anna's Hummingbird	*Calypte anna*	MBTA
Barn Swallow	*Hirundo rustica*	MBTA
Belted Kingfisher	*Megaceryle alcyon*	MBTA
Bewick's Wren	*Thryomanes bewickii*	MBTA
Black Phoebe	*Sayornis nigricans*	MBTA
Black-crowned Night-Heron	*Nycticorax nycticorax*	MBTA
Black-headed Grosbeak	*Pheucticus melanocephalus*	MBTA
Brown-headed Cowbird	*Molothrus ater*	MBTA
Bufflehead	*Bucephala albeola*	MBTA
Bullock's Oriole	*Icterus bullockii*	BCC, MBTA
Bushtit	*Psaltriparus minimus*	MBTA
California Scrub-Jay	*Aphelocoma californica*	MBTA
California Towhee	*Melozone crissalis*	MBTA
Canada Goose	*Branta canadensis*	MBTA
Cedar Waxwing	*Bombycilla cedrorum*	MBTA
Chestnut-backed Chickadee	*Poecile rufescens*	MBTA
Cliff Swallow	*Petrochelidon pyrrhonota*	MBTA
Common raven	*Corvus corax*	MBTA
Common Yellowthroat	*Geothlypis trichas*	MBTA
Cooper's Hawk	*Accipiter cooperii*	MBTA
Dark-eyed Junco	*Junco hyemalis*	MBTA
Double-crested Cormorant	*Phalacrocorax auritus*	MBTA
Downy Woodpecker	*Dryobates pubescens*	MBTA
Eurasian Collared-Dove	*Streptopelia decaocto*	None
European Starling	*Sturnus vulgaris*	None
Golden-crowned Sparrow	*Zonotrichia atricapilla*	MBTA
Great Blue Heron	*Ardea herodias*	MBTA
Great Egret	*Ardea alba*	MBTA
Great Horned Owl	*Bubo virginianus*	MBTA
Green Heron	*Butorides virescens*	MBTA
Hermit Thrush	*Catharus guttatus*	MBTA
House Finch	*Haemorhous mexicanus*	MBTA
Killdeer	*Charadrius vociferus*	MBTA
Lark Sparrow	*Chondestes grammacus*	MBTA
Lesser Goldfinch	*Spinus psaltria*	MBTA
Lincoln's Sparrow	*Melospiza lincolnii*	MBTA
Mallard	*Anas platyrhynchos*	MBTA
Marsh Wren	*Cistothorus palustris*	MBTA
Mourning Dove	*Zenaida macroura*	MBTA
Northern Flicker	*Colaptes auratus*	MBTA
Northern Mockingbird	*Mimus polyglottos*	MBTA
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	MBTA
Nuttall's Woodpecker	*Dryobates nuttallii*	BCC, MBTA
Oak Titmouse	*Baeolophus inornatus*	BCC, MBTA

Common Name	Scientific Name	Status[a]
Orange-crowned Warbler	*Leiothlypis celata*	MBTA
Pied-billed Grebe	*Podilymbus podiceps*	MBTA
Pine Siskin	*Spinus pinus*	MBTA
Red-breasted Sapsucker	*Sphyrapicus ruber*	MBTA
Red-shouldered Hawk	*Buteo lineatus*	MBTA
Red-tailed Hawk	*Buteo jamaicensis*	MBTA
Red-winged Blackbird	*Agelaius phoeniceus*	MBTA
Ring-necked Duck	*Aythya collaris*	MBTA
Rock Pigeon	*Columba livia*	None
Ruby-crowned Kinglet	*Regulus calendula*	MBTA
Savannah Sparrow	*Passerculus sandwichensis*	MBTA
Say's Phoebe	*Sayornis saya*	MBTA
Sharp-shinned Hawk	*Accipiter striatus*	MBTA
Snowy Egret	*Egretta thula*	MBTA
Song Sparrow	*Melospiza melodia*	MBTA
Sora	*Porzana carolina*	MBTA
Spotted Sandpiper	*Actitis macularius*	MBTA
Spotted Towhee	*Pipilo maculatus*	MBTA
Swainson's Hawk	*Buteo swainsoni*	CT, MBTA
Swainson's Thrush	*Catharus ustulatus*	MBTA
Tree Swallow	*Tachycineta bicolor*	MBTA
Turkey Vulture	*Cathartes aura*	MBTA
Unidentified Swallow	-	MBTA
Western Bluebird	*Sialia mexicana*	MBTA
Western Kingbird	*Tyrannus verticalis*	MBTA
White-breasted Nuthatch	*Sitta carolinensis*	MBTA
White-crowned Sparrow	*Zonotrichia leucophrys*	MBTA
White-tailed Kite	*Elanus leucurus*	CFP, MBTA
White-throated Swift	*Aeronautes saxatalis*	MBTA
Wilson's Warbler	*Cardellina pusilla*	MBTA
Yellow Warbler	*Setophaga petechia*	SSC,MBTA
Yellow-rumped Warbler	*Setophaga coronata*	MBTA

Special Status Codes: SSC=California Department of Fish and Wildlife Species of Special Concern; CFP=California Fish and Game Code Section 3511 Fully Protected; CT=California Endangered Species Act-Threatened; BCC=U.S. Fish and Wildlife Service Birds of Conservation Concern; MBTA=Protected under the *Migratory Bird Treaty Act*

a. ECORPS 2021f used the 2008 Birds of Conservation Concern list. The 2021 BCC list is used throughout this document.

Source: ECORP 2021e; CNDDB 2022a; USFWS 2020; USFWS 2021.

Table I.3-2. Cumulative List of Birds Identified at Arroyo Mocho Survey Area (February - July 2021)

Common Name	Scientific Name	Status[a]
Acorn Woodpecker	*Melanerpes formicivorus*	MBTA
American Crow	*Corvus brachyrhynchos*	MBTA
American Kestrel	*Falco sparverius*	MBTA
Anna's Hummingbird	*Calypte anna*	MBTA
Ash-throated Flycatcher	*Myiarchus cinerascens*	MBTA
Bewick's Wren	*Thryomanes bewickii*	MBTA
Brown-headed Cowbird	*Molothrus ater*	MBTA
Black-headed Grosbeak	*Pheucticus melanocephalus*	MBTA
Black Phoebe	*Sayornis nigricans*	MBTA
Brewer's Blackbird	*Euphagus cyanocephalus*	MBTA
Band-tailed Pigeon	*Patagioenas fasciata*	MBTA

Common Name	Scientific Name	Status[a]
Bullock's Oriole	*Icterus bullockii*	BCC, MBTA
Bushtit	*Psaltriparus minimus*	MBTA
California Towhee	*Melozone crissalis*	MBTA
California Quail	*Callipepla californica*	None
California Scrub-Jay	*Aphelocoma californica*	MBTA
California Thrasher	*Toxostoma redivivum*	BCC, MBTA
Cliff Swallow	*Petrochelidon pyrrhonota*	MBTA
Cooper's Hawk	*Accipiter cooperii*	MBTA
Common Raven	*Corvus corax*	MBTA
Dark-eyed Junco	*Junco hyemalis*	MBTA
Downy Woodpecker	*Dryobates pubescens*	MBTA
European Starling	*Sturnus vulgaris*	None
Golden-crowned Sparrow	*Zonotrichia atricapilla*	MBTA
Golden Eagle	*Aquila chrysaetos*	CFP, BGEPA, MBTA
Hermit Thrush	*Catharus guttatus*	MBTA
House Finch	*Haemorhous mexicanus*	MBTA
House Wren	*Troglodytes aedon*	MBTA
Hutton's Vireo	*Vireo huttoni*	MBTA
Lesser Goldfinch	*Spinus psaltria*	MBTA
Mallard	*Anas platyrhynchos*	MBTA
Mourning Dove	*Zenaida macroura*	MBTA
Nashville Warbler	*Leiothlypis ruficapilla*	MBTA
Northern Flicker	*Colaptes auratus*	MBTA
Nuttall's Woodpecker	*Dryobates nuttallii*	BCC, MBTA
Oak Titmouse	*Baeolophus inornatus*	BCC, MBTA
Orange-crowned Warbler	*Leiothlypis celata*	MBTA
Olive-sided Flycatcher	*Contopus cooperi*	SSC, BCC, MBTA
Phainopepla	*Phainopepla nitens*	MBTA
Pine Siskin	*Spinus pinus*	MBTA
Pacific-slope Flycatcher	*Empidonax difficilis*	MBTA
Ruby-crowned Kinglet	*Regulus calendula*	MBTA
Rufous-crowned Sparrow	*Aimophila ruficeps*	MBTA
Red-tailed Hawk	*Buteo jamaicensis*	MBTA
Spotted Towhee	*Pipilo maculatus*	MBTA
Sharp-shinned Hawk	*Accipiter striatus*	MBTA
Steller's Jay	*Cyanocitta stelleri*	MBTA
Turkey Vulture	*Cathartes aura*	MBTA
Unidentified Accipiter	-	MBTA
Unidentified Hummingbird	-	MBTA
Violet-green Swallow	*Tachycineta thalassina*	MBTA
White-breasted Nuthatch	*Sitta carolinensis*	MBTA
White-crowned Sparrow	*Zonotrichia leucophrys*	MBTA
Western Bluebird	*Sialia mexicana*	MBTA
Western Tanager	*Piranga ludoviciana*	MBTA
Willow Flycatcher	*Empidonax traillii*	CE, MBTA
Wilson's Warbler	*Cardellina pusilla*	MBTA
Wrentit	*Chamaea fasciata*	BCC, MBTA
Yellow-rumped Warbler	*Setophaga coronata*	MBTA

Special Status Codes: CE=California Endangered Species Act-Endangered; CFP=California Fish and Game Code Section 3511 Fully Protected Species; BCC=U.S. Fish and Wildlife Service Bird of Conservation Concern; MBTA=Protected under the *Migratory Bird Treaty Act*; BGEPA = Protected under the *Bald and Golden Eagle Protection Act*

a. ECORPS 2021f used the 2008 Birds of Conservation Concern list. The 2021 BCC list is used throughout this document.

Source: ECORP 2021f; CNDDB 2022a; USFWS 2020, USFWS 2021.

Table I.3-3. Arroyo Mocho Plant List

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
FERNS				
Equisetaceae – Horsetail Family				
Equisetum hymale subsp. affine	common scouring rush	Native	---	---
Pteridaceae – Brake Family				
Adiantum jordanii	California maidenhair fern	Native	---	---
Pellaea andromedifolia	coffee fern	Native	---	---
Pentagramma triangularis	gold back fern	Native	---	---
GYMNOSPERMS				
Pinaceae – Pine Family				
Pinus sabiniana	foothill pine	Native	---	---
MAGNOLIIDS				
Lauraceae – Laurel Family				
Umbellularia californica	California bay	Native	---	---
EUDICOTS				
Adoxaceae – Muskroot Family				
Sambucus nigra ssp. cerulea	blue elderberry	Native	---	---
Anacardiaceae – Sumac or Cashew Family				
Toxicodendron diversilobum	poison oak	Native	---	---
Apiaceae – Carrot Family				
Anthriscus caucalis	burchevril	Non-Native	---	---
Conium maculatum	poison hemlock	Non-Native	Moderate	---
Lomatium californicum	California lomatium	Native	---	---
Lomatium dasycarpum subsp. dasycarpum	woolly fruited lomatium	Native	---	---
Lomatium nudicaule	pestle parsnip	Native	---	---
Lomatium utriculatum	common lomatium	Native	---	---
Perideridia californica	California yampah	Native	---	---
Sanicula bipinnata	poison sanicle	Native	---	---
Sanicula crassicaulis	Pacific sanicle	Native	---	---
Scandix pecten-veneris	Shepherd's needle	Non-Native	---	---
Tauschia hartwegii	Hartweg's tauschia	Native	---	---
Torilis arvensis	hedge parsley	Non-Native	Moderate	---
Torilis nodosa	knotted-hedge parsley	Non-Native	---	---
Yabea microcarpa	California hedge parsely	Native	---	---
Apocynaceae – Dogbane Family				
Apocynum cannabinum	Indian hemp	Native	---	---

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Asclepias fascicularis	narrow-leaved milkweed	Native	---	---
Asteraceae – Sunflower Family				
Achillea millefolium	yarrow	Native	---	---
Achyrachaena mollis	blow-wives	Native	---	---
Agoseris grandiflora var. grandiflora	bigflower agoseris	Native	---	---
Agoseris heterophylla var. cryptopleura	mountain dandelion	Native	---	---
Agoseris heterophylla var. heterophylla	annual agoseris	Native	---	---
Artemisia californica	California sagebrush	Native	---	---
Artemisia douglasiana	mugwort	Native	---	---
Baccharis pilularis subsp. consanguinea	coyote brush	Native	---	---
Baccharis salicifolia subsp. salicifolia	mule fat	Native	---	---
Brickellia californica	California brickelbush	Native	---	---
Carduus pycnocephalus subsp. pycnocephalus	Italian thistle	Non-Native	Moderate	On List
Carduus tenuiflorus	slender flowered thistle	Non-Native	Limited	On List
Centaurea melitensis	tocalote	Non-Native	Moderate	On List
Centaurea solstitialis	yellow star thistle	Non-Native	High	On List
Crepis vesicaria subsp. taraxacifolia	beaked hawksbeard	Non-Native	---	---
Dittrichia graveolens	stinkwort	Non-Native	Moderate	---
Ericameria linearifolia	narrowleaf goldenbush	Native	---	---
Eriophyllum confertiflorum var. confertiflorum	golden-yarrow	Native	---	---
Eriophyllum jepsonii (CRPR 4.3)	Jepson's woolly sunflower	Native	---	---
Euthamia occidentalis	western goldenrod	Native	---	---
Grindelia hirsutula	Great Valley gumweed	Native	---	---
Helenium puberulum	sneezeweed	Native	---	---
Helianthella californica var. californica	California helianthella	Native	---	---
Hemizonella minima	opposite leaved tarweed	Native	---	---
Holocarpha heermannii	Heermann's tarweed	Native	---	---
Lactuca serriola	prickly lettuce	Non-Native	---	---
Lagophylla ramosissima	hare’s ear	Native	---	---
Lasthenia gracilis	needle goldfields	Native	---	---

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Lasthenia microglossa	small-ray goldfields	Native	---	---
Logfia gallica	narrowleaf cottonrose	Non-Native	---	---
Madia exigua	small tarweed	Native	---	---
Madia gracilis	slender tarweed	Native	---	---
Matricaria discoidea	pineapple weed	Non-Native	---	---
Micropus californicus var. californicus	slender cottonweed	Native	---	---
Micropus californicus var. subvestitus	slender cottonweed	Native	---	---
Pentachaeta alsinoides	pygmy daisy	Native	---	---
Psilocarphus tenellus	slender woolly marbles	Native	---	---
Senecio flaccidus var. douglasii	Douglas' groundsel	Native	---	---
Sonchus asper subsp. asper	prickly sowthistle	Non-Native	---	---
Sonchus oleraceus	common sowthistle	Non-Native	---	---
Stebbinsoseris heterocarpa	grassland stebbinsoseris	Native	---	---
Uropappus lindleyi	silverpuffs	Native	---	---
Wyethia glabra	shining mules ears	Native	---	---
Wyethia helenioides	woollyleaf mule ears	Native	---	---
Betulaceae – Birch Family				
Alnus rhombifolia	white alder	Native	---	---
Boraginaceae – Borage or Waterleaf Family				
Amsinckia intermedia	common fiddleneck	Native	---	---
Amsinckia menziesii	ranchers fireweed	Native	---	---
Cynoglossum grande	hound's tongue	Native	---	---
Nemophila heterophylla	canyon nemophila	Native	---	---
Pectocarya pusilla	little pectocarya	Native	---	---
Pholistoma membranaceum	white fiesta flower	Native	---	---
Brassicaceae – Mustard Family				
Barbarea orthoceras	American wintercress	Native	---	---
Brassica nigra	black mustard	Non-Native	Moderate	---
Cardamine hirsuta	hairy bitter cress	Non-Native	---	---
Cardamine oligosperma	bitter cress	Native	---	---
Caulanthus lasiophyllus	California mustard	Native	---	---
Draba verna	spring draba	Non-Native	---	---
Lepidium latifolium	broadleaf peppergrass	Non-Native	High	On List
Thysanocarpus curvipes spp. curvipes	fringepod	Native	---	---
Thysanocarpus curvipes spp. elegans	elegant fringepod	Native	---	---
Tropidocarpum gracile	dobie pod	Native	---	---

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Caprifoliaceae – Honeysuckle Family				
Lonicera hispidula	California honeysuckle	Native	---	---
Symphoricarpos albus var. laevigatus	snowberry	Native	---	---
Caryophyllaceae – Pink Family				
Cerastium glomeratum	mouse-ear chickweed	Non-Native	---	---
Herniaria hirsuta subsp. cinerea	grey herniaria	Native	---	---
Stellaria media	common chickweed	Non-Native	---	---
Chenopodiaceae – Goosefoot Family				
Chenopodium californicum	California pigweed	Native	---	---
Convolvulaceae – Morning-Glory Family				
Calystegia purpurata subsp. purpurata	purple western morning glory	Native	---	---
Convolvulus arvensis	bindweed	Non-Native	---	On List
Crassulaceae – Stonecrop Family				
Crassula connata	pygmyweed	Native	---	---
Dudleya cymosa subsp. paniculata	Diablo Range dudleya	Native	---	---
Cucurbitaceae – Gourd Family				
Marah fabacea	California man-root	Native	---	---
Ericaceae – Heath Family				
Arctostaphylos glauca	big berry manzanita	Native	---	---
Fabaceae – Pea Family				
Acmispon americanus var. americanus	Spanish clover	Native	---	---
Acmispon wrangelianus	calf lotus	Native	---	---
Hirschfeldia incana	hoary mustard	Non-Native	Moderate	---
Hoita macrostachya	California hemp	Native	---	---
Lathyrus vestitus var. vestitus	pacific pea	Native	---	---
Lotus corniculatus	birdfoot trefoil	Non-Native	---	---
Lupinus albifrons var. albifrons	silver bush lupine	Native	---	---
Lupinus bicolor	dove lupine	Native	---	---
Lupinus microcarpus var. densiflorus	dense-flowered lupine	Native	---	---
Lupinus succulentus	succulent lupine	Native	---	---
Medicago polymorpha	burclover	Non-Native	Limited	---
Melilotus albus	white sweet clover	Non-Native	---	---
Melilotus indicus	sourclover	Non-Native	---	---

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Rupertia physodes	California tea	Native	---	---
Trifolium albopurpureum	branched Indian clover	Native	---	---
Trifolium dubium	shamrock clover	Non-Native	---	---
Trifolium gracilentum	pinpoint clover	Native	---	---
Trifolium hirtum	rose clover	Non-Native	Limited	---
Trifolium oliganthum	fewflower clover	Native	---	---
Trifolium willdenovii	tomcat clover	Native	---	---
Vicia sativa var.. sativa	spring vetch	Non-Native	---	---
Fagaceae – Oak Family				
Quercus agrifolia	coast live oak	Native	---	---
Quercus douglasii	blue oak	Native	---	---
Geraniaceae – Geranium Family				
Erodium botrys	long-beaked filaree	Non-Native	---	---
Erodium brachycarpum	foothill filaree	Non-Native	---	---
Erodium moschatum	white-stem filaree	Non-Native	---	---
Geranium dissectum	cut-leaf geranium	Non-Native	Moderate	---
Geranium molle	dovefoot geranium	Non-Native	---	---
Grossulariaceae – Gooseberry Family				
Ribes californicum var. californicum	California gooseberry	Native	---	---
Ribes quercetorum	foothill gooseberry	Native	---	---
Lamiaceae – Mint Family				
Lamium amplexicaule	henbit	Non-Native	---	---
Lepechinia calycina	pitcher sage	Native	---	---
Marrubium vulgare	horehound	Non-Native	Limited	---
Monardella villosa subsp. villosa	coyote mint	Native	---	---
Pogogyne serpylloides	thymeleaf mesa mint	Native	---	---
Salvia mellifera	black sage	Native	---	---
Stachys rigida var. quercetorum	hedge nettle	Native	---	---
Montiaceae – Miner's Lettuce Family				
Claytonia parviflora subsp. parviflora	narrow leavedminer's lettuce	Native	---	---
Claytonia perfoliata subsp. perfoliata	miner's lettuce	Native	---	---
Myrsinaceae – Myrsine Family				
Lysimachia arvensis	scarlet pimpernel	Non-Native	---	---
Onagraceae – Evening Primrose Family				
Clarkia affinis	chaparral clarkia	Native	---	---

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Clarkia unguiculata	elegant clarkia	Native	---	---
Epilobium brachycarpum	tall annual willow-herb	Native	---	---
Epilobium canum subsp. canum	California fuschia	Native	---	---
Orobanchaceae – Broomrape Family				
Castilleja affinis subsp. affinis	Indian paintbrush	Native	---	---
Papaveraceae – Poppy Family				
Papaver heterophyllum	wind poppy	Native	---	---
Phrymaceae – Lopseed Family				
Diplacus aurantiacus	bush monkeyflower	Native	---	---
Erythranthe cardinalis	scarlet monkeyflower	Native	---	---
Erythranthe guttata	common yellow monkeyflower	Native	---	---
Plantaginaceae – Plantain Family				
Collinsia heterophylla var. heterophylla	Chinese houses	Native	---	---
Collinsia sparsiflora var. collina	hillside collinsia	Native	---	---
Keckiella breviflora var. breviflora	gaping keckiella	Native	---	---
Penstemon heterophyllus var. purdyi	Purdy's foothill penstemon	Native	---	---
Plantago erecta	dwarf plantain	Native	---	---
Verbascum thapsus	woolly mullein	Non-Native	Limited	---
Veronica anagallis-aquatica	water speedwell	Non-Native	---	---
Platanaceae – Plane-Tree or Sycamore Family				
Platanus racemosa	western sycamore	Native	---	---
Polemoniaceae – Phlox Family				
Leptosiphon androsaceus	false baby stars	Native	---	---
Leptosiphon bicolor	true baby stars	Native	---	---
Microsteris gracilis	slender phlox	Native	---	---
Polygonaceae – Buckwheat Family				
Eriogonum fasciculatum var. fasciculatum	California buckwheat	Native	---	---
Eriogonum nudum var. auriculatum	naked-stem buckwheat	Native	---	---
Rumex conglomeratus	green dock	Non-Native	---	---
Rumex salicifolius	willow dock	Native	---	---
Primulaceae – Primrose Family				
Primula hendersonii	shooting stars	Native	---	---
Ranunculaceae – Buttercup Family				

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Delphinium californicum subsp. interius (CRPR 1B.2)	Hospital Canyon larkspur	Native	---	---
Delphinium hesperium subsp. pallescens	foothill larkspur	Native	---	---
Delphinium patens subsp. patens	spreading larkspur	Native	---	---
Delphinium variegatum subsp. variegatum	royal larkspur	Native	---	---
Ranunculus californicus var. californicus	California buttercup	Native	---	---
Ranunculus hebecarpus	delicate buttercup	Native	---	---
Rhamnaceae – Buckthorn Family				
Ceanothus cuneatus var. cuneatus	buck brush	Native	---	---
Rhamnus ilicifolia	hollyleaf redberry	Native	---	---
Rosaceae – Rose Family				
Aphanes occidentalis	Lady's mantle	Native	---	---
Heteromeles arbutifolia	toyon	Native	---	---
Oemleria cerasiformis	Oso berry	Native	---	---
Prunus ilicifolia subsp. ilicifolia	holly-leafed cherry	Native	---	---
Rubus armeniacus	Himalayan blackberry	Non-Native	High	---
Rubiaceae – Madder Family				
Galium murale	tiny bedstraw	Non-Native	---	---
Galium parisiense	wall bedstraw	Non-Native	---	---
Galium porrigens var. porrigens	climbing bedstraw	Native	---	---
Salicaceae – Willow Family				
Populus fremontii subsp. fremontii	Fremont cottonwood	Native	---	---
Salix gooddingii	Gooding’s black willow	Native	---	---
Salix laevigata	red willow	Native	---	---
Salix lasiolepis	arroyo willow	Native	---	---
Sapindaceae – Soapberry Family				
Aesculus californica	California buckeye	Native	---	---
Saxifragaceae – Saxifrage Family				
Lithophragma affine	woodland star	Native	---	---
Micranthes californica	California saxifrage	Native	---	---
Scrophulariaceae – Figwort Family				

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Scrophularia californica	bee plant	Native	---	---
Simaroubaceae – Quassia or Simarouba Family				
Ailanthus altissima	tree of heaven	Non-Native	Moderate	On List
Solanaceae – Nightshade Family				
Solanum umbelliferum	blue witch	Native	---	---
Urticaceae – Nettle Family				
Urtica dioica subsp. holosericea	hoary nettle	Native	---	---
Valerianaceae – Valerian Family				
Plectritis ciliosa	longspur seablush	Native	---	---
Plectritis congesta subsp. brachystemon	sea blush	Native	---	---
Plectritis macrocera	white plectritis	Native	---	---
Verbenaceae – Vervain Family				
Phyla nodiflora	common lippia	Native	---	---
Verbena lasiostachys var. scabrida	robust vervain	Native	---	---
Viscaceae – Mistletoe Family				
Phoradendron leucarpum subsp. tomentosum	oak mistletoe	Native	---	---
MONOCOTS				
Agavaceae – Agave Family				
Chlorogalum pomeridianum var. pomeridianum	soap plant	Native	---	---
Cyperaceae – Sedge Family				
Carex nudata	torrent sedge	Native	---	---
Juncaceae – Rush Family				
Juncus balticus subsp. ater	Baltic rush	Native	---	---
Liliaceae – Lily Family				
Calochortus albus	white fairy lantern	Native	---	---
Fritillaria affinis	checker lily	Native	---	---
Orchidaceae – Orchid Family				
Piperia michaelii (CRPR 4.2)	Michael's piperia	Native	---	---
Poaceae – Grass Family				
Aira caryophyllea	silver hairgrass	Non-Native	---	---
Avena barbata	slender oats	Non-Native	Moderate	---
Avena fatua	wild oats	Non-Native	Moderate	---

Species Name	Common Name	Origin	CAL-IPC Rating	CDFA Rating
Bromus diandrus	ripgut brome	Non-Native	Moderate	---
Bromus hordeaceus	soft chess	Non-Native	Limited	---
Bromus laevipes	woodland brome	Native	---	---
Bromus madritensis	foxtail chess	Non-Native	---	---
Bromus sitchenis var. carinatus	California brome	Native	---	---
Bromus sterilis	poverty brome	Non-Native	---	---
Cynosurus echinatus	dogtail grass	Non-Native	Moderate	---
Dactylis glomerata	orchard grass	Non-Native	Limited	---
Elymus glaucus subsp. glaucus	blue wildrye	Native	---	---
Elymus triticoides	Creeping wildrye	Native	---	---
Festuca bromoides	brome fescue	Non-Native	---	---
Festuca californica	California fescue	Native	---	---
Festuca idahoensis	Idahoe fescue	Native	---	---
Festuca microstachys	Eastwood fescue	Native	---	---
Festuca myuros	foxtail fescue	Non-Native	Moderate	---
Festuca perennis	Italian ryegrass	Non-Native	Moderate	---
Gastridium phleoides	nit grass	Non-Native	---	---
Hordeum marinum subsp. gussoneanum	Mediterranean barley	Non-Native	Moderate	---
Hordeum murinum subsp. leporinum	hare barley	Non-Native	Moderate	---
Lamarckia aurea	goldentop	Non-Native	---	---
Melica californica	California melic grass	Native	---	---
Melica torreyana	Torrey's melic grass	Native	---	---
Poa secunda subsp. secunda	one-sided bluegrass	Native	---	---
Polypogon monspeliensis	rabbitsfoot grass	Non-Native	Limited	---
Polypogon viridis	bentgrass	Non-Native	---	---
Stipa cernua	nodding needlegrass	Native	---	---
Stipa lepida	foothill needlegrass	Native	---	---
Stipa pulchra	purple needlegrass	Native	---	---
Themidaceae – Brodiaea Family				
Dipterostemon capitatus subsp. capitatus	blue dicks	Native	---	---
Triteleia laxa	Ithuriel's spear	Native	---	---
Typhaceae – Cattail Family				
Typha angustifolia	narrow-leaved cattail	Native	---	---

Reporter: All observations are from Nomad Ecology (2021a) botanical surveys performed in 2020 and 2021.
a Nomenclature:

Nomenclature follows The Jepson Manual 2nd Ed. (Baldwin et al. 2012). Synonyms are provided where plant names used in previous studies have been superseded.

b Cal-IPC Rating:

High, Moderate, or Limited, reflecting the level of each invasive species' negative ecological impact in California. (Cal-IPC 2006).

c CNPS Rank:

CRPR 1B = California Rare Plant Rank 1B, species are considered rare and endangered throughout their range (CNPS 2020)

CRPR 4 = California Rare Plant Rank 4, plants of limited distribution that are not considered rare or endangered (CNPS 2020).

Ranks at each level also include a threat rank (e.g. CRPR 4.3) and are determined as follows:

0.1-Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)

0.2-Moderately threatened in California (20-80% occurrences threatened / moderate degree and immediacy of threat)

0.3-Not very threatened in California (less than 20% of occurrences threatened / low degree and immediacy of threat or no current threats known)

Source: Nomad Ecology 2021a.

Table I.3-4. Special-Status Amphibians, Reptiles, and Fish Species with Potential to Occur on the Arroyo Mocho Site

Scientific Name	Common Name	Listed Status[b]	Habitat Requirements	Potential for Occurrences
Amphibians and Reptiles				
Ambystoma californiense	California tiger salamander	FT, CT	Occurs in vernal and seasonal pools and associated grasslands, oak savanna, woodland, and coastal scrub. Needs underground refuges (e.g., small mammal burrows, pipes) in upland areas such as grassland and scrub habitats.	Low Potential. Low suitable breeding habitat on-site, known CNDDB closest breeding occurrence 1.1. miles away. Low to moderate upland and dispersal habitat, no ground squirrel burrows observed.
Rana boylii	Foothill yellow-legged frog	West/ Central Coast Clade: CE, SSC, PT[a]	Found in rocky streams and rivers with rocky substrate and open, sunny banks in forests, woodlands, and chaparral. May also occur in isolated pools and vegetated backwaters.	High Potential. Highly suitable breeding, upland, and dispersal habitat occurs on-site. CNDDB occurrence listed within Study Area, and recent observation from LLNL.
Rana draytonii	California red-legged frog	FT, SSC	Occurs in semi-permanent or permanent water at least 2 feet deep, bordered by emergent or riparian vegetation, and upland grassland, forest, or scrub habitats for aestivation and dispersal.	Moderate Potential. Low suitable breeding habitat. High quality upland, and dispersal habitat on-site. CNDDB occurrence in Study Area.
Actinemys marmorata	Western pond turtle	SSC	Occurs in rivers, ponds, and freshwater marshes, and nests in upland areas (sandy banks or grassy open fields) up to 1,640 feet from water.	High Potential. Moderate suitable breeding, upland, and dispersal habitat on-site. One CNDDB occurrence in Study Area and one recent observation from LLNL in 2020.
Masticophis lateralis euryxanthus	Alameda whipsnake	FT, CT	Limited range, mostly in Alameda and Contra Costa counties, utilizing chaparral, scrub, and rocky outcrops as core habitat. Also uses surrounding woodlands and grassland for foraging and dispersal.	High Potential. High suitable habitat onsite including Diablan scrub, oak-woodland, etc.

Scientific Name	Common Name	Listed Status[b]	Habitat Requirements	Potential for Occurrences
Phrynosoma blainvillii	Blainville's (coast) Horned Lizard	SSC	Occurs in variety of habitats, such as valley-foothill hardwood, conifer and riparian habitats, as well as in pine-cypress, juniper, and annual grass habitats; however, it is most common in sandy washes with scattered shrubs. Open areas are required for basking and foraging. Often found near ant nests.	Moderate Potential. Low suitable habitat on-site, however CNDDB occurrence only .43 miles away. Lacking friable, sandy soil and ant nests.
Fishes				
Oncorhynchus mykiss	Steelhead – Central California Coast DPS	FT, SSC	Occurs in fresh water, fast-flowing, highly oxygenated, clear, cool streams where riffles tend to dominate pools; small streams with high elevation headwaters close to the ocean that have no impassible barriers; spawning and high elevation headwaters.	Not likely. No CNDDB occurrences within 3 miles, Study Area is considered outside of historic and current range, and significant barriers limit upstream dispersal.

Special Status Codes: FE=Federally listed as endangered species; FT=Federally listed as threatened species; PT=Proposed for federal listing as threatened; FC=Federally listed as a candidate species for listing. CE=California listed as endangered species. CT=California listed as threatened species. SSC=California species of special concern

a. Foothill yellow-legged frog was proposed for listing as threatened under the federal Endangered Species Act on 12/28/21 after the Sequoia 2021 report was finalized.

b. Updated with CDFW Special Animals List, January 2022 (CNDDB 2022a).

Source: Sequoia 2021b.

Table I.3-5. Bat Species Detected at Site 300 in the 2021 Bat Survey Report

Scientific Name	**Common Name**	**Status**
Antrozous pallidus	Pallid Bat	SSC
Corynorhinus townsendii	Townsend's Big-eared Bat	SSC
Eptesicus fuscus	Big Brown Bat	None
Eumops perotis	Western Mastiff Bat	SSC
Lasiurus blossevillii	Western Red Bat	SSC
Lasiurus cinereus	Hoary Bat	None
Lasionycteris noctivagans	Silver-haired Bat	None
Myotis californicus	California Myotis	None
Myotis ciliolabrum	Small-footed Myotis	None
Myotis evotis	Long-eared Myotis	None
Myotis thysanodes	Fringed Myotis	None
Myotis yumanensis	Yuma Myotis	None
Parastrellus hesperus	Canyon Bat	None
Tadarida brasiliensis	Mexican Free-tailed Bat	None

Special Status Codes: SSC=California Species of Special Concern

Source: ECORP 2021b.

Table I.3-6. Special-Status Herpetofauna Species with Potential for Occurrence at Lawrence Livermore's Site 300

Common Name (Scientific Name)	Status[a]			Documented Onsite
	ESA	CESA	Other Status	
California Tiger Salamander (Central California Distinct Population Segment) (*Ambystoma californiense*)	FT	CT		Yes

Common Name (Scientific Name)	Status[a]			Documented Onsite
	ESA	CESA	Other Status	
Western Spadefoot (*Spea hammondii*)			SSC	Yes
Foothill Yellow-legged Frog West/Central Coast Clade (*Rana boylii*)	PT[b]	CE	SSC	No
California Red-legged Frog (*Rana draytonii*)	FT		SSC	Yes
Northwestern/ Southwestern Pond Turtle (*Actinemys marmorata, A. pallida*)			SSC	Yes
Blainville's (coast) Horned Lizard (*Phrynosoma blainvillii*)			SSC	Yes
Northern California Legless Lizard (*Anniella pulchra*)			SSC	Yes
California Glossy Snake (*Arizona elegans occidentalis*)			SSC	Yes
Alameda Whipsnake (*Masticophis lateralis euryxanthus*)	FT	CT		Yes
San Joaquin Coachwhip (*Masticophis flagellum ruddocki*)			SSC	Yes

Special Status Codes: ESA=Federal Endangered Species Act; CESA=California Endangered Species Act; CT=CESA- or NPPA-listed, Threatened; CE=CESA or NPPA listed, Endangered; SSC=CDFW Species of Special Concern (CDFW, updated July 2021): FT=ESA listed, Threatened; PT=Proposed for ESA listing as Threatened.

a. Updated with the 2022 CNDDB (CNDDB 2022a).

b. Foothill yellow-legged frog was proposed for listing as threatened under the federal Endangered Species Act on 12/28/21 after the ECORP 2021e report was finalized.

Source: ECORP 2021a.

Table I.3-7. Species Documented During Herpetofauna Surveys at Lawrence Livermore's Site 300

Species	Location	Method	Sign	Photo
California Toad (*Anaxyrus boreas*)	North of Quadrat S216	Microhabitat Surveys	Animal	No
Coast Range Fence Lizard (*Sceloporus occidentalis bocourtii*)	Ubiquitous around dwellings and rocks outcrops	Quadrats, Microhabitat Surveys, Incidental	Animal	Yes
Western Side-blotch Lizard *(Uta stansburiana elegans)*	Ubiquitous across non-developed parts of the site	Quadrats, Microhabitat Surveys, Incidental	Animal	Yes
San Francisco (Northern) Alligator Lizard *(Elgaria coerulea coerulea)*	Coverboard 1	Coverboard	Animal	No
California (Southern) Alligator Lizard *(Elgaria multicarinata multicarinata)*	Coverboard 11, Quadrats P7, P99, P84, P72b, P24, P50	Coverboard, Incidental, Microhabitat Survey, Quadrats	Animal	Yes

Species	Location	Method	Sign	Photo
Skilton's (Western) Skink *(Eumeces skiltonianus)*	Coverboard 1, P99	Coverboard, Quadrats	Animal	No
Variegated (Gilbert's) Skink *(Eumeces gilberti cancellosus)*	P99b	Quadrats	Animal	Yes
California (Western) Whiptail *(Aspidoscelis tigris mundus)*	P57d, P57e, P84	Quadrats	Animal	No
Blainville's (coast) Horned Lizard *(Phrynosoma blainvillii)*		Driving Surveys, Walking Road Surveys, Microhabitat Surveys	Animal	Yes
Northern Legless Lizard *(Anniella pulchra)*	Quadrat P57b	Quadrats	Animal	Yes
Pacific Gopher Snake *(Pituophis catenifer catenifer)*	Sitewide	Driving Surveys, Walking Road Surveys	Animal	Yes
California Glossy Snake *(Arizona elegans occidentalis)*	Corral Hollow Ecological Preserve	Microhabitat Surveys	Shed skin	No
California Night Snake *(Hypsiglena ochrorhyncha nuchalata)*	Quadrat P38	Quadrats	Animal	Yes
Western Yellow-bellied Racer *(Coluber constrictor mormon)*	Quadrat P84b	Quadrats	Shed skin	No
Alameda Whipsnake *(Masticophis lateralis euryxanthus)*	The Oasis (documented by LLNL staff)	Incidental	Animal (dead)	Yes
San Joaquin Coachwhip *(Masticophis flagellum ruddocki)*	Quadrats P37, P105	Quadrats	Shed skin	Yes
Northern Pacific Rattlesnake *(Crotalus oreganus oreganus)*	Facility-wide	Quadrats, Microhabitat Surveys, Walking Road Surveys, Incidental	Animal	Yes

Source: ECORP 2021a.

Table I.3-8. Site 300 Plant List Compiled from 2020-2021 Botanical Surveys and Prior Species Reports

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
FERNS					
Pteridaceae – Brake Family					
Pellaea andromedifolia	coffee fern	Native	---	NE, BS, ICF	---
Pellaea mucronata	bird's foot fern	Native	---	ICF	Not known to occur in the Great Valley ecoregion in Alameda County. Possible misidentification of *Pellaea andromedifolia*.
Pentagramma triangularis	gold back fern	Native	---	NE, BS, ICF	---
GYMNOSPERMS					
Cupressaceae – Cypress Family					
Juniperus californica	California juniper	Native	---	NE, BS, ICF	---
EUDICOTS					
Adoxaceae – Muskroot Family					
Sambucus nigra ssp. cerulea	blue elderberry	Native	---	NE, BS, ICF	Synonym: *Sambucus mexicana*
Amaranthaceae – Amaranth Family					
Amaranthus albus	tumbleweed	Non-Native	---	ICF	---
Amaranthus blitoides	mat amaranth	Native	---	BS	---
Amaranthus californicus	California pigweed	Native	---	ICF	---
Anacardiaceae – Sumac or Cashew Family					
Toxicodendron diversilobum	poison oak	Native	---	NE, BS, ICF	---
Apiaceae – Carrot Family					
Anthriscus caucalis	bur chervil	Non-Native	---	NE	---
Apiastrum angustifolium	mock parsley	Native	---	NE, BS, ICF	---
Bowlesia incana	bowlesia	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Lomatium caruifolium var. *caruifolium*	caraway leaved lomatium	Native	---	NE, BS, ICF	---
Lomatium macrocarpum	bigseed biscuitroot	Native	---	NE	---
Lomatium utriculatum	common lomatium	Native	---	NE, BS, ICF	---
Sanicula bipinnata	poison sanicle	Native	---	NE, BS, ICF	---
Sanicula bipinnatifida	purple sanicle	Native	---	NE, BS, ICF	---
Sanicula crassicaulis	Pacific sanicle	Native	---	NE, ICF	---
Torilis arvensis	hedge parsley	Non-Native	Moderate	NE	---
Torilis nodosa	knotted hedge parsley	Non-Native	---	BS	---
Yabea microcarpa	California hedge parsely	Native	---	NE, BS, ICF	---
Apocynaceae – Dogbane Family					
Asclepias fascicularis	narrow-leaved milkweed	Native	---	NE, BS, ICF	---
Nerium oleander	oleander	Non-Native	---	NE	---
Asteraceae – Sunflower Family					
Achillea millefolium	yarrow	Native	---	NE, BS, ICF	---
Achyrachaena mollis	blow-wives	Native	---	NE, BS, ICF	---
Agoseris heterophylla var. *cryptopleura*	mountain dandelion	Native	---	NE, BS, ICF	---
Agoseris heterophylla var. *heterophylla*	annual agoseris	Native	---	NE, BS, ICF	---
Ancistrocarphus filagineus	woolly fishhooks	Native	---	NE, BS, ICF	---
Artemisia californica	California sagebrush	Native	---	NE, BS, ICF	---
Artemisia douglasiana	mugwort	Native	---	NE	---
Baccharis pilularis subsp.	coyote brush	Native	---	NE, BS,	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
consanguinea				ICF	
Baccharis salicifolia subsp. *salicifolia*	mule fat	Native	---	NE, BS, ICF	---
Blepharizonia laxa	glandular big tarweed	Native	---	NE, ICF	---
Blepharizonia plumosa (CRPR 1B.2) [d]	big tarweed	Native	---	NE, ICF	---
Carduus pycnocephalus subsp. *pycnocephalus*	Italian thistle	Non-Native	Moderate	NE, BS, ICF	---
Carduus tenuiflorus	slender flowered thistle	Non-Native	Limited	NE, ICF	---
Centaurea calcitrapa	purple star thistle	Non-Native	Moderate	NE	---
Centaurea melitensis	tocalote	Non-Native	Moderate	NE, BS, ICF	---
Centaurea solstitialis	yellow star thistle	Non-Native	High	NE, BS, ICF	---
Centromadia fitchii	Fitch's spikeweed	Native	---	NE, ICF	---
Centromadia pungens subsp. *pungens*	common spikeweed	Native	---	ICF	---
Chondrilla juncea	skeleton weed	Non-Native	Moderate	NE	---
Cirsium cymosum var. *cymosum*	peregrine thistle	Native	---	NE	---
Cirsium occidentale subsp. *venustum*	Venus thistle	Native	---	BS, ICF	Not known to occur in the Great Valley ecoregion. Possible misidentification of *Cirsium cymosum*var. *cymosum.*
Cirsium vulgare	bull thistle	Non-Native	Moderate	NE, BS, ICF	---
Crepis vesicaria subsp. *taraxacifolia*	beaked hawksbeard	Non-Native	---	NE	---
Crocidium multicaule	spring gold	Native	---	NE	---
Cynara cardunculus	artichoke thistle	Non-Native	Moderate	ICF	---
Deinandra kelloggii	Kellogg's tarweed	Native	---	NE, BS, ICF	---
Deinandra lobbii	Lobb’s tarplant	Native	---	BS, ICF	Possible misidentification of *Deinandra kelloggii.*
Dittrichia graveolens	stinkwort	Non-Native	Moderate	NE, ICF	---
Eastwoodia elegans	yellow mock aster	Native	---	NE	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Ericameria linearifolia	interior goldenbush	Native	---	NE, BS, ICF	---
Erigeron canadensis	horseweed	Native	---	NE, BS, ICF	Synonym: *Conyza canadensis*
Erigeron reductus var. *angustatus*	California rayless daisy	Native	---	BS	---
Euthamia occidentalis	western goldenrod	Native	---	NE	---
Gnaphalium palustre	marsh cudweed	Native	---	BS, ICF	---
Grindelia hirsutula	Great Valley gumweed	Native	---	NE, BS, ICF	---
Gutierrezia californica	California matchweed	Native	---	NE, BS, ICF	---
Helianthus annuus	common sunflower	Native	---	ICF	---
Helianthus californicus	California sunflower	Native	---	NE	---
Helminthotheca echioides	bristly ox-tongue	Non-Native	Limited	BS, ICF	Synonym: *Picris echioides*
Hesperevax caulescens (CRPR 4.2) [d]	hogwallow starfish	Native	---	BS, ICF	---
Hesperevax sparsiflora var. *sparsiflora*	few-flowered evax	Native	---	NE, BS	---
Heterotheca grandiflora	Telegraph weed	Native	---	ICF	---
Heterotheca sessiliflora subsp. *echioides*	bristly goldenaster	Native	---	NE, BS, ICF	---
Holocarpha obconica	San Joaquin tarplant	Native	---	NE, BS, ICF	---
Hypochaeris glabra	smooth cat's ear	Non-Native	Limited	NE, BS, ICF	---
Hypochaeris radicata	rough cat's ear	Non-Native	Moderate	NE, BS, ICF	---
Lactuca saligna	willowleaf lettuce	Non-Native	---	NE	---
Lactuca serriola	prickly lettuce	Non-Native	---	NE, BS, ICF	---
Lagophylla ramosissima	hare’s ear	Native	---	NE, ICF	---
Lasthenia gracilis	needle goldfields	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Lasthenia microglossa	small-ray goldfields	Native	---	NE, BS, ICF	---
Lasthenia minor	coastal goldfields	Native	---	NE, BS, ICF	---
Layia gaillardioides	woodland layia	Native	---	BS, ICF	---
Layia platyglossa	tidy tips	Native	---	NE, BS, ICF	---
Leptosyne calliopsidea	leafy-stemmed coreopsis	Native	---	NE, BS	Synonym: *Coreopsis calliopsidea*
Logfia filaginoides	California filago	Native	---	NE, BS, ICF	Synonym: *Filago californica*
Logfia gallica	narrowleaf cottonrose	Non-Native	---	NE, BS, ICF	Synonym: *Filago gallica*
Madia gracilis	slender tarweed	Native	---	BS	---
Malacothrix coulteri	snake's-head	Native	---	NE, BS, ICF	---
Matricaria discoidea	pineapple weed	Non-Native	---	NE, BS, ICF	Synonym: *Chamomilla suaveolens*
Micropus californicus	cottonweed	Native	----	BS, ICF	Infraspecific identification notprovided in previous studies.
Micropus californicus var. *californicus*	slender cottonweed	Native	---	NE	---
Micropus californicus var. *subvestitus*	slender cottonweed	Native	---	NE	---
Microseris acuminata	needle microseris	Native	---	NE, ICF	---
Microseris douglasii subsp. *douglasii*	silver puffs	Native	---	NE, ICF	---
Microseris douglasii subsp. *tenella*	Douglas' silverpuffs	Native	---	NE, BS, ICF	---
Monolopia lanceolata	common hillside daisy	Native	---	NE	---
Monolopia major	cupped monolopia	Native	---	NE, BS, ICF	---
Packera breweri	Brewer’s butterweed	Native	---	BS, ICF	Synonym: *Senecio breweri*
Pentachaeta alsinoides	pygmy daisy	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Pseudognaphalium californicum	California cudweed	Native	---	ICF	Synonym: *Gnaphalium californicum* Not known to occur in San Joaquin County or eastern Alameda County. Possible misidentification of *Pseudognaphalium luteoalbum.*
Pseudognaphalium luteoalbum	cudweed	Non-Native	---	NE, ICF	Synonym: *Gnaphalium luteoalbum*
Psilocarphus brevissimus	woolly marbles	Native	---	BS	---
Psilocarphus tenellus	slender woolly marbles	Native	---	NE, BS	---
Rafinesquia californica	California chicory	Native	---	BS	---
Senecio flaccidus var. *douglasii*	Douglas' groundsel	Native	---	NE	---
Senecio sylvaticus	woodland ragwort	Non-Native	---	NE	---
Senecio vulgaris	groundsel	Non-Native	---	NE, BS, ICF	---
Silybum marianum	milk-thistle	Non-Native	Limited	NE, BS, ICF	---
Solidago canadensis	Canada goldenrod	Native	---	BS	Unlikely in Alameda County or southeastern San Joaquin County.Possible misidentification of *Euthamia occidentalis*.
Sonchus asper subsp. *asper*	prickly sowthistle	Non-Native	---	NE, BS, ICF	---
Sonchus oleraceus	common sowthistle	Non-Native	---	NE, BS, ICF	---
Stebbinsoseris heterocarpa	grassland stebbinsoseris	Native	---	NE, ICF	---
Stephanomeria virgata var. *pleurocarpa*	tall stephanomeria	Native	---	ICF	---
Stylocline gnaphaloides	everlasting neststraw	Native	---	NE, BS, ICF	---
Taraxacum officinale	dandelion	Non-Native	---	BS	---
Uropappus lindleyi	silverpuffs	Native	---	NE, BS, ICF	---
Wyethia helenioides	woollyleaf mule ears	Native	---	NE	---
Xanthium strumarium	cocklebur	Non-Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Boraginaceae – Borage or Waterleaf Family					
Amsinckia eastwoodiae	Eastwood's amsinckia	Native	---	NE, ICF	---
Amsinckia grandiflora (CRPR 1B.1, SE, FE) [d]	large-flowered fiddleneck	Native	---	NE, BS, ICF	---
Amsinckia intermedia	common fiddleneck	Native	---	NE, BS, ICF	Synonym: *Amsinckia menziesii* var. *intermedia*
Amsinckia lycopsoides	bugloss fiddleneck	Native	---	NE, ICF	---
Amsinckia menziesii	ranchers fireweed	Native	---	NE, BS, ICF	Synonym: *Amsinckia menziesii* var. *menziesii*
Amsinckia tessellata var. *gloriosa*	large-flowered devil's fiddleneck	Native	---	NE	---
Amsinckia tessellata var. *tessellata*	devil's lettuce	Native	---	NE, BS, ICF	---
Amsinckia vernicosa	green fiddleneck	Native	---	NE, BS	---
Cryptantha flaccida	weak-stemmed cryptantha	Native	---	BS, ICF	---
Cryptantha intermedia var. *intermedia*	common cryptantha	Native	---	NE, BS, ICF	---
Cryptantha microstachys	Tejon cryptantha	Native	---	BS	---
Emmenanthe penduliflora var. *penduliflora*	whispering bells	Native	---	ICF	---
Eriodictyon californicum	yerba santa	Native	---	NE, BS, ICF	---
Heliotropium curassavicum var. *oculatum*	salt heliotrope	Native	---	NE, BS, ICF	---
Nemophila menziesii var. *menziesii*	baby blue eyes	Native	---	NE, BS, ICF	---
Nemophila pedunculata	spreading nemophila	Native	---	BS, ICF	---
Pectocarya penicillata	northern pectocarya	Native	---	NE, BS, ICF	---
Pectocarya pusilla	little pectocarya	Native	---	NE	---
Phacelia ciliata var. *ciliata*	Great Valley phacelia	Native	---	NE, BS, ICF	---
Phacelia distans	common phacelia	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Phacelia douglasii	Douglas' phacelia	Native	---	BS, ICF	---
Phacelia imbricata subsp. *imbricata*	imbricate phacelia	Native	---	NE, BS, ICF	---
Phacelia tanacetifolia	tansy leafed phacelia	Native	---	NE, BS, ICF	---
Pholistoma auritum var. *auritum*	blue fiesta flower	Native	---	NE	---
Pholistoma membranaceum	white fiesta flower	Native	---	NE, BS, ICF	---
Plagiobothrys bracteatus	bracted popcorn flower	Native	---	NE, ICF	---
Plagiobothrys canescens var. *canescens*	valley popcorn flower	Native	---	NE, BS, ICF	---
Plagiobothrys fulvus var. *campestris*	common popcorn flower	Native	---	NE	---
Plagiobothrys nothofulvus	popcorn flower	Native	---	NE	---
Plagiobothrys stipitatus var. *micranthus*	small-flowered popcorn flower	Native	---	BS, ICF	---
Plagiobothrys stipitatus var. *stipitatus*	small-flowered popcorn flower	Native	---	NE	---
Plagiobothrys tenellus	slender popcorn flower	Native	---	NE, BS, ICF	---
Plagiobothrys trachycarpus	rough-fruit popcorn flower	Native	---	NE	---
Brassicaceae – Mustard Family					
Athysanus pusillus	common sandweed	Native	---	NE, BS, ICF	---
Brassica nigra	black mustard	Non-Native	Moderate	NE, BS, ICF	---
Capsella bursa-pastoris	shepherd's purse	Non-Native	---	NE, BS, ICF	---
Caulanthus flavescens	yellow California mustard	Native	---	NE, BS, ICF	Synonym: *Guillenia flavescens*
Caulanthus lasiophyllus	California mustard	Native	---	NE, BS, ICF	Synonym: *Guillenia lasiophylla*
Descurainia sophia	tansy mustard	Non-Native	Limited	BS, ICF	---
Erysimum capitatum var. *capitatum*	western wallflower	Native	---	NE, BS	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Hirschfeldia incana	hoary mustard	Non-Native	Moderate	NE	---
Lepidium appelianum	hairy whitetop	Non-Native	Limited	BS	Synonym: *Cardaria pubescens*
Lepidium latifolium	broadleaf peppergrass	Non-Native	High	NE	---
Lepidium nitidum	shining peppergrass	Native	---	NE, BS, ICF	---
Nasturtium officinale	watercress	Native	---	NE, BS, ICF	---
Sinapis arvensis	charlock	Native	Limited	NE, ICF	---
Sisymbrium altissimum	tumble mustard	Non-Native	---	BS	---
Sisymbrium irio	London rocket	Non-Native	Moderate	NE	---
Sisymbrium officinale	hedge mustard	Non-Native	---	NE, BS	---
Sisymbrium orientale	mustard	Non-Native	---	ICF	---
Thysanocarpus curvipes spp. *curvipes*	fringepod	Native	---	NE, BS, ICF	---
Thysanocarpus curvipes spp. *elegans*	elegant fringepod	Native	---	NE, BS, ICF	---
Tropidocarpum gracile	dobie pod	Native	---	NE, ICF	---
Campanulaceae – Bluebell Family					
Downingia insignis	cupped downingia	Native	---	BS, ICF	---
Caprifoliaceae – Honeysuckle Family					
Lonicera interrupta	chaparral honeysuckle	Native	---	BS, ICF	Not known to occur in the GreatValley ecoregion. Possible misidentification of *Lonicera subspicata* var. *denudata*.
Lonicera subspicata var. *denudata*	Santa Barbara honeysuckle	Native	---	NE	---
Caryophyllaceae – Pink Family					
Cerastium glomeratum	mouse-ear chickweed	Non-Native	---	NE, BS, ICF	---
Herniaria hirsuta subsp. *cinerea*	grey herniaria	Native	---	NE, BS, ICF	---
Loeflingia squarrosa	California loeflingia	Native	---	BS	---
Minuartia californica	California sandwort	Native	---	BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Minuartia douglasii	Douglas' sandwort	Native	---	NE, BS	---
Sagina apetala	dwarf pearlwort	Native	---	ICF	---
Sagina decumbens var. *occidentalis*	western pearlwort	Native	---	BS	---
Silene antirrhina	sleepy silene	Native	---	NE, BS, ICF	---
Silene gallica	windmill pink	Non-Native	---	NE, BS, ICF	---
Spergularia marina	saltmarsh sandspurrey	Native	---	BS	---
Spergularia rubra	sandspurrey	Non-Native	---	NE	---
Stellaria media	common chickweed	Non-Native	---	NE, BS, ICF	---
Stellaria nitens	smooth chickweed	Native	---	NE, BS, ICF	---
Chenopodiaceae – Goosefoot Family					
Atriplex patula	spear oracle	Native	---	BS	Not known to occur in the Great Valley ecoregion. Possible misidentification of *Atriplex rosea.*
Atriplex rosea	tumbling oracle	Non-Native	---	ICF	---
Atriplex semibaccata	Australian saltbush	Non-Native	---	NE, BS, ICF	---
Atriplex serenana	bractscale	Native	---	ICF	---
Chenopodium album	lambs quarters	Non-Native	---	NE, ICF	---
Chenopodium californicum	California pigweed	Native	---	NE, BS, ICF	---
Chenopodium murale	nettle-leaf goosefoot	Non-Native	---	ICF	---
Chenopodium rubrum	red goosefoot	Native	---	BS	---
Chenopodium vulvaria	stinking goosefoot	Non-Native	---	BS	---
Monolepis nuttalliana	poverty weed	Native	---	BS	---
Salsola australis	tumbleweed	Non-Native	Limited	NE	---
Salsola tragus	Russian thistle	Non-Native	Limited	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Convolvulaceae – Morning-Glory Family					
Convolvulus arvensis	bindweed	Non-Native	---	NE, ICF	---
Crassulaceae – Stonecrop Family					
Crassula connata	pygmyweed	Native	---	NE, BS, ICF	---
Cucurbitaceae – Gourd Family					
Marah fabacea	California man-root	Native	---	NE, BS, ICF	---
Euphorbiaceae – Spurge Family					
Croton setiger	turkey mullein	Native	---	NE, BS, ICF	---
Euphorbia ocellata subsp. *ocellata*	sand spurge	Native	---	NE, ICF	Synonym: *Chamaesyce ocellata*
Euphorbia spathulata	warty spurge	Native	---	NE, BS, ICF	---
Fabaceae – Pea Family					
Acmispon americanus var. *americanus*	Spanish clover	Native	---	NE	---
Acmispon brachycarpus	short podded lotus	Native	---	BS, ICF	Synonym: *Lotus humstratus*
Acmispon wrangelianus	calf lotus	Native	---	NE, BS, ICF	Synonym: *Lotus wrangelianus*
Astragalus asymmetricus	San Joaquin milk vetch	Native	---	NE, BS, ICF	---
Astragalus didymocarpus var. *didymocarpus*	common dwarf milkvetch	Native	---	NE, BS, ICF	---
Astragalus gambelianus	Gambel's dwarf milk vetch	Native	---	NE, ICF	---
Lupinus albifrons var. *albifrons*	silver bush lupine	Native	---	NE, BS, ICF	---
Lupinus benthamii	spider lupine	Native	---	BS, ICF	---
Lupinus bicolor	dove lupine	Native	---	NE, BS, ICF	---
Lupinus concinnus	Bajada lupine	Native	---	NE	---
Lupinus microcarpus var. *densiflorus*	dense-flowered lupine	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Lupinus microcarpus var. *microcarpus*	chick lupine	Native	---	NE, BS	---
Lupinus succulentus	succulent lupine	Native	---	NE, BS, ICF	---
Medicago polymorpha	burclover	Non-Native	Limited	NE, BS, ICF	---
Melilotus alba	white sweet-clover	Non-Native	---	BS, ICF	---
Melilotus indicus	sourclover	Non-Native	---	NE, BS, ICF	---
Melilotus officinalis	yellow sweet clover	Non-Native	---	NE	---
Trifolium albopurpureum	branched Indian clover	Native	---	NE, BS, ICF	Synonym: *Trifolium albopurpureum* var. *albopurpureum*
Trifolium ciliolatum	tree clover	Native	---	NE, ICF	---
Trifolium depauperatum var. *amplectens*	pale sack clover	Native	---	NE, BS	---
Trifolium depauperatum var. *stenophyllum*	dwarf sac clover	Native	---	NE, ICF	---
Trifolium dichotomum	branched indian clover	Native	---	BS	Synonym: *Trifolium albopurpureum* var. *dichotomum*
Trifolium gracilentum	pinpoint clover	Native	---	NE, BS, ICF	---
Trifolium microcephalum	hairy clover	Native	---	NE, ICF	---
Trifolium microdon	thimble clover	Native	---	NE, BS	---
Trifolium oliganthum	fewflower clover	Native	---	NE, BS	---
Trifolium willdenovii	tomcat clover	Native	---	NE, BS, ICF	---
Vicia americana subsp. *americana*	American vetch	Native	---	NE	---
Vicia sativa	common vetch	Non-Native	---	ICF	---
Vicia tetrasperma	four seeded vetch	Non-Native	---	NE, BS	---
Vicia villosa var. glabrescens	smooth vetch	Non-Native	---	NE, BS	---
Vicia villosa var. villosa	woolly vetch	Non-Native	---	NE, ICF	---
Fagaceae – Oak Family					
Quercus douglasii	blue oak	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Quercus lobata	valley oak	Native	---	NE, BS, ICF	---
Frankeniaceae – Frankenia Family					
Frankenia salina	alkali heath	Native	---	NE	---
Geraniaceae – Geranium Family					
California macrophylla (CRPR CBR) [d]	round leaved filaree	Native	---	NE, ICF	Synonym: *Erodium macrophylla*
Erodium botrys	long-beaked filaree	Non-Native	---	NE, BS, ICF	---
Erodium brachycarpum	foothill filaree	Non-Native	---	NE, BS, ICF	---
Erodium cicutarium	red-stemmed filaree	Non-Native	Limited	NE, BS, ICF	---
Erodium moschatum	white-stem filaree	Non-Native	---	NE, BS, ICF	---
Geranium dissectum	cut-leaf geranium	Non-Native	Moderate	NE, ICF	---
Geranium molle	dove's foot geranium	Non-Native	---	NE, BS, ICF	---
Grossulariaceae – Gooseberry Family					
Ribes malvaceum	chaparral currant	Native	---	NE, BS, ICF	---
Ribes quercetorum	foothill gooseberry	Native	---	NE, ICF	---
Juglandaceae – Walnut Family					
Juglans hindsii (waif)	Northern California black walnut	Native	---	NE	---
Lamiaceae – Mint Family					
Lamium amplexicaule	henbit	Non-Native	---	BS	---
Marrubium vulgare	horehound	Non-Native	Limited	NE, BS, ICF	---
Mentha pulegium	pennyroyal	Non-Native	Moderate	ICF	---
Pogogyne serpylloides	thyme-like pogogyne	Native	---	NE, BS, ICF	---
Salvia columbariae	chia	Native	---	NE, BS,	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
				ICF	
Salvia mellifera	black sage	Native	---	NE, BS, ICF	---
Stachys albens	white-hedge nettle	Native	---	NE, BS, ICF	---
Trichostema lanceolatum	vinegar weed	Native	---	NE, BS, ICF	---
Linaceae – Flax Family					
Hesperolinon californicum	California dwarf flax	Native	---	NE, BS, ICF	---
Hesperolinon disjunctum	coast range western flax	Native	---	NE	---
Linum usitatissimum	common flax	Non-Native	---	ICF	---
Loasaceae – Loasa Family					
Mentzelia affinis	yellowcomet	Native	---	NE, BS, ICF	---
Mentzelia dispersa	bushy blazing star	Native	---	NE, ICF	---
Malvaceae – Mallow Family					
Eremalche parryi subsp. *parryi*	Parry's mallow	Native	---	NE, BS, ICF	---
Malva parviflora	cheeseweed	Non-Native	---	NE, BS, ICF	---
Malvella leprosa	alkali mallow	Native	---	NE, BS, ICF	---
Montiaceae – Miner's Lettuce Family					
Calandrinia menziesii	red maids	Native	---	NE, BS, ICF	---
Claytonia exigua subsp. *exigua*	viridis	Native	---	NE, BS, ICF	---
Claytonia parviflora subsp. *parviflora*	narrow leavedminer's lettuce	Native	---	NE, BS, ICF	---
Claytonia perfoliata subsp. *perfoliata*	miner's lettuce	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Claytonia rubra	red miner's lettuce	Native	---	ICF	Not known to occur in Alameda orSan Joaquin Counties or the Great Valley ecoregion. Possible misidentification of *Claytonia parviflora* subsp. *parviflora* or *C.perfoliata* subsp. *perfoliata.*
Myrtaceae – Myrtle Family					
Eucalyptus camaldulensis	red gum	Non-Native	Limited	NE	---
Eucalyptus globulus	bluegum	Non-Native	Moderate	NE	---
Oleaceae – Olive Family					
Forestiera pubescens	desert olive	Native	---	NE, BS, ICF	---
Onagraceae – Evening Primrose Family					
Camissonia contorta	contorted suncup	Native	---	NE, BS, ICF	---
Camissoniopsis hirtella	hairy sun-cups	Native	---	BS, ICF	Synonym: *Camissonia hirtella*
Camissoniopsis intermedia	intermediate sun-cups	Native	---	ICF	Synonym: *Camissonia intermedia*
Clarkia affinis	chaparral clarkia	Native	---	NE, BS, ICF	---
Clarkia purpurea subsp. *purpurea*	wine cup clarkia	Native	---	BS, ICF	---
Clarkia purpurea subsp. *quadrivulnera*	wine cup clarkia	Native	---	NE	---
Clarkia tembloriensis subsp. *tembloriensis*	Temblor Range clarkia	Native	---	NE, BS, ICF	---
Clarkia unguiculata	elegant clarkia	Native	---	BS, ICF	---
Epilobium brachycarpum	tall annual willow-herb	Native	---	NE, BS, ICF	---
Epilobium campestre	smooth boisduvalia	Native	---	NE, BS	---
Epilobium canum subsp. *canum*	California fuschia	Native	---	NE, BS, ICF	---
Epilobium cleistogamum	cleistogamous boisduvalia	Native	---	NE, ICF	---
Eremothera boothii subsp. *decorticans*	shredding evening-primrose	Native	---	NE, BS, ICF	Synonym: *Camissonia boothii* subsp. *decorticans*
Tetrapteron graciliflorum	hill sun cup	Native	---	NE, BS, ICF	Synonym: *Camissonia graciliflora*

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Orobanchaceae – Broomrape Family					
Aphyllon californica subsp. *jepsonii*	Jepson's California broom rape	Native	---	BS, ICF	Synonym: *Orobanche californica* subsp. *jepsonii*
Aphyllon purpureum	purple broomrape	Native	---	BS, ICF	Synonym: *Orobanche purpureum*
Castilleja affinis subsp. *affinis*	Indian paintbrush	Native	---	NE	---
Castilleja attenuata	valley tassels	Native	---	NE, BS, ICF	---
Castilleja densiflora subsp. *densiflora*	dense flower owl's clover	Native	---	NE	---
Castilleja exserta subsp. *exserta*	purple owl's clover	Native	---	NE, BS, ICF	---
Castilleja foliolosa	woolly indian paintbrush	Native	---	NE, BS, ICF	---
Triphysaria pusilla	dwarf owl's clover	Native	---	NE	---
Papaveraceae – Poppy Family					
Eschscholzia californica	California poppy	Native	---	NE, BS, ICF	---
Eschscholzia rhombipetala (CRPR 1B.1) [d]	diamond-petaled California poppy	Native	---	NE, ICF	---
Papaver californicum	fire poppy	Native	---	ICF	---
Papaver heterophyllum	wind poppy	Native	---	NE, BS, ICF	Synonym: *Stylomecon heterophylla*
Platystemon californicus	cream cups	Native	---	NE, BS, ICF	---
Phrymaceae – Lopseed Family					
Diplacus aurantiacus	bush monkeyflower	Native	---	NE, BS, ICF	Synonym: *Mimulus aurantiacus*
Erythranthe guttata	common yellow monkeyflower	Native	---	NE, BS, ICF	Synonym: *Mimulus guttatus*
Erythranthe latidens	broad toothed monkeyflower	Native	---	BS	Synonym: *Mimulus latidens*
Plantaginaceae – Plantain Family					
Callitriche sp.	star-wort	Native	---	NE	---
Callitriche marginata	California water-starwort	Native	---	ICF	---
Callitriche verna	vernal star-wort	Native	---	BS	Not known from Alameda or SanJoaquin

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
					counties. Possible misidentification of *Callitriche marginata*.
Collinsia heterophylla var. *heterophylla*	Chinese houses	Native	---	NE, BS, ICF	---
Collinsia sparsiflora var. *collina*	hillside collinsia	Native	---	NE, BS, ICF	---
Collinsia sparsiflora var. *sparsiflora*	field collinsia	Native	---	NE	---
Plantago elongata	annual coast plantain	Native	---	BS	---
Plantago erecta	dwarf plantain	Native	---	NE, BS, ICF	---
Plantago lanceolata	English plantain	Non-Native	---	NE, BS	---
Nuttallanthus texanus	blue toadflax	Native	---	BS	Synonym: *Linaria canadensis*
Verbascum thapsus	woolly mullein	Non-Native	Limited	NE	---
Veronica peregrina subsp. *xalapensis*	speedwell	Native	---	BS, ICF	---
Platanaceae – Sycamore Family					
Platanus racemosa	California sycamore	Native	---	BS	---
Polemoniaceae – Phlox Family					
Allophyllum divaricatum	straggling gilia	Native	---	BS	---
Eriastrum pluriflorum subsp. *pluriflorum*	many-flowered eriastrum	Native	---	NE, BS, ICF	---
Gilia achilleifolia subsp. *achilleifolia*	California gilia	Native	---	NE	---
Gilia capitata subsp. *staminea*	capitate gilia	Native	---	NE, BS, ICF	---
Gilia clivorum	many stemmed gilia	Native	---	NE, ICF	---
Gilia tricolor	bird's eye gilia	Native	---	BS, ICF	Infraspecific identification notprovided in previous studies.
Gilia tricolor subsp. *diffusa*	bird's eye gilia	Native	---	NE	---
Gilia tricolor subsp. *tricolor*	bird's eye gilia	Native	---	NE	---
Leptosiphon bicolor	true baby stars	Native	---	NE, BS, ICF	Synonym: *Linanthus bicolor*

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Linanthus dichotomus	evening snow	Native	---	BS	---
Microsteris gracilis	slender phlox	Native	---	NE, BS, ICF	Synonym: *Phlox gracilis*
Navarretia nigelliformis subsp. *radians* (CRPR 1B.2) [d]	adobe navarretia	Native	---	BS, ICF	---
Navarretia pubescens	purple navarretia	Native	---	NE, ICF	---
Polygonaceae – Buckwheat Family					
Chorizanthe membranacea	pink spineflower	Native	---	NE	---
Eriogonum angulosum	anglestem buckwheat	Native	---	NE, BS, ICF	---
Eriogonum fasciculatum var. *foliolosum*	leafy California buckwheat	Native	---	NE	---
Eriogonum fasciculatum var. *polifolium*	Eastern Mojave buckwheat	Native	---	NE, BS, ICF	---
Eriogonum gracile var. *gracile*	slender buckwheat	Native	---	NE, ICF	---
Eriogonum nudum var. ?	naked-stem buckwheat	Native	---	NE, BS, ICF	Infraspecific variety present at Site 300 needs taxonomic study and mayrepresent a new taxon with distribution from Mount Diablo toSanta Barbara County.
Eriogonum wrightii var. *subscaposum*	Wright's buckwheat	Native	---	JS	---
Eriogonum wrightii var. *trachygonum*	Wright's buckwheat	Native	---	NE, BS	---
Polygonum aviculare subsp. *depressum*	common knotweed	Non-Native	---	BS	Synonym: *Polygonum arenastrum*
Pterostegia drymarioides	fairy mist	Native	---	NE, BS, ICF	---
Rumex conglomeratus	whorled dock	Non-Native	---	BS	---
Rumex crispus	curly dock	Non-Native	---	NE, BS, ICF	---
Rumex salicifolius	willow dock	Native	---	BS, ICF	---
Primulaceae – Primrose Family					
Androsace elongata subsp. acuta (CRPR 4.2) [d]	California androsace	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Primula clevelandii subsp. *patula*	shooting stars	Native	---	NE	---
Primula hendersonii	shooting stars	Native	---	NE, BS, ICF	Synonym: *Dodecatheon hendersonii*
Ranunculaceae – Buttercup Family					
Delphinium gypsophilum (CRPR CBR) [d]	gypsum loving larkspur	Native	---	NE, BS, ICF	---
Delphinium hesperium	western larkspur	Native	---	BS	Infraspecific identification notprovided in previous studies.
Delphinium hesperium subsp. *pallescens*	foothill larkspur	Native	---	NE, BS, ICF	---
Delphinium parryi	Parry's larkspur	Native	---	ICF	---
Delphinium patens subsp. *patens*	spreading larkspur	Native	---	NE, BS, ICF	---
Delphinium variegatum subsp. *variegatum*	royal larkspur	Native	---	NE	---
Ranunculus californicus var. *californicus*	California buttercup	Native	---	NE	---
Ranunculus canus var. *canus*	Hartweg's buttercup	Native	---	NE, BS, ICF	---
Ranunculus hebecarpus	pubescent-fruited buttercup	Native	---	NE, BS	---
Ranunculus muricatus	prickle-fruited buttercup	Non-Native	---	ICF	---
Ranunculus sceleratus	celery-leaved buttercup	Native	---	BS	Not known to occur in Alameda County or western San Joaquin County. Possible misidentification ofother *Ranunculus* sp.
Rosaceae – Rose Family					
Aphanes occidentalis	Lady's mantle	Native	---	NE, BS, ICF	---
Heteromeles arbutifolia	toyon	Native	---	NE, BS, ICF	---
Prunus virginiana var. *demissa*	choke cherry	Native	---	NE, BS, ICF	---
Rubus leucodermis	blackcap raspberry	Native	---	BS	Not known to occur in Alameda County or San Joaquin County. Possible misidentification of *Rubusursinus.*
Rubus ursinus	California blackberry	Native	---	NE, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Rubiaceae – Madder Family					
Galium aparine	bedstraw	Native	---	NE, BS, ICF	---
Galium parisiense	wall bedstraw	Non-Native	---	NE, ICF	---
Galium porrigens var. *porrigens*	climbing bedstraw	Native	---	NE	---
Galium porrigens var. *tenue*	graceful bedstraw	Native	---	NE, BS, ICF	---
Sherardia arvensis	field madder	Non-Native	---	NE	---
Salicaceae – Willow Family					
Populus fremontii subsp. *fremontii*	Fremont cottonwood	Native	---	NE, BS, ICF	---
Salix laevigata	red willow	Native	---	NE, BS, ICF	---
Salix lasiolepis	arroyo willow	Native	---	NE, ICF	---
Sapindaceae – Soapberry Family					
Aesculus californica	California buckeye	Native	---	NE, BS, ICF	---
Saxifragaceae – Saxifrage Family					
Lithophragma affine	woodland star	Native	---	NE, BS	---
Lithophragma parviflorum var. *parviflorum*	pink woodland star	Native	---	NE, ICF	---
Micranthes californica	California saxifrage	Native	---	NE, BS, ICF	Synonym: *Saxifraga californica*
Scrophulariaceae – Figwort Family					
Scrophularia californica	bee plant	Native	---	NE, BS, ICF	---
Solanaceae – Nightshade Family					
Datura wrightii	jimsonweed	Native	---	NE, ICF	---
Nicotiana acuminata var. *multiflora*	many-flowered tobacco	Non-Native	---	ICF	---
Nicotiana glauca	tree tobacco	Non-Native	Moderate	NE, BS, ICF	---
Nicotiana quadrivalvis	Indian tobacco	Native	---	NE, BS	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Solanum americanum	small-flowered nightshade	Native	---	ICF	---
Solanum umbelliferum	blue witch	Native	---	NE, BS, ICF	---
Urticaceae – Nettle Family					
Hesperocnide tenella	western nettle	Native	---	NE, BS, ICF	---
Urtica dioica subsp. *holosericea*	hoary nettle	Native	---	NE, BS, ICF	---
Urtica urens	dwarf nettle	Non-Native	---	NE, BS, ICF	---
Valerianaceae – Valerian Family					
Plectritis ciliosa	longspur seablush	Native	---	NE, BS, ICF	---
Plectritis congesta subsp.*brachystemon*	sea blush	Native	---	NE, BS, ICF	Synonym: *Plectritis brachystemon; P.congesta*
Plectritis macrocera	white plectritis	Native	---	NE, ICF	---
Verbenaceae – Vervain Family					
Phyla nodiflora	common lippia	Native	---	NE	---
Verbena bracteata	bracted verbena	Native	---	NE, ICF	---
Violaceae – Violet Family					
Viola pedunculata	johnny jump-up	Native	---	NE, ICF	---
Viola purpurea subsp. *quercetorum*	foothill violet	Native	---	BS	---
Viscaceae – Mistletoe Family					
Phoradendron leucarpum subsp. *tomentosum*	oak mistletoe	Native	---	NE, BS, ICF	Synonym: *Phoradendron villosum*
Vitaceae – Grape Family					
Vitis californica	California wild grape	Native	---	ICF	---
MONOCOTS					
Agavaceae – Agave Family					
Chlorogalum pomeridianum var. *pomeridianum*	soap plant	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Alliaceae – Onion or Garlic Family					
Allium serra	jeweled onion	Native	---	NE, BS, ICF	---
Allium crispum	crinkled onion	Native	---	BS, ICF	---
Araceae – Arum Family					
Lemna sp.	duckweed	Native	---	NE	---
Lemna miniscula	least duckweed	Native	---	BS	---
Cyperaceae – Sedge Family					
Bolboschoenus fluviatilis	river bulrush	Native	---	BS	Synonym: *Scirpus fluviatilis*
Cyperus eragrostis	tall flatsedge	Native	---	NE, BS, ICF	---
Eleocharis macrostachya	creeping spikerush	Native	---	BS, ICF	---
Schoenoplectus acutus	hardstem bulrush	Native	---	BS	Synonum: *Scirpus acutus*
Iridaceae – Iris Family					
Sisyrinchium bellum	blue-eyed grass	Native	---	NE, ICF	---
Juncaginaceae – Arrowgrass Family					
Triglochin scilloides	flowering quillwort	Native	**---**	**BS, ICF**	Synonym: *Lillaea scillioides*
Juncaceae – Rush Family					
Juncus balticus subsp. *ater*	Baltic rush	Native	---	NE, BS, ICF	---
Juncus bufonius	toad rush	Native	---	BS, ICF	Infraspecific identification notprovided in previous studies.
Juncus bufonius var. *bufonius*	toad rush	Native	---	NE	---
Juncus bufonius var. *occidentalis*	western toad rush	Native	---	NE	---
Juncus mexicanus	Mexican rush	Native	---	NE	---
Juncus occidentalis	western rush	Native	---	BS	---
Juncus oxymeris	pointed rush	Native	---	BS	Not known from eastern Alameda County or San Joaquin County. Possible misidentification of *Juncus xiphioides.*
Juncus patens	spreading rush	Native	---	NE, BS, ICF	---
Juncus xiphioides	iris-leaved rush	Native	---	NE, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Liliaceae – Lily Family					
Calochortus clavatus var. *pallidus*	pale yellow mariposa	Native	---	NE, BS, ICF	---
Calochortus venustus	butterfly mariposa lily	Native	---	NE, BS, ICF	---
Fritillaria agrestis (CRPR 4.2) [d]	stinkbells	Native	---	NE, BS, ICF	---
Poaceae – Grass Family					
Alopecurus carolinianus	Carolina foxtail	Native	---	ICF	---
Alopecurus saccatus	Pacific foxtail	Native	---	BS, ICF	---
Avena barbata	slender oats	Non-Native	Moderate	NE, BS, ICF	---
Avena fatua	wild oats	Non-Native	Moderate	NE, BS, ICF	---
Brachypodium distachyon	false brome	Non-Native	Moderate	NE	---
Bromus arenarius	Australian brome	Non-Native	---	BS, ICF	---
Bromus diandrus	ripgut brome	Non-Native	Moderate	NE, BS, ICF	---
Bromus hordeaceus	soft chess	Non-Native	Limited	NE, BS, ICF	---
Bromus japonicus	Japanese chess	Non-Native	Limited	BS, ICF	---
Bromus madritensis	foxtail chess	Non-Native	---	NE, BS, ICF	Synonym: *Bromus madritensis* subsp. *madritensis*
Bromus racemosus	smooth brome	Non-Native	---	NE	---
Bromus rubens	foxtail chess	Non-Native	High	NE, BS, ICF	*Bromus madritensis* subsp. *rubens*
Bromus sitchensis var. *carinatus*	California brome	Native	---	NE, BS, ICF	---
Bromus sterilis	poverty brome	Non-Native	---	NE, BS	---
Bromus tectorum	cheat grass	Non-Native	High	BS, ICF	---
Crypsis schoenoides	swamp timothy	Non-Native	---	ICF	---
Cynodon dactylon	Bermuda grass	Non-Native	Moderate	ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Deschampsia danthonioides	annual hairgrass	Native	---	NE, BS, ICF	---
Distichlis spicata	saltgrass	Native	---	NE, BS, ICF	---
Elymus caput-medusae	Medua head	Non-Native	High	BS	Synonym: *Taeniatherum caput-medusae*
Elymus elymoides	squirreltail	Native	---	BS	---
Elymus glaucus subsp. *glaucus*	blue wildrye	Native	---	NE, BS, ICF	---
Elymus multisetus	big squirreltail	Native	---	NE, BS, ICF	---
Elymus triticoides	creeping wildrye	Native	---	NE, BS, ICF	Synonym: *Leymus triticoides*
Festuca bromoides	brome fescue	Non-Native	---	NE, ICF	Synonym: *Vulpia bromoides*
Festuca microstachys	Eastwood fescue	Native	---	NE, BS, ICF	Synonym: *Vulpia microstachys* var.*ciliata, V. m.* var. *confusa,* and *V. m.*var. *pauciflora*
Festuca myuros	foxtail fescue	Non-Native	Moderate	NE, BS, ICF	Synonym: *Vulpia myuros*
Festuca octoflora	eight-weeks fescue	Native	---	BS, ICF	Synonym: *Vulpia octoflora* var. *hirtella*
Festuca perennis	Italian ryegrass	Non-Native	Moderate	NE, BS, ICF	Synonym: *Lolium perenne, L. multiflorum*
Gastridium phleoides	nitgrass	Non-Native	---	ICF	Synonym: *Gastridium ventricosum*
Hordeum brachyantherum subsp. *brachyantherum*	meadow barley	Native	---	NE	---
Hordeum depressum	low barley	Native	---	BS, ICF	---
Hordeum marinum subsp. *gussoneanum*	Mediterranean barley	Non-Native	Moderate	NE, BS, ICF	---
Hordeum murinum subsp. *leporinum*	hare barley	Non-Native	Moderate	NE, BS, ICF	---
Koeleria gerardii	annual june grass	Non-Native	---	NE, BS, ICF	---
Koeleria macrantha	junegrass	Native	---	NE, BS, ICF	Synonym: *Koeleria phleoides*
Lamarckia aurea	goldentop	Non-Native	---	NE, BS,	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
				ICF	
Melica californica	California melic grass	Native	---	NE, BS, ICF	---
Phalaris paradoxa	paradox canary grass	Non-Native	---	ICF	---
Poa annua	annual bluegrass	Non-Native	---	BS, ICF	---
Poa bulbosa subsp. *vivipara*	bulbous bluegrass	Native	---	NE, BS, ICF	---
Poa secunda subsp. *secunda*	one-sided bluegrass	Native	---	NE, BS, ICF	---
Polypogon interruptus	ditch beard grass	Non-Native	---	BS, ICF	---
Polypogon monspeliensis	rabbitsfoot grass	Non-Native	Limited	NE, BS, ICF	---
Schismus arabicus	Arabian schismus	Non-Native	---	NE, BS, ICF	---
Schismus barbatus	common Mediterranean grass	Non-Native	Limited	ICF	Not known from Alameda County, San Joaquin County, or northern SanJoaquin Valley. Possible misidentification of *Schismusarabicus.*
Stipa cernua	nodding needlegrass	Native	---	NE, BS, ICF	Synonym: *Nasella cernua*
Stipa pulchra	purple needlegrass	Native	---	NE, BS, ICF	Synonym: *Nasella pulchra*
Potamogetonaceae – Potamogeton Family					
Potamogeton crispus	crispate-leaved pondweed	Non-Native	---	BS	---
Themidaceae – Brodiaea Family					
Brodiaea elegans subsp. *elegans*	harvest brodiaea	Native	---	NE, BS, ICF	---
Dipterostemon capitatus subsp. *capitatus*	blue dicks	Native	---	NE, BS, ICF	Synonym: *Dichelostemma capitatum* subsp. *capitatum*
Muilla maritima	common muilla	Native	---	NE	---
Triteleia hyacinthina	white hyacinth	Native	---	BS, ICF	---
Triteleia laxa	Ithuriel's spear	Native	---	NE, BS, ICF	---

Species Name[a]	Common Name	Origin	CAL-IPC Rating[b]	Reporter[c]	Notes
Typhaceae – Cattail Family					
Typha angustifolia	narrow-leaved cattail	Native	---	NE, BS, ICF	---
Typha domingensis	Cattail	Native	---	BS	---
Typha latifolia	broad-leaf cattail	Native	---	NE, BS, ICF	---

a. Nomenclature:
Nomenclature follows The Jepson Manual 2nd Ed. (Baldwin et al. 2012). Synonyms are provided where plant names used in previous studies have been superseded.

b. Cal-IPC Rating:
High, Moderate, or Limited, reflecting the level of each invasive species' negative ecological impact in California. (Cal-IPC 2006).

c. Reporter:
NE = Nomad Ecology (2021) botanical surveys performed in 2020 and 2021.
ICF = Species reported by ICF (formerly Jones & Stokes) (2000)
BS = BioSystems (BS) (1986).

d. Special Status Codes:
FE = Federally Endangered under the Federal Endangered Species Act.
SE = State Endangered under the California Endangered Species Act.
CNPS Rank:
CRPR 1B = California Rare Plant Rank 1B, species are considered rare and endangered throughout their range (CNPS 2020)
CRPR 4 = California Rare Plant Rank 4, plants of limited distribution that are not considered rare or endangered (CNPS 2020).
Ranks at each level also include a threat rank (e.g. CRPR 4.3) and are determined as follows:
0.1-Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)
0.2-Moderately threatened in California (20-80% occurrences threatened / moderate degree and immediacy of threat)
0.3-Not very threatened in California (less than 20% of occurrences threatened / low degree and immediacy of threat or no current threats known)
CBR = Considered but Rejected

Sources: BioSystems 1986a; BioSystems 1986b; Jones and Stokes 2002b; Cal-IPC 2006; Baldwin et al. 2012; CNPS 2020; Nomad Ecology 2021b.

Table I.3-9. Species Captured During 2021 Alameda Whipsnake Surveys At Site 300

Common name	Scientific Name	Individuals Captured[a]	Alive	Dead	% Mortality Within Species[b]
Snakes					
Alameda Whipsnake	*Masticophis lateralis euryxanthus*	*2*	*2*	*0*	*0*
San Joaquin Coachwhip	*Masticophis flagellum rudocki*	*1*	*1*	*0*	*0*
California Kingsnake	*Lampropeltis californiae*	*1*	*1*	*0*	*0*
Pacific Gophersnake	*Pituophis catenifer*	*6*	*6*	*0*	*0*
California Glossy Snake	*Arizona elegans occidentalis*	*3*	*3*	*0*	*0*
Western Yellow-bellied	*Coluber constrictor mormon*	*1*	*1*	*0*	*0*
Long-nosed Snake	*Rhinocheilus lecontei*	*1*	*1*	*0*	*0*
California Nightsnake	*Hypseglena ochrorhyncha*	*2*	*2*	*0*	*0*
Northern Pacific Rattlesnake	*Crotalus oreganus*	*4*	*4*	*0*	*0*
Lizards					
Coast Range Fence Lizard	*Sceloporus occidentalis bocourtii*	*9*	*9*	*0*	*0*
Western Side-blotched Lizard	*Uta stansburiana elegans*	*28*	*27*	*1*	*3.6*
Skilton's (Western) Skink	*Eumeces skiltonianus*	*3*	*3*	*0*	*0*
Variegated (Gilbert's) Skink	*Eumeces gilberti cancellosus*	*1*	*1*	*0*	*0*
California Whiptail	*Aspidoscelis tigris mundus*	*4*	*3*	*1*	*25*
Small Mammals					
Pocket Mouse	*Perognathus spp.*	*3*	*3*	*0*	*0*
Western Harvest Mouse	*Reithrodontomys megalotis*	*4*	*3*	*1*	*25*
California Meadow Vole	*Microtus californicus*	*1*	*1*	*0*	*0*

a. Does not include recaptures.
b. Mortality occurred while in the trap.
Source: LLNL 2021c.

Table I.3-10. Livermore Site Plant List

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
FERNS					
Azollaceae – Mosquito Fern Family					
Azolla filiculoides	mosquito fem	Native		JS97	
GYMNOSPERMS					
Cupressaceae – Cypress Family					
Cedrus deodora	deodar cedar	Cultivated		NE20	
Pinaceae – Pine Family					
Pinus radiata	monterey pine	Cultivated		NE20	
EUDICOTS					
Adoxaceae – Muskroot Family					
Sambucus nigra ssp. cerulea	Blue elderberry	Native		LLNL10, NE20	Synonym: *Sambucus mexicana*
Aizoaceae – Fig-marigold Family					
Carpobrotus sp.	ice-plant	Non-Native		JS02	
Anacardiaceae – Sumac or Cashew Family					
Schinus molle	Peruvian pepper tree	Cultivated	Limited	NE20	
Apiaceae – Carrot Family					
Anthriscus caucalis	Bur-chervil	Non-Native		NE20	
Foeniculum vulgare	sweet fennel	Non-Native	Moderate	JS02	
Asteraceae – Sunflower Family					
Artemisia douglasiana	mugwort	Native		JS02, LLNL10	
Baccharis pilularis subsp.	coyote brush	Native		LLNL10,	

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
consanguinea				NE20	
Baccharis salicifolius	mule fat	Native		JS97, JS02, LLNL10, NE20	
Carduus pycnocephalus	Italian thistle	Non-Native	Moderate	NE20	
Carduus tenuiflorus	Slender flowered thistle	Non-Native	Limited	NE20	
Centaurea solstitialis	yellow star-thistle	Non-Native	High	JS97, NE20	
Centromadia fitchii	Fitch's spikeweed	Native		JS97	Synonym: *Hemizonia fitchii*
Cirsium vulgare	bull thistle	Non-Native	Moderate	JS97, JS02, NE20	
Erigeron bonariensis	South American horseweed	Non-Native		JS97	Synonym: *Conyza bonariensis*
Erigeron canadensis	Canada horseweed	Native		JS97, NE20	Synonym: *Conyza canadensis*
Gnaphalium luteoalbum	weedy cudweed	Non-Native		JS97	Synonym: *Pseudognaphalium luteoalbum*
Grindelia hirsutula	common gumplant	Native		NE20	Synonym: Great Valley gumweed
Helminthotheca echioides	bristly ox-tongue	Non-Native	Limited	JS97, NE20	Synonym: *Picris echioides*
Lactuca serriola	prickly.lettuce	Non-Native		JS02, NE20	
Senecia vulgaris	common groundsel	Non-Native		JS02	
Silybum marianum	milk thistle	Non-Native	Limited	JS02, NE20	
Sonchus oleraceus	common sow-thistle	Non-Native		JS02	
Tragopogon porrifolius	salsify	Non-Native		JS02	
Xanthium strumarium	common cocklebur	Native		JS97, JS02, NE20	
Boraginaceae – Borage or Waterleaf Family					
Heliotropium curassavicum	salt heliotrope	Native		JS02, NE20	
Plagiobothrys stipitatus	stalked popcorn flower	Native		NE20	

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
Brassicaceae – Mustard Family					
Hirschfeldia incana	Mediterranean mustard	Non-Native	Moderate	JS97, JS02, NE20	
Lepidium latifolium	perennial peppercress	Non-Native	High	JS02, NE20	
Nasturtium officinale	Watercress	Native		JS97, NE20	Synonym: *Rorippa nasturtium-aquaticum*
Raphanus sativus	Wild radish	Non-Native	Limited	JS02, NE20	
Casuarinaceae – Beefwood Family					
Casuarina sp.	she-oak	Non-Native		JS97, NE20	
Chenopodiaceae – Goosefoot Family					
Atriplex prostrata	fat-hen	Non-Native		JS97	Synonym: *Atriplex triangularis*
Atriplex semibaccata	Australian saltbush	Non-Native		JS97	
Salsola tragus	Russian thistle	Non-Native	Limited	NE20	
Convolvulaceae – Morning Glory Family					
Convolvulus arvensis	bindweed	Non-Native		JS97	
Euphorbiaceae – Spurge Family					
Croton setiger	turkey mullein	Native		JS97	Synonym: *Eremocarpus setigerus*
Euphorbia spathulata	warty spurge	Native		JS02	
Fabaceae – Pea Family					
Lotus corniculatus	bird's-foot trefoil	Non-Native		JS97, NE20	
Medicago polymorpha	burclover	Non-Native	Limited	JS97, NE20	
Melilotus indica	sourclover	Non-Native		JS97, NE20	
Robinia pseudoacacia	black locust	Non-Native	Limited	NE20	
Trifolium hirtum	rose clover	Non-Native		NE20	

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
Vicia sativa	common vetch	Non-Native		NE20	
Vicia villosa	winter vetch	Non-Native		JS97	
Fagaceae – Oak Family					
Quercus agrifolia	coast live oak	Native		LLNL10, NE20	
Quercus coccinea	scarlet oak	Cultivated		NE20	
Quercus douglasii	blue oak	Native		LLNL10	
Quercus lobata	valley oak	Native		LLNL10	
Geraniaceae – Geranium Family					
Erodium botrys	long-beaked filaree	Non-Native		NE20	
Erodium cicutarium	red-stemmed filaree	Non-Native	Limited	NE20	
Erodium moschatum	white-stemmed filaree	Non-Native		NE20	
Geranium dissectum	cut-leaf geranium	Non-Native		JS02, NE20	
Juglandaceae – Walnut Family					
Juglans sp.	black walnut	(unknown)		JS02	
Lamiaceae – Mint Family					
Marrubium vulgare	horehound	Non-Native	Limited	JS02, NE20	
Salvia mellifera	black sage	Native		LLNL10	
Lythraceae – Loosestrife Family					
Lythrum hyssopifolium	hyssop loosestrife	Non-Native	Moderate	JS97, NE20	
Malvaceae – Mallow Family					
Malva sp.	cheeseweed			JS02	
Oleaceae – Olive Family					
Ligustrum lucidum	glossy privet	Cultivated	Limited	JS02, NE20	

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
Onagraceae – Evening Primrose Family					
Epilobium brachycarpum	tall-annual willow-herb	Native		JS97, JS02, NE20	
Epilobium canum	California fuschia	Native		JS02	
Epilobium ciliatum	hairy willow-herb	Native		JS97, JS02, NE20	
Oenothera biennis	common evening-primrose	Non-Native		JS97, NE20	
Oxalidaceae– Wood Sorrel Family					
Oxalis corniculata	creeping wood sorrel	Non-Native		JS02	
Papaveraceae – Poppy Family					
Eschscholzia californica	California poppy	Native		JS97, JS02, NE20	
Phrymaceae – Lopseed Family					
Diplacus aurantiacus	sticky monkeyflower	Native		LLNL10	Synonym: *Mimulus aurantiacus*
Plantaginaceae – Plantain Family					
Plantago lanceolata	English plantain	Non-Native	Limited	JS97, JS02, NE20	
Veronica anagallis-aquatica	water speedwell	Non-Native		JS97	
Platanaceae – Sycamore Family					
Platanus X acerifolia	London plane tree	Cultivated		NE20	
Platanus racemosa	California sycamore	Native		LLNL10	
Polygonaceae – Buckwheat Family					
Eriogonum fasciculatum	California buckwheat	Native		LLNL10	
Persicaria maculosa	lady's thumb	Non-Native		JS97	Synonym: *Polygonum persicaria*
Rumex conglomeratus	whorled dock	Non-Native		JS97	

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
Rumex crispus	curly dock	Non-Native	Limited	JS97, JS02, NE20	
Rumex californicus	willow dock	Native		JS02	Synonym: *Rumex salicifolius* var. *denticulatus*
Ranunculaceae – Buttercup Family					
Ranunculus sceleratus	celery-leaved buttercup	Native		JS97	
Rosaceae – Rose Family					
Heteromeles arbutifolia	toyon	Native		LLNL10	
Prunus dulcis	almond	Cultivated		JS02	
Pyracantha sp	firethorn	Cultivated		JS02	
Rosa californica	California rose	Native		LLNL10	
Rubus ursinus	California blackberry	Native		LLNL10	
Salicaceae – Willow Family					
Populus fremontii	Fremont cottonwood	Native		JS97, LLNL10, NE20	
Salix exigua	narrow-leaved willow	Native		JS97, NE20	
Salix gooddingii	black willow	Native		JS97, NE20	
Salix laevigata	red willow	Native		JS97, NE20	
Salix lasiolepis	arroyo willow	Native		JS97, JS02, NE20	
Sapindaceae – Soapberry Family					
Aesculus californica	California buckeye	Native		JS02	
Solanaceae – Nightshade Family					
Nicotiana glauca	Tree tobacco	Non-Native		JS02	
Urticaceae – Nettle Family					

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
Urtica dioica subsp. holosericea	Hoary nettle	Native		JS02, NE20	
Vitaceae – Grape Family					
Vitis vinifera	Cultivated grape	Non-Native		JS02	
MONOCOTS					
Cyperaceae – Sedge Family					
Bolboschoenus robustus	Alkali bulrush	Native		JS97	Synonym: *Scirpus robustus*
Cyperus eragrostis	Tall flatsedge	Native		JS97, JS02, NE20	
Schoenoplectus californicus	California bullrush	Native		NE20	
Juncaceae – Rush Family					
Juncus balticus	Baltic rush	Native		LLNL10	
Juncus xiphioides	Iris-leaved rush	Native		NE20	
Poaceae – Grass Family					
Avena barbata	Slender wild oats	Non-Native		NE20	
Avena fatua	Wild oats	Non-Native	Moderate	JS97, JS02	
Bromus diandrus	Ripgut brome	Non-Native	Moderate	JS97, JS02, NE20	
Bromus hordeaceus	Soft chess	Non-Native	Limited	NE20	
Bromus madritensis	Foxtail brome	Non-Native		NE20	
Bromus racemosus	Smooth brome	Non-Native		NE20	
Bromus sitchensis	Rescue brome	Native		JS02	Synonym: *Bromus catharticus*
Crypsis schoenoides	Swamp timothy	Non-Native		JS97	
Cynodon dactylon	Bermuda grass	Non-Native	Moderate	JS97, JS02, NE20	
Distichlis spicata	Saltgrass	Native		JS97, NE20	

Species Name [a]	Common Name	Origin	CAL-IPC Rating [b]	Reporter [c]	Notes
Echinochloa crus-gallii	Barnyard grass	Non-Native		JS97	
Elymus triticoides	Creeping wildrye	Native		JS02, NE20	Synonym: *Leymus triticoides*
Festuca bromoides	Brome fescus	Non-Native		NE20	
Festuca perennis	Perennial rye-grass	Non-Native	Moderate	JS97, JS02, NE20	Synonym: *Lolium multiflorum*
Hordeum marinum subsp. gussoneanum	Mediterranean barley	Non-Native	Moderate	NE20	
Hordeum murinum subsp. leporinum	hare barley	Non-Native	Moderate	JS02, NE20	
Leptochloa fascicularis	bearded sprangletop	Native		JS97	Synonym: *Leptochloa fusca*
Panicum capillare	witchgrass	Native		JS02	
Paspalum dilatatum	dallisgrass	Non-Native		JS02, NE20	
Phalaris aquatica	Harding grass	Non-Native	Moderate	JS97, NE20	
Polypogon monspeliensis	annual rabbit's-foot grass	Non-Native	Limited	JS97, JS02, NE20	
Stipa miliacea	smilo grass	Non-Native	Limited	JS02	Synonym: *Piptatherum miliaceum*
Typhaceae – Cattail Family					
Typha angustifolia	narrow-leaved cattail	Native		JS97, NE20	
Typha latifolia	broad-leaved cattail	Native		JS97, NE20	

a Nomenclature:
Nomenclature follows The Jepson Manual 2nd Ed. (Baldwin et al. 2012). Synonyms are provided where plant names used in previous studies have been superseded.

b Cal-IPC Rating:
High, Moderate, or Limited, reflecting the level of each invasive species' negative ecological impact in California. (Cal-IPC 2006).

c Reporter:
JS97 = Jones and Stokes 1997
LLNL10 = Lawrence Livermore National Laboratory 2010
NE20 = Nomad Ecology 2020

d Status:
No special status plants have been observed at the Livermore Site.

Table I.3-11. Amphibians and Reptile Species Observed at the Livermore Site and Site 300 in 1986, 1991, and 2001 Surveys

Scientific Name	Common Name	Livermore Site	Site 300	Status
Ambystoma californiense	California tiger salamander	-	X	FT, ST
Batrachoseps attenuatus	California slender salamander	-	X	None
Anaxyrus boreas	California toad	X	X	None
Pseudacris sierra	Sierran treefrog	X	X	None
Rana draytonii	California red-legged frog	X	X	FT, CDFW:SSC
Lithobates catesbeianus	American bullfrog	X	-	None
Sceloporus occidentalis	Western fence lizard	X	X	None
Sceloporus graciosus	Sagebrush lizard	-	X	None
Uta stansburiana	Side-blotched lizard	-	X	None
Phrynosoma coronatum frontale	California horned lizard	-	X	None
Eumeces skiltonianus	Western skink	-	X	None
Eumeces gilberti	Gilbert's skink	-	X	None
Aspidoscelis tigris	Western whiptail	-	X	None
Elgaria coerulea	Northern alligator lizard	-	X	None
Coluber constrictor	Racer	-	X	None
Coluber constrictor mormon	Western yellow-bellied racer	X	-	None
Masticophis lateralis euryxanthus	Alameda whipsnake	-	X	FT, ST
Masticophis lateralis	California whipsnake	-	X	None
Masticophis flagellum ruddocki	San Joaquin whipsnake	-	X	CDFW:SSC
Anniella pulchra	Northern legless lizard	-	X	None
Tantilla planiceps	Western black-headed snake	-	X	None
Pituophis catenifer	Gopher snake	X	X	None
Lampropeltis getula	Common king snake	-	X	None
Thamnophis sirtalis	Common garter snake	-	X	None
Arizona elegans	Glossy snake	-	X	CDFW:SSC
Rhinocheilus lecontei	Long-nosed snake	-	X	None
Crotalus viridis	Western rattlesnake	-	X	None

Special Status Codes: CDFW:SSC = California Department of Fish and Wildlife-Species of Special Concern (CDFW Special Animals List, January 2022); FT = Threatened under the Federal Endangered Species Act; ST = Threatened under the California Endangered Species Act
-: Species not observed at the Livermore Site or Site 300.
Source: NNSA 2005, Appendix E – Ecology and Biological Assessment; CNDDB 2022a.

Table I.3-12. Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys

Species		Livermore Site	Site 300	Status[a]
Scientific Name	Common Name			
Bucephala clangula	Common goldeneye	X	X	MBTA
Bucephala albeola[a]	Bufflehead	X	X	MBTA
Branta canadensis	Canada goose	X	-	MBTA
Anas platyrhynchos	Mallard	X	X	MBTA
Anas clypeata[a]	Northern shoveller	-	X	MBTA
Anas cyanoptera[a]	Cinnamon teal	-	X	MBTA
Aythya collaris	Ring-necked duck	X	-	MBTA
Sterna forsteri	Forster's tern	X	-	BCC, MBTA
Rallus limicola[b]	Virginia rail	-	X	MBTA

Species		Livermore Site	Site 300	Status[a]
Scientific Name	Common Name			
Ardea herodias	Great blue heron	X	-	MBTA
Ardea alba[a]	Great egret	X	X	MBTA
Egretta thula	Snowy egret	X	-	MBTA
Butorides virescens[b]	Green heron	X	X	MBTA
Nycticorax nycticorax	Black-crowned night-heron	X	X	MBTA
Phalacrocorax auritus[a]	Double-crested cormorant	X	X	MBTA
Podilymbus podiceps[a]	Pied-billed grebe	X	X	MBTA
Gallinago gallinago[a]	Common snipe	X	X	MBTA
Tringa meanoleuca[a]	Greater yellowlegs	X	X	MBTA
Cathartes aura	Turkey vulture	X	X	MBTA
Elanus leucurus[a]	White-tailed kite	X	X	CDFW:FP, MBTA
Circus cyaneus	Northern harrier	-	X	CDFW:SSC, BCC, MBTA
Buteo jamaicensis	Red-tailed hawk	X	X	MBTA
Buteo lagopus[a]	Rough-legged hawk	-	X	MBTA
Buteo lineatus[a]	Red-shouldered hawk	X	X	MBTA
Buteo regalis	Ferruginous hawk	-	X	MBTA
Buteo swainsoni	Swainson's hawk	-	X	CT, MBTA
Accipiter cooperii	Cooper's hawk	X	X	MBTA
Accipiter striatus	Sharp-shinned hawk	X	X	MBTA
Aquila chrysaetos	Golden eagle	X	X	CDFW:FP, BGEPA, MBTA
Pandion haliaetus	Osprey	X	X	MBTA
Fulica americana	Coot	X		MBTA
Falco sparverius	American kestrel	X	X	MBTA
Falco mexicanus	Prairie falcon	-	X	MBTA
Callipepla californica	California quail	-	X	None
Charadrius vociferus	Killdeer	X	X	MBTA
Columba livia	Rock dove	X	X	None
Zenaida macroura	Mourning dove	X	X	MBTA
Geococcyx californianus	Greater roadrunner	-	X	MBTA
Tyto alba	Barn owl	X	X	MBTA
Bubo virginianus	Great horned owl	-	X	MBTA
Athene cunicularia[c]	Burrowing owl	X	X	MBTA, CDFW:SSC, BCC
Asio flammeus	Short-eared owl	-	X	MBTA, CDFW:SSC, BCC
Megascops kennicottii[a]	Western screech owl	-	X	MBTA
Chordeiles minor	Common nighthawk	-	X	MBTA
Aeronautes saxatalis	White-throated swift	X	X	MBTA
Calypte anna	Anna's hummingbird	X	X	MBTA
Calypte costae	Costa's hummingbird	-	X	MBTA
Selasphorus rufus	Rufous hummingbird	-	X	MBTA
Selasphorus sasin	Allen's hummingbird	-	X	MBTA, BCC
Melanerpes formicivorus	Acorn woodpecker	X	X	MBTA

Species		Livermore Site	Site 300	Status[a]
Scientific Name	Common Name			
Colaptes auratus	Northern flicker	X	X	MBTA
Dryobates nuttallii	Nutall’s woodpecker	X	X	BCC, MBTA
Tyrannus verticalis	Western kingbird	X	X	MBTA
Tyrannus vociferans[a]	Cassin’s kingbird	-	X	MBTA
Myiarchus cinerascens	Ash-throated flycatcher	-	X	MBTA
Contopus sordidulus	Western wood-pewee	X	X	MBTA
Empidonax difficilis	Pacific-slope flycatcher	-	X	MBTA
Empidonax traillii[d]	Willow flycatcher	-	X	SE, MBTA
Sayornis nigricans	Black phoebe	X	X	MBTA
Sayornis saya	Say's phoebe	X	X	MBTA
Eremophila alpestris	Horned lark		X	MBTA
Petrochelidon pyrrhonota	Cliff swallow	X	X	MBTA
Hirundo rustica[b]	Barn swallow	X	X	MBTA
Stelgidopterxyx serripennis[a]	Northern rough winged swallow	X	X	MBTA
Tachycineta bicolor[a]	Tree swallow	-	X	MBTA
Aphelocoma californica	Western scrub jay	X	X	MBTA
Corvus brachyrhynchos	American crow	X	X	MBTA
Corvus corax	Common raven	X	X	MBTA
Baeolophus inornatus	Plain titmouse	X	X	None
Poecile rufescens	Chestnut-backed chickadee	X	-	MBTA
Sitta carolinensis	White-breasted nuthatch	X	-	MBTA
Salpinctes obsoletus	Rock wren	-	X	MBTA
Thryomanes bewickii[a]	Bewick’s wren	X	X	MBTA
Troglodytes aedon[a]	House wren	-	X	MBTA
Turdus migratorius	American robin	X	X	MBTA
Catharus guttatus	Hermit thrush	-	X	MBTA
Catharus ustulatus[a]	Swainson’s thrush	-	X	MBTA
Ixoreus naevius[a]	Varied thrush	-	X	MBTA
Sialia currucoides[a]	Mountain bluebird	-	X	MBTA
Sialia mexicana[a]	Western bluebird	-	X	MBTA
Mimus polyglottos	Northern mockingbird	X	X	MBTA
Toxostoma redivivum	California thrasher	-	X	BCC, MBTA
Anthus rubescens	American pipit	-	X	MBTA
Himantopus mexicanus	Black-necked stilt	X	-	MBTA
Lanius ludovicianus	Loggerhead shrike	X	X	CDFW:SSC, MBTA
Sturnus vulgaris	European starling	X	X	None
Vireo huttoni	Hutton's vireo	-	X	MBTA
Setophaga petechia	Yellow warbler	-	X	CDFW:SSC, MBTA
Setophaga coronata	Yellow-rumped warbler	X	X	MBTA
Setophaga nigrescens[a]	Black-throated gray warbler	-	X	MBTA
Geothlypis trichas[a]	Common yellowthroat	-	X	MBTA
Geothlypis tolmiei	MacGillivray's warbler	-	X	MBTA
Leiothlypis celata	Orange-crowned warbler	-	X	MBTA
Cardellina pusilla	Wilson's warbler	-	X	MBTA

Species		Livermore Site	Site 300	Status[a]
Scientific Name	**Common Name**			
Piranga ludoviciana	Western tanager	-	X	MBTA
Passerina caerulea[a]	Blue-grosbeak	-	X	MBTA
Passerina amoena	Lazuli bunting	-	X	MBTA
Pheucticus melanocephalus	Black-headed grosbeak	-	X	MBTA
Melozone crissalis	California towhee	-	X	MBTA
Artemisiospiza belli belli[a]	Bell's sage sparrow	-	X	None
Amphispiza bilineata[a]	Black-throated sparrow	-	X	MBTA
Aimophila ruficeps	Rufous-crowned sparrow	-	X	MBTA
Pooecetes gramineus	Vesper sparrow	-	X	MBTA
Chondestes grammacus	Lark sparrow	-	X	MBTA
Passerculus sandwichensis	Savannah sparrow	-	X	MBTA
Passerella iliaca	Fox sparrow	-	X	MBTA
Ammodramus savannarum[a]	Grasshopper sparrow	-	X	CDFW:SSC, MBTA
Junco hyemalis[a]	Oregon junco	X	X	MBTA
Melospiza lincolnii	Lincoln's sparrow	-	X	MBTA
Melospiza melodia	Song sparrow	X	X	CDFW:SSC, MBTA
Zonotrichia atricapilla	Golden-crowned sparrow	X	X	MBTA
Zonotrichia leucophrys	White-crowned sparrow	X	X	MBTA
Agelaius phoeniceus	Red-winged blackbird	X	X	MBTA
Agelaius tricolor	Tricolored blackbird	-	X	CDFW:SSC, ST, BCC, MBTA
Sturnella neglecta	Western meadowlark	X	X	MBTA
Euphagus cyanocephalus	Brewer's blackbird	X	X	MBTA
Molothrus ater	Brown-headed cowbird	X	X	MBTA
Icterus bullockii	Bullock's oriole	-	X	BCC, MBTA
Icterus galbulab	Northern oriole	X	X	None
Haemorhous mexicanus	House finch	X	X	MBTA
Spinus psaltria	Lesser goldfinch	-	X	MBTA
Spinus tristis	American goldfinch	X	X	MBTA
Passer domesticus[b]	House sparrow	X	X	None
Psaltriparus minimus[a]	Bushtit	X	X	MBTA
Bombycilla cedrorum[a]	Cedar waxwing	X	X	MBTA
Phalaenoptilus nuttallii[a]	Common poorwill	-	X	MBTA
Baeolphus inornatus[a]	Oak titmouse	-	X	BCC, MBTA
Meleagris gallopavo[a]	Wild turkey	-	X	None
Phainopepla nitens	Phainopepla	-	X	MBTA
Megaceryle alcyon	Belted kingfisher	X	-	MBTA
Regulus calendula	Ruby-crowned kinglet	X	X	MBTA

Special Status Codes: BCC = USFWS Bird of Conservation Concern (USFWS 2021 BCC lists); BGEPA = Protected under the *Bald and Golden Eagle Protection Act*; CDFW:SSC = California Department of Fish and Wildlife-Species of Special Concern (CDFW Special Animals List, January 2022); MBTA = Protected under the *Migratory Bird Treaty Act*; ST = Threatened under the California Endangered Species Act

a. Not recorded in 2002 survey at Site 300 or found in related documentation.
b. New record in 2002 survey or related documentation.
c. The burrowing owl was observed at the Livermore Site from 1994 through 1998.
d. The willow flycatcher was observed at the Livermore Site from 1994 through 1998.
-: Species not observed at the Livermore Site or Site 300.
Source: NNSA 2005, Appendix E – Ecology and Biological Assessment; CNDDB 2022a, USFWS 2020, USFWS 2021.

Table I.3-13. Federally and State-Listed Threatened, Endangered, and Other Special Status Animal Species with Potential to Occur at the Livermore Site in 2001 and 2002

Species		Status	
Common Name	**Scientific Name**	**Federal**	**State**
Mammals			
American badger	*Taxidea taxus*	None	CDFW:SSC
Amphibians			
California red-legged frog	*Rana draytonii*	FT	CDFW:SSC
Birds			
Cooper's hawk	*Accipiter cooperii*	MBTA	None
Golden eagle	*Aquila chrysaetos*	BGEPA, MBTA	CDFW:FP
Red-tailed hawk	*Buteo jamaicensis*	MBTA	None
Red-shouldered hawk	*Buteo lineatus*	MBTA	None
White-tailed Kite	*Elanus leucurus*	MBTA	CDFW:FP
Bushtit	*Psaltriparus minimus*	MBTA	None
Mallard	*Anas platyrhynchos*	MBTA	None
Bufflehead	*Bucephala albeola*	MBTA	None
Great egret	*Ardea alba*	MBTA	None
Cedar waxwing	*Bombycilla cedrorum*	MBTA	None
Turkey vulture	*Cathartes aura*	MBTA	None
Killdeer	*Charadrius vociferus*	MBTA	None
Mourning dove	*Zenaida macroura*	MBTA	None
California (Western) Scrub-Jay	*Aphelocoma californica*	MBTA	None
American crow	*Corvus brachyrhynchos*	MBTA	None
Common raven	*Corvus corax*	MBTA	None
Dark-eyed junco	*Junco hyemalis*	MBTA	None
Song sparrow	*Melospiza melodia*	CDFW:SSC, MBTA	None
Golden-crowned sparrow	*Zonotrichia atricapilla*	MBTA	None
White-crowned sparrow	*Zonotrichia leucophrys*	MBTA	None
American kestrel	*Falco sparverius*	MBTA	None
House finch	*Haemorhous mexicanus*	MBTA	None
Lesser goldfinch	*Spinus psaltria*	MBTA	None
Cliff swallow	*Petrochelidon pyrrhonota*	MBTA	None
Northern rough winged swallow	*Stelgidopteryx serripennis*	MBTA	None
Red-winged blackbird	*Agelaius phoeniceus*	MBTA	None
Brewer's blackbird	*Euphagus cyanocephalus*	MBTA	None
Brown-headed cowbird	*Molothrus ater*	MBTA	None
Western meadowlark	*Sturnella neglecta*	MBTA	None

Species		Status	
Common Name	**Scientific Name**	**Federal**	**State**
Loggerhead shrike	*Lanius ludovicianus*	MBTA	CDFW:SSC
Northern mockingbird	*Mimus polyglottos*	MBTA	None
Yellow-rumped warbler	*Setophagacoronata*	MBTA	None
Nuttall's woodpecker	*Dryobates nuttallii*	BCC, MBTA	None
Pied-billed grebe	*Podilymbus podiceps*	MBTA	None
Ruby-crowned kinglet	*Regulus calendula*	MBTA	None
Common snipe	*Gallinago gallinago*	MBTA	None
Greater yellowlegs	*Tringa melanoleuca*	MBTA	None
Burrowing owl[a]	*Athene cunicularia*	BCC, MBTA	CDFW:SSC
Anna's hummingbird	*Calypte anna*	MBTA	None
Rufous hummingbird	*Selasphorus rufus*	MBTA	None
Bewick's wren	*Thryomanes bewickii*	MBTA	None
American robin	*Turdus migratorius*	MBTA	None
Say's phoebe	*Sayornis saya*	MBTA	None

a The burrowing owl was observed at the Livermore Site prior to 1998.

Special Status Codes:

BCC = USFWS Bird of Conservation Concern (USFWS 2021 BCC lists)
BGEPA = Protected under the *Bald and Golden Eagle Protection Act*
CDFW:FP = California Department of Fish and Wildlife Fully Protected Species (2022 CDFW special animals list)
CDFW:SSC = California Species of Special Concern (2022 CDFW special animals list)
FT = Threatened under the Federal Endangered Species Act
MBTA = Protected under the *Migratory Bird Treaty Act*

Sources: Jones and Stokes 2001, CDFG 2002a, CDFG 2002b, LLNL 2003ab, LLNL 2003by, LLNL 2003ac. Appendix E, LLNL 2005 SWEIS, CNDDB 2022a, USFWS 2020, USFWS 2021.

Table I.3-14. Mammal Species Observed at the Livermore Site in 1986 and 2002 Surveys

Species	
Scientific Name	**Common Name**
Didelphis virginiana	Virginia opossum
Sylvilagus audubonii	Desert cottontail
Lepus californicus	Black-tailed hare
Ostospermophilus beecheyi	California ground squirrel
Microtus californicus	California vole
Mus musculus	House mouse
Canis latrans	Coyote
Vulpes vulpes	Red fox
Urocyon cinereoargenteus	Gray fox
Procyon lotor	Raccoon
Mephitis mephitis	Striped skunk
Felis catus	Feral house cat
Taxidea taxus	American badger
Puma concolor	Mountain lion

Sources: LLNL 1992a, LLNL 2003bh, CSUS 2003, Jones and Stokes 2003, NNSA 2005, Appendix E – Ecology and Biological Assessment.

Table I.3-15. Site 300 Wildlife Species List

(*Includes species for which there are verified observations; it is not intended to be a complete list of Site 300 species*)

Common Name	Scientific Name	Status	Source[a]
Invertebrates			
Valley ElderberryLonghorn Beetle	*Desmocerus californicus dimorphus*	FT	2002a
California linderiella	*Linderiella occidentalis*	None	2016a, 2010, 2002d
California Clam Shrimp	*Cyzicus californicus*	None	2002d
Amphibians			
California Tiger Salamander	*Ambystoma californiense*	FT, ST	2021e, 2002g
California Newt	*Taricha torosa*	None	2005b
California Slender Salamander	*Batrachoseps attenuatus*	None	2008
Arboreal Salamander	*Aneides lugubris*	None	2005b
Western Spadefoot	*Spea hammondii*	CDFW:SSC	2021e, 2002g
California Toad	*Anaxyrus boreas*	None	2021e, 2002g
Sierran Treefrog	*Pseudacris sierra*	None	2021e, 2002g
California Red-legged Frog	*Rana draytonii*	FT, CDFW:SSC	2021e, 2002g
Reptiles			
Western Pond Turtle	*Actinemys marmorata*	CDFW:SSC	2005b
Skilton's (Western) Skink	*Eumeces skiltonianus*	None	2021a, 2021f, 2002c, 2002g
Variegated (Gilbert's) Skink	*Eumeces gilberti cancellosus*	None	2021a, 2021f, 2002c, 2002g
California Whiptail	*Aspidoscelis tigris mundus*	None	2021a, 2021f, 2002c, 2002g
California (Southern) Alligator Lizard	*Elgaria multicarinata*	None	2021a, 2002c, 2002g
San Francisco (Northern) Alligator Lizard	*Elgaria coerulea coerulea*	None	2021a
California Legless Lizard	*Anniella pulchra*	CDFW:SSC	2021a, 2002c
Blainville's (Coast) Horned Lizard	*Phrynosoma blainvillii*	CDFW:SSC	2021a, 2021e, 2002c
Common Side- blotched Lizard	*Uta stansburiana*	None	2021a, 2021f, 2002c, 2002g
Coast Range Fence Lizard	*Sceloporus occidentalis bocourtii*	None	2021a, 2021f, 2002c, 2002g
California Kingsnake	*Lampropeltis californiae*	None	2021f, 2002c, 2002g
Long-nosed Snake	*Rhinocheilus lecontei*	None	2021f, 2002c, 2002g
Western Black- headed Snake	*Tantilla planiceps*	None	2002c
California Glossy Snake	*Arizona elegans occidentalis*	CDFW:SSC	2021a, 2021f, 2002c, 2002g
Pacific Gophersnake	*Pituophis catenifer*	None	2021a, 2021f, 2002c, 2002g
Western Yellow-bellied Racer	*Coluber constrictor mormon*	None	2021f, 2002c, 2002g
San Joaquin Coachwhip	*Masticophis flagellum ruddocki*	CDFW:SSC	2021a, 2021f, 2002g

Common Name	Scientific Name	Status	Source[a]
Alameda Whipsnake	*Masticophis lateralis euryxanthus*	FT, ST	2021a, 2021f, 2002c
California Nightsnake	*Hypsiglena ochrorhyncha nuchalata*	None	2021a, 2021f, 2002c, 2002g
Pacific Ring-necked Snake	*Diadophis punctatus amabilis*	None	2020c, 2005b
Northern Pacific Rattlesnake	*Crotalus oreganus*	None	2021a, 2021f, 2002c, 2002g
Birds			
Pied-billed Grebe	*Podilymbus podiceps*	MBTA	2003a
Great Egret	*Ardea alba*	MBTA	2021g, 2003a
American White Pelican	*Pelecanus erythrorhynchos*	MBTA, CDFW:SSC	2016
Double-crested Cormorant	*Phalacrocorax auritus*	MBTA	2003a
Red-shouldered Hawk	*Buteo lineatus*	MBTA	2020a, 2016, 2003a
Golden Eagle	*Aquila chrysaetos*	MBTA, BGEPA, CDFW:FP	2021g, 2016, 2003a
Rough-legged Hawk	*Buteo lagopus*	MBTA	2016, 2003a
Ferruginous Hawk	*Buteo regalis*	MBTA	2020a, 2016, 2003a
Red-tailed Hawk	*Buteo jamaicensis*	MBTA	2021e, 2016, 2003a
Swainson's Hawk	*Buteo swainsoni*	MBTA, ST	2016, 2003a
White-tailed Kite	*Elanus leucurus*	MBTA,CDFW:FP	2003a
Cooper's Hawk	*Accipiter cooperii*	MBTA	2020a, 2016, 2003a
Sharp-shinned Hawk	*Accipiter striatus*	MBTA	2016, 2003a
Northern Harrier	*Circus cyaneus*	MBTA, CDFW:SSC, BCC	2021g, 2016, 2003a
Turkey Vulture	*Cathartes aura*	MBTA	2021g, 2016, 2003a
Osprey	*Pandion haliaetus*	MBTA	2016, 2003a
Bufflehead	*Bucephala albeola*	MBTA	2021g, 2003a
Common Goldeneye	*Bucephala clangula*	MBTA	2003a
Mallard	*Anas platyrhynchos*	MBTA	2021g, 2016, 2003a
Northern Shoveler	*Anas clypeata*	MBTA	2003a
Cinnamon Teal	*Anas cyanoptera*	MBTA	2021g, 2003a
Prairie Falcon	*Falco mexicanus*	MBTA	2020b, 2016, 2003a
American Peregrine Falcon	*Falco peregrinus anatum*	MBTA, CDFW:FP	2016
Merlin	*Falco columbarius*	MBTA	2011
American Kestrel	*Falco sparverius*	MBTA	2021g, 2016, 2003a
Wild Turkey	*Meleagris gallopavo*	None	2003a
California Quail	*Callipepla californica*	None	2021g, 2003a

Common Name	Scientific Name	Status	Source[a]
Virginia Rail	*Rallus limicola*	MBTA	1992
Sora	*Porzana carolina*	MBTA	2009
Killdeer	*Charadrius vociferus*	MBTA	2020a, 2003a
American Avocet	*Recurvirostra americana*	MBTA	2002f
Greater Yellowlegs	*Tringa melanoleuca*	MBTA	2003a
Wilson’s Snipe	*Gallinago delicata*	MBTA	2003a
Long-billed curlew	*Numenius americanus*	MBTA, CDFW:SSC	2014
Western Gull	*Larus occidentalis*	MBTA	2016
Mourning Dove	*Zenaida macroura*	MBTA	2021g, 2016, 2003a
Rock Pigeon	*Columba livia*	None	2016, 1992
Eurasian Collared-dove	*Streptopelia decaocto*	None	2021g, Woollett 2017
Greater Roadrunner	*Geococcyx californianus*	MBTA	2021g, 2003a
Barn Owl	*Tyto alba*	MBTA	2021e, 2003a
Short-eared Owl	*Asio flammeus*	MBTA, CDFW:SSC, BCC	2003a
Great Horned Owl	*Bubo virginianus*	MBTA	2021e, 2003a
Long-eared Owl	*Asio otus*	MBTA, CDFW:SSC, BCC	2003a
Burrowing Owl	*Athene cunicularia*	MBTA, CDFW:SSC, BCC	2021e, 2016, 2003a
Western Screech-Owl	*Megascops kennicottii*	MBTA	2003a
Common Poorwill	*Phalaenoptilus nuttallii*	MBTA	2003a
White-throated Swift	*Aeronautes saxatalis*	MBTA	2016, 2003a
Allen’s Hummingbird	*Selasphorus sasin*	MBTA, BCC	1992
Rufous Hummingbird	*Selasphorus rufus*	MBTA	2003a
Costa’s Hummingbird	*Calypte costae*	MBTA	2003a
Anna’s Hummingbird	*Calypte anna*	MBTA	2021g, 2016, 2003a
Lewis’s Woodpecker	*Melanerpes lewis*	MBTA	2018
Northern Flicker	*Colaptes auratus*	MBTA	2016, 2003a
Nuttall’s Woodpecker	*Dryobates nuttallii*	MBTA, BCC	2003a
Acorn Woodpecker	*Melanerpes formicivorus*	MBTA	1992
Ash-throated Flycatcher	*Myiarchus cinerascens*	MBTA	2003a
Cassin’s Kingbird	*Tyrannus vociferans*	MBTA	2003a
Western Kingbird	*Tyrannus verticalis*	MBTA	2016, 2003a

Common Name	Scientific Name	Status	Source[a]
Western Wood-pewee	*Contopus sordidulus*	MBTA	1992
Willow Flycatcher	*Empidonax traillii*	SE, MBTA	2005a
Say's Phoebe	*Sayornis saya*	MBTA	2020a, 2016, 2003a
Pacific-slope Flycatcher	*Empidonax difficilis*	MBTA	2003a
Black Phoebe	*Sayornis nigricans*	MBTA	2021g, 2016, 2003a
Loggerhead Shrike	*Lanius ludovicianus*	MBTA, CDFW:SSC	2020a, 2016, 2003a
California (Western) Scrub-Jay	*Aphelocoma californica*	MBTA	2021g, 2003a
Common Raven	*Corvus corax*	MBTA	2021e, 2016, 2003a
American Crow	*Corvus brachyrhynchos*	MBTA	2021g, 2003a
California Horned Lark	*Eremophila alpestris actia*	MBTA	2021g, 2016, 2003a
Tree Swallow	*Tachycineta bicolor*	MBTA	2003a
Cliff Swallow	*Petrochelidon pyrrhonota*	MBTA	2021g, 2016, 2003a
Barn Swallow	*Hirundo rustica*	MBTA	2016
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	MBTA	2016, 2003a
Oak Titmouse	*Baeolophus inornatus*	MBTA, BCC	2003a
Bushtit	*Psaltriparus minimus*	MBTA	2003a
House Wren	*Troglodytes aedon*	MBTA	2016, 2003a
Rock Wren	*Salpinctes obsoletus*	MBTA	2003a
Bewick's Wren	*Thryomanes bewickii*	MBTA	2003a
Ruby-crowned Kinglet	*Regulus calendula*	MBTA	2020a, 2003a
Blue-gray Gnatcatcher	*Polioptila caerulea*	MBTA	2019
Hermit Thrush	*Catharus guttatus*	MBTA	2003a
Western Bluebird	*Sialia mexicana*	MBTA	2021g, 2003a
Varied Thrush	*Ixoreus naevius*	MBTA	2003a
American Robin	*Turdus migratorius*	MBTA	2021g, 2003a
Swainson's Thrush	*Catharus ustulatus*	MBTA	2003a
Mountain Bluebird	*Sialia currucoides*	MBTA	2021g, 2003a
California Thrasher	*Toxostoma redivivum*	MBTA, BCC	2021g, 2003a
Northern Mockingbird	*Mimus polyglottos*	MBTA	2021g, 2003a
European Starling	*Sturnus vulgaris*	None	2021g, 2016, 2003a
Cedar Waxwing	*Bombycilla cedrorum*	MBTA	2021g, 2003a
Phainopepla	*Phainopepla nitens*	MBTA	2003a

Common Name	Scientific Name	Status	Source[a]
MacGillivray's Warbler	*Geothlypis tolmiei*	MBTA	2003a
Common Yellowthroat	*Geothlypis trichas*	MBTA	2021g, 2003a
Wilson's Warbler	*Cardellina pusilla*	MBTA	2021g, 2003a
Orange-crowned Warbler	*Leiothlypis celata*	MBTA	2003a
Yellow Warbler	*Setophaga petechia*	MBTA, CDFW:SSC,	2003a
Yellow-rumped Warbler	*Setophaga coronata*	MBTA	2021g, 2003a
Black-throated Gray Warbler	*Setophaga nigrescens*	MBTA	2003a
Song Sparrow	*Melospiza melodia*	CDFW:SSC, MBTA	2003a
Lincoln's Sparrow	*Melospiza lincolnii*	MBTA	2003a
Fox Sparrow	*Passerella iliaca*	MBTA	2003a
White-crowned Sparrow	*Zonotrichia leucophrys*	MBTA	2021g, 2016, 2003a
Golden-crowned Sparrow	*Zonotrichia atricapilla*	MBTA	2021g, 2016, 2003a
Dark-eyed Junco	*Junco hyemalis*	MBTA	2021g, 2003a
Black-throated Sparrow	*Amphispiza bilineata*	MBTA	2003a
California Towhee	*Melozone crissalis*	MBTA	2021g, 2003a
Vesper Sparrow	*Pooecetes gramineus*	MBTA	1992
Lark Sparrow	*Chondestes grammacus*	MBTA	2003a
Bell's Sparrow	*Artemisiospiza belli*	MBTA	2003a
Savannah Sparrow	*Passerculus sandwichensis*	MBTA	2016, 2003a
Grasshopper Sparrow	*Ammodramus savannarum*	MBTA, CDFW:SSC	2003a
Rufous-crowned Sparrow	*Aimophila ruficeps*	MBTA	2016, 2003a
Lazuli Bunting	*Passerina amoena*	MBTA	2003a
Blue Grosbeak	*Passerina caerulea*	MBTA	2003a
Black-headed Grosbeak	*Pheucticus melanocephalus*	MBTA	1992
Western Tanager	*Piranga ludoviciana*	MBTA	2021g, 2003a
Bullock's Oriole	*Icterus bullockii*	MBTA, BCC	2021g, 2003a
Brown-headed Cowbird	*Molothrus ater*	MBTA	2021g, 2003a
Red-winged Blackbird	*Agelaius phoeniceus*	MBTA	2016, 2003a
Tricolored Blackbird	*Agelaius tricolor*	BCC, CDFW:SSC, MBTA, ST	2021e, 2016, 2003a
Western Meadowlark	*Sturnella neglecta*	MBTA	2021g, 2016, 2003a
Brewer's Blackbird	*Euphagus cyanocephalus*	MBTA	2016, 2003a

Common Name	Scientific Name	Status	Source[a]
Lesser Goldfinch	*Spinus psaltria*	MBTA	2021g, 2016, 2003a
House Finch	*Haemorhous mexicanus*	MBTA	2021g, 2016, 2003a
Mammals			
Broad-footed Mole	*Scapanus latimanus*	None	2011
Big Brown Bat	*Eptesicus fuscus*	None	2021b
Townsend's Big-eared Bat	*Corynorhinus townsendii*	CDFW:SSC	2021b
Hoary Bat	*Lasiurus cinereus*	None	2021b, 2003b
Western Red Bat	*Lasiurus blossevillii*	CDFW:SSC	2021b, 2003b
Silver-haired Bat	*Lasionycteris noctivagans*	None	2021b
Small-footed Myotis	*Myotis ciliolabrum*	None	2021b
California Myotis	*Myotis californicus*	None	2021b, 2003b
Long-legged Myotis	*Myotis Volans*	None	2021b
Fringed Myotis	*Myotis thysanodes*	None	2021b
Yuma Myotis	*Myotis yumanensis*	None	2021b, 2003b
Long-eared Myotis	*Myotis evotis*	None	2021b
Canyon Bat	*Parastrellus hesperus*	None	2021b, 2003b
Pallid Bat	*Antrozous pallidus*	CDFW:SSC	2021b, 2003b
Brazilian Free-tailed Bat	*Tadarida brasiliensis*	None	2021b, 2003b
Western Mastiff Bat	*Eumops perotis*	CDFW:SSC	2021b
Audubon's (Desert) Cottontail	*Sylvilagus audubonii*	None	2021c, 2002b, 2002g
Black-tailed Jackrabbit	*Lepus californicus*	None	2002b, 2002g
California Ground Squirrel	*Ostospermophilus beecheyi*	None	2021c, 2021g, 2002g
Botta's Pocket Gopher	*Thomomys bottae*	None	2002e, 2002g
Heermann's Kangaroo Rat	*Dipodomys heermanni*	None	2021c, 2002e, 2002g
San Joaquin Pocket Mouse	*Perognathus inornatus*	None	2002b
California Pocket Mouse	*Chaetodipus californicus*	None	2021d, 2002e, 2002g
House Mouse	*Mus musculus*	None	2002e, 2002g
California Vole	*Microtus californicus*	None	2021f
Deer Mouse	*Peromyscus maniculatus*	None	2002e, 2002g
Western Harvest Mouse	*Reithrodontomys megalotis*	None	2021d, 2021f, 2002e, 2002g
Dusky-footed Woodrat	*Neotoma fuscipes*	None	2002e, 2002g
Diablo Range Woodrat	*Neotoma fuscipes perplexa*	None	2021d
Brush Mouse	*Peromyscus boylii*	None	2021d, 2002e, 2002g
Bryant's Woodrat	*Neotoma bryanti*	None	2021d
Red Fox	*Vulpes vulpes*	None	2005b
Gray Fox	*Urocyon cinereoargenteus*	None	2005b
Coyote	*Canis latrans*	None	2021c, 2021g, 2002b, 2002g

Common Name	Scientific Name	Status	Source[a]
Raccoon	*Procyon lotor*	None	2021c, 2002g
American Badger	*Taxidea taxus*	CDFW:SSC	2021c, 2021e, 2002b, 2002g
Long-tailed Weasel	*Mustela frenata*	None	2002g
Western Spotted Skunk	*Spilogale gracilis*	None	2002g
Striped Skunk	*Mephitis mephitis*	None	2021c, 2002g
Mountain Lion	*Puma concolor*	Candidate CESA	2002g
Bobcat	*Lynx rufus*	None	2021c, 2002b, 2002g
Wild Pig	*Sus scrofa*	None	2021c, 2021g, 2002b, 2002g
Mule Deer	*Odocoileus hemionus*	None	2021c, 2021g, 2002b, 2002g

Special Status Codes:
BGEPA = Protected under the *Bald and Golden Eagle Protection Act*
BCC = USFWS Bird of Conservation Concern (USFWS 2021 BCC lists)
Candidate CESA = Candidate for listing under the California Endangered Species Act
CDFW:FP = California Department of Fish and Wildlife-Fully Protected Species (CDFW Special Animals List, January 2022)
CDFW:SSC = California Department of Fish and Wildlife-Species of Special Concern (CDFW Special Animals List, January 2022)
FT = Threatened under the Federal Endangered Species Act
MBTA = Protected under the *Migratory Bird Treaty Act*
SE = Endangered under the State Endangered Species Act
ST = Threatened under the State Endangered Species Act

a.
References:
1992: DOE 1992
2002a: Arnold 2002
2002b: Clark et al. 2003
2002c: Swaim 2002
2002d: Weber 2002
2002e: West 2003
2003a: LLNL 2002
2003b: Rainey and Pierson 2003
2010: Dexter 2010
2016a: ESA 2016
2016b: Garcia and Associates (GANDA) 2016
2021a: ECORP 2021a
2021b: ECORP 2021b
2021c: 2021c
2021d:.2021d
2021e: LLNL 2021b
2021f: Murphy 2021

Observations by LLNL Wildlife Biologists:
2002f: Scott, J.
2002g: Van Hattem, M. and J. Woollett
2005a: Van Hattem, M.
2005b: Woollett, J.
2008: Burkholder, L
2009: Woollett, J.
2011: Woollett, J.
2014: Woollett, J.
2018: Murphy, C.
2019: Murphy, C.
2020a: Aquino, P.
2020b: Murphy, C.
2020c: Paterson, L.
2021g: Aquino, P.

I.4 References

10 CFR Part 1022 — "Compliance with Floodplain and Wetland Environmental Review Requirements." *Energy*. U.S. Department of Energy. *Code of Federal Regulations*. Available online: https://www.ecfr.gov/cgi-bin/text-idx?SID=16254389c07c98991085c732029dae22&mc=true&node=pt10.4.1022&rgn=div5

16 U.S.C. §§ 703–712 — United States Code (U.S.C.). "Migratory Bird Act of 1918." 16 U.S.C. §§ 703–712. Available online: https://uscode.house.gov/view.xhtml?path=/prelim@title16/chapter7&edition=prelim

16 U.S.C. §1531 et seq. — U.S.C. "Endangered Species Act of 1973." 16 U.S.C. §1531 et seq. Available online: https://uscode.house.gov/view.xhtml?path=/prelim@title16/chapter35&edition=prelim

Arnold 2002 — Arnold, R.A. *Report on the Threatened Valley Elderberry Longhorn Beetle and Its Elderberry Food Plant at the Lawrence Livermore National Laboratory Site 300*. 2002. UCR-SR-209166. ID 1665. Pleasant Hill, CA: Prepared for Lawrence Livermore National Laboratory, CA by Entomological Consulting Services, Ltd. 2002.

Baldwin et al. 2012 — Baldwin, B.G., D.H. Goldman, D. J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilken, editors. *The Jepson manual: vascular plants of California, second edition*. University of California Press, Berkeley. 2012.

BioSystems 1986a — BioSystems Analysis, Inc. *Vegetation of Site 300, Lawrence Livermore National Laboratory, San Joauin County, California.* UCRL-15873. ID 1564. Prepared for Science Applications International Corp., Pleasanton, CA by BioSystems Analysis, Inc., Santa Cruz, CA. November 1986.

BioSystems 1986b — BioSystems Analysis, Inc. *Wildlife Studies of Site 300 Emphasizing Rare and Endangered Species, Lawrence Livermore National Laboratory, San Joaquin County, California*. UCRL-15865. 1986.

California ESA — California Department of Fish and Wildlife. "California Endangered Species Act." *California Fish and Game Code* §§ 2050–2089.25. Available online: http://leginfo.legislature.ca.gov/faces/codes_displayexpandedbranch.xhtml?tocCode=FGC&division=3.&title=&part=&chapter=1.5.&article=

Clark et al. 2003	Clark, H.O., D.A. Smith, B.L. Cypher, and P.A. Kelly. *Mesocarnivore Surveys on Lawrence Livermore National Laboratory Site 300 Alameda and San Joaquin Counties, California.* LLNL-SR-808017. ID 1660. Fresno, CA: California State University, Stanislaus, Endangered Species Recovery Program. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. February 21, 2003.
CNDDB 2022a	California Natural Diversity Database. "Special Animals List." State of California, Natural Resources Agency, Department of Fish and Wildlife, Biogeographic Data Branch." 2022. Available online: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109405&inline (accessed January 2022).
CNDDB 2022b	California Natural Diversity Database. "State and Federally Listed Endangered, Threatened, and Rare Plants of California State of California, Natural Resources Agency." Department of Fish and Wildlife, Biogreographic Data Branch. January 2022. Available online: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109390&inline (accessed January 2022).
CNPS 2020	California Native Plant Society. *Inventory of Rare and Endangered Plants (online edition)*. Sacramento, CA. Available online: http://www.rareplants.cnps.org/
Cal-IPC 2006	California Invasive Plant Inventory. Cal-IPC Publication 2006-02. California Invasive Plant Council: Berkeley, CA. Available: www.cal-ipc.org.
CWB 2019	California State Water Resources Control Board. *State Policy for Water Quality Control: State Wetland Definition and Procedures for Discharges of Dredged or Fill Material to Waters of the State*. Adopted April 2, 2019 and Revised April 6, 2021. Available online: https://www.waterboards.ca.gov/water_issues/programs/cwa401/docs/2021/procedures.pdf
DOE 1992	U.S. Department of Energy. *Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore*. DOE/EIS-0157. ID 1841. 1992. Available online: https://www.energy.gov/nepa/downloads/eis-0157-final-environmental-impact-statement
Dexter 2010	Dexter, Wendy. *2009-2010 Wet Season Branchiopod Survey Report, Site 300 Experimental Test Site, Lawrence Livermore National Laboratory, Alameda and San Joaquin Counties,*

California. 2010. USFWS Permit # TE-016591-1.1. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Condor Country Consulting, Inc., Martinez, CA.

ECORP 2021a ECORP Consulting, Inc. *Herpetological Survey for the Lawrence Livermore National Laboratory Site 300 for the 2021 Sitewide Environmental Impact Statement, Alameda County, California.* LLNL-SR-826640. ID 2105. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by ECORP Consulting, Inc., Redlands, California. August 2021.

ECORP 2021b ECORP Consulting, Inc. *Bat Survey for the Lawrence Livermore National Laboratory Experimental Test Site 300 for the 2021 Sitewide Environmental Impact Statement, Alameda and San Joaquin Counties, California*. LLNL-SR-826544. ID 2102. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by ECORP Consulting, Inc., Redlands, California. August 2021.

ECORP 2021c ECORP Consulting, Inc. *Carnivore Survey Results for the Lawrence Livermore National Laboratory Site 300 Fish for the 2021 Sitewide Environmental Impact Statement, Alameda and San Joaquin Counties, California*. LLNL-SR-826543. ID 2101. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by ECORP Consulting, Inc., Redlands, California. August 2021.

ECORP 2021d ECORP Consulting, Inc. *Small Mammal Trapping Survey for the Lawrence Livermore National Laboratory Site 300 for the 2021 Sitewide Environmental Impact Statement, Alameda County, California.* LLNL-SR-826653 ID 2106. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by ECORP Consulting, Inc., Redlands, California. August 2021.

ECORP 2021e ECORP Consulting, Inc. *Passerine Bird Surveys for the Lawrence Livermore National Laboratory Site 200 for the 2021 Sitewide Environmental Impact Statement, Alameda County, California.* LLNL-SR-826650. ID 2107. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by ECORP Consulting, Inc., Redlands, California. August 2021.

ECORP 2021f ECORP Consulting, Inc. *Avian Surveys Report for the Lawrence Livermore National Laboratory Arroyo Mocho Pumping Station for the 2021 Sitewide Environmental Impact Statement, Alameda County, California.* LLNL-SR-826648. ID 2108. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by ECORP Consulting, Inc., Redlands, California. August 2021.

EO 13186 — "Responsibilities of Federal Agencies to Protect Migratory Birds." 66 FR 3853 dated January 17, 2001. Available online: https://www.energy.gov/sites/default/files/nepapub/nepa_documents/RedDont/Req-EO13186migratorybirds.pdf

ESA 2016 — Environmental Sciences Associates (ESA). *90-day Report for Listed Large Branchiopod Survey at LLNL Site 300 (2016 Season)*. USFWS File No.: 2016-TA-0314. ID 1402. 2016.

GANDA 2016 — Garcia and Associates (GANDA). *2014-2016 Avian Point Count and Migration Surveys at Site 300 for the Lawrence Livermore National Laboratory*. San Francisco, CA. LLNL-TR-815378. ID1399. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Garcia and Associates, San Francisco, CA. April 19, 2016.

IT IS 2022 — Integrated Taxonomic Information System on-line database, www.itis.gov, CC0 https://doi.org/10.5066/F7KH0KBK (accessed April 2022).

Jones and Stokes 1997 — Jones and Stokes. *Delineation of Waters of the United States for Arroyo Las Positas, prepared for Lawrence Livermore National Laboratory, Alameda County, California.* JSA 97-107. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. November 7, 1997.

Jones and Stokes 2001 — Jones and Stokes. *Biological Assessment for the United States Department of Energy's Lawrence Livermore National Laboratory, (Site 300)*. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. November 2001.

Jones and Stokes 2002a — Jones and Stokes. *Delineation of Waters of the United States for Arroyo Las Positas, for Lawrence Livermore National Laboratory*. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. September 2002.

Jones and Stokes 2002b — Jones and Stokes. *Special-Status Plant Species Surveys and Vegetation Mapping at Lawrence Livermore National Laboratory*. UCRL-TR-224972. ID 1549. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. September 2002.

Jones and Stokes 2003 — Jones and Stokes. *2002 Small Mammal Inventory at Lawrence Livermore National Laboratory Site 300*. UCRL-SR-209045. ID 1663. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Jones and Stokes. September 2003.

LLNL 2002 — Lawrence Livermore National Laboratory. *LLNL Avian Monitoring Program Variable Circular Plot Point Count and Constant Effort Mist Netting*. LLNL-MI-808021. ID 1662. Livermore, CA. 2002.

LLNL 2021a — Lawrence Livermore National Laboratory. *2019-2021 Nesting Bird Survey Summary Report for the Lawrence Livermore National Laboratory Site 200 for the 2021 Sitewide Environmental Impact Statement, Alameda County, California*. LLNL-AR-826687. ID 2109. Environmental Functional Area, Water Resources & Environmental Planning. September 2021.

LLNL 2021b — Lawrence Livermore National Laboratory. *FY19 and FY20 Report for the Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Natural Resources Management Plan*. LLNL-AR-826662. ID 2110. Environmental Functional Area, Water Resources & Environmental Planning. Livermore, CA. September 2021.

LLNL 2021c — Lawrence Livermore National Laboratory. *Results of a 20-Day Trapping Survey for Alameda Whipsnake* (*Masticophis lateralis euryxanthus*), *Lawrence Livermore National Laboratory, Site 300 Experimental Test Site, Alameda and San Joaquin Counties, California*. LLNL-AR-827444. ID 2112. Environmental Functional Area, Water Resources & Environmental Planning. Lawrence Livermore, CA. September 2021.

LLNL 2021d — Lawrence Livermore National Laboratory. *2020 Mitigation and Monitoring Report for the Arroyo Las Positas Management Project.* LLNL-TR-820238. ID 2125. Livermore, CA. March 2021.

LLNL 2021e — Lawrence Livermore National Laboratory. *FY19 and FY20 Report for the Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Natural Resources Management Plan*. LLNL-AR-826662. ID 2110. Livermore, CA. September 2021.

Murphy 2021 — Murphy, C. C. *Results of a 20-Day Trapping Survey for Alameda Whipsnake (Masticophis lateralis euryxanthus), Lawrence Livermore National Laboratory, Site 300 Experimental Test Site, Alameda and San Joaquin Counties, California*. LLNL-AR-827444. ID 2112. Lawrence Livermore National Laboratory, Livermore, CA. September 2021.

NNSA 2005 — National Nuclear Security Administration. *Final Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement*. DOE/EIS-0348 and DOE/EIS-0236-S3. ID 1087. National Nuclear Security Administration.

March 2005. Available online: https://www.energy.gov/nepa/downloads/eis-0348-and-eis-0236-s3-final-site-wide-environmental-impact-statement

Nomad Ecology 2020 — Nomad Ecology. *Wetland/Aquatic Resources Delineation for the 2021 Sitewide Environmental Impact Statement. Lawrence Livermore National Laboratory Facilities, Alameda and San Joaquin Counties, California*. LLNL-TR-816689. ID 1883. Prepared for Lawrence Livermore National Laboratory by Nomad Ecology, Martinez, CA. September 2020.

Nomad Ecology 2021a — Nomad Ecology. *Botanical Resource Survey Report, Arroyo Mocho, Lawrence Livermore National Laboratory, Alameda County for the 2021 Sitewide Environmental Impact Statement. Prepared for Lawrence Livermore National Laboratory*. LLNL-SR-824961. ID 2079. Prepared for Lawrence Livermore National Laboratory by Nomad Ecology, Martinez, CA. June 2021.

Nomad Ecology 2021b — Nomad Ecology. *Final Site 300 Sensitive Botanical Resource Report for the 2021 Sitewide Environmental Impact Statement. Lawrence Livermore National Laboratory Facilities, Alameda and San Joaquin Counties, California*. Prepared for Lawrence Livermore National Laboratory. LLNL-SR-825226. ID 2083. Prepared for Lawrence Livermore National Laboratory by Nomad Ecology, Martinez, CA. June 2021.

Rainey and Pierson 2003 — Willian E. Rainey, Ph.D. and Elizabeth D. Pierson, Ph.D. *Site 300 Bat Survey*. LLNL-SR-807999. ID 1658. Prepared for Lawrence Livermore National Laboratory, Livermore, CA.

Sequoia 2021a — Sequoia Ecological Consulting, Inc. *California Red-legged Frog USFWS Protocol Survey Report for the 2021 Sitewide Environmental Impact Statement, Lawrence Livermore National Laboratory, Site 200 – Livermore Campus, Livermore, California*. LLNL-SR-824306. ID 2082. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Sequoia Ecological Consulting. May 2021.

Sequoia 2021b — Sequoia Ecological Consulting, Inc. *Arroyo Mocho Habitat Suitability Assessment for Sensitive Reptiles, Amphibians, and Fish for the 2021 Sitewide Environmental Impact Statement*, *Lawrence Livermore National Laboratory, California*. LLNL-SR-826592. ID 2104. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Sequoia Ecological Consulting. September 2021.

Shepard 2020 — Shepard, E. *Valley Elderberry Longhorn Beetle Surveys at the Lawrence Livermore National Laboratory - Site 300 for the 2021 Sitewide Environmental Impact Statement*. LLNL-SR-817701. ID 1989. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. December. 2020.

Shepard 2021 — Shepard, E. *Valley Elderberry Longhorn Beetle Surveys at the Lawrence Livermore National Laboratory - Site 300 for the 2021 Sitewide Environmental Impact Statement*. LLNL-SR-824027. ID 2049. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. June 2021.

Swaim 2002 — Swaim, K. 2002. *Results of Surveys for Special Status Reptiles at the Site 300 Facilities of Lawrence Livermore National Laboratory.* LLNL-TR-408889. ID 1664. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. October 30, 2002.

West 2003 — West, E. and J. Woollett. *2002 Small Mammal Inventory at Lawrence Livermore National Laboratory, Site 300*. ID 1663. Prepared for Lawrence Livermore National Laboratory, Livermore, CA. September 2003.

Woollett 2019 — Woollett, Deborah (Smith). *Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve, Alameda and San Joaquin Counties, California*. Prepared for Lawrence Livermore National Laboratory. LLNL- SR-768323. ID 1409. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Working Dogs for Conservation, Bozeman, MT. Prepared for January 2019.

Woollett 2021 — Woollett, Deborah (Smith). *Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve: 2020 Deployment. Alameda and San Joaquin Counties, California. Prepared for Lawrence Livermore National Laboratory*. LLNL-TR-818743. ID 2002. Prepared for Lawrence Livermore National Laboratory, Livermore, CA by Working Dogs for Conservation, Bozeman, MT. January 2021.

USACE 1987 — United States Army Corps of Engineers. *Corps of Engineers Wetlands Delineation Manual*. Technical Report Y 87 1. Environmental Laboratory, USACE Waterways Experiment Station, Vicksburg, MS. January 1987. Available online: https://www.lrh.usace.army.mil/Portals/38/docs/USACE%2087%20Wetland%20Delineation%20Manual.pdf

USACE 2008 United States Army Corps of Engineers. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (Version 2.0). ERDS/EL TR-08-28. Wetlands Regulatory Assistance Program. U.S. Army Engineer Research and Development Center, Vicksburg, MS. September 2008. Available online: https://usace.contentdm.oclc.org/utils/getfile/collection/p266001coll1/id/7627

USFWS 2020 U.S. Fish and Wildlife Service. "List of Migratory Bird Species Protected by the MBTA." Updated in 2020 Available online: https://www.fws.gov/birds/policies-and-regulations/laws-legislations/migratory-bird-treaty-act.php (accessed January 2022).

USFWS 2021 U.S. Fish and Wildlife Service. *Birds of Conservation Concern 2021, Migratory Bird Program*. U.S. Fish and Wildlife Service, Migratory Bird Program. April 2021. Available online: https://www.fws.gov/migratorybirds/pdf/management/birds-of-conservation-concern-2021.pdf (accessed January 2022).

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