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Draft Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement

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Appendix E through P

Prepared by:

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COVER SHEET

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Abstract: The National Nuclear Security Administration (NNSA), a separately organized agency within DOE, has the responsibility to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile to meet national security requirements. NNSA manages DOE's nuclear weapons programs and facilities, including those at Lawrence Livermore National Laboratory (LLNL). The continued operation of LLNL is critical to NNSA's Stockpile Stewardship Program and to preventing the spread and use of nuclear weapons worldwide. LLNL maintains core competencies in activities associated with research and development, design, and surveillance of nuclear weapons, as well as the assessment and certification of their safety and reliability.

This *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS) prepared pursuant to NEPA, analyzes the potential environmental impacts of continued operation, including near term proposed projects of LLNL. Alternatives analyzed in this LLNL SW/SPEIS include the No Action Alternative, the Proposed Action, and the Reduced Operation Alternative. This document is also a Supplement to the *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* for use of proposed materials at the National Ignition Facility (NIF). This combination ensures timely analysis of these activities concurrent with the environmental analyses being conducted for the site-wide activities and will be referred to as the LLNL SW/SPEIS.

This document assesses the environmental impacts of LLNL operations on land uses and applicable plans, socioeconomic characteristics and environmental justice, community services, prehistoric and historic cultural resources, aesthetics and scenic resources, geology and soils, biological resources, water, noise, traffic and transportation, utilities and energy, materials and waste management, human health and safety, site contamination, and accidents.

Public Comments: In preparing this Draft LLNL SW/SPEIS, NNSA considered comments received during the public scoping period, from June 17, 2002, through September 16, 2002. Two public scoping meetings were held on July 10 and 11, 2002, in Livermore and Tracy, California. Comments made at these meetings, as well as comments received by fax, e-mail and U.S. mail during the scoping period, were considered in the preparation of this LLNL SW/SPEIS. A summary of the comments is included in this draft.

The comment period for this document will run from February 27, 2004, to May 27, 2004. Public hearings on the Draft LLNL SW/SPEIS will also be held during this 90-day comment period. The dates, times, and locations of these hearings will be announced in the *Federal Register* and in local newspapers. All comments received during the comment period will be considered by NNSA in the Final LLNL SW/SPEIS.

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ABBREVIATIONS AND ACRONYMS

1, 1-DCA	1, 1-dichoroethane
1, 1-DCE	1, 1-dichloroethylene
1, 2-DCA	1, 2-dichloroethane
1, 2-DCE	1, 2-dichloroethylene
AAQS	Ambient Air Quality Standards
ABAG	Association of Bay Area Governments
ACDEH	Alameda County Department of Environmental Health
ACE	Altamont Commuter Express
ACGIH	American Conference of Governmental Industrial Hygienists
ACHCS	Alameda County Health Care Services
ACHP	Advisory Council on Historic Preservation
ACL	Ambient concentration limit
ADS	Associate Directors
ADT	Average daily traffic
AET	Applied Energy Technologies
AIHA	American Industrial Hygiene Association
ALARA	As low as reasonably achievable
^{241}Am	Americium-241
Am/Pu button	Americium/plutonium metal button
AMP	Advanced Materials Program
ANSI	American National Standards Institute
APDS	Autonomous Pathogen Detection System
APE	Area of Potential Effect
AQCR	Air Quality Control Region
ARES	Amateur Radio Emergency Services
ARF x RF	Airborne release fraction and respirable fraction
ARM	Assembly, resupply, and maintenance
ARO	Assurance Review Office
ARPA	Archaeological Resources Protection Act
ASCI	Advanced Simulation and Computing Initiative
ATA	Advanced Test Accelerator

ATSDR	Agency for Toxic Substances and Disease Registry
ASD	Atmospheric Sciences Division
AVLIS	Advanced Vapor Laser Isotope Separation
AWQC	Ambient water quality criteria
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
BART	Bay Area Rapid Transit
BASIS	Biological Aerosol Sentry and Information System
BBRP	Biology and Biotechnology Research Program
BCP	Business commercial park
BDRP	Biological Defense Research Program
BEIR	Biological Effects of Ionization
BMP	Best management practice
BSL	BioSafety Level
CAA	*Clean Air Act*
CAAQS	California Ambient Air Quality Standards
$CaCl_2$	Calcium Chloride
CAIC	Computer Incident Advisory Center
CAIRS	Computerized Accident/Incident Report
Cal-EPA	California Environmental Protection Agency
CaO	Calcium Oxide
CAR	Computing Applications and Research
CARB	California Air Resources Board
CBD	Chronic beryllium disease
CBNP	Chemical and Biological National Security
CCAA	California Clean Air Act
CCB	Change Control Board
CCP	Central Characterization Project
CCR	California Code of Regulations
CD	Critical Decision
CDC	Center for Disease Control
CDFG	California Department of Fish and Game

CEDD	California Employment Development Department
CEDE	Committed Effective Dose Equivalent
CEPRC	Chemical Emergency Planning and Response Commission
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act of 1970
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFES	Community facility elementary school
CFF	Contained Firing Facility
CFR	Code of Federal Regulations
CHEW	Chemical Exchange Warehouse
CHP	California Highway Patrol
Ci	Curie
Cl_2	Chloride
CIAC	Computer Incident Advisory Center
CIMIS	California Irrigation Management Information System
CMGRAMS	Controlled materials group
CMS	Chemistry and Materials Science
CNEL	Community Noise Equivalent Level
CNPS	California Native Plant Society
CO	Carbon monoxide
CRD	Catalytic reductive dehalogenation
CSA	Container storage area
CSO	Council on Strategic Operations
CSU	Container storage unit
CT	California toxic
CWSC	California Water Service Company
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
CWG	Community Work Group
CY	Calendar year
DARHT	Dual Axis Radiographic Hydrodynamic Test
dB	Decibel

dB(A)	A-weighted decibel
D&D	Decontamination and Decommissioning
DC	Direct current
DCG	Derived Concentration Guide
DDO	Deputy Director of Operations
DDSO	Deputy Director for Strategic Operations
DEAR	Department of Energy Acquisition Regulation
DHS	Department of Health Services
DLM	Designated level methodology
DNT	Defense and Nuclear Technologies
DOD	United States Department of Defense
DOE	United States Department of Energy
DOE/OAK	DOE Oakland Operations Office
DOF	California Department of Finance
DOR	Direct Oxygen Reduction
DOT	United States Department of Transportation
DP	Office of Defense Programs
DR	Damage ration
DRB	Drainage Retention Basin
DTSC	Department of Toxic Substances Control
DWTF	Decontamination and Waste Treatment Facility
DU	Depleted uranium
E2	Energy Efficiency
EA	Environmental assessment
ECAP	East (Alameda) County Area Plan
EDD	California Employment Development Department
EDE	Effective dose equivalent
EDO	Environmental Duty Officer
EDS	Engineering Demonstration System
EED	Energy and Environment Directorate
EIR	Environmental impact report
EIS	Environmental Impact Statement

EML	Effluent pollutant limit
EMPC	Energetic Material Processing Center
EMRL	Environmental Monitoring Radiation Laboratory
EO	Executive Order
EOG	Environmental Operations Group
EOO	Emergency Operations Office
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPD	Environmental Protection Department
EPDTG	Environmental Protection Department Training Group
EPL	Effluent pollutant limit
EPTP	Environmental Protection Training Department
ER	Environmental restoration
ERPG	Emergency Response Planning Guidelines
ERD	Environmental Restoration Division
ES&H	Environment, Safety, and Health
ES&H WG	ES&H Working Group
EST	Environmental support team
EUV	Extreme ultraviolet
EUVL	Extreme ultraviolet lithography
EWSF	Explosives Waste Storage Facility
EWTF	Explosives Waste Treatment Facility
°F	Fahrenheit
FAC	Equally Likely to Occur in Wetlands for Uplands
FACU	Usually Occurs in Uplands
FACW	Usually Occurs in Wetlands
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FESSP	Fission Energy and Systems Safety Program
FFA	Federal Facility Agreement
FFCA	*Federal Facilities Compliance Act*
FHC	Fuel hydrocarbon

FIRP	Facility Infrastructure Recapitalization Project
FONSI	Finding of no significant impact
FPOC	Facility Point of Contact
FR	Federal Register
FR/O	Federal Reserve/Open Space
Freon 11	trichlorofluoromethane
Freon 113	trichlorotrifluoroethane
FSP	Facility safety plan
FTE	Full Time Equivalent
FY	Fiscal year
GAB	Gross alpha and gross beta
GET	Geosciences and Environmental Technology
GGS	Geophysics and Global Security
GIS	Geographic Information System
GPS	Global positioning system
GRR	Guidance Request Response
GSA	General Service Area
GSF	Gross Square Feet
GWH	Giga-watts per hour
GWP	Ground Water Project
GWPMP	Ground Water Project Management Program
GWTF	Groundwater treatment facility
GWTS	Groundwater treatment system
HAC	Hazard Assessment and Control
HAP	Hazardous air pollutants
HAZMAT	Hazardous Material
HCAL	Hazards Control Department’s Analytical Laboratory
HCD	Hazards Control Department
HCI	Hydrochloric Acid
HE	High explosives
HEA	Health and Ecological Assessment
HEAF	High Explosives Application Facility

HEDC	High Explosives Development Center
HEDP	High-energy-density physics
HEPA	High-efficiency particulate air (filter)
HHI	Health Hazard Index
HOV	High occupancy vehicle
HR	Human Resources
HSD	Health Services Department
HSWA	Hazardous and Solid Waste Amendments
HQs	Hazard quotients
HVAC	Heating, Ventilation, and Air Conditioning
HW	Hazardous Waste
HWCA	*Hazardous Waste Control Act*
HWM	Hazardous Waste Management Division
IBIS	Innovative Business and Information Services
I & C	Instrumentation and Control
ICC	Integrated Computing and Communications
ICF	Inertial Confinement Fusion
ICRP	International Commission on Radiological Protection
IDLH	Immediately-Dangerous to Life or Health
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
IQR	Interquartile Range
IS/EA	Initial Study/Environmental Assessment
ISCT	Industrial Source Complex Short Team
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
ISRF	International Security Research Facility
ITP	Integrated Technology Project
IWS	Integration work sheet
IWS/SP	Integrated Work Sheets/Safety Plan
JCATS	Joint Conflict and Tactical Simulation
LANL	Los Alamos National Laboratory

LBNL	Lawrence Berkeley National Laboratory
LCF	Latent Cancer Fatalities
LCW	Low Pressure Cooling Water
LDRD	Laboratory Directed Research and Development
LEDO	Laboratory Emergency Duty Officer
LEPC	Local Emergency Planning Committee
Leq	Equivalent-Continuous Sound Level
LINAC	Linear Accelerator
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level Waste
LOEC	Lowest observed effect concentration
LOS	Limit of sensitivity
LPF	Leak Path Factor
LPT	Lymphocyte proliferation test
L/RWD	Lost/Restricted Work Day
LSA	Low Specific Activity
LSO	Laser Safety Officer
LSO	Livermore Safety Officer
LS&T	Laser Science and Technology
LWC	Low work day cases
LWD	Lost work days
LWRP	Livermore Water Reclamation Plant
m	meter
MAPEP	Mixed Analyte Performance Evaluation Program
MAR	Materials at Risk
mCi	Millicurie
MCL	Maximum contaminant level
MDC	Minimum detectable concentration
MDD	Materials Distribution Division
MEI	Maximally exposed individual
mg	milligram
MLLW	Mixed low-level waste

MJ	Megajoules
MM	Modified Mercalli
MOU	Memorandum of understanding
MPL	Maximum permitted level
MRP	Monitoring and Reporting Program
MSDS	Material safety data sheet
mrem	millirem
MSE	Molten-salt extraction
MSR	Materials and Storage Retrieval
mSv	Millisievert
MTBE	Methyl tertiary-butyl ether
MTC	Metropolitan Transit Commission
MVM	Million vehicle miles
MWH	Megawatt hours
MWMP	Medical Waste Management Plant
NAAQS	National Ambient Air Quality Standards
NAI	Non-Proliferation, Arms Control and International Security
NARAC	National Atmospheric Release Advisory Center
NCR	Nonconformance report
NCRP	National Council on Radiation Protection and Measurements
NEPA	*National Environmental Policy Act*
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NEUMA	Neutron Multiplying Assembly
NHPA	*National Historical Preservation Act*
NIF	National Ignition Facility
NNSA	National Nuclear Security Administration
NO_2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOD	Notice of deficiency
NOEC	No observed effect concentration
NOI	Notice of Intent
NO_x	Nitrogen oxide

NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPOC	Non-precursor organic compounds
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
N&S	Necessary and Sufficient
nSv	Nanosievert
NTS	Nevada Test Site
NWP	Nationwide permit
O_2	Oxygen
O_3	Ozone
OAASIS	Occupational Accident Injury/Illness Analysis Support and Information System
OAB	Optics Assembly Building
OBT	Organically bound tritium
OCRWM	Office of Civilian Radioactive Waste Management
OES	Office of Emergency Services
ORAD	Operations and Regulatory Affairs Division
OSHA	Occupational Safety and Health Administration
OSP	Operational space and parks
OU	Operable unit
P2	Pollution Prevention
PA	Programmatic agreement
PAAA	*Price-Anderson Amendments Act*
PAG	Protective Action Guide
PAT	Physics and Advanced Technologies
PG&E	Pacific Gas and Electric
PCB	Polychlorinated biphenyl
PCE	Perchloroethylene (or perchloroethene tetrachloroethene)
PDD	Presidential Decision Directive
PEIS	Programmatic Environmental Impact Statement
PG&E	Pacific Gas and Electric

PHA	Public health assessment
pHMS	pH Monitoring Station
PL	Public Law
PM	Performance measure
PMCL	Primary maximum contaminant level
POC	Precursor Organic Compounds
POTW	Publicly owned treatment works
ppb	Parts per billion
ppm	Parts per million
PPE	Personal protective equipment
PPOA	Pollution prevention opportunity assessment
PPVS	Plant Performance Verification Series
PQL	Practical quantitation limit
PSA	Project-Specific Analysis
PSI	Pounds per square inch
PTU	Portable treatment unit
Pu	Plutonium
PVC	Polyvinyl chlorides
QA	Quality assurance
QC	Quality control
R&D	Research and Development
RAIP	Remedial Action Implementation Plan
RCRA	*Resource Conservation and Recovery Act* of 1976
RDWP	Remedial Design Work Plan
RD	Remedial Design
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
rem	Radiation equivalent man
RG	Risk Group
RHWM	Radioactive and Hazardous Waste Management Complex
RI/FS	Remedial investigation/feasibility study
RL	Reporting limit
RMA	Radioactive Materials Area

RMMA	Radioactive Materials Management Area
ROD	Record of Decision
ROI	Region of Influence
ROW	Right of Way
RTW	Return to Work Program
RWQCB	Regional Water Quality Control Board
SAA	Streambed alteration agreement
SAAQS	State Ambient Air Quality Standards
SAER	Site Annual Environmental Report
SBSSMP	Stockpile Stewardship and Management Program
SHPO	State Historic Preservation Officer
SNL/CA	Sandia National Laboratories/California
SAR	Safety analysis report
SARA	*Superfund Amendment and Reauthorization Act* of 1986
SAT	Space Action Team
SCIF	Sensitive Compartmented Information Facility
SDF	Sewer Diversion Facility
SE	Standard error
SEP	Safety and Environmental Protection
SERC	State Emergency Response Commission
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SHARP	Super High Altitude Research Project
SHPO	State Historic Preservation Officer
SI	Système International d'Unités
SIS	Special Isotope Separator
SJEHD	San Joaquin Environmental Health Department
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SMC	Senior Management Council
SMCL	Secondary maximum contaminant level
SME	Subject matter expert or Safety Management Evaluation
SMS	Sewer Monitoring Station
SNL/CA	Sandia National Laboratories, California

SNM	Special nuclear material
SO_2	Sulfur dioxide
SOP	Standard operating procedures
SOV	Summary of violations
SPCC	Spill Prevention Control and Countermeasure
SRS	Savannah River Site
SSM PEIS	Stockpile Stewardship and Management PEIS
SST/SGT	Safe Sescure Trailers/Safeguards Transport
STP	Site treatment plant
STU	Solar treatment unit
Sv	Sievert
SVE	Soil vapor extraction
SWEA	Site-Wide Environmental Assessment
SWEIS	Site-Wide Environmental Impact Statement
SW-MEI	Site-wide maximally exposed individual member (of the public)
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TBACT	Toxic best available control technology
TBD	To Be Determined
TBOS	Tetrabutyl orthosilicate
TCA	trichloroethane
TCE	Trichloroethene (or trichloroethylene)
TCLP	Toxicity characteristic leaching procedure
TCP	Traditional cultural properties
TDS	Total dissolved solids
TEEL	Temporary Emergency Exposure Limit
TF	Treatment facilitie
TKEBS	Tetrakis (2-ethylbutyl) silane
TLD	Thermoluminescent dosimeter
TNT	Trinitrotoluene
TOC	Total organic carbon
TOX	Total organic halides

TPY	Tons per year
TRAGIS	Transportation Routing Analysis Geographic Information System
TRC	Total reportable cases
TRU	Transuranic waste
TRUPACT II	Transuranic Package Transporter II
TSCA	*Toxic Substances Control Act*
TSF	Terascale Simulation Facility
TSMP	Transportation Systems Management Program
TSS	Total suspended solids
TTO	Total toxic organics
TWMS	Total Waste Management System
U	Uranium
UC	University of California
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
UV/H_2O_2	Ultraviolet/hydrogen peroxide
VOC	Volatile organic compound
VTF	Vapor treatment facility
WAA	Waste accumulation area
WDR	Waste Discharge Requirements
WFO	Work For Others
WIPP	Waste Isolation Pilot Plant
WMD	Weapons of mass destruction
WSS	Work Smart Standards
Zone 7	Alameda County Flood Control and Conservation District, Zone 7

UNIT OF MEASURE AND ABBREVIATIONS

ac	acre
BGY	billion gallons per year
cm	centimeters
ft^3	cubic feet
ft^3/s	cubic feet per second
m^3	cubic meters
yd^3	cubic yards
Ci	Curie
dB	decibel
^oC	degrees Celsius
^oF	degrees Fahrenheit
ft	feet
gal	gallon
gpd	gallons per day
g	gram
g/sec	grams per second
g	gravity
ha	hectare
Hz	Hertz
hr	hour
K	kelvin
kg	kilogram
kJ	kilojoule
km	kilometer
km/hr	kilometer per hour
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatt hour
L	liter

MJ	megajoule
MVA	megavolt-ampere
MW	megawatt
MWh	megawatt hour
MWe	megawatt-electric
MWt	megawatt-thermal
m	meter
m/sec	meters per second
µCi	microcurie
µCi/g	microcuries per gram
µg	microgram
µg/m^3	micrograms per cubic meter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µm	micron or micrometer
µohms/cm	microohms per centimeter
mPa	micropascal
mi	mile
mph	miles per hour
mCi	millicurie
mCi/g	millicurie per gram
mCi/ml	millicurie per millimeter
mg	milligram
mg/L	milligram per liter
ml	milliliter
mmHg	millimeters of mercury
M	million
MeV	million electron volts
MGD	million gallons per day
MGY	million gallons per year
mrem	millirem
mrem/yr	millirem per year

nCi	nanocurie
nCi/g	nanocuries per gram
ppb	part per billion
ppbv	part per billion by volume
ppm	part per million
PM_{10}	particulate matter of aerodynamic diameter less than 10 micrometers
PM_{25}	particulate matter of aerodynamic diameter less than 25 micrometers
Pa	pascal
pCi	picocurie
pCi/g	picocuries per gram
pCi/L	picocuries per liter
lb	pound
lbm	pounds mass
psi	pounds per square inch
lb/yr	pounds per year
qt	quart
rem[a]	Roentgen equivalent, man
sec	second
ft^2	square feet
km^2	square kilometers
m^2	square meters

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 (^ok)	subtract 273.15	Celsius (^oC)	kelvin (^ok)	Multiply by 9/5, then add 306.15	Fahrenheit (^oF)

Note: 1 sievert = 100 rems

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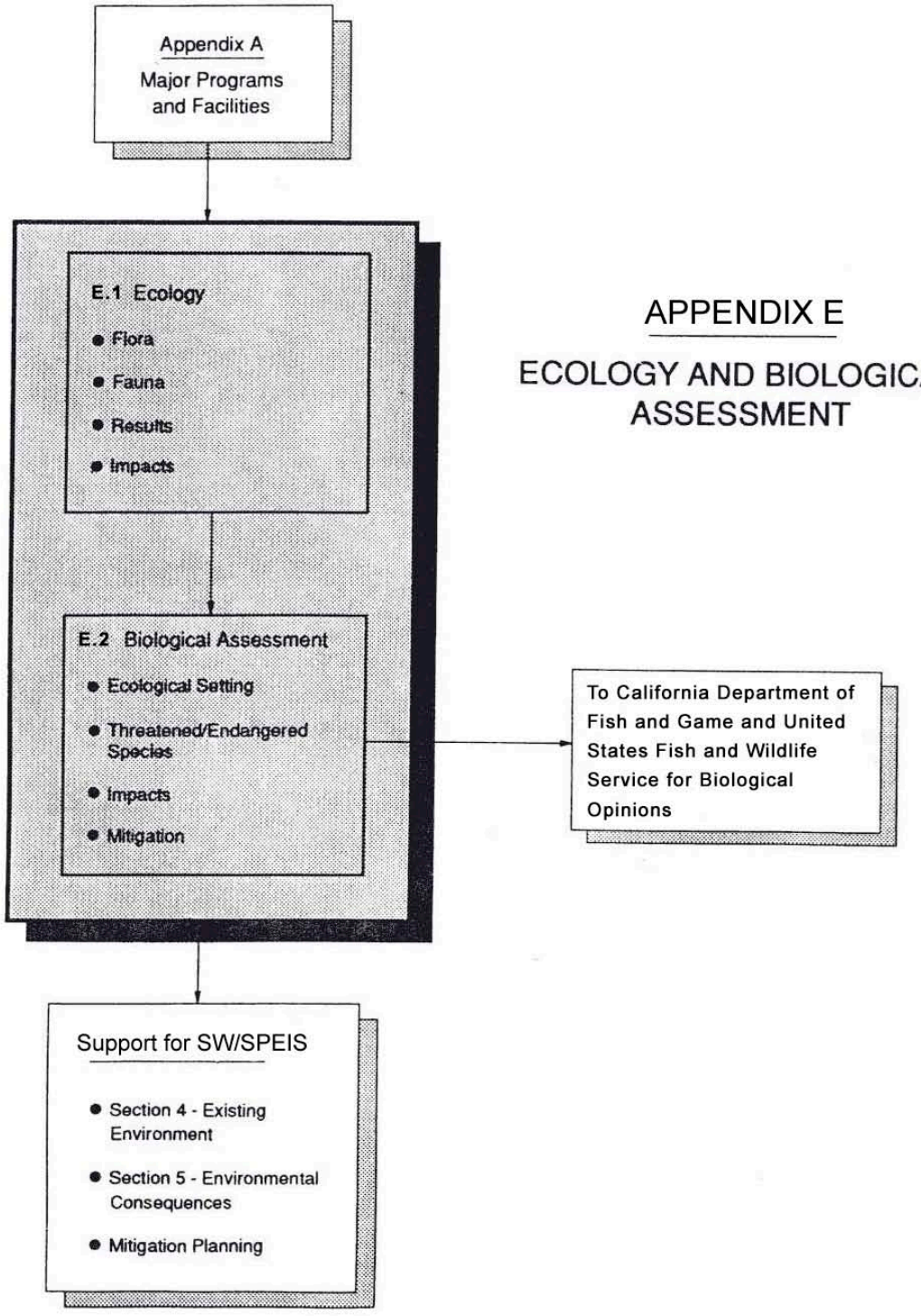
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APPENDIX E: ECOLOGY AND BIOLOGICAL ASSESSMENT

This appendix contains two major sections. Section E.1 is a discussion of the ecological characteristics at the Livermore Site and Site 300, referred to collectively as the study sites and presents information on the flora and fauna in the upland areas (see Appendix F for a detailed analysis of wetlands at the study sites). This section focuses largely on the biological features of Site 300, because this approximately 7,000-acre site is largely undeveloped and represents the most biologically diverse area under study. In contrast, the Livermore Site is a developed area that provides marginal wildlife habitat for most species because of the high degree of human activity and the few areas of undisturbed vegetation.

Section E.2, a biological assessment, complies with the U.S. Department of Energy (DOE) guidelines requiring that a biological assessment be prepared in conjunction with a site-wide environmental impact statement (SWEIS). Prepared pursuant to Section 7(c) of the *Endangered Species Act* and to the *California Endangered Species Act*, this biological assessment includes a description of existing biological conditions; the status of threatened and endangered species and other species of concern at the study sites; the impacts, if any, of operations on these species; a determination if effects would occur to species of concern; and mitigation measures where appropriate.

The relationship of Appendix E to other appendices and to Chapters 4 and 5 of the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS) is illustrated in Figure E–1. The analyses prepared for the biological assessment provide the basis for the discussion of impacts of the Proposed Action as described in the LLNL SW/SPEIS, Section 5.3.7. The analysis of the biological impacts of existing operations is complaint with DOE/NNSA requirements as well as to state and Federal endangered species acts.



Source: LLNL 1992a.

FIGURE E–1.—*Appendix E Interface with Other Site-wide Environmental Impact Statement Sections, Appendices, and Regulatory Reviews*

E.1 Ecology

E.1.1 Flora

The flora and vegetation at the Livermore Site and Site 300 have been described in several extensive surveys (BioSystems 1986a, 1986b, Jones and Stokes 1997, 2002a).

E.1.1.1 *Methods*

A plant species list for Site 300 was generated during the 1986 rare plant surveys, which were conducted on foot beginning on March 30, 1986, and continuing at biweekly intervals through mid-May 1986 (BioSystems 1986b). Sampling to typify vegetation composition was conducted in 1986 using a rapid descriptive technique generally termed as "the relevé method." More details on the relevé methodology may be found in the 1986 survey report (BioSystems 1986a, LLNL 1992a).

More recent plant species lists for Site 300 were generated from on-foot surveys conducted in 1997 and 2002, using California Department of Fish and Game (CDFG) guidelines to sample vegetation along meandering transects that paralleled roads and fire breaks. The 1997 survey was conducted between April 30 and May 12 and on September 23. The 2002 survey was conducted between March 27 and April 3 (Jones and Stokes 2002a).

E.1.1.2 *Results*

Flora

In 1997, 281 plant species were identified at Site 300; an additional 84 plant species were identified in 2002 (Jones and Stokes 2002a). A checklist of 406 plant species is provided in Attachment 2 combining the results of these 2 surveys with an earlier survey done in 1986 (BioSystems 1986b). Attachment 2, also provides a list of species for the Livermore Site. Table E.1.1.2–1 provides the results of the 1986 survey by analyzing the constancy and importance of plant species. Constancy is the percentage of all relevés (descriptive technique for sampling vegetation) in which a given species is encountered. Importance values are the sum of constancy and mean cover. As such, the importance value is a parameter that represents the frequency at which a species is observed added to the percent of groundcover of this particular species (BioSystems 1986a, LLNL 1992a).

The 1986 survey found that the nonnative grass species, *Avena barbata*, was the most frequently encountered plant at Site 300. Other frequently encountered species were *Bromus hordeaceus (B. mollis), B. diandrus, Erodium cicutarium, B. madritensis rubens*, and *Vulpia myuros*, all nonnative annuals introduced from Europe (Robbins 1940). Collectively, these six species are dominant in annual grasslands over much of lowland California (Heady 1977, BioSystems 1986a). The most commonly encountered plants at Site 300 are provided in Table E.1.1.2–1.

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey (continued)*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Trifolium oliganthum	6.42	0.13	0.05	6.55
Stylocfine gnaphalioides	6.42	0.07	0.03	6.49
Typha latifolia	5.05	1.26	0.48	6.30
Microseris lindleyi	5.96	0.01	0.01	5.98
Elymus elymoides	5.51	0.34	0.14	5.84
Salvia mellifera	5.05	0.68	0.26	5.72
Mimulus guttatus	5.51	0.20	0.12	5.70
Microseris douglasii	5.51	0.15	0.08	5.66
Linanthus bicolor	5.51	0.16	0.09	5.66
Claytonia parviflora	5.51	0.05	0.03	5.56
Quercus douglasii	5.05	0.50	0.20	5.55
Logfia gallica	5.51	0.04	0.02	5.55
Calochortus invenustus	5.51	0.02	0.01	5.52
Hordeum murinum leporinum	5.05	0.12	0.06	5.16
Amsinckia menziesii	5.05	0.03	0.02	5.08
Delphinium patens	5.05	0.03	0.02	5.08
Stylocline filaginea	5.05	0.03	0.01	5.07
Microsteris gracilis	5.05	0.02	0.01	5.07
Achyrachoena mollis	4.59	0.22	0.21	4.81
Silene gaffica	4.59	0.08	0.05	4.67
Schismus arabicus	4.59	0.07	0.03	4.65

Source: BioSystems 1986a.

The proportion and relative importance of native versus introduced species in the vegetation on Site 300 are similar to patterns documented in other cismontane annual grassland communities, where a handful of introduced species dominate and native species are less common (Heady 1958, Pitt 1975, Talbot et al. 1939).

Poa secunda (scabrella) was the most important native grass identified, occurring on nearly 39 percent of all relevés with an average cover of about 8 percent. Other important native species included the annual herbs *Trifolium tridentatum, Orthocarpus purpurascens, Lotus subpinnatus,* and *Amsinckia intermedia* (BioSystems 1986b).

Community Type Classification

In 1986, a survey delineated 14 plant community types at Site 300 that were combined to form five major types: (1) coastal sage scrub, (2) oak woodland, (3) introduced grasslands, (4) native grasslands, and (5) seeps and springs. In addition to those recognized, six relevés could not be placed in the classification scheme. Two were from the vernal pool and the remaining four were in other unique habitats; i.e., in a clay scald, a *Quercus lobata* stand, an unusual landslide deposit dominated by *Grindelia camporum*, and a *Melica californica* sward, for which no replicate samples could be obtained.

An alternative plant community classification and map have been recently completed. Community types used by Jones and Stokes generally follow the List of California Terrestrial Natural Communities recognized by the California Natural Diversity Data Base (CNDDB). The community types provided in the newer classification are numerically coded and are hierarchical. For example, the general category of Coastal Scrub is coded 32.000.00. California Sagebrush Scrub, a type of Coastal Scrub, is coded 32.010.00 (Jones and Stokes 2002a).

Maps showing the plant habitat types were prepared in 1992 and 2002, based on data collected from the 1986, 1997, and 2002 surveys (LLNL 1992a, Jones and Stokes 2002a). Figure E.1.1.2–1 provides a map of these plant communities at Site 300. A comparison of the two classifications is provided in Table E.1.1.2–2.

TABLE E.1.1.2–2.—*Comparison of Two Classifications Systems of Plant Community Types at Site 300*

Jones & Stokes (2002a) (Natural Community Code/Community Name)	BioSystems (1986)
30.000.00 Scrub and chaparral	
32.000.00 Coastal scrub	Coastal sage scrub
37.000.00 Undifferentiated chaparral scrubs	N/A
40.000.00 Grass and herb dominated communities	
41.000.00 Native grassland	Cismontane native grassland
41.180.00 One-sided bluegrass	Cismontane native grassland
42.000.00 Nonnative grassland	Cismontane annual grassland
44.100.00 Northern vernal pools	Vernal pools
45.700.00 Freshwater seeps	Freshwater seep
50.000.00 Bog and marsh	
52.130.00 Cattail wetland	Freshwater seep
60.000.00 Riparian and bottomland habitat	
61.000.00 Riparian forest and woodland	Northern riparian woodland
63.000.00 Low to high elevation riparian forests and woodlands	N/A
70.000.00 Broad leafed upland tree dominated	
71.000.00 Oak woodlands and forests	Blue oak woodland
80.000.00 Coniferous upland forest and woodland	
89.000.00 Juniper woodlands	Cismontane annual grassland

Sources: BioSystems 1986a, Jones and Stokes 2002a.
N/A = not applicable.

Coastal Sage Scrub Community (32.000.00)

Coastal scrub is a shrub-dominated community occurring in the Coast Ranges within the area where the climate has a maritime influence. Although the BioSystems report recognized three types of coastal scrub at Site 300, its vegetation map did not differentiate between the types. In the present vegetation map, most of the areas designated as Coastal Scrub are dominated by a combination of species including California matchweed (*Gutierrezia californica*), *Artemesia californica, Salvia mellifera,* and *Eriogonum fasiculatum*. This general community type also includes stands dominated by other species, such as bush lupine (*Lupinus albifrons*), for which there is currently no equivalent CNDDB community type (Jones and Stokes 2002a).

The coastal scrub general community type occurs in the southwestern part of Site 300 (Figure E.1.1.2–1) and was estimated to cover approximately 108 acres (BioSystems 1986a, LLNL 1992a).

The newer classification further divided the coastal scrub general community into two specific community types: California sagebrush scrub (32.010.00) and California sagebrush-black sage scrub (32.120.00). California sagebrush scrub is a category of coastal scrub with California sagebrush (*Artemisia californica*) the dominant species. California sagebrush-black sage scrub is a category of coastal scrub with California sagebrush and black sage (*Salvia mellifera*) both being dominant species (Jones and Stokes 2002a).

Poison-Oak Scrub (37.000.00)

Poison-oak scrub is a scrub community dominated by poison oak (*Toxicodendron diversilobum*) and occurs in only two locations at Site 300. BioSystems neither classified this habitat type nor is it currently included in the CNDDB classification (Jones and Stokes 2002a).

Native Grassland (41.000.00)

Native grassland is a community dominated by native grasses, primarily one-sided bluegrass (*Poa secunda*) and needlegrass (*Nassella pulchra* and *N. cernua*). This community type is equivalent to BioSystems' Cismontane Native Grassland habitat type. Because many areas of native grassland are managed by controlled burns, the 2002 survey team was unable to assign more specific categories within this general community type (Jones and Stokes 2002a).

The native grass-dominated communities on Site 300 represent a unique resource. The plant species composition of this community type suggests two patterns of variation that may illuminate the structure of pristine California grasslands: (1) most investigators such as Heady (1977) and Barry (1972) agree with Clements (1920) that *Nassella* (*Stipa) pulchra* should dominate native grassland communities, as it often does on very sandy soils (Hull and Muller 1977); however, as discussed by Bartolome and Gemmil (1981), this conclusion may not be accurate. Dominance by *Poa secunda (P. scabrella)* of Site 300 native grasslands specifically contradicts the notion that *Stipa* would dominate California grasslands in the absence of grazing and introduced annuals; and (2) the role of native forbs in native grassland communities has not received much study (Heady 1977). Data from Site 300 suggest that both native annual and perennial forbs can assume an important role under the conditions of frequent burning and no

grazing and thus may once have been important dominants or codominants of California grassland communities (BioSystems 1986a).

Stands of native grasslands on Site 300 cover approximately 723 acres and are confined mainly to the northern half of the site (Figure E.1.1.2–1) (BioSystems 1986a). Occurrence of native grass-dominated vegetation correlates with annual prescribed burning.

California Annual Grassland (42.040.00)

California annual grassland is a community dominated by annual grasses that were introduced from Mediterranean Europe during the Spanish colonial era. BioSystems mapped two habitat types corresponding to this map unit, xeric cismontane annual grassland and mesic cismontane annual grassland. The 2002 survey team did not attempt to differentiate xeric and mesic grassland map units because of the drought conditions and because many of these areas had been burned (Jones and Stokes 2002a).

California annual grassland is the largest community type at Site 300, covering approximately 5,647 acres. The most important species are *Avena barbata*, *Bromus diandrus, B. hordeaceus (B. mollis),* and *B. madritensis rubens* (BioSystems 1986a).

Northern Vernal Pool (44.100.00)

Vernal pools at Site 300 are not typical and do not correspond to any of the vernal pool categories in the CNDDB classification. Therefore, they were assigned to the general category of northern vernal pool. Unlike typical vernal pools containing species endemic to vernal pool habitat, the three vernal pools at Site 300 have vegetation composed mostly of wetland generalists that are often found in, but not restricted to, vernal pools. Species observed included stipitate-popcorn flower (*Plagiobothrys stipitatus*), annual hair grass (*Deschampsia danthonioides*), cleistogamous spike-primrose (*Epilobium cleistogamum*), and creeping spikerush (*Eleocharis macrostachya*) (Jones and Stokes 2002a, 2002c).

Freshwater Seep (45.700.00)

Vegetation in the Site 300 freshwater seeps is generally dominated by herbaceous perennial hydrophytes, although riparian scrub is also associated with seeps at several locations. Where perennial soil moisture is present, the dominant species is usually narrow-leaved cattail (*T. angustifolia),* although broad-leaved cattail (*T. latifolia*) is also present. Other common species in the seeps include creeping wild rye (*Leymus triticoides*), hoary nettle (*Urtica dioica*), saltgrass (*Distichlis spicata),* Baltic rush (*Juncus balticus*), white hedgenettle (*Stachys albens*), and annual rabbit's-foot grass (*Polypogon monspeliensis*). Woody vegetation is associated with freshwater seeps in some areas. Mulefat (*Baccharis salicifolius*) is present at scattered locations in seeps that occur along the bottoms of drainages (Jones and Stokes 2002c). Freshwater seep corresponds to BioSystems' seeps and springs habitat type (Jones and Stokes 2002a).

Cattail Wetland (52.130.00)

The BioSystems report included cattail wetland in the seeps and springs habitat type. This community is dominated by cattails (*Typha latifolia* and *T. angustifolia*) (Jones and Stokes 2002a).

Seasonal Pond

Seasonal pond designates areas that are seasonally inundated, but that do not have native wetland or vernal pool vegetation. The vegetation is sparse and consists of weedy wetland or ruderal species. Seasonal pond does not have a corresponding CNDDB classification, and the BioSystems report did not identify this habitat (Jones and Stokes 2002a).

Mexican Elderberry Scrub (63.410.00)

Mexican elderberry scrub is a general category of scrub dominated by Mexican elderberry (*Sambucus mexicanus*). The BioSystems report mapped this area as northern riparian woodland at Site 300. This vegetation unit does not correspond closely to any of the CNDDB community types (Jones and Stokes 2002a).

Mulefat Scrub (63.510.00)

Sections of stream channel dominated by mulefat (*Baccharis salicifolius*) were classified as mulefat scrub. The BioSystems report included this vegetation unit with seeps and springs (Jones and Stokes 2002a).

Great Valley Willow Scrub (63.140.00)

Sections of stream channel along Elk Ravine dominated by willows (*Salix* species) were classified as Great Valley willow scrub. This community is an open to dense shrubby streamside thicket dominated by willows, occurring along the major rivers and tributaries throughout the Great Valley watershed. The BioSystems report did not include this habitat type (Jones and Stokes 2002a).

Blue Oak/Grass Woodland (71.020.05)

Blue oak/grass woodland corresponds, in part, to the blue oak woodland of the BioSystems report. The dominant species is blue oak (*Quercus douglasii*), with an understory dominated by annual grasses (Jones and Stokes 2002a).

Valley Oak Forests and Woodlands (71.040.00)

Valley oak forests and woodlands are dense to open tree-dominated communities in which valley oak (*Quercus lobata*) is a dominant species. Fremont cottonwood and willows are also present in the woody overstory in this map unit at Site 300. The BioSystems report discussed, but did not map, valley oaks at Site 300 (Jones and Stokes 2002a).

California Juniper Woodland and Scrub (89.100.00)

California juniper woodland and scrub is an open woody plant community dominated by California juniper (*Juniperus californicus*) with a shrubby understory of coastal scrub species. The BioSystems report did not differentiate this habitat type from coastal sage scrub (Jones and Stokes 2002a).

Juniper-Oak Cismontane Woodland (89.100.01)

Juniper-oak cismontane woodland is an open woody plant community dominated by California juniper and blue oak. The BioSystems report did not differentiate this habitat type from blue oak woodland (Jones and Stokes 2002a).

Disturbed

Areas that are paved, occupied by buildings, or otherwise cleared of vegetation were classified as Disturbed. Disturbed areas do not have a corresponding CNDDB classification. In the BioSystems report, this habitat type was only mapped for developed site facilities and was not applied to other areas, such as fire breaks (Jones and Stokes 2002a).

Urban Habitat

Areas landscaped with ornamental trees and shrubs were classified as urban habitat. Urban habitat does not have a corresponding CNDDB classification. In the BioSystems report, this habitat type was not differentiated from disturbed areas (Jones and Stokes 2002a).

E.1.1.3 *Impacts of Current Operations*

Disturbances to vegetation on Site 300 from current operations are much less than the impacts of land use practices on private lands nearby, where upland and riparian plant communities have been altered by grazing and other agricultural activities. Impacts at Site 300, however, do include the direct loss of vegetation by construction of facilities such as testing sites, firing tables, closed landfills, wastewater facilities, maintenance buildings, security facilities, fences, and roads. These disturbed areas, totaling less than 5 percent of total site acreage, are almost devoid of vegetation. Facilities in the southern half of the site have disturbed mostly introduced grassland plant communities. The generally small facilities in the northern half of the site have not significantly disturbed large areas of land even when adjacent to native grassland habitats.

Other operational practices on Site 300 include the exclusion of grazing and other agricultural practices; construction and maintenance of fire roads and breaks; vegetation management using prescribed burning, herbicides, and disking for fire control; weed control along roads, power poles, and security fence perimeters; and minor construction in or adjacent to existing facilities (BioSystems 1986a, Jones and Stokes 2001).

Lack of Livestock Grazing

Baseline comparisons of the flora on Site 300 with that of neighboring, grazed parcels show a greater complement of native grasses and herbs on Site 300, because no livestock grazing has

been permitted since 1953. Slopes and substrates show less instability and erosion, probably the result of a more stable plant cover and the retention of soil-binding native plant species (BioSystems 1986a).

Disking and Applying Herbicides to Contain Fires

Most of the property has not been disked or dry-farmed since it was acquired. The limited disking for fire control has had a minor impact on the overall vegetation of Site 300. Infrequently, a narrow swath of land is disked along the northern, and part of the northeastern and eastern boundaries of the site. This perimeter disking, when done, is performed in May, providing added protection during prescribed burning against the possible escape of fire to offsite properties. The disked areas favor establishment and maintenance of introduced grasses and moderate cover of tarweeds (*Holocarpha obconica*, *Hemizonia kelloggii*, *H. lobbii*) (BioSystems 1986a). Although disking remains an option, depending on seasonal conditions, prescribed burning is preferred for wildfire control (LLNL 2003ah). For general weed and fire control, herbicides such as Krovar®, Oust®, and Roundup Pro® are applied in the fall and winter to the road shoulders, around buildings, and around power poles in the firing areas. In the General Services Area (GSA) and around landscaped areas, road shoulders, and power poles, herbicides such as Roundup Pro®, Ronstar®, and Pendulum®, are applied in the fall and winter months, avoiding areas where sensitive plant species exist. Environmental Restoration Division (ERD) test wells are sprayed whenever necessary with Roundup Pro® (LLNL 2003ah). Herbicides have favored the introduction and maintenance of ruderal type vegetation in these areas (Frenkel 1970).

Prescribed Burn

Prescribed burning is conducted annually as a means of wildfire control. Site 300 began a burning program in the northeastern half of the site in the 1950s and has continued the program annually since 1960. The prescribed burn area includes approximately 2,000 acres, which is divided into 24 plots. Burning typically begins at the end of May and lasts several weeks, though this schedule depends on the length of the growing season and amount of rainfall (LLNL 1992a, 2003).

Fire limits the development of coastal sage scrub vegetation in burn areas on Site 300 to rocky sites and influences the composition and distribution of native grasslands. Restriction of coastal sage scrub to rocky sites is associated with reduced dry grass fuel levels and increased patchiness of all fuels. Although vegetation in rocky areas is subject to local fires, the rocks offer some protection and the vegetation may not be burned in every fire. Shrubs that would otherwise be eliminated then increase in importance. Native grassland communities on Site 300 occur almost exclusively in areas with annual prescribed burning (BioSystems 1986a).

Dyer (2002) notes that prescribed burns can play an important role in establishing and restoring native grassland communities in California. Barry (1972) indicated that frequent fire is required to establish and maintain grasslands dominated by native grasses in lowland California. This conclusion is borne out by grassland vegetation found at Site 300. Figure E.1.1.3–1 shows the distribution of native grassland vegetation in relation to the limits of prescribed fires in 1986, with a high correspondence between them. Not all plant communities within the perimeter of

annual prescribed fire on Site 300 are native grass-dominated, but the lack of introduced grasses on some habitats strongly correlates with the pattern and frequency of fires (BioSystems 1986a). A comprehensive inventory of native grasslands has not been conducted for California. Notably, Barry (1972) did not mention the presence of native grasslands in the vicinity of Site 300. An estimated 723 acres of native grassland communities occur on Site 300. Using the evaluation criteria established by Barry (1972), Site 300 could be judged one of the largest native grasslands of this kind currently known in California.

Lawrence Livermore National Laboratory (LLNL) biologists have been investigating the effect of prescribed burns on the distribution of *Amsinckia grandiflora* and *Blepharizonia plumosa*, while also developing techniques to restore native perennial grasslands. Birds may be responsible for high levels of granivory in burned, open plots of *Amsinckia grandiflora.* Fire germination experiments suggest that fire may stimulate germination of *Blepharizonia plumosa* ray seeds and older seeds, but inhibit germination of recent-year disc seeds. One of the goals of ongoing research is to demonstrate that burn frequency affects the spread of *P. secunda* (LLNL 2002dj).

The diamond-petaled poppy (*Eschscholzia rhombipetala)*, a plant thought to be extinct until rediscovered in 1993 and thus on the California Native Plant Society (CNPS) 1A List, is present at two locations at Site 300. A small population consisting of 10 individual plants was identified in 1997 in the southwest corner of the site, and a second larger population of 300 individuals was identified in 2002 in the central western part of Site 300. Both populations are not in locations where they are being adversely affected by site operations. The diamond-petaled poppy is not listed by the U.S. Fish and Wildlife Service (USFWS) or CDFG. However, USFWS has designated the diamond-petaled poppy as a target for long-term conservation, and its extreme rarity suggests that it should be considered for listing as endangered (Jones and Stokes 2002a). LLNL biologists have been monitoring the status of these populations and evaluating proposed activity impacts for potential impacts to this species. The latest population studies are provided in *Rare Plant Restoration and Monitoring at Lawrence Livermore National Laboratory Site 300 Project Progress Report, Fiscal Year 2000, October 1999–September 2000* (LLNL 2002dj) and *Population Characteristics of Eschscholzia Rhombipetala, Lawrence Livermore National Laboratory, Livermore, CA* (LLNL 2003ap).

The big tarplant (*Blepharizonia plumosa)*, listed on the CNPS Rare Plant 1B List, is widespread and common at Site 300. This was observed at 26 localities on Site 300 in 1997, with the largest stand occupying more than 84 acres. The number of individual big tarplants present at Site 300 in 1997 was estimated to be 145,468. The big tarplant was observed at a number of locations at Site 300 in 1997, with most found in the northern half of the site. The abundance of big tarplant on Site 300 and its common occurrence in disturbed places suggest that site management practices have not adversely affected the populations at Site 300. The controlled burning does not appear to have an adverse long-term effect on the populations, as high plant densities were observed in 1997 in areas that are burned annually (Jones and Stokes 2002a). LLNL biologists have conducted an extended monitoring program to monitor the status of the big tarplant at Site 300 and evaluate the impact of prescribed burns and other disturbances on the ecology of this species.

The round-leaved filaree (*Erodium macrophyllum)*, listed on the CNPS Rare Plant 2 List, was identified at one location at Site 300. Round-leaved filaree is not listed by USFWS or CDFG. List 2 species also meet the definition of rare or endangered species under Section 15380(d) of CNPS the CEQA guidelines, but they are more common outside of California. The Site 300 population of round-leaved filaree is located in the central western portion of Site 300, approximately 525 feet northeast of the larger diamond-petaled poppy population. The population consists of about 200 individuals in an area of about 3.5 acres. All but two of the plants were observed in fire trails (Jones and Stokes 2002a).

The presence of round-leaved filaree primarily in the fire trails suggests that this disturbance has provided a benefit to the population at Site 300. The nature of this benefit is not clear, but it could range from uncovering buried, dormant seeds to providing a microsite free from competing nonnative grasses (Jones and Stokes 2002a). The round-leaved filaree was included in the 2002 - 2003 rare plant monitoring program to obtain more information on its ecological requirements.

The gypsum-loving larkspur (*Delphinium gypsophilum* ssp. *gypsophilum*), listed on the CNPS Rare Plant 4 List, occurs at six locations with most being on upper slopes in perennial grassland at Site 300. Gypsum-loving larkspur is not listed by USFWS or CDFG. It was placed on List 4 by the CNPS. List 4 species are not considered to be rare or endangered but are uncommon enough to warrant monitoring. However, local public ordinances or resource agencies may define List 4 species as important biological resources, setting a threshold of significance that encompasses impacts on these species. It does not appear that the gypsum-loving larkspur would be adversely affected if fire roads are maintained in their present positions through the existing population(s) and if no new fire roads were constructed through them (Jones and Stokes 2002a).

The California androsace, or California rock jasmine (*Androsace elongata* ssp. *acuta*), a CNPS Rare Plant 4 List species, is widespread and common at Site 300. California androsace is not listed by USFWS or CDFG. The occurrences of California androsace on Site 300 appear to have been relatively unaffected by construction of Site 300 facilities and fire trails, because this species occurs on rock outcrops and relatively steep slopes. Burns are not likely to have a substantial adverse effect on the occurrences, because the plants bloom and set seed in early spring before most fires occur, and because the low vegetation cover where the plants occur would support only a low-intensity fire that would be unlikely to destroy the seed bank (Jones and Stokes 2002a).

Stinkbells (*Fritillaria agrestis*), a CNPS Rare Plant 4 List species, are found at several locations at Site 300. This species is not listed by USFWS or CDFG. The stinkbells occurrences at Site 300 are in a remote location that has not been affected by construction of Site 300 facilities. A fire trail cuts through the habitat and may have removed a portion of the largest stand. The stands are outside of the area that receives regular burns. However, burns would not likely have a substantial adverse effect on the occurrences because the plants bloom and set seed in early spring, before most fires occur, and because the lower vegetation cover where the plants occur would support only a low-intensity fire that would be unlikely to destroy the seed bank (Jones and Stokes 2002a).

The hogwallow starfish (*Hesperevax caulescens)*, a CNPS Rare Plant 4 List species, is found at one location west of Building 851 at Site 300. The location of Building 851 and other structures

at Site 300 discussed in Appendix E are shown on maps in Appendix A of this LLNL SW/SPEIS. This species is not listed by USFWS or CDFG. The hogwallow starfish occurrence at Site 300 is at a remote location that does not appear to have been affected by construction of Site 300 facilities. A fire trail cuts through the habitat and is likely to have removed portion of the population. Burns are not likely to have a substantial adverse effect on the occurrence because the plants bloom and set seed in early spring, before most fires occur, and because the low vegetation cover where the plants occur would support only a low-intensity fire that would be unlikely to destroy the seed bank (Jones and Stokes 2002a).

With more attention being focused on the control of invasive plant species, research is evaluating the effect of prescribed burns in managing certain invasive plants. A series of prescribed burns, when annual grasses are dry but before *Centaurea solstitialis* (yellow starthistle) flowers open, have been used to prevent yellow starthistle seed production elsewhere in the Coast Range annual grasslands of California. Fire was used to burn the dry annual grass vegetation and seeds, and it scorched the yellow starthistle flowers enough to prevent seed development. After the third annual burn, perennial grass (purple needlegrass) was increased three-fold, when compared to unburned sites, and yellow starthistle was reduced 96 percent (Lass et al. 1999). This research suggests that annual burns at Site 300 could help reduce spread of certain invasive species on the property.

E.1.2 Fauna

A number of baseline faunal studies for the Livermore Site and Site 300 in 1986, 1991, 2001 and 2002 were prepared (BioSystems 1986a, DOE 1982a, ESA 1990, LLNL 1992a, UC 1987). These surveys assessed the status of threatened or endangered wildlife species, as well as the presence of other amphibians, reptiles, and mammals without special status species. Additional information on special status species may be found in the biological assessment (Section E.2). Many species of breeding birds were noted in the 1991 surveys because most of the fieldwork occurred during the nesting season. Observation of additional migrant and wintering species would be expected if surveys occurred during other seasons.

In 2002, specific surveys were conducted to determine the current status at Site 300 of the California linderiella fairy shrimp, the valley elderberry longhorn beetle, amphibians, reptiles, small mammals, mesocarnivores, bats, breeding raptors, and tricolored blackbirds (Arnold 2002, Bloom 2002, Condor Country Consulting 2002, CSUS 2003, Jones and Stokes 2002b, LLNL 2002di, LLNL 2003ab, LLNL 2003by, Swaim 2002a, Swaim 2002b).

E.1.2.1 *Methods*

Species of wildlife observed during fieldwork were recorded when possible. In addition, during threatened and endangered surveys, sensitive species surveys, and wetlands surveys, notes were kept on species of amphibians, reptiles, birds, and mammals observed. Notes on all wildlife species observed were also kept during night spotlighting, scent station maintenance, and small mammal trapping. More specific information on the field methodologies used is provided in the individual survey reports (Arnold 2002, Bloom 2002, Condor Country Consulting 2002, Jones and Stokes 2001, Jones and Stokes 2002b, LLNL 2002di, LLNL 2003ab, LLNL 2003by).

E.1.2.2 *Results*

Branchiopods

The California linderiella fairy shrimp (*Linderiella occidentalis*), a Federal species of concern, occurs at Site 300. During a 2001–2002 wet season survey, this branchiopod species was found in a vernal pool (FS-04) in the northwest part of the site. Another branchiopod, the California clam shrimp (*Cyzicus californicus*), which is not on Federal or California special status species lists, was also found in this vernal pool (Condor Country Consulting 2002).

Insects

The recent valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) survey at Site 300 is the only insect investigation that has been performed at LLNL (Arnold 2002). The results of this survey are provided in Section E.2.

Amphibians and Reptiles

Four amphibian and three reptile species were recorded at the Livermore Site in 2001 including the California red-legged frog (*Rana aurora draytonii*), western toad (*Bufo boreas*), Pacific treefrog (*Hyla regilla*), bullfrog (*Rana catesbeiana*), western fence lizard (*Sceloporus graciosus*), western yellow-bellied racer (*Coluber constrictor mormon*), and gopher snake (*Pituophis melanoleucus*). The California red-legged frog has been observed in the Arroyo Las Positas, western perimeter drainage ditch, and the Drainage Retention Basin (DRB). The bullfrog was reported in the DRB (LLNL 1992a, LLNL 2002bz).

Five amphibian and 19 reptiles species, including 3 subspecies of the whipsnake, were observed at Site 300 in 1986 (BioSystems 1986c), 1991, and 2002 (Swaim 2002a) (Table E.1.2.2–1). Ponds occur along the perimeter of Site 300, and some of the onsite drainages contain aquatic vegetation supported by underground springs and seeps. Two species of salamanders were observed at Site 300: the California slender salamander (*Batrachoseps attenuatus*) and the California tiger salamander (*Ambystoma californiense*) (BioSystems 1986c). However, the California slender salamander was not observed in the 2002 survey (LLNL 2003ab). The western toad (*Bufo boreas*), Pacific treefrog (*Hyla regilla*), red-legged frog (*Rana aurora draytonii*), and western spade foot toad (*Spea hammondii*) are species known to occur onsite (LLNL 2003ab).

Conditions are far more favorable for reptiles than amphibians at Site 300. Grassland provides ideal habitat for racers (*Coluber constrictor*) and gopher snakes (*Pituophis melanoleucus*). Rock sites provide suitable habitat for such species as the western fence lizard (*Sceloporus occidentalis*), western skink (*Eumeces skiltonianus*), common kingsnake (*Lampropeltis getulus*), and the western rattlesnake (*Crotalus viridis*). The western rattlesnake species has been observed to be widespread and abundant in all habitats on Site 300. Seeps and springs provide excellent habitat for the northern alligator lizard (*Gerrhonotus coeruleus*). Side-blotched lizards (*Uta stansburiana*) and California horned lizards (*Phrynosoma coronatum frontale*), more commonly found in southern California, frequent areas with more open vegetation and sandy oils. The CDFG Ecological Preserve, along the Corral Hollow drainage adjacent to Site 300 includes the glossy snake (*Arizona elegans*), long-nosed snake (*Rhinocheilus lecontei*), and San Joaquin whipsnake (*Masticophis flagellum ruddocki*).

The California red-legged frog, a federally listed threatened species and state species of special concern, was recorded at Site 300 in 1991. In a 2001 survey, the California red-legged frog and California tiger salamander (a federally listed proposed threatened species) were found at a number of breeding and nonbreeding locations at Site 300 (Jones and Stokes 2001). Details regarding the results of the 2001 survey for these species are provided in Section E.2. The western spadefoot toad is a Federal species of concern and State species of special concern. During wet years, this amphibian has been observed at Song Pond and the Overflow Pond located in the GSA of Site 300 (LLNL 2003ab). A State species of special concern, the California horned lizard, was observed in 1991 and occurs site-wide in sandy soil (LLNL 1992a). The San Joaquin whipsnake (*Masticophis flagellum ruddocki*), silvery legless lizard (*Anniella pulchra pulchra*), and California black-headed snake (*Tantilla planiceps*) were observed at Site 300 during a special status reptile survey in 2002 (Swaim 2002a). The silvery legless lizard and San Joaquin whipsnake are Federal species of concern and State species of special concern.

Birds

In 1991, 75 species of birds were observed at the study sites; this includes 70 species observed at Site 300, and 31 species at the Livermore Site (Table E.1.2.2–2). These species were recorded in 1986 during springtime surveys for threatened and endangered species (BioSystems 1986a, BioSystems 1991, LLNL 1992a). In 2002, an intensive avian survey and related supporting documentation identified the presence of 90 bird species at Site 300 (LLNL 2003by). Table E.1.2.2–2 shows 120 bird species at Site 300 based on identifications provided from the 1986, 1991, and 2002 surveys (BioSystems 1986c, LLNL 1992a, LLNL 2003by). In 2001, 52 bird species were observed during spring and fall surveys at the Livermore Site (LLNL 2003bz).

Site 300, with its interspersion of several different habitats and its abundance of seeds and insects, supports a variety of birds. The western meadowlark (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), and savannah sparrow (*Passerculus sandwichensis*) were the most common small birds seen throughout the open grassland areas. Vegetation at springs and seeps provides nesting habitat for red-winged blackbirds (*Agelaius phoeniceus*) and tricolored blackbirds (*A. tricolor*). These water sources attract a greater number of birds than normally found in the adjacent grasslands. For example, the mourning dove (*Zenaida macroura*), cliff and barn swallow (*Hirundo pyrrhonota* and *H. rustica*), and California quail (*Callipepla californica*) all require water daily.

The number of tricolored blackbirds can vary greatly among survey years. For example, tricolored blackbirds were observed onsite in 1986 but not in 1991 (LLNL 1992a). However, 835 nests were found in Elk Ravine over 3-day surveys in August and September 2002. Nest location analysis determined that 91.7 percent of nests were located in stinging nettle (*Urtica dioca*), 6.8 percent in cattail (*Typha latifolia*), 1 percent in Russian thistle (*Salsola tragus*), and 0.5 percent in horehound (*Marrubium vulgare*) (LLNL 2002di).

TABLE E.1.2.2–2.—*Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Passer domesticus[b]	House sparrow	X	X
Psaltriparus minimus[a]	Bushtit	X	X
Bombycilla garrulus[a]	Cedar waxwing	X	X
Phalaenoptilus nuttallii[a]	Common poorwill	X	
Baeolphus inornatus[a]	Oak titmouse	X	
Meleagris gallopavo[a]	Wild turkey	X	
Phainopepla nitens	Phainopepla	X	
Ceryle alcyon	Belted kingfisher		X
Regulus calendula	Ruby-crowned kinglet	X	X

Sources: BioSystems 1986a; LLNL 2003by, LLNL 2003bz.
[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 (LLNL 2003ai).
[d] The willow flycatcher was observed at Site 300 in 2003 (LLNL 2003cc).

Oak woodlands and a few cottonwoods provide nesting habitat for the western kingbird (*Tyrannus verticalis*), northern oriole (*Icterus galbula*), loggerhead shrike (*Lanius ludovicianus*), and American goldfinch (*Carduelis tristis*). Coastal sage scrub supports the scrub jay (*Aphelocoma coerulescens*), California thrasher (*Toxostoma redivivum*), Bell's sage sparrow (*Amphispiza belli*), Anna's hummingbird (*Calypte anna*), rufous-crowned sparrow (*Aimophila ruficeps*), and white-crowned sparrow (*Zonotrichia leucophrys*). Ecotones of sage scrub and grassland provide ideal habitat for the mourning dove, California quail, lazuli bunting (*Passerino amoena*), and lark sparrow (*Chondestes grammacus*). Rocky outcrops and cliffs provide breeding sites for white-throated swift (*Aeronautes saxatalis*), cliff swallow, Say's phoebe (*Sayornis saya*), and rock wren (*Salpinctes obsoletus*).

Site 300 also supports a population of nesting raptors. A breeding raptor survey, conducted at Site 300 in April and July 2002, identified four species of diurnal raptors and four species of owls. The raptors included the turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), and American kestrel (*Falco sparverius*), the most frequently observed raptor on Site 300. Owls observed included the barn owl (*Tyto alba*), western screech owl (*Otus kennicottii*), great horned owl (*Bubo virginianus*), and western burrowing owl (*Athene cunicularia*). The survey detected the presence of four active red-tailed hawk, four great horned owl, and three burrowing owl nests, although LLNL biologists have observed as many as 18 nesting pairs of burrowing owls in previous years. One inactive barn owl nest was found on the exterior of the Advanced Test Accelerator (ATA) Building. Also, numerous recently fledged American kestrels and one young western screech owl were observed. Blue oaks and conglomerate cliffs were the most frequently used nest structures. The numbers of breeding pairs and diversity of these birds of prey were relatively low compared to those identified on other large land units in the State of California. A pair of turkey vultures was

observed, although no nest was found (Bloom 2002). Although no golden eagle or white-tailed kite nests were found, both species have occasionally nested onsite in the past. The golden eagle nested at Site 300 in 1996, and the white-tailed kite (*Elanus leucurus*) nested in a valley oak at Site 300 in 1997 and 1998 (LLNL 1997o, Bloom 2002). In addition to these species, the northern harrier (*Circus cyaneus*), and prairie falcon (*Falco mexicanus*) were identified in 1986 and 1991 surveys (BioSystems 1986c, LLNL 1992a). Ferruginous hawks, pergrine falcons, broad-winged hawks, osprey, and Swainson's hawk have also been detected at Site 300 during season surveys. Breeding pairs are not anticipated to occur on the property.

A relatively large population of loggerhead shrikes (*Lanius ludovicianus*) was present at Site 300 in 2002. A total of 18 pairs of loggerhead shrike were identified during the 2002 surveys with 9 of the 18 pairs actively nesting. Six of the nests were in junipers and three were in oaks (Bloom 2002). Figure E.1.2.2–1 shows the nest locations of loggerhead shrike in 2002.

Bird species nesting at the Livermore Site include those recorded in the building areas, the security zone, and Arroyo Seco. Species nesting in the built-up area are those typical of suburban areas, including the killdeer (*Charadrius vociferus*), rock dove (*Columbia livia*), scrub jay, American crow (*Corvus brachyrhynchos*), American robin (*Turdus migratorius*), European starling (*Sturnus vulgaris*), house finch (*Carpodacus mexicanus*), and house sparrow (*Passer domesticus*). Species observed in the grass-dominated security zones include the western kingbird (*Tyrannus verticalis*), horned lark, and western meadowlark (LLNL 1992a).

Raptors observed at the Livermore Site include the turkey vulture (*Cathartes aura*), red-tailed hawk, Cooper's hawk (*Accipter cooperii*), barn owl, golden eagle, osprey, and white-tailed kite (LLNL 1992a, LLNL 2003bz). Numerous pairs of white-tailed kites (*Elanus lecurus*), a state-protected raptor, have successfully nested and fledged young at the Livermore Site since 1994. During 1999, three pairs of white-tailed kites *(Elanus lecurus)* successfully fledged 18 young. The kites were marked with aluminum leg bands to initiate long-term studies of the species in a semiurban edge habitat (LLNL 2001v).

Twenty-four species of birds at Site 300 are either Federal species of concern or State species of special concern. The Swainson's hawk (*Buteo swainsoni*) is listed as threatened by the CDFG. This hawk was observed in 1994 on the southeastern perimeter of Site 300 and on the adjacent CDFG Ecological Reserve. The Swainson's hawk nests within riparian habitats and is often associated with alfalfa crops and other forms of agriculture. This species was observed within close proximity to Site 300, but may forage occasionally within the site boundaries (LLNL 2003by).

The ferruginous hawk (*Buteo regalis)* is a Federal species of concern and State species of special concern. Ferruginous hawks are relatively common in the winter at Site 300, routinely observed in association with open grassland habitats (LLNL 2003by).

The Cooper's hawk (*Accipiter cooperii)* is a State of California species of special concern. This hawk has been observed associated with cottonwood or willow trees at the Elk Ravine Constant Effort Banding Station and along Corral Hollow Road (LLNL 2003by).

The sharp-shinned hawk (*Accipiter striatus*) is a State species of special concern. This species was detected during the 2002 avian monitoring program at Site 300 (LLNL 2003by).

The golden eagle (*Aquila chrysaetos*) is a State species of special concern. The golden eagle is found at Site 300 and is known to have nested within the site boundaries and dependably nests within close proximity to Site 300 along Corral Hollow Road. This eagle has often been observed foraging on California ground squirrels (*Spermophilus beecheii*) at Site 300.

The northern harrier (*Circus cyaneus)* is a State species of special concern. The northern harrier is relatively common in the winter at Site 300, routinely observed in association with open grassland habitats. Breeding has been documented at Site 300 (LLNL 2003by).

The osprey (*Pandion haliaetus)* is a State species of special concern. A single sub-adult Osprey was observed flying over Corral Hollow in 2000, likely a dispersing juvenile or early migrant (LLNL 2003by).

The white-tailed kite (*Elanus leucurus)* is a State of California fully protected species. The white-tailed kite was not observed in 2002, but is known to breed occasionally at Site 300. This species has been declining noticeably within the Tri-valley region for the past 3 years and also in southern California where long-term monitoring of this species has occurred (LLNL 2003by).

The horned lark (*Eremophila alpestris)* is a State species of special concern. This species is very common at Site 300 and has been detected at many of the variable circular plot point count stations in 2002. No horned larks were banded, implying that this species probably spends little time within riparian habitats at Site 300 (LLNL 2003by).

The grasshopper sparrow (*Ammodramus savannarum)* is a Federal species of concern. This species was observed in localized groups within the northern third of Site 300 (LLNL 2003by).

Bell's sage sparrow (*Amphispiza belli)* is a Federal species of concern. Bell's sage sparrow was only detected west of Building 854 in coastal sage scrub habitat. This species is likely to only be found within the sage scrub community and is a likely breeder for Site 300 (LLNL 2003by).

The prairie falcon (*Falco mexicanus)* is a State species of special concern. A single prairie falcon was observed at the northeast corner of Site 300 in 2000 (LLNL 2003by).

The tricolored blackbird (*Agelaius tricolor)* is a Federal species of concern and State species of special concern. A regionally important breeding colony of tricolored blackbirds is located in Elk Ravine, near Building 812. This species has also been observed foraging within the grasslands of Site 300 in the nonbreeding season. A total of 835 nests were located in 2002 within Elk Ravine (LLNL 2003by).

The loggerhead shrike (*Lanius ludovicianus)* is a Federal species of concern and State species of special concern. This species is common at Site 300 in both the breeding and nonbreeding season. This species is likely distributed in nearly all habitats, including urban areas of Site 300 (LLNL 2003by, Bloom 2002).

The California thrasher (*Toxostoma redivivum)* is a Federal species of concern. Nesting has been observed in coastal sage scrub habitat near Building 858 and observed in coastal sage scrub habitat east of Building 854 (LLNL 2003by).

The oak titmouse (*Baeolphus inornatus*) is a Federal species of concern. Nesting has only been observed in an oak snag in the southwest corner of Site 300, characteristic of its close association with oak habitat (LLNL 2003by).

The yellow warbler (*Dendroica petechia)* is a State species of special concern. It was banded at an Elk Ravine Constant Effort Mist Netting Station and only observed at that location, which is associated with a riparian habitat (LLNL 2003by).

Almost all of the bird species listed in Table E.1.2.2–2 also receive protection under the *Migratory Bird Treaty Act* (16 *United States Code* [U.S.C.] §703 et seq.). This law governs the taking, killing, possessing, transporting, and importation of migratory birds, their eggs, parts and nests. Executive Order 13186, Responsibilities of Federal agencies to Protect Migratory Birds, issued on January 10, 2001, provides additional guidance on the responsibilities of Federal agencies to protect migratory birds on property under their jurisdiction.

Mammals

Twenty-six species of mammals were recorded during threatened and endangered species surveys in 1986 and 1991 (BioSystems 1986c, LLNL 1992a). Additional surveys have been conducted at Site 300 during which four additional species were observed (Jones and Stokes 2002b, CSUS 2003, LLNL 2003bh) and at the Livermore Site (LLNL 2003bz). All the species were seen at Site 300, and 12 species were observed at the Livermore Site (Table E.1.2.2–3). The investigation included conducting ground surveys in open areas, night spotlighting, establishing scent stations, and trapping small mammals.

Productive and diverse grasslands on Site 300 support an abundance of rodents and lagomorphs (rabbits and hares). Conditions are ideal for California ground squirrels (*Spermophilus beecheyi)* in the northern portion of Site 300 where the terrain is less rugged. Other common rodents include the house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), Heermann's kangaroo rat (*Dipodomys heermanni*), valley pocket gopher (*Thomomys bottae*), and, in the higher grass cover, the California vole (*Microtus californicus*) and western harvest mouse (*Reithrodontomys megalotis*). Lagomorphs such as black-tailed hares (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*) are also widespread and abundant, with the latter tending to occupy areas with more cover (LLNL 1992a, Jones and Stokes 2002b).

TABLE E.1.2.2–3.—*Mammal Species Observed at the Livermore Site and Site 300 in 1986 and 2002 Surveys*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Didelphis virginiana	Virginia opossum	X	X
Sylvilagus audubonii	Desert cottontail	X	X
Lepus californicus	Black-tailed hare	X	X
Spermophilus beecheyi	California ground squirrel	X	X
Thomomys bottae	Valley pocket gopher	X	
Perognathus californicus	California pocket mouse	X	
Perognathus inornatus	San Joaquin pocket mouse	x	
Dipodomys heermanni	Heermann's kangaroo rat	X	
Reithrodontomys megalolis	Western harvest mouse	X	
Peromyscus maniculatus	Deer mouse	X	
Neotoma lepida	Desert woodrat	X	
Microtus californicus	California vole	X	X
Mus musculus	House mouse	X	X
Sus scrofa	Feral swine	X	
Canis latrans	Coyote	X	X
Vulpes vulpes	Red fox	X	X
Urocyon cinereoargenteus	Gray fox	X	X
Procyon lotor	Raccoon	X	X
Mustela frenata	Long-tailed weasel	X	
Taxidea taxus	Badger	X	
Spilogale gracilis	Western spotted skunk	X	
Mephitis mephitis	Striped skunk	X	X
Felis concolor	Mountain lion	X	
Felis domesticus	Feral house cat	X	X
Lynx rufus	Bobcat	X	
Tadarida brasiliensis	Mexican free-tailed bat	X	
Antrozous pallidus	Pallid bat	X	
Myotis volans	Long-legged myotis	X	
Myotis yumanensis	Yuma myotis	X	
Odocoileus hemionus	Black tailed deer	X	

Sources: LLNL 1992a, LLNL 2003bh, CSUS 2003, Jones and Stokes 2002b.

Many mammalian predators are supported by the rich prey base. Grassland predators include the long-tailed weasel (*Mustela frenata*), western spotted skunk (*Spilogale gracilis*), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), badger (*Taxidea taxus*), and bobcat (*Lynx rufus*). Red foxes (*Vulpes vulpes*), which have been reported from nearby areas to the east and north of the site, have greatly expanded their range in the Central Valley (BioSystems 1986c). They show a preference for more disturbed areas, often denning in roadside culverts, and were observed near

Site 300 in 1991. Sage scrub, wooded, and riparian habitats attract other mammalian predators not normally found in grasslands including bobcat, gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), and mountain lion (*Felis concolor*). Although these habitats are preferred, they are relatively limited on Site 300; consequently, grassland areas are used as well. Only minor areas of riparian vegetation are associated with the seeps and springs that occur along the canyon bottoms. Black-tailed deer (*Odocoileus hemionus*) prefer these habitats, but are frequently seen in the open grasslands (LLNL 1992a).

A mesocarnivore survey was conducted from mid-September through mid-October 2002, involving eight spotlighting sessions. An average of 19.8 miles (range of 14 to 28 miles) was driven for each session. Table E.1.2.2–4 summarizes the spotlighting results for the following three mesocarnivores: badger (*Taxidea taxus*), bobcat (*Lynx rufus*), and coyote (*Canis latrans*). Other species observed included burrowing owl *(Athene cunicularia*), great-homed owl (*Bubo virginianus*), barn owl (*Tyto alba*), lesser nighthawk (*Chordeiles acutipennis*), western meadowlark (*Sturnella neglecta*), red-tailed hawk (*Buteo jamaicensis*), kangaroo rat (genus *Dipodomys*), deer mouse (*Peromyscus maniculatus*), black-tailed hare (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), western toad (*Bufo boreas*), California red-legged frog (*Rana aurora draytonii*), feral swine (*Sus scrofa*), and black-tailed deer (*Odocoileus hemionus*) (CSUS 2003).

Table E.1.2.2–4 also includes the results of a camera-monitored scent station survey at 30 locations, with observations made for 14 days at the first 10 locations and for 7 days at the other locations. The camera stations and spotlight sessions were effective in detecting the presence of mesocarnivores. Both methods detected the presence of bobcat, a rather difficult predator to observe. Orloff (BioSystems 1986c) detected gray foxes on Site 300, while no foxes were detected in the 2002 survey. Additionally, raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) were detected in 1986, but not in 2002 (BioSystems 1986c, CSUS 2003).

TABLE E.1.2.2–4.—*Species and Numbers of Individual Mammals Recorded During Night Spotlighting and Predator Scent-Baited Camera Stations at Site 300 in 2002*

Species	Spotlighting [a]	Camera Stations [b]
Badger	10	1
Black-tailed deer	—	7
Feral swine	—	2
Bobcat	1	1
Coyote	14	3
Hare	—	7

Source: CSUS 2003.
[a] Spotlighting conducted on the nights of September 16, 17, and 30 and October 1, 8, 9, 14, and 15, 2002.
[b] Predator Scent-Baited Camera Stations were operated at 30 locations.

A small mammal survey was conducted May 14 to May 19, June 20 to June 22, and July 30 to August 1, 2002. Trapping was performed in six major communities: coastal scrub, annual grassland, native grassland, riparian, oak savanna, and spring/seep wetland. Additionally,

trapping was performed on native grassland and seep communities before and after annual prescribed burns.

A total of 210 small mammals, representing 9 species in 3 families, were captured during 2,689 trap nights at Site 300. Species captured included the valley pocket gopher (*Thomomys bottae*), California pocket mouse (*Perognathus californicus*), San Joaquin pocket mouse (*Perognathus inornatus*), Heermann's kangaroo rat (*Dipodomys heermanni*), western harvest mouse (*Reithrodontomys megalotus*), deer mouse (*Peromyscus maniculatus*), brush mouse (*Peromyscus boylii*), California vole (*Microtus californicus*), dusky-footed woodrat (*Neotoma fuscipes*), and house mouse (*Mus musculus*). No state or federally listed threatened or endangered species were observed during the 2002 small mammal survey. However, the San Joaquin pocket mouse is a Federal species of concern (Jones and Stokes 2002b).

Table E.1.2.2–5 summarizes the total number of individuals of each species captured at each survey site during each trapping period of the small mammal survey. The number of species captured in descending order at Site 300 communities was: riparian (7), coastal scrub and annual grassland (5), native grassland and seep/spring wetland (3), and oak savannah (2). The number of individual mammals captured by community in descending order was riparian (65), coastal scrub (63), annual grassland (28), seep/spring wetland (17) communities, oak savanna (5), and native grassland (4) (Jones and Stokes 2002b).

Surveys were conducted in 1991 at the Livermore Site and Site 300, for one federally listed endangered species, the San Joaquin kit fox (*Vulpes macrotis mutica*), and at Site 300 for two federally listed candidate species, the San Joaquin pocket mouse (*Perognathus inornatus*) and the riparian woodrat (*Neotoma fuscipes riparia*). Of the three species only the San Joaquin pocket mouse was observed; the San Joaquin kit fox was not observed onsite (LLNL 1992a).

Surveys were conducted for the San Joaquin kit fox in 1991, and hundreds of project-specific surveys have been conducted at the site since 1993. No kit fox were recorded at Site 300 in 1991, and none have been detected there in subsequent surveys including one in 2002 (CSUS 2003). However, this species has been observed in close proximity to Site 300 (Orloff et al. 1986, Sproul and Fleet 1993). A comprehensive mitigation and monitoring plan was developed for this species in the *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories* (1992 LLNL EIS/EIR) (LLNL 1992a, Jones and Stokes 2001).

A report is being prepared of a bat survey at Site 300. Preliminary information indicates that the following special status species were observed: Pallid bat (*Antrozous pallidus*), a State species of special concern; the long-legged myotis (*Myotis volans*), a Federal species of concern; and the Yuma myotis (*Myotis yumanensis*), a Federal species of concern (LLNL 2003bh).

Ten species of mammals were recorded at the Livermore Site (Table E.1.2.2–3). Common species recorded during night spotlighting and at scent stations were the feral house cat, desert cottontail, black-tailed hare, red fox, and gray fox. In addition, the Virginia opossum (*Didelphis virginiana*) was recorded frequently at the scent stations (Table E.1.2.2–4).

E.1.2.3 *Impacts of Current Operations*

Program activities for Site 300 are discussed in Chapter 3 and Appendix A of the LLNL SW/SPEIS. The activities discussed in Section E.1.1 for vegetation would also affect wildlife at Site 300, as would vehicle traffic, fencing of facilities, explosives testing, surface impoundments, and the sewage lagoon.

Prescribed Burn

Prescribed burns may have a positive, neutral, or negative effect on wildlife depending on the species and time of year. Animals living underground, such as ground squirrels, burrowing owls, and pocket mice or animals, such as lizards, that escape into crevices and holes, are unlikely to be directly affected by fast-moving grass fires (BioSystems 1986c). Rodents inhabiting this region are adapted to periodic grass fires, so burning should not have an adverse impact on them. Burns stimulate new vegetative growth and create range conditions that probably support a greater diversity of wildlife than if the area were not burned. These newly burned areas provide excellent foraging habitat for open-country raptors. Annual burning provides a diversity of habitat for ground-nesting bird species, including raptors, but also may result in mortality for the young before they have fledged and habitat reduction for some grassland nesting passerines.

A research proposal has recently been coordinated with the USFWS to evaluate the effects of prescribed burning on the Alameda whipsnake at Site 300 and several other locations (Swaim 2002c). The research proposal received a favorable biological opinion by the USFWS (USFWS 2002a). No Alameda whipsnake mortality due to fire has been observed at Site 300 to date (LLNL 2001c).

Lack of Livestock Grazing

Site 300, which is surrounded on three sides by heavily grazed lands, has not been grazed for almost 50 years. Studies have suggested that grazing may increase habitat stability for rodent species including the California ground squirrel (Balestreri 1981, Laughrin 1970). Other studies have indicated that heavy grazing lowers the density of some rodent species such as kangaroo rats and pocket mice (O'Farrell and McCue 1981, O'Farrell et al. 1981). The exclusion of grazing on Site 300 appears to have resulted in an abundance of several granivorous rodents (e.g., kangaroo rats and pocket mice) that no longer need to compete with livestock for food. Despite the lack of grazing, however, ground squirrel populations have overall remained more plentiful in the flatter, northern half of Site 300. Many herbivorous animals generally prefer perennial grasses to the less nutritious annuals. These perennial grasslands have developed in areas where grazing has been excluded and where annual prescribed burns occur.

The exclusion of livestock grazing may have a mixed effect on the bird population. Ground-nesting species, including raptors, probably benefit from the resultant tall grass. Foraging suitability for other open-country raptors, such as golden eagles, is enhanced by the presence of low cover perennial grasslands; in other areas, foraging suitability is reduced where tall annuals obscure ground visibility. Overall, however, raptor habitat potential is excellent onsite (BioSystems 1986c).

The exclusion of livestock grazing also has a positive impact because springs and associated wetlands that are important to many species of wildlife have not been degraded or destroyed by livestock.

Ground Squirrel Control

Presently, there is no active ground squirrel control program anywhere at Site 300. Control is done, on an as needed basis, around the surface impoundment, using Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations (LLNL 2003ah). The impact from the application of these rodenticides is anticipated to be negligible when used in accordance with their U.S. Environmental Protection Agency (EPA) pesticide label instructions.

Disking, Grading Fire Trails, and Applying Herbicides to Contain Fires

Site 300 maintenance staff annually receives training on special status species identification and distribution, and preactivity surveys for the presence of sensitive natural resources are performed prior to disking. The perimeter-disking project proceeds only after consultation with the LLNL wildlife biologist. The Site 300 maintenance staff follows mitigation measures provided by the wildlife biologist to protect sensitive wildlife and habitats such as American badger dens from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years (LLNL 2001c).

Approximately 85 miles of fire trails are graded every spring along existing routes (BioSystems 1986c). Some ground-dwelling species such as California horned lizard and silvery legless lizard may be adversely affected if present during grading operations (Stebbins 2003).

Herbicide applications discussed earlier for vegetation would be anticipated to have minimal impact on wildlife species when used in accordance with their EPA pesticide label instructions. At no time are herbicides sprayed on habitat suitable for the Alameda whipsnake or California red-legged frog. Prior to late-Fall application, ground areas subject to spraying are assessed by a LLNL wildlife biologist. Also, herbicide projects proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Vehicle Traffic

Vehicles traveling along the paved roads and the better fire trails could cause wildlife mortality. This cause of wildlife mortality, however, would be minimal along the dirt roads and fire trails in the more remote and biologically diverse areas.

The nocturnal seasonal migrations of amphibians such as the California tiger salamander and California red-legged frog could result in mortality along roads. But again, impacts should be minimal as nighttime vehicle traffic is sparse and migrations are infrequent.

Fencing of Facilities

The perimeter of Site 300 includes approximately 0.5 mile of chain-link and 13.4 miles of barbed wire fencing (LLNL 2003bi). Large mammals generally cannot enter areas equipped with gates and chain-link fences.

Fencing around the surface impoundments mentioned below only exclude some of the larger species of wildlife. However, fences also provide perches for many species of birds, including burrowing owls and loggerhead shrikes.

Explosives Testing

All three primary outdoor explosives testing facilities at Site 300 are approximately 1 mile from the site's northern border; explosives testing is conducted almost entirely during the day. The explosions are weekly to daily, and wildlife exists near these facilities with relatively minimal impact.

Diurnal raptors that forage directly over the facilities are the species most vulnerable to flying debris and shock overpressure; these include the golden eagle, prairie falcon, northern harrier, black-shouldered kite, ferruginous hawk, and red-tailed hawk. Smaller birds may also be affected.

Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

Visual inspection of the explosive process water surface impoundments revealed few wildlife species existing within the waters. The impoundments are lined with a high density polyethylene liner. A few scattered cattail were observed in one small area; the remainder of the shoreline is devoid of vegetation. Shorebirds have been seen foraging along the edge. The California tiger salamander and western toad are known to use these impoundments, but they are considered suboptimal habitats because they lack submergent and emergent vegetation. Amphibian use of the impoundments would likely be strictly transitory with accompanying minimal impacts.

The highly eutrophic sewage oxidation pond supports many aquatic species, including a nesting pair of mallards. Wading birds such as the green heron have been observed at this location. The California red-legged frog and California tiger salamander have also been observed at the overflow pond (also referred to as the percolation pond) only and not at the oxidation pond. Breeding has been reported for these two amphibian species at a number of locations at Site 300 (Jones and Stokes 2001, LLNL 2003ab).

E.2 BIOLOGICAL ASSESSMENT

This biological assessment addresses the status of threatened, endangered, and other species of concern (referred to as sensitive species) that are known to occur at the Livermore Site and Site 300. This assessment was prepared pursuant to the *Endangered Species Act* and the *California Endangered Species Act*.

The original version of Section E.2.1, Livermore Site, was prepared by Jim Woollett (LLNL) as a separate biological assessment in September 1997 and amended in August 1998 (LLNL 1998a). An additional amendment to this part of the biological assessment was made in 2002 by Michael van Hattem (LLNL) to address the Bullfrog Management Program. Preparation of this part of the biological assessment involved contact and coordination with members of the staff of the USFWS Sacramento office (USFWS 1997, USFWS 1998, USFWS 2002e). There has been minimal change in the biological and operational conditions at the Livermore Site since the USFWS approved the 1998 and 2002 amendments. To facilitate review of the biological

assessment by the USFWS, this part of the document has retained essentially the same format as provided in November 1997, but has incorporated the 1998 and 2002 amendments. Where needed, this biological assessment provides updates or new information on the mission and operations of the Livermore Site.

The original version of Section E.2.2, Site 300, was prepared as a separate biological assessment by Brook Vinnedge, Steven Avery, and Scott Frazier (Jones and Stokes 2001). Preparation of this part of the biological assessment involved contact with members of the USFWS Sacramento office staff. Contributions to the biological assessment were also made by Karen Swaim (Swaim Biological Consulting) and Jim Woollett (LLNL). There has been minimal change in the biological and operational conditions at Site 300 in the time since the assessment was approved (USFWS 2002b). Therefore, the document has been prepared in essentially the same format as provided in December 2001, to facilitate its review by USFWS. Where needed, this part of the biological assessment provides updates or new information on the mission and operations of Site 300 as described in this LLNL SW/SPEIS from special status plant surveys; valley elderberry longhorn beetle survey results; and from the schedule of Site 300 activities discussed previously.

Federal agencies are required by Section 7 (a)(2) of the *Endangered Species Act* (16 U.S.C. §1536) to ensure that their actions are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the critical habitat of such species…"

The *California Endangered Species Act* (California Fish and Game Code Sections 2050 through 2098) includes provisions intended to protect threatened and endangered species that may be affected by development projects subject to the *California Environmental Quality Act* (CEQA). The *California Endangered Species Act* states that agencies should not approve projects that would jeopardize the continued existence of threatened or endangered species, or result in the destruction or adverse modification of habitat essential to the continued existence of those species if there are reasonable and prudent alternatives available that would conserve the species or its habitat.

This biological assessment presents the results of surveys conducted for Federal and state endangered and threatened species; Federal candidate plant and animal species; and state species of special concern. These surveys were conducted to determine what impacts, if any, the Proposed Action and the alternatives would have on these species and to ensure compliance with the *United States Endangered Species Act* and *California Endangered Species Act* for activities undertaken at the Livermore Site and Site 300.

For the LLNL SW/SPEIS, consultation under Section 7 of the *Endangered Species Act* was initiated with the USFWS on October 21, 2002, when a letter was sent to their office in Sacramento, California, requesting a list of endangered, threatened, and other species of concern that may occur or are known to occur at the Livermore Site and Site 300. A response received on October 28, 2002, provided two lists, one for the Livermore Site and one for Site 300 (Attachment 1). This list has been used to update the status of listed species at these two LLNL sites (Table E.2–1). Species accounts for Federal and California species with endangered, threatened, or candidate status are provided in Attachment 3 at the end of this appendix.

Data for the Livermore Site and Site 300 are presented separately, in part, because they are separate geographic and biological locations. Additionally, the USFWS elected to provide separate biological opinions for these sites in the 1992 LLNL EIS/EIR, and separate consultation has been conducted with USFWS since then. Text from biological assessments submitted in 1992, 1997, 2001, and related amendments, has been incorporated into this document with little change to retain the nature of carefully coordinated and implemented agreements during the past decade made between LLNL, DOE, and USFWS regarding species protected by the *Endangered Species Act* (LLNL 1992a, LLNL 1998a, Jones and Stokes 2001). However, the biological assessment includes new information or changes in the regulatory status of species present at the Livermore Site and Site 300.

E.2.1 Livermore Site

E.2.1.1 *Introduction*

LLNL is a multiprogram national laboratory operated by University of California for NNSA. It undertakes multidisciplinary fundamental and applied research and development activities in a broad range of scientific and technical fields and maintains close interaction with scientific and technical personnel within universities and industry. LLNL's primary mission is to ensure that the nation's nuclear weapons are safe and secure and reliable and to prevent the spread and use of weapons of mass destruction worldwide. Major research programs include defense technologies, energy, biomedical and environmental research, environmental restoration, and waste management (LLNL 2002d).

The Livermore Site is located about 40 miles east of San Francisco at the southeastern end of the Livermore Valley in southern Alameda County, California. The central business district of the city of Livermore is about 3 miles to the west. The Livermore Site occupies essentially all of Section 12, Township 3 South, Range 3 East of the U.S. Geological Survey (USGS) Altamont Quadrangle, California, and a portion of Sections 1, 2, and 11, for a total area of 1.3 square miles (821 acres). Lands to the north are zoned industrial. Lands to the east and south are zoned agricultural and lands to the west are zoned residential.

Before World War II, the present-day Livermore Site was part of the Wagoner Ranch; cattle grazing was the dominant land use. The Navy purchased the site in 1942 and established the Livermore Naval Air Station as a flight-training base. Runways were constructed near the center of the site with a rectangular grid street system along the southern portion of the site.

The transition from Navy operations to a research facility began in 1950 when the California Research and Development Corporation (a subsidiary of Standard Oil, Inc.) began construction of the Materials Test Accelerator Facility as authorized by the Atomic Energy Commission. In 1951, the University of California Radiation Laboratory in Berkeley began using some of the Livermore facilities in support of nuclear weapons research being conducted by the Los Alamos Scientific Laboratory in New Mexico.

In 1952, the University of California established a second laboratory dedicated to nuclear weapons research. The University of California operated what is now called LLNL for the Atomic Energy Commission from 1952 to 1975, then for the Energy Research and Development Agency (DOE's predecessor) until 1977, and for DOE/NNSA since then.

E.2.1.2 *Affected Species*

The species considered in the biological assessment for the Livermore Site is the California red-legged frog (*Rana aurora draytonii*), a federally listed threatened species (61 FR 25813 et seq.).

Critical Habitat

Although critical habitat for the California red-legged frog was established by USFWS on March 13, 2001, most of that critical habitat was rescinded by a court order (USDCDC 2002). Livermore Site areas formerly designated as California red-legged frog critical habitat are shown in Figure 4.9.3–1 of this LLNL SW/SPEIS. However, it is possible that during the next few years the critical habitat for this species may be reinstated again at the Livermore Site when the USFWS publishes a new critical habitat proposal (USFWS 2003).

E.2.1.3 *Unaffected Species*

With the exception of the California red-legged frog noted above, none of the species included in the species list provided by USFWS for the Altamont Quadrangle have been detected on the Livermore Site (USFWS 2002d). A special status plant survey conducted in July 2002 did not detect any threatened, endangered, or candidate plant species at the Livermore Site (Jones and Stokes 2002a).

The California tiger salamander (*Ambystoma californiense*) is a federally listed proposed threatened species (68 FR 28649) that has not been observed at the Livermore Site, but has been detected in close proximity. The California tiger salamander has been detected at Sandia National Laboratories/California (SNL/CA) in two detention ponds that are within approximately 1,100 feet of the southern boundary of LLNL (NNSA 2003a).

E.2.1.4 *Consultations to Date*

- For the 1990-1991 EIS/EIR (Appendix F of the 1992 LLNL EIS/EIR) biological assessment consultations performed in 1990–1991.

- NNSA Livermore Site Office initiated formal consultation with the submittal of a biological assessment to USFWS in August 1997, regarding the originally proposed

Arroyo Maintenance Plan, and received a biological opinion in the latter part of October 1997 (USFWS 1997). Phase One of the Arroyo Project was completed in the first half of November 1997. No "take" of the California red-legged frog was detected before, during, or after this project.

- In June 1998, DOE submitted an amended biological assessment that LLNL prepared to address comments in the USFWS October 1997 biological opinion (1-1-97-F-173) on the proposed Arroyo Las Positas Maintenance Project (LLNL 1998a). The USFWS approved the amended biological assessment in October 1998 (USFWS 1998).

- In July 2002, NNSA submitted a Bullfrog Management Plan amendment for the biological opinion (1-1-97-F-173) on the Arroyo Las Positas Maintenance Project (DOE 2002j).

- In August 2002, USFWS approved the Bullfrog Management Plan amendment for the biological opinion (1-1-97-F-173) on the Arroyo Las Positas Maintenance Project (USFWS 2002e).

- In October 2002, USFWS provided a species list for both the Livermore Site and Site 300 for the LLNL SWEIS (USFWS 2002d).

E.2.1.5 *Proposed Action Project Activities*

Current projects at the Livermore Site with the potential to affect special status species include:

- The ongoing Arroyo Las Positas Maintenance Project
- Maintenance on other onsite drainage systems (i.e., DRB, B571 Wetland)
- Bullfrog management activities
- Construction-related activities for a number of LLNL SWEIS projects
- Maintenance of security buffers components located in critical habitat designated for the California red-legged frog
- Decontamination and demolition of facilities
- Maintenance of facilities, paved roads, and utilities
- Landscaping and grounds maintenance
- Herbicide application
- Invasive species control
- Vehicle traffic

Although formerly designated critical habitat for the California red-legged frog has been rescinded, the USFWS may redesignate critical habitat for this species over the 10-year period covered by the LLNL SWEIS (USDCDC 2002, USFWS 2003).

This biological assessment discusses the temporal and spatial effects that the Proposed Action project activities may have on federally listed threatened, endangered, and candidate species and their critical habitats, and outlines mitigation measures specific to those effects. Mitigation measures would be implemented over the next 10 years according to the Proposed Action schedule described in Section E.2.1.5.12, Schedule of Continuing Activities.

E.2.1.5.1 *The Arroyo Las Positas Maintenance Project*

The ongoing Arroyo Las Positas Maintenance Project, as approved by USFWS, consists of creating a vegetative mosaic of frog habitat in the Arroyo Las Positas with a cyclical 5-year maintenance plan, possibly affecting several wetland assemblages identified in the center of the site. Future curtailment of treated groundwater releases into the arroyo, potential mitigation values, and offsite compensation for loss of wetland habitat are also discussed (LLNL 1998a, USFWS 1998).

Five-year Arroyo Las Positas Maintenance

For identification purposes, Arroyo Las Positas was divided into three reaches: Reach 1 runs along the eastern boundary of the Livermore Site, adjacent to Greenville Road; Reach 2 follows the northern site boundary south of and parallel to Patterson Pass Road; and Reach 3 is a part the arroyo running northward to Patterson Pass Road as it leaves the site boundary.

It is believed that the flood capacity of the arroyo drainage can be returned to the 100-year storm event level by a recently constructed berm approximately 18 to 24 inches high, along the south side of Reach 2 (Figure E.2.1.5.1–1). A berm is not required in Reach 1, because an elevated embankment already exists approximately 100 feet to the west of the streambed, or Reach 3, because adequate capacity is already present in the channel.

The required capacity would be maintained by cyclically dredging (removing in-channel vegetation and associated pediments) pre-designated sections of the arroyo on a 5-year, rotating basis. This “checkerboard” maintenance design would continue to be conducted in late summer and executed using a backhoe operated from the upper bank and top of the side slope in 100- or 300-foot linear portions of the drainage (outlined in Figure E.2.1.5.1–2) to an approximate depth of 18 inches. The removed material would be immediately placed into a dump truck and transported to an appropriate disposal site, which may include reuse onsite or deposition at a landfill depending on the results of soil sampling from the project area. The net effect of this plan would be that no more than 20 percent of existing *Typha*-type wetland vegetation would be removed each year from the onsite drainage and that there would be sufficient habitat areas present for the frog throughout the channel to allow natural movements or connectivity between the offsite upstream and downstream portions of the arroyo (LLNL 1998a).

A survey in 2002 documented the presence of the California red-legged frog throughout the portion of Arroyo Las Positas within the boundaries of the Livermore Site (LLNL 2003ab). As a result, portions of the arroyo are maintained in shorter (100-foot) sections because of dense growth and proliferation of vegetation and/or presence of California red-legged frog habitat; these sections need to be expanded from the original areas in coordination with the USFWS. Any vegetative growth on concrete aprons in the arroyo would be removed with heavy equipment, as needed, without damaging adjacent habitat areas. Infrequently, erosion repair and stabilization measures would need to be performed; no heavy equipment would be operated in the stream bottom during this work (LLNL 1998a).

Annual Arroyo Las Positas Maintenance

Willow stands have gained a foothold at several locations along the arroyo in the streambed. To ensure woody growth does not occur in the stream bottom at these locations and in other areas, willows would be hand-cut at basal height prior to winter rains. All cuttings would be collected and placed in a truck for disposal. Removal of storm debris such as branches and trash would be accomplished on an as-needed basis. Some loading of cuttings and debris for removal would be executed using a front-end loader or other similar heavy equipment operated from the upper bank. In some areas of the arroyo, *Typha* patches could grow more quickly and densely than the 5-year maintenance program would accommodate. If a patch is too thick to allow winter flow passage, a trimming extension from a riding mower on the upper bank would be used in the late summer to cut the *Typha* to a height of no less then 48 inches. A rake extension from the mower would be used to collect the trimmings for removal (LLNL 1998a). The rake would have rounded tines spaced approximately 4 inches apart and could be drawn across the top of the *Typha* stands to collect the cuttings. Loose vegetation could also be retrieved up the side slope with this extension. These activities would be performed under the supervision of a qualified wildlife biologist. All trucks and heavy equipment would remain on the upper banks and top of side slopes of the arroyo.

Upper-bank mowing of the arroyo would be accomplished using a tractor with a mowing hook-up set at a height of 6 inches or greater. Upland mowing is scheduled to occur once a year (June) to minimize fire risk. The infall pool in Reach 1 and the two pools in Reach 3 (all currently with frog populations) would not be dredged if hydric conditions exist in the drainage, but would have vegetation trimmed as needed to a height of 24 inches by rotary-powered tools such as weed-whackers, within a 50-foot buffer of the pool and in the late fall. A qualified wildlife biologist would perform the entire vegetative cutting. The pelagic (open water) pioneer vegetation and marginal zone vegetation of the pool would be cut by hand. Vegetative growth such as *Typha* would be cut 6 inches above the water surface in the pelagic zone, and the encroaching vegetative growth from the margin of the pool would also be trimmed to maintain semi-marsh conditions. No wading in the pooled areas of the arroyo would be allowed. Initial winter rains would be allowed to flush sediments and remove the encroaching vegetation or rhizomes from the center of the pools and naturally maintain the depth and longevity of these breeding areas.

If dredging activities were required in Reach 2 or Reach 3, water from onsite treatment facilities would be diminished for the short time it would take to complete maintenance of the section. This

would inhibit sedimentation or particulate transport to downstream locations during the activity (LLNL 1998a).

Hydrologic Conditions

Water velocity and volume measurements were collected at several points in the arroyo as part of a data collection effort requested by USFWS in 1998. This information was considered valuable in assessing the relative quantity of water discharged into the arroyo from the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) groundwater treatment facilities (TFs). The augmented flow contribution in the arroyo from TFC and TFD (Figure E.2.1.5.1–3) effluent might provide summertime inundation to the wetlands that, under natural regimes, would be unavailable. Additional information on flow contributions from these treatment facilities are found in the amended biological assessment (LLNL 1998a). TFA and TFB discharge to Arroyo Las Positas, approximately 100 gallons per minute, via a tributary along Vasco Road.

E.2.1.5.2 *Other Onsite Drainage Systems (DRB and the B571 Wetland)*

Vegetative growth in identified site-wide drainages would be removed periodically when the channels do not have free-flowing lotic conditions. Sediment deposits would be removed by backhoe to maintain channel capacity. This removal could include minor grading to reestablish flowlines. Areas graded or otherwise exposed would be seeded to prevent erosion. LLNL would also need to perform the following types of maintenance activities to keep the drainage systems functional:

- Erosion repairs and preventive measures including installation or repair of rip rap or gabion structures, fill, and installation of jute netting or other erosion control fabrics
- Removal of storm debris such as branches, silt, and trash
- Watershed upgrades with additional or relocated inlets
- Installation or removal of culverts

Vegetation and sediment removal would be accomplished prior to late-summer conditions. All frog-related mitigation measures would be implemented as stated in Section E.2.1.9 of this biological assessment.

California red-legged frogs have been observed in the DRB. If California red-legged frogs are discovered during maintenance activities in one of the alternative habitat areas (DRB and the B571 wetland) as displayed in Figure E.2.1.5.2–1, they could be relocated to the arroyo. Bullfrogs (*Rana catesbeiana*) have been found in the DRB, but have not been detected in the B571 wetland.

E.2.1.5.3 *Bullfrog Management Plan Activities*

History and Response to Bullfrogs at the Livermore Site

Bullfrogs were originally discovered at the Livermore Site in 1997 in the southern sediment basin, a sediment trap south of the DRB. For several years, bullfrogs were controlled as observed. In 2000, a series of control measures were implemented in the DRB: (1) a 0.25 inch mesh aluminum containment screen was installed on the DRB effluent culvert to prevent movement of frogs and larger larvae between the DRB and the Arroyo Las Positas; (2) gigging was started and soon after replaced by high-powered air rifles with scope-mounted halogen lights; (3) education of the LLNL community was implemented through briefings, news releases, and Earth Day presentations; (4) dewatering of the DRB occurred in December 2000/January 2001; and (5) May through October weekly boat surveys were conducted to remove egg masses (DOE 2002j).

The 2000/2001 DRB dewatering effort was a substantial task for many reasons, but especially because of the size (12.5 million gallons/5.5 acres) and design of the basin, which cannot be drained without mechanical pumping. A diesel powered 6-inch pump ran continuously for 10 to 12 hours a day for almost a month to accomplish draining after the basin had already been drained to its lowest point without pumping. The dewatering was also costly (approximately $40,000), unsightly, and subject to intense public scrutiny. One of three LLNL cafeterias is on the western border of the DRB (DOE 2002j). This cafeteria is being replaced in 2004 with a new cafeteria located just north of the DRB.

Project Description/Control Techniques

Dewatering

As previously discussed, dewatering has been successfully implemented in the DRB. The overall success of the previous dewatering project was high, with nearly all bullfrog larvae being removed, in addition to several thousand channel catfish (*Ictalurus punctatus*). Although dewatering is a valuable management technique for bullfrog larvae removal, it is not a sustainable technique for annual or biennial use in the DRB. The size, capacity, design, cost, and scrutiny make dewatering the DRB a less desirable management technique.

The intent is to retain dewatering as a potential option for invasive species management in the DRB, but to implement other control techniques such as Rotenone treatments, which are more economically feasible in the long-term and considerably easier to implement.

Although bullfrogs are primarily confined to the DRB at this time, it is conceivable that they will ultimately colonize the Arroyo Las Positas. If bullfrog breeding occurs in the Arroyo Las Positas it will be necessary for LLNL wildlife biologists to temporarily terminate CERCLA surface releases, thus stranding and desiccating the bullfrog larvae. Rotenone may also be needed, but will only be used as a secondary technique due to the inherent challenges involved in treating a lotic system (DOE 2002j).

Rotenone

Rotenone is a naturally occurring compound derived from the roots of tropical plants in the bean family *Leguminosae,* including jewel vine (*Derris* spp.) and lacepod (*Lonchocarpus* spp.) (Finlayson et al. 2000). Response to rotenone is species-specific, although animals using a high degree of aquatic respiration are probably most susceptible (Wilson and McCranie 1994). Rotenone works by inhibiting the biochemical process at the cellular level making it impossible for fish, amphibians, and aquatic insects to use the oxygen absorbed in the blood and needed in the release of energy during absorption (Finlayson et al. 2000). Rotenone is a commonly used pesticide in North America and has been used in fisheries management since 1934. Rotenone is applied as a wettable paste/powder or as an emulsifiable spray concentrate containing approximately 5 percent rotenone (Wilson and McCranie 1994). Common application methods include using drip stations or sprayers and pumping through hoses into the propeller wash of powerboats. Treatments with 5 percent rotenone usually range from 0.5 pound per minute to 5.0 pounds per minute, with a typical treatment rate of 2 pounds per minute (Finlayson et al. 2000).

The degradation of rotenone is affected by temperature, light, oxygen, pH, turbidity, and dilution by inlets and runoff. For example, the DRB can often exceed 80°F during summer months with no stratification, and under these conditions, the half-life of 5 percent rotenone is approximately 0.94 day (Wilson and McCranie 1994). Rotenone also is an unstable compound that is non-persistent and essentially does not bioaccumulate (Wilson and McCranie 1994, DOE 2002j). Both the DRB and the Arroyo Las Positas are ideal for rotenone treatments because none of the previously listed limnological parameters would be limiting. The total amount of rotenone used in the treatment would not exceed the maximum dosage on the label and would be performed by a licensed applicator.

E.2.1.5.4 *Construction Related Activities*

Under the Proposed Action, construction projects would result in the disturbance of 462,000 square feet (10.6 acres) of soil in undeveloped areas at the Livermore Site.

Included in the 462,000 square feet of soil disturbance are previously planned No Action Alternative projects including the East Avenue Closure, the Extension of 5th Street, the International Security Research Facility (ISRF), and a generic office building.

The East Avenue Closure involves disturbance of 172,000 square feet of soil and related vegetation. An environmental assessment prepared for this project was released in September 2002 (DOE 2002i). Groundbreaking for this project began in April 2003.

The 5th Street Extension Project involves disturbance of 132,000 square feet of soil and related vegetation. This project is located on the west side of the Livermore Site and involves extension of 5th Street from Avenue A to West Perimeter Drive.

Construction of the ISRF would involve disturbance of 64,000 square feet of soil and related vegetation for the facility and an additional 54,000 square feet for related parking. This project would be located on the southwest side of the Livermore Site near a developed area.

A generic office building would involve disturbance of 40,000 square feet of soil and related vegetation. The project would be located on the east side of the Livermore Site east of the DRB.

Proposed construction activities over the next 10 years at the Livermore Site in previously developed areas include the Office of Science (50,000 square feet) and the Consolidated Security Facility (50,000 square feet). A management plan for the Arroyo Seco proposes some restoration activities for that arroyo during the next 10 years. A separate biological assessment was prepared for that project and submitted to the USFWS in August 2003.

Potential impacts of these construction projects on the California red-legged frog are provided in Section E.2.6.4. Mitigation measures identified in Section E.2.1.9 would further reduce the potential for proposed construction activities to adversely affect this species.

E.2.1.5.5 *Maintenance of Security Buffer Areas Located in Formerly Designated Critical Habitat for the California Red-Legged Frog*

Proposed perimeter fence maintenance activities in the security buffer areas on the north and east side of the Livermore Site would not be in close proximity to the Arroyo Las Positas and DRB where the California red-legged frog is present, and critical habitat for the California red-legged frog in these security buffer zones has been rescinded. Security buffer maintenance activities would be anticipated to have minimal impact on the California red-legged frog. Mitigation measures are provided in Section E.2.1.9 to minimize any adverse impact.

E.2.1.5.6 *Decontamination and Demolition of Facilities*

Under the Proposed Action, the following three structures at the Livermore Site would be decontaminated and demolished: Buildings 171, 292, and 514. Afterwards, the areas where these structures were located would be landscaped for soil retention. More information on these activities can be found in Appendix A of the LLNL SWEIS.

E.2.1.5.7 *Maintenance of Facilities, Paved Roads, and Utilities*

LLNL must maintain facilities, paved roads, and utility systems at the Livermore Site in order for the site mission to be accomplished. Utilities maintained include water, electrical, fuel, and sewer systems. Larger road projects may involve separate NEPA analysis, such as the East Avenue Security Upgrade (DOE 2002i).

E.2.1.5.8 *Landscaping and Grounds Maintenance*

Landscaping and grounds maintenance operations are performed at the Livermore Site in support of the site mission. These activities involve mowing lawns; trimming shrubbery; planting and maintaining plant species at various locations on the installation; and providing site landscaping. These activities occur primarily during the months of March through October.

E.2.1.5.9 *Herbicide Application*

Herbicide application at the Livermore Site is performed primarily to eliminate vegetation along security fences and on the perimeter of certain facilities.

E.2.1.5.10 *Invasive Species Control*

The following invasive plant species have been observed in the Arroyo Seco at the Livermore Site: bull thistle (*Cirsium vulgare)*, Italian thistle (*Carduus pycnocephalus*), Mediterranean mustard (*Hirschfeldia incana*), milk thistle (*Silybum marianum*), and perennial peppercress (*Lepidium latifolium*) (Jones and Stokes 2002a). A formal program does not exist at Livermore Site to control invasive plant species.

The bullfrog, a known predator of the California red-legged frog, has been observed at the Livermore Site since 1997 (LLNL 2003ab). A Bullfrog Management Program has been coordinated with the USFWS to reduce, if not eliminate, the presence of this species at the Livermore Site and has operated since 2000 (DOE 2002j, USFWS 2002e). This is discussed in detail in Section E.2.1.5.3.

E.2.1.5.11 *Vehicle Traffic*

Vehicle traffic at the Livermore Site is limited primarily to employees and contractors who work at this site on a regular basis. Most of the vehicle traffic occurs during daylight hours, with the level of nighttime vehicle traffic being much lighter.

E.2.1.5.12 *Schedule of Continuing Activities*

- Under the cyclical 5-year maintenance plan, removal of in-channel vegetation (of pre-designated sections) would be conducted in late summer and executed using a backhoe operated from the upper bank and top of the side slope in 100- or 300-foot linear portions of the drainage.

- For the annual maintenance program, cattail vegetation cutting would occur in August to September, before winter and prior to the onset of frog movements away from the main flow of the arroyo.

- As needed, bullfrog management would be conducted after August 1 and before February, using either the previously demonstrated dewatering technique or the application of rotenone. Additionally, ongoing egg mass removal, and adult bullfrog control efforts are performed. Shooting happens every spring/summer/fall. Egg masses are removed once a week from May through September.

- Construction and demolition projects would be conducted at the times indicated in Chapter 3 under the No Action Alternative, Proposed Action, and Reduced Operation Alternative and Appendix A.

- Other recurring operations would be performed as needed.

E.2.1.6 *Potential Effects of the Project on Threatened and Proposed Threatened Species*

E.2.1.6.1 *Arroyo Las Positas Maintenance Activities*

The revised maintenance plan prepared in 1998 included provisions that enhance long-term frog population survivability and provide added in-stream habitat values for the frog. The potential for individual "take" of a frog during the maintenance work is considered low for the following reasons:

- Preactivity surveys by a site biologist would be performed before late summer removal of sediment from streambed vegetation
- All maintenance crew members would be knowledgeable of in-stream markers for section delineation and sensitive frog pools
- Crew members could identify frogs and would not wade into the arroyo
- No heavy equipment would be placed on the side slopes (except during erosion repair) or in the arroyo (LLNL 1998a)

The glides created by the streambed dredging and vegetation removal would enhance breeding opportunities for the species, and the "checkerboard" succession of the annual maintenance activities would provide a mosaic of glides and adjacent assemblages of wetland vegetation to the benefit of the California red-legged frog. Frog numbers could increase in the arroyo onsite as the habitat quality further improves, leading to frog colonization of other suitable habitats in the larger arroyo system.

It cannot be assured, but it is expected that the glides created for the California red-legged frogs will adequately serve as breeding sites and dispersal locations, and that the dredging maintenance of certain sections would, over time, enhance relative populations of the frog in the arroyo. For example, prior to the listing of the frog as "threatened," catch basins that trapped winter sediment transport at Site 300 were occupied by frogs within a month after dredging. Egg masses were detected subsequently at these locations in the spring. A similar pattern would be expected at the Livermore Site arroyo pools under the proposed maintenance plan. In addition, with the implementation of the other onsite mitigation measures (e.g., California red-legged frogs detected at other Livermore Site locations being translocated to suitable arroyo habitat), "take" would be minimized if California red-legged frogs were to appear in any of the other onsite drainages (LLNL 1998a).

Use of heavy equipment to mow the entire upper bank of the arroyo once in the spring and the possible trimming of the *Typha* to 48 inches in height (in late summer) would probably not result in mortality of frogs. To minimize adverse effects of arroyo maintenance, operations would be conducted approximately 50 feet from the wetted channel and during temperature extremes that motivate the frog to be closely tied to the local, hydric conditions. Raking of the trimmed *Typha* would occur during the daytime and on the side slopes where frogs are unlikely to be in the late summer because of minimal vegetation or cover and high temperatures. In addition, a qualified wildlife biologist would supervise the activity. The frog's shelter would remain intact and cattails

tend to grow prolifically in these areas of the drainage throughout fall and winter months. It is also unlikely that in-stream willow cutting at basal height would lead to frog mortality, because no wading in the stream would occur and the willows would always be of small stature.

Overall, the action of heavy equipment disrupting habitat and the length of time that is required for the vegetation to return to a reasonable maturity (2 years) would cause 20 to 40 percent of the arroyo to be in transition or habitat succession at any particular time (LLNL 1998a).

E.2.1.6.2 *Maintenance for Other Onsite Drainage Systems (DRB and the B571 Wetland)*

The potential for individual "take" of a frog during the maintenance work is considered low for the following reasons:

- Preactivity surveys by a site biologist would be performed prior to maintenance activities
- All maintenance crew members would be knowledgeable of markers for delineating sensitive frog areas
- Crew members could identify frogs and would not wade into the DRB or the B571 wetland
- No heavy equipment would be placed on the side slopes (except during erosion repair) in the DRB and other drainage locations

E.2.1.6.3 *Bullfrog Management Plan*

Both bullfrog control techniques (i.e., dewatering and rotenone) would negatively affect species that require water for hydration or respiration (i.e., invertebrates, amphibian larvae, and fish). Most amphibians, with the exception of bullfrogs, would be metamorphosed by August 1; therefore, the impact to the native herpetofauna community would be greatly reduced if not eliminated. Aquatic invertebrates would be negatively affected but are capable of rapid colonization and are, therefore, not likely to be extirpated by either control technique. The only native fish detected in either the DRB or the Arroyo Las Positas is the prickly sculpin (*Cottus asper*). The following three nonnative fish species have also been observed: mosquito fish (*Gambusia affinis*), catfish (*Ictalurus*), and goldfish (*Carrassius auratus*). Fish present during dewatering would be negatively affected by the control techniques, but are also capable of colonization (DOE 2002j, LLNL 2003bz).

E.2.1.6.4 *Construction Activities*

Proposed construction activities for the next 10 years would not be in areas where the California red-legged frog is routinely present and impacts from such construction would be minimal. Mitigation measures are provided in Section E.2.1.9 to minimize any adverse impact.

E.2.1.6.5 *Maintenance of Security Buffer Components Located in Formerly Designated Critical Habitat for the California Red-Legged Frog*

Proposed perimeter fence maintenance activities in the security buffer areas on the north and east side of the Livermore Site would not be in close proximity to the Arroyo Las Positas and DRB

where the California red-legged frog is present, and critical habitat that had been designated for the California red-legged frog in these security buffer zones has been rescinded. Security buffer maintenance activities, which occur in upland areas, would have minimal impact on the California red-legged frog. Mitigation measures are provided in Section E.2.1.9 to minimize adverse impacts.

E.2.1.6.6 *Decontamination and Demolition of Facilities*

The decontamination and demolition of Buildings 171, 292, and 514 at the Livermore Site could potentially result in direct mortality of California red-legged frogs if individual frogs were present at the project site during demolition. However, these facilities occur in upland areas that are not typically frequented by California red-legged frogs. The proposed decontamination and demolition would likely have minimal adverse effect on this species. These activities would eliminate approximately 95,000 square feet (2.2 acres) of developed space at the Livermore Site after these structures have been demolished and then landscaped to prevent erosion of soil into wetland areas.

E.2.1.6.7 *Maintenance of Facilities, Paved Roads, and Utilities*

The routine maintenance of facilities, paved roads, and utilities at the Livermore Site could potentially result in mortality of California red-legged frogs, because the entire site is within the dispersal capability of this species. However, because the maintenance of facilities, paved roads, and utilities are primarily in upland areas, these activities would pose a minimal risk to California red-legged frogs. Additionally, these activities would be conducted during the daylight hours when this species is not typically active.

E.2.1.6.8 *Landscaping and Grounds Maintenance*

Landscaping and grounds maintenance activities at the Livermore Site have the potential to result in mortality of California red-legged frogs, because the entire site is within the dispersal capability of this species. However, because the landscaping and grounds maintenance activities avoid known wetland breeding areas and associated nonbreeding areas, these activities would pose a minimal risk to California red-legged frogs. Additionally, these activities would be conducted during the daylight hours when this species is not typically active.

E.2.1.6.9 *Herbicide Application*

Herbicide application at the Livermore Site is primarily for maintaining security fences free of vegetation. At no time are herbicides sprayed on habitat suitable for California red-legged frog breeding. Herbicide applications should pose minimal risk provided the formulations are applied in accordance with EPA pesticide label instructions; under conditions with little or no wind to avoid herbicide drift; only to the extent necessary; and in accordance with the additional LLNL safeguards discussed in E.2.2.6.1.1.9.

E.2.1.6.10 *Invasive Species Control*

Bullfrog control represents the only invasive species control activities at the Livermore Site. The beneficial impacts of those activities are discussed in Section E.2.1.6.3

E.2.1.6.11 *Vehicle Traffic*

Vehicle traffic has the potential to result in mortality of California red-legged frogs at the Livermore Site. However, the risk is minimal because California red-legged frogs are more active at night when traffic is limited.

E.2.1.7 *Interrelated Actions*

Interrelated actions are defined as part of a larger action and are dependent upon the larger action for their justification. The *Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (SSM PEIS) selected the Livermore Site for construction of the National Ignition Facility (NIF). NNSA is completing installation and beginning commissioning of the NIF at LLNL. The goals of NIF are to achieve fusion ignition in the laboratory for the first time by using inertial confinement fusion technology, based on an advanced design solid state laser, and to conduct high-energy density experiments in support of national security and civilian applications. The NIF will provide NNSA with the ability to evaluate weapon performance issues to ensure that the nation's nuclear deterrent remains safe and reliable without underground nuclear testing.

The SSM PEIS discussed the potential for affecting the nearby Arroyo Las Positas and potential foraging habitat for the western burrowing owl. The SSM PEIS concluded that there would be no adverse impact to these resources from the construction and operation of the NIF. The NIF facility construction is now complete. Few impacts would occur to biological resources during operation of the NIF. Traffic to and from the NIF could result in the loss of individuals of some species due to road kill. No adverse impacts to special status species would be expected from operation of the NIF.

E.2.1.8 *Cumulative Effects*

Livermore Site activities described in this biological assessment include those that are expected to occur over the next 10 years. No other projects are envisioned for site operations. SNL/CA is managing its section of Arroyo Seco to protect California red-legged frog habitat and to create a 30-acre wildlife reserve on the east side of that facility. The incremental effect of the Proposed Action on biological resources within the area would be positive, particularly in the long term, when taken in the context of the continuing conversion of wildlife habitat for agricultural, residential, commercial, and industrial use in the vicinity of the Livermore Site. Because operations described here would not be expected to adversely affect listed species and sensitive habitat present at the Livermore Site and surrounding land, there would not be any cumulative effects.

E.2.1.9 *Conservation and Mitigations*

Mitigation measures for activities that could potentially impact the California red-legged frog at the Livermore Site are listed below.

E.2.1.9.1 *Arroyo Las Positas Maintenance Project*

Mitigation and compensation for the potential impacts of this project are organized into two groups. The first group represents a series of mitigation measures for implementation during

high-bank maintenance activities. The second group consists of measures for implementation during the dredging operations. These measures, previously approved by the USFWS, are also applicable for protection of California red-legged frogs site-wide in other aquatic environments (LLNL 1998a, USFWS 1998).

Bank-Mowing and Cattail-Pruning Mitigation Measures

A qualified wildlife biologist would survey the project site for California red-legged frogs prior to work being initiated. Areas identified as having California red-legged frogs would be marked with LLNL special status species flagging, tape, or other visible demarcations. A map would be disseminated to the project crew with the sensitive frog location exclusion zones clearly outlined. All vegetation cutting and removal in these areas would be performed in a manner that would not directly affect frogs.

A qualified wildlife biologist would be present at the project location during the late summer arroyo work and would actively monitor the progress of the dredging and trimming operations. If a red-legged frog were observed, all work in the area that could affect the frog would be halted until the frog was contained safely in a bucket with an inch or two of water and a shaded top. As soon as work had proceeded through the area, the frog would be returned to its point of capture.

Vegetation cutting within 50 feet of the frog pools in Reaches 1 and would be performed using rotary tools to a height of at least 24 inches. A qualified wildlife biologist would perform all vegetation cutting within this area. Vegetation located in the pelagic and marginal zones of occupied frog habitat would be cut using pruning shears or handsaws. No wading in the arroyo would occur in these areas.

The cattail vegetation cutting would occur in August to September, before winter and prior to the onset of frog movements away from the main flow of the arroyo. Preactivity surveys would be performed in the work location prior to disturbance, and a qualified wildlife biologist would be available should a frog be detected (LLNL 1998a).

Dredging and Site-wide Mitigation Measures

A qualified wildlife biologist would survey the project site for California red-legged frogs prior to work being initiated. Areas identified as having California red-legged frogs would be marked with LLNL special status species flagging, tape, or other visible demarcations. Prior to the project impact activity, these areas would be searched and any frogs found would be collected by a service-approved biologist and placed in a ponded enclosure until the annual maintenance procedures of dredging, etc., have been completed; then they would be returned to the arroyo at or near the location where they were collected. Similarly, if frogs were found in other drainages onsite during or prior to maintenance activities, they would be collected and relocated to the arroyo. Documentation of the number and distributions of frog relocations would be sent to USFWS at the end of the year.

Prior to work in the arroyo, all persons involved would be briefed on the status, behavior, markers, and regulatory status of the frog; penalties for take of frogs and habitat; and special protection measures being implemented. A qualified wildlife biologist, who would have the authority to stop activities in order to avoid a take, would directly oversee all activities. No

vehicles would be used in the arroyo channel bottom for erosion repair, removal of sediments or vegetation, or for collection of vegetation cuttings, except in those locations that contain concrete aprons that periodically may require scraping (LLNL 1998a).

E.2.1.9.2 *Maintenance for Other Onsite Drainage Systems*

Mitigation for the other drainage system maintenance activities in the DRB and B571 wetland would follow the same safeguards established for the Arroyo Las Positas Maintenance Program in Section E.2.1.9.1. These measures were previously coordinated and approved by the USFWS (LLNL 1998a, USFWS 1998).

E.2.1.9.3 *Bullfrog Management Plan*

Mitigation for bullfrog management was previously coordinated and approved by USFWS (DOE 2002j, USFWS 2002e). These mitigation measures would include seasonal control techniques, surveys and relocation, and water sampling.

Seasonal Control Techniques: Based on historic surveys of the Arroyo Las Positas and the DRB, the California red-legged frog metamorphoses occurs in July, therefore any control technique would occur after August 1 and before February.

Surveys and Relocation: Intensive nocturnal surveys would be completed prior to either control technique. Adult California red-legged frogs detected within a control area would be captured and fitted with a radio transmitter and left in place or relocated to the Arroyo Las Positas as described in the 10(a)(l)(A) Federal Fish and Wildlife Permit Number TE053672-0.

Water Sampling: If rotenone is used, pretreatment and post treatment water sampling would be completed to ensure that rotenone is not released from the control area before it has degraded to accepted regulatory levels.

E.2.1.9.4 *Construction Activities*

Mitigation for the construction activities would follow the same safeguards established for the Arroyo Las Positas Maintenance Program provided in Section E.2.1.9.1. These measures were previously coordinated and approved by USFWS (LLNL 1998a, USFWS 1998).

E.2.1.9.5 *Maintenance of Security Buffer Components Located in Formerly Designated Critical Habitat for the California Red-Legged Frog*

Mitigation for the maintenance of security buffer components (e.g., weed control along fences and mowing of grass and other vegetation in the buffer zones) would follow the safeguards provided in Section E.2.1.9.1. These measures were previously coordinated and approved by USFWS (LLNL 1998a, USFWS 1998).

E.2.1.9.6 *Demolition, Routine Maintenance, Herbicide Control, and Vehicle Traffic*

Mitigation for the demolition and routine maintenance activities would follow the same safeguards established for the Arroyo Las Positas Maintenance Program provided in Section

E.2.1.9.1. These measures were previously coordinated and approved by USFWS (LLNL 1998a, USFWS 1998). Herbicide application would be conducted in accordance with EPA pesticide label, and ground areas subject to spraying would be surveyed by a LLNL wildlife biologist to prevent adverse impacts to the California red-legged frog. No specific mitigation measure is proposed for vehicle traffic. However, the limited number of vehicles operating at night at the Livermore Site would help to minimize transportation impacts to the California red-legged frog.

E.2.1.10 *Compensation and Set-Asides*

Mitigation credits for a total of 17 acres of offsite habitat could be necessary as DOE compensation for annual arroyo maintenance impacts; CERCLA-related discharges of water to the arroyo, (which will subsequently be eliminated); and site-wide habitat modifications resulting from operational activities. The intent of this subsection is to describe the process for estimating comprehensive offsite mitigation bank values for known site-wide impacts to frogs and habitat in 1998 and in the future at LLNL. Based on the following calculations provided in the amended biological assessment submitted in June 1998 and approved by USFWS in August 1998 (LLNL 1998a, USFWS 1998), a 17-acre area of compensation is proposed as appropriate:

1. Total mitigated wetland acreage for CERCLA-related water discharge cessation into the arroyo in the future = 10 acres.

The additional water LLNL is responsible for adding to the arroyo from groundwater remediation efforts allows approximately 10 acres of the arroyo to remain inundated perennially from the DRB outfall to the Patterson Pass Road overpass. This area is delineated as wetland habitat.

2. Total mitigated acreage for the remaining arroyo habitat impacts due to maintenance (annual dredging, etc., which affects various sections of habitat quality for 2 years each) = 4 acres.

    a. Calculation of overall acreage:
    The arroyo drainage consists of the following areas (see Figure E.2.1.5.2–1):
    16 acres total (7,000 feet × 100 feet mainstem) - 10 acres (see above) = 6 acres
    + 1.8 acres (800 feet × 100 feet central tributary)
    + 2.3 acres (1,000 feet × 100 feet tributary) = 10.1 acres

    b. Calculation of appropriate mitigable acreage:
    A 40 percent compensation calculation due to annual maintenance impacts would be applied only to the 10.1 acres (DRB to Greenville Road infall plus two tributaries) that are not part of the CERCLA mitigation acreage (DRB to Patterson Pass Road).
    10.1 acres total × 20 percent/year (× 2 years) = 4.0 acres

3. Potential impacts to California red-legged frogs or habitat in locations (DRB, southern tributary, and B571 wetland) outside Arroyo Las Positas could total 3 acres.

The site-wide habitat consists of the following areas:

	Mitigation Value *
5.5 acres (800 feet × 300 feet DRB)	× .25
0.5 acres (200 feet × 100 feet southern tributary)	× 1.0
0.7 acres (300 feet × 100 feet B571 tributary)	× 1.0
Total= 3.0 acres	

* The numeric mitigation value expresses the impact to the habitat value expected in each area as a result of planned maintenance or project construction. The DRB habitat would not likely be altered over time. The southern tributary would be filled and moved to the east when another facility is constructed at its location. The B571 tributary would require infrequent trimming of cattails and wetland vegetation to satisfy flood capacity requirements.

4. Therefore, total compensatory offsite acreage would be 17 acres. The 1:1 mitigation ratio identified in the 1997 biological assessment would be applied. The additional 0.5:1 identified in the 1997 biological assessment would not need to be applied to this revised project because a loss of connectivity would not occur in the arroyo system as part of the revised project (LLNL 1998a).

10 acres (CERCLA-related discharges)
4 acres (loss of habitat in transition due to maintenance)
3 acres (potential future site-wide impacts)
17 acres TOTAL

E.2.1.11 *Conclusion and Determination*

Under the Proposed Action, the amended Arroyo Las Positas Maintenance Project and Site-wide Drainage Systems and future cessation of treated groundwater discharge could adversely affect the California red-legged frog by causing take of an individual or individuals and loss of in-stream habitat. As a result of the redesign of the proposed Maintenance Project, the near-future effect on the frog population and habitat at LLNL, as well as for dispersal of frogs within the arroyo continuum, would be considered positive. The bullfrog management program would have a positive effect on the California red-legged frog population at LLNL. The cumulative effects of the project should, in fact, result in the enhancement of breeding and hiding pools for the frog onsite, protection of a wetland community, and conservation for potential future loss of specific site-wide habitat values by appropriate offsite compensation. Take-avoidance mitigation measures would also be implemented during all components of the maintenance plan in the arroyo and site-wide drainage systems to protect frogs and their offspring.

Construction-related projects may affect (but are not likely to adversely affect) the California red-legged frog. Proposed Livermore Site construction activities for the next 10 years would not be in areas where the California red-legged frog is routinely present. Direct effects would be minimized through implementation of pre-construction surveys.

Demolition of facilities would be likely to provide a long-term indirect benefit to the California red-legged frog. With approximately 85 percent of the Livermore Site already developed, any demolition of existing structures would help reduce the amount of developed land. Direct effects would be minimized through implementation of pre-demolition surveys.

Maintenance of facilities, paved roads, and utilities may affect (but are not likely to adversely affect) the California red-legged frog. These operations would occur primarily within upland areas at the Livermore Site. Maintenance activities would continue to be routinely reviewed by LLNL wildlife biologists to minimize the potential for direct effects on this amphibian.

Landscaping and grounds maintenance activities may affect (but are not likely to adversely affect) the California red-legged frog. However, because the landscaping and grounds maintenance activities would continue to avoid known wetland breeding areas and associated nonbreeding areas, these activities would pose a minimal risk to California red-legged frogs.

Herbicide application may affect (but are not likely to adversely affect) the California red-legged frog. Herbicides would have minimal impact on this species when used in accordance with their EPA pesticide label instructions. Also, herbicide projects would proceed only after approval is received from LLNL wildlife biologists.

Vehicle traffic may affect (but is not likely to adversely affect) the California red-legged frog. However, the potential impact is reduced because the majority of traffic occurs during the daylight hours when adults of this species are not typically active; most of the California red-legged frog breeding and nonbreeding areas are in less developed parts of the site; and migrations of this species are infrequent.

E.2.2 Site 300

E.2.2.1 *Introduction*

Site 300, an NNSA facility, is located in San Joaquin and Alameda counties, California. This part of the biological assessment relates to continuing Site 300 activities under the Proposed Action: grading and maintaining fire trails; storm drainage system maintenance; culvert improvement and installation; prescribed annual burning; proposed termination of surface water releases; construction related projects; decontamination and demolition of facilities; maintenance of facilities, paved roads, and utilities; landscaping and grounds maintenance; herbicide application and disking; invasive species control; ground squirrel control; vehicle traffic; explosive testing; high explosive process water surface impoundments and a sewage oxidation pond. The biological assessment has been prepared to determine the extent that which these Proposed Action activities would affect any of the threatened or endangered species, or their critical habitat listed below. This biological assessment has been prepared in accordance with legal requirements set forth under Section 7 of the *Endangered Species Act* (16 U.S.C. §1536[cj]).

E.2.2.2 *Affected Species*

The species considered in this biological assessment are:

- California red-legged frog (*Rana aurora draytonii*), a federally listed threatened species (61 FR 25813-25833)

- Alameda whipsnake (*Masticophis lateralis euryxanthus*), a federally listed threatened species (62 FR 64306)

- California tiger salamander (*Ambystoma californiense*), a federally listed proposed threatened species (68 FR 28649)

Based on habitat assessments, field surveys, and distribution data, the California red-legged frog, Alameda whipsnake, and California tiger salamander were identified as either having the potential to occur or as occurring at the Site 300 Proposed Action project areas. The areas pertaining to the Proposed Action addressed in this biological assessment include formerly designated critical habitat for the Alameda whipsnake and California red-legged frog (Figure E.2.2.2–1).

E.2.2.2.1 *Critical Habitat*

E.2.2.2.1.1 Alameda Whipsnake

Although critical habitat for the Alameda whipsnake was established by USFWS on October 3, 2000, 400,000 acres of that critical habitat were rescinded by a recent court order (CC Times 2003). Site 300 contains about 1,592 acres of formerly designated Alameda whipsnake critical habitat (Figure E.2.2.2–1). It is possible that during the next few years that critical habitat for this species may be reinstated again at Site 300 when the USFWS publishes a new critical habitat proposal. Primary constituent elements for the Alameda whipsnake include habitats that support scrub communities such as mixed chaparral, chamise-redshank chaparral, coastal scrub, annual grassland, and oak woodlands adjacent to scrub habitats (65 FR 58933). The formerly designated critical habitat within Site 300 contains many the Alameda whipsnake primary constituent elements, including annual grassland and oak woodland habitats linked to sage scrub habitats and rock outcrops (Jones and Stokes 2001).

E.2.2.2.1.2 California Red-Legged Frog

Although critical habitat for the California red-legged frog was established by the USFWS on March 13, 2001, most of that critical habitat has been rescinded by a court order (USDCDC 2002). However, it is possible that during the next few years the critical habitat for this species may be reinstated again at Site 300 when the USFWS publishes a new critical habitat proposal (USFWS 2003). Site 300 contains approximately 4,050 acres of formerly designated California red-legged frog critical habitat, (60 percent of the Site 300). Primary constituent elements for the California red-legged frog include both aquatic and upland habitat where suitable breeding and nonbreeding habitat are intermingled throughout the landscape and are interconnected by continuous dispersal habitat (66 FR 14626 March 13, 2001) (Jones and Stokes 2001).

E.2.2.3 *Unaffected Species*

The large-flowered fiddleneck (*Amsinckia grandiflora*) is federally listed as endangered (50 FR 19374, May 8, 1985) and state-listed as endangered. The large-flowered fiddleneck occurs in two populations (one experimental and one natural) in designated critical habitat near Building 858 (LLNL 2001bb). A small population of this species has also been known to occur in Draney Canyon, near the Site 300 Alameda/San Joaquin county line, but this population has not been observed since 1997. A portion of Site 300 (640 acres) is designated critical habitat for this species; however, there would be no affect on this species or its critical habitat as a result of the Proposed Action activities (refer to Figure E.2.2.2–1). Dr. Tina Carlsen monitors this population of large-flowered fiddleneck at Site 300 (Jones and Stokes 2002a). Any future projects that could affect this species or its critical habitat would be evaluated separately.

The San Joaquin kit fox (*Vulpes macrotis mutica*) is federally listed as endangered (32 FR 4001) and state-listed as threatened. Protocol-level surveys were conducted for this species in 1991, and hundreds of project-specific surveys have been conducted at the site since 1993. No kit fox were recorded at Site 300 in 1991 and none have been detected there in subsequent surveys, including a recent mammal (mesocarnivore) survey in 2002 (CSUS 2003). Available data suggest that Proposed Action projects would not likely affect the San Joaquin kit fox. Although no kit fox were observed in the above-mentioned surveys, LLNL wildlife biologists continue to monitor for the presence of kit foxes at Site 300 due to records of this species in the vicinity of the site. A comprehensive mitigation and monitoring plan was developed for this species in the 1992 LLNL EIS/EIR (LLNL 1992a).

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is federally listed as a threatened species (45 FR 52803). Protocol level surveys were conducted in 1991 and project-specific surveys have been conducted at Site 300 since 1993. No beetles were detected at Site 300 during any of those surveys. In May of 1997, USFWS issued Site 300 a biological opinion for pruning elderberry shrubs along the edge of a fire trail in the southeast corner of the site for three separate time periods. One pruning occurred in May/June 1997, and no beetles or evidence of beetles were detected (Jones and Stokes 2001). In 2002, four surveys were conducted during April and May at Site 300 for the valley elderberry longhorn beetle and its host, the blue elderberry plant. Elderberry plants were found at six locations at Site 300 and two locations on adjacent land southeast of Site 300 in a CDFG preserve. During these surveys, 10 exit holes, considered to be from valley elderberry longhorn beetles, were found in elderberry plants. Additionally, six adult beetles were observed in a canyon just north of Elk Ravine, with two of the adults clearly exhibiting identifying characteristics of the valley elderberry longhorn beetle (Arnold 2002). No facility construction activities would be allowed to occur within a 300-foot radius of known locations of elderberry bushes without prior consultation with the USFWS. Because of these protective measures, the valley elderberry longhorn beetle would not be adversely affected.

Two seasonal pools at Site 300 were altered prior to 1990 to make them deeper. Protocol-level surveys were conducted at these two sites in 1991; no vernal pool fairy shrimp, vernal pool tadpole shrimp, or longhorn fairy shrimp were identified in the pools. During a 2001–2002 wet season survey, the California fairy shrimp (*Linderiella occidentalis*), a Federal species of concern, was found in a vernal pool (FS-04) in the northwest part of Site 300. Another

branchiopod, the California clam shrimp (*Cyzicus californicus*), which is not on Federal or California special status species lists, was also found in this vernal pool (Jones and Stokes 2001, Condor Country Consulting 2002). However, because the Proposed Action projects would not affect these two seasonal pools, listed shrimp species are not considered in this biological assessment.

The Swainson's hawk (*Buteo swainsoni*) is state-listed as threatened by the CDFG. This hawk was observed in 1994 on the southeastern perimeter of Site 300 and the adjacent CDFG Ecological Reserve. The Swainson's hawk nests within riparian habitats and is often associated with alfalfa crops and other forms of agriculture. This species was observed within close proximity to Site 300, but probably forages occasionally within the site boundaries (LLNL 2003by). The Swainson's hawk is not considered in this biological assessment because Proposed Action projects would not likely affect the occasional foraging activity at Site 300.

The willow flycatcher (*Empidonax traillii*) is state-listed as endangered by the CDFG. This flycatcher was observed for the first time at Site 300 during a constant effort mist netting survey in Elk Ravine in 2003 (LLNL 2003ac). The willow flycatcher was observed in part of Elk Ravine that is not being affected by continuing activities and is not anticipated to be adversely impacted.

E.2.2.4 *Consultations to Date*

- 1990–1991 EIS/EIR (Appendix F) biological assessment consultations.

- Spring 1994: Site 300 biologists informally consulted with USFWS on a proposed sewage pond maintenance project at Site 300 when the California red-legged frog was proposed endangered.

- May 1997: USFWS issued a biological opinion with mitigation measures identified for the valley elderberry longhorn beetle habitat alteration along a Site 300 fire trail.

- 1998 to present: Numerous informal Section 7 consultations with USFWS for project-specific activities that could, as proposed, indirectly affect threatened and endangered species (e.g., the California red-legged frog or the Alameda whipsnake) or their habitat.

- December 20, 2000: Site 300 biologist Jim Woollett met with biologist Curt McCasland of USFWS to discuss the proposed and ongoing project activities for annual maintenance and operational activities within developed areas at Site 300 and within critical habitat areas for the California red-legged frog and the Alameda whipsnake at Site 300. A subsequent telephone conversation on the same topic between Mr. Woollett and Mr. McCasland occurred on January 22, 2001. Formal consultation was not required for these maintenance projects because they will be conducted in developed, industrial areas, which do not contain the species and do not comprise the primary constituent habitat elements for the species.

- March 2, 2001: Site 300 submitted a technical assistance request to USFWS for proposed maintenance and operational activities in the Alameda whipsnake and California red-legged frog critical habitat.

- May 2001: Phone conversation and field meeting with USFWS biologist Don Hankins indicated that formal consultation was required for the proposed project (fire trail maintenance, storm drain system maintenance, culvert improvements and installations, prescribed burning, and termination of cooling tower water releases) that had been included in the technical assistance request.

- September 10, 2001: A species list was received from USFWS. The list includes species potentially occurring at the project site that are listed as threatened, endangered, or proposed for such listing under the *Endangered Species Act*.

- September 20, 2001: LLNL staff met with USFWS biologist Don Hankins to discuss the several continuing operators and their potential effects on the California red-legged frog, California tiger salamander, and the Alameda whipsnake and their habitats. This biological assessment incorporates avoidance and mitigation measures and enhancement opportunities discussed at that meeting.

- December 6, 2001: NNSA submitted the November 2001 biological assessment to USFWS for continuing operations at Site 300.

- May 17, 2002: USFWS issued a biological opinion that continuing operations as described in the biological assessment are not likely to jeopardize the continued existence of the California red-legged frog or the Alameda whipsnake at Site 300 and also are not likely to destroy or adversely modify their designated habitat at this facility (USFWS 2002b).

- October 28, 2002: USFWS provided a species list for both the Livermore Site and Site 300 for the LLNL SWEIS (USFWS 2002d).

E.2.2.5 *Proposed Action Project Activities*

The Proposed Action would comprise 15 Site 300 management activities: (1) grading and maintaining fire trails; (2) ongoing program of maintenance of the storm drainage system; (3) improving and installing culverts; (4) prescribed annual burning; (5) termination of surface-water releases from Buildings 827, 851, and 865; (6) construction related projects; (7) demolition of facilities; (8) maintenance of facilities, paved roads, and utilities; (9) landscaping and grounds maintenance; (10) herbicide application and disking; (11) invasive species control; (12) ground squirrel control; (13) vehicle traffic; (14) explosive testing; and (15) explosive process water surface impoundments and sewage oxidation pond.

The biological opinion (1-1-02-F-0062) for the continuing operations of Site 300 authorized the incidental take of 25 California red-legged frogs and 5 Alameda whipsnakes during fire trail grading, storm drainage system maintenance, culvert improvement and installation activities, prescribed burns, and termination of surface water releases from several buildings (USFWS 2002b). However, the Proposed Action for this LLNL SW/SPEIS includes a number of additional projects noted above. Therefore, NNSA requests that the level of incidental take of California red-legged frogs and Alameda whipsnakes be modified to address all Site 300 operations included in this LLNL SW/SPEIS.

Although critical habitat was formerly designated for the California red-legged frog and the Alameda whipsnake at Site 300, the designation has been rescinded. The USFWS may redesignate critical habitat for these species during the 10-year period covered by the LLNL SW/SPEIS (USDCDC 2002, USFWS 2003, CC Times 2003). Therefore, NNSA may request a conference on this topic.

This section of the biological assessment discusses the temporal and spatial effects that the proposed project activities at Site 300 may have on federally listed threatened, endangered, proposed, and candidate species and their critical habitats, and outlines mitigation measures that would be specific to those effects. Mitigation measures would be implemented as identified in sections on continuing activities (see also Section E.2.2.5.16).

E.2.2.5.1 *Grading and Maintaining Fire Trails*

An 85-mile system of dirt fire trails currently allows vehicle access to all areas of Site 300 (Figure E.2.2.5.2–1). The purpose of the trails is to curtail onsite and offsite movement of wildfires. Fire trails also provide the only access to remote areas of Site 300 for fire protection and security personnel. Annual fire trail grading has been performed in late April and early May since 1953, when the trails were first cut. Grading is generally very shallow across the surface of the trail.

E.2.2.5.2 *Storm Drainage System Maintenance*

Storm drain systems associated with roadways are periodically cleaned to remove debris. This activity minimizes potential for flooding and subsequent erosion of nearby facilities and support structures. Figure E.2.2.5.2–1 identifies locations where storm drainage system maintenance and general maintenance would occur.

Maintenance of culverts involves hand tools such as shovels, or heavy equipment such as backhoes, and is generally performed during the dry season or when water is not present. Maintenance at these crossings could include the removal of vegetation from existing wetlands and drainages. This activity would be infrequent, however, and generally would be conducted in late summer, when California red-legged frog adults and tadpoles can be verified as no longer present in waterbodies. The following maintenance activities could be involved in keeping watercourses and drainages operational:

- Erosion repairs and preventive measures, including installation or repair of riprap or gabion structures
- Fill and installation of jute netting, or other erosion control fabrics
- Removal of storm debris such as branches, silt, and trash
- Watershed upgrades with additional or relocated inlets

E.2.2.5.3 *Culvert Improvement and Installation*

Four sites have been identified (Figure E.2.2.5.2–1) where existing culverts should be upgraded or new culverts installed to prevent upland runoff from cutting through fire trails and to reduce sediment load in nearby drainages. NNSA proposes to install new culverts or replace culverts as follows:

- Replace one existing culvert, approximately 18 to 24 inches in diameter, at the Oasis wetland with two culverts, each 24 inches in diameter and 60 feet long, to transport water down the slope. The eroded slope would be replaced with approximately 200 cubic yards of native soil. After the culvert is laid and the slope has been rebuilt, the slope would be stabilized with an erosion-control blanket and an appropriate erosion-control seed mix.

- Install two new culverts at Round Valley, each 36 inches in diameter and 40 feet long.

- Install a new culvert at Lower Elk Ravine, 48 inches in diameter (or smaller) and 40 feet long.

E.2.2.5.4 *Prescribed Annual Burning*

Grassland areas immediately surrounding shot facilities and specific locations on the Site 300 perimeter are burned annually under prescribed conditions (Figure E.2.2.5.4–1). The purpose of the prescribed burns is to prevent wildfires.

This maintenance activity has taken place since the site began operations in 1955. Each year, typically during the last week in May through the first week in July, approximately 2,000 acres are burned (Jones and Stokes 2001, LLNL 2003q). Figure E.2.2.5.4–1 denotes the areas subject to prescribed burning. No riparian, wetland, or sage scrub habitats are affected by the burning activity. These prescribed burns move quickly with relatively low heat due to the frequency of burning and low overall fuel volume. In addition to this burning activity, a small portion in the experimental large-flowered fiddleneck population is annually burned according to a study design approved by USFWS (LLNL 2001bb).

Approximately 620 acres of designated California red-legged frog critical habitat and approximately 385 acres of designated Alameda whipsnake critical habitat fall within a scheduled prescribed burn area at Site 300 (Figure E.2.2.5.4–1) (USFWS 2002b).

There is a confirmed beneficial result of annual burning on native plants such as bunchgrass (BioSystems 1986a); a native bunchgrass prairie habitat occurs at Site 300 almost solely within the prescribed burn areas.

E.2.2.5.5 *Termination of Surface Water Releases*

Some buildings at Site 300 have used or continue to use cooling tower systems that circulate water to cool buildings and equipment. A byproduct of the cooling tower systems is a regular release of blowdown water into proximal drainages. These regular water releases have inadvertently created perennial wetlands of various sizes adjacent to the towers (Table E.2.2.5.5–1, Figure E.2.2.5.5–1).

Potable water is supplied to the artificial wetlands at Buildings 827, 851, and 865 since their cooling tower water supply has ceased. In 1996, for example, operations at Building 865 were discontinued and the facility was designated inactive. Potable water was then supplied to the wetland originally created by this cooling tower. Potable water was also supplied to wetlands at Buildings 851 and 827 following a project in 1994 to redirect the cooling tower water to subsurface leach fields to comply with regional water board requirements to eliminate these discharges.

TABLE E.2.2.5.5–1.—*Summary of Wetland Features Associated with Cooling Tower Water Releases*

Cooling Tower Location	Wetland	Wetland Suitable CRLF Area Acres	Breeding Habitat Acres	CRLF or CTS Present
Building 801 (1 pool)	Artificial	0.03	0.001	None detected
Building 827	Artificial	0.03	No pools	None detected
Building 851	Artificial	0.02	No pools	None detected
Building 865 (3 breeding pools)	Artificial	0.55	0.0003	CRLF (breeding)
Total Acreage		**0.62**	**0.004**	

Source: Jones and Stokes 2001.
Note: CTS = California tiger salamander; CRLF = California red-legged frog.

The artificial wetland at Building 801, however, is still fed by cooling tower water. There are no plans to terminate water releases from Building 801; however, maintenance in the drainage channel to remove cattails would be conducted as needed. Water would not be removed from any of the wetlands created by potable water prior to development of the enhancement areas (see Section E.2.2.9.1). Because of the termination of water releases, 0.62 acre of artificial wetlands would be eliminated (Jones and Stokes 2001).

The Building 801 cooling tower has been discharging water into its associated wetland for over 20 years. The pool associated with the wetland was formed within the last year after vegetation was cleared around the culvert. Buildings 827 and 851 have been discharging potable water into the artificially created wetlands for about 7 years. Wetlands associated with Buildings 851 and 827 do not have standing water.

At Building 865, a 0.55-acre wetland was artificially created over 16 years ago by cooling tower surface water releases. This is the only artificially created wetland that contains California red-legged frogs. There are three California red-legged frog breeding pools associated with this wetland; each pool is approximately 7 feet in diameter, and all are located below outfall culverts.

E.2.2.5.6 *Construction Related Projects*

Under the Proposed Action, the Energetic Materials Processing Center (EMPC) would be constructed at Site 300 (see Figure E.2.2.5.6–1). This planned facility would be comprised of approximately 40,000 square feet and would be located in the southeast quadrant of Site 300. The facility would replace Buildings 805, 806, and 813. The operations of Building 807 would move to this center, but Building 807 would be retained and waste packaging operations from Building 805 would be moved to Building 807. The EMPC would house modern explosives machining, pressing, assembly, inspection, and some radiography. An additional building would provide an inert machine, offices, and shower/change room facilities. Three magazines capable of storing 1,000 pounds of explosives each would also be built (LLNL 2002ap).

Two projects would be constructed if either the Proposed Action or the No Action Alternative were selected. The first would be a wetland enhancement project previously coordinated with the USFWS involving the enhancement and protection of 1.86 acres of wetland after the termination of artificial wetlands near Buildings 801, 827, 851, and 865. This project is discussed in Section E.2.2.5.5 (Jones and Stokes 2001, USFWS 2002b). The second project would involve receipt of water from the Hetch Hetchy water system as a part of the Site 300 Revitalization Project as described in Appendix A of this LLNL SWEIS. Construction aspects of this second project have already been completed.

E.2.2.5.7 *Decontamination and Demolition of Facilities*

Under the Proposed Action, Building 808 at Site 300 would be decontaminated and demolished. After the structure has been demolished, the area would be landscaped for soil retention. This building would be demolished if either the Proposed Action or the No Action Alternative were selected.

E.2.2.5.8 *Maintenance of Facilities, Paved Roads, and Utilities*

LLNL would continue to maintain facilities, paved roads, and utility systems at Site 300 in support of the site mission. Utilities maintained would include water, electrical, fuel, and sewer systems. These operations would occur primarily within developed areas representing less than 5 percent of the total site acreage.

E.2.2.5.9 *Landscaping and Grounds Maintenance*

LLNL would continue to conduct landscaping and grounds maintenance operations at the Site 300 in support of the site mission. These activities would include mowing lawns; trimming shrubbery; planting and maintaining plant species at various locations on Site 300; and performing site landscaping. Landscaping and grounds maintenance activities would occur primarily within developed areas representing less than 5 percent of the total site acreage.

E.2.2.5.10 *Herbicide Application and Disking*

For general weed and fire control at Site 300, herbicides such as Krovar®, Oust®, and Roundup Pro® would be applied in the fall and winter to the road shoulders, around buildings, and around power poles in the firing areas. In the remainder of the GSA and around landscaped areas, road shoulders, and around power poles, herbicides such as Roundup Pro®, Ronstar®, and Pendulum®, would be applied in the fall and winter months, avoiding areas where sensitive plant species exist. Area around Environmental Restoration Division test wells would be sprayed for weed control whenever necessary with Roundup Pro® (LLNL 2003ah).

Most of the property has not been disked or dry-farmed since it was acquired. Infrequently, a narrow swath of land would be disked along the northern, and part of the northeastern and eastern boundaries of the site. This perimeter disking, when done, would be performed in May, providing added protection during prescribed burning against the possible escape of fire to offsite properties. Although disking would remain an option (depending on seasonal conditions), prescribed burning would be preferred for wildfire control (LLNL 2003ah).

E.2.2.5.11 *Invasive Species Control*

Field bindweed (*Convolvulus arvensis*), bull thistle (*Cirsium vulgare)*, Italian thistle (*Carduus pycnocephala*), Mediterranean mustard (*Hirschfeldia incana*), milk thistle (*Silybum marianum*), and yellow star-thistle (*Centaurea solstitialis*) are among the invasive plant species present at Site 300 (Jones and Stokes 2002a). A formal invasive species control program has not been established at Site 300. However, annual prescribed burns have been used elsewhere against certain invasive plant species such as yellow starthisle, which is present at Site 300 (see Section E.2.2.5.4) (Lass et al. 1999). Prescribed burns could have an ancillary benefit in controlling this species (Pollak and Kan 1998). Additionally, the design for the enhanced wetlands at the Super High Altitude Research Project (SHARP) Facility would include measures to reduce the establishment of invasive plants (see Section E.2.2.9.2).

The bullfrog, a known predator of the California red-legged frog, has not been observed at Site 300. However, if it should be detected there, then a bullfrog management program would be implemented with the same procedures described for the Livermore Site in Section E.2.1.5.2.

The feral pig (*Sus scrofa*), a known predator of the California red-legged frog, is occasionally removed from Site 300 and would continue to be removed, as necessary (LLNL 2003ab).

E.2.2.5.12 *Ground Squirrel Control*

Presently, there is no active ground squirrel control program anywhere at Site 300. Control would be done, on an as needed basis, around the explosive process water surface impoundments, using Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations (LLNL 2003ah).

E.2.2.5.13 *Vehicle Traffic*

Vehicle traffic at Site 300 is limited primarily to the small staff of workers required to maintain and operate this site. Most of the vehicle traffic would continue to occur during daylight hours, with nighttime vehicle traffic continuing to be being sparse.

E.2.2.5.14 *Explosive Testing*

At Site 300, three primary outdoor explosives testing facilities are approximately 1 mile from the site's northern border. Explosives testing would be conducted almost entirely during the day. The explosions would occur on a daily to weekly basis. A fourth explosives testing facility is now enclosed.

E.2.2.5.15 *Explosive Process Water Surface Impoundments and Sewage Oxidation Pond*

Explosive process water surface impoundments and a sewage oxidation pond are present at Site 300. The impoundments are lined with a high-density polyethylene liner.

E.2.2.5.16 *Schedule of Continuing Activities*

- Fire trail grading would occur annually from approximately April through mid-June, with April and May typical.
- Prescribed burning would occur annually typically from the last week of May through the first week of July, depending on weather conditions.
- Removal of storm debris such as branches and trash from the storm drainage system would be conducted as needed.
- Vegetation and sediment removal around culverts would occur during the dry season, prior to October 15.
- Culvert improvement and installation activities also would occur during the dry season, prior to October 15.
- Termination of water release would occur only when California red-legged frog mitigation sites are established. The preferred time to terminate water release would be at the end of the dry season (late September to early November).

- Construction and demolition projects would be conducted at the times indicated in Chapter 3 under the No Action Alternative, Proposed Action, and Reduced Operation Alternative and Appendix A of the LLNL SW/SPEIS.

- Other recurring operations would be performed as needed.

E.2.2.6 *Potential Effects of the Proposed Action Activities on Threatened and Proposed Threatened Species*

This section describes the potential direct and indirect effects of Proposed Action activities on the California red-legged frog, California tiger salamander, and the Alameda whipsnake. The primary direct-effect mechanisms considered in this biological assessment would include fire trail grading; prescribed burns; storm drainage system maintenance, improvement, and culvert installation; termination of surface water releases; construction related projects; decontamination and demolition of facilities; maintenance of facilities, paved roads, and utilities; landscaping and grounds maintenance; herbicide application and disking; invasive species would control; ground squirrel control; vehicle traffic; explosive testing; and operation of high explosive process water ponds and sewage lagoon. Potential indirect effects on listed species would include degradation of water quality and formation of barriers to migration/dispersal. A discussion of the direct and indirect effects for each species follows.

E.2.2.6.1 *California Red-Legged Frog*

E.2.2.6.1.1 Direct Effects

E.2.2.6.1.1.1 Burning and Fire Trail Grading

There would be no direct effect on the California red-legged frog's primary constituent elements or its formerly designated critical habitat as a result of burning or fire trail grading. Approximately 620 acres of formerly designated California red-legged frog critical habitat falls within a prescribed burn area, all of which is upland grassland habitat (USFWS 2002b). It is unlikely that modification of this habitat would cause the direct mortality of any individual frogs, for four reasons: (1) perennial aquatic habitat where some frogs spend a majority of the year is not burned; (2) prescribed burning would occur typically from May through July, outside the dispersal period, thereby reducing the potential for direct effects on individual California red-legged frog from fire trail grading or burning in upland habitat; (3) most areas are burned annually and the fires do not generate much heat and California red-legged frog, using upland burrows for aestivation, are unlikely to be affected by a low-intensity fire; and (4) the grading of fire trails would occur along existing trails, previously disturbed (Jones and Stokes 2001).

E.2.2.6.1.1.2 Storm Drainage System Maintenance

This activity would occur during the dry season. However, there could be some water remaining in the storm drainage system. Sediment removal would improve frog habitat and thus have a positive effect on the population, but it could also lead to mortality of individual frogs. Therefore, any wet drainages would be inspected by a biologist prior to and during excavation.

E.2.2.6.1.1.3 Culvert Improvement and Installation

These activities at the Oasis, Round Valley, and Lower Elk Ravine locations would have the potential to result in direct mortality of individual frogs. However, because work would be conducted during the dry season, it is unlikely that the replacement and installation of new culverts would directly affect frogs. Mitigation and avoidance measures to further minimize potential for direct effects on the California red-legged frog or its habitat are provided in E.2.2.6.1 (Jones and Stokes 2001).

E.2.2.6.1.1.4 Termination of Surface Water Releases

This activity would directly affect the California red-legged frog and its habitat by eliminating the source of water sustaining one wetland where frogs are known to occur (Jones and Stokes 2001).

Affected Site 1: Building 865 Wetland

This artificially created wetland consists of three small pools below culvert outfalls and a 328-foot long wetland. The wetland is choked with cattails (in the foreground of the upper photo in Figure E.2.2.6.1.1.4–1). Pools average 7 feet in diameter; three of the four are known breeding locations for California red-legged frogs. The Site 300 biologist has monitored this pond for 6 years; frogs have been present at the site each year (Jones and Stokes 2001).

Removal of the artificial water source currently supplied to the Building 865 wetland would affect 0.55 acre of wetland habitat and approximately 0.003 acre of breeding habitat (Jones and Stokes 2001).

Affected Site 2: Building 801 Wetland

This site consists of a small pool and associated wetland. The pool, sparsely vegetated with cattails, is roughly 6.6 feet in diameter with an area of less than 0.001 acre. The wetland, heavily vegetated with cattails, is 0.03 acre in area. Water has been discharged into this wetland for a number of years; however, the pool has only existed since the outfall below the culvert was cleared of vegetation. Although the California red-legged frog does not occur at this site, the pool provides potential breeding habitat for this species. This wetland would continue to be fed by the Building 801 cooling tower; therefore, no net impact would be expected (Jones and Stokes 2001).

Affected Sites 3 and 4: Buildings 851 and 827 Wetlands

The cooling towers at Buildings 851 and 827 have associated wetlands of less than 0.02 acre for both sites. There is no standing water at either of these locations, and neither wetland provides occupied California red-legged frog habitat. The Site 300 biologist has monitored these wetlands consistently for the last 6 years and has never observed a California red-legged frog at either wetland. The termination of water from the two sources would impact low-quality California red-legged frog habitat.

E.2.2.6.1.1.5 Construction Related Activities

Under the Proposed Action, construction of the EMPC would result in the disturbance of approximately 40,000 square feet of soil at Site 300. A field reconnaissance of the proposed EMPC site was performed to detect the presence of special status wildlife species and/or their habitats at Site 300. No California red-legged frogs were detected in the proposed construction area (LLNL 2003ag). The construction location would be within the area at Site 300 where designated critical habitat for the California red-legged frog has been rescinded by court order until further notice (USDCDC 2002). Depending on the outcome of ongoing critical habitat litigation, it is possible that the USFWS could redesignate this area as critical habitat for the California red-legged frog.

The proposed EMPC construction would be within the dispersal capability of California red-legged frogs from breeding and nonbreeding areas in the southeastern part of Site 300. Therefore, a pre-activity survey would be conducted prior to the groundbreaking for the EMPC to minimize the potential for incidental take of California red-legged frogs.

E.2.2.6.1.1.6 Decontamination and Demolition of Facilities

It is unlikely that Building 808 decontamination and demolition activities would result in direct mortality of the California red-legged frog unless individuals of this species are present at the project site. However, this facility is located in an upland area that is not typically frequented by California red-legged frogs. The proposed decontamination and demolition would likely have minimal adverse effect on this species. The decontamination and demolition of Building 808 at Site 300 would eliminate approximately 1,500 square feet of developed space after this structure has been demolished and then landscaped for soil retention.

E.2.2.6.1.1.7 Maintenance of Facilities, Paved Roads, and Utilities

The routine maintenance of facilities, paved roads, and utilities at Site 300 would probably not result in direct mortality of California red-legged frogs, because the maintenance of facilities, paved roads, and utilities would be primarily in upland areas, which would pose minimal risk to California red-legged frogs. Additionally, these maintenance activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.1.1.8 Landscaping and Grounds Maintenance

Landscaping and grounds maintenance activities at Site 300 would probably not result in direct mortality of California red-legged frogs, because these activities would avoid known wetland breeding areas and associated nonbreeding areas. Additionally, these activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.1.1.9 Herbicide Application and Disking

Herbicide application at the Site 300 would be performed primarily to eliminate vegetation along security fences and on the perimeter of some facilities. Preactivity surveys for the presence of sensitive natural resources would be performed prior to disking, and Site 300 maintenance staff

would receive training annually on special status species identification and distribution. The Site 300 maintenance staff would follow mitigation measures established by wildlife biologist to protect sensitive wildlife and habitats (e.g., American badger dens) from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years. The perimeter-disking project would proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Herbicides would not be applied to aquatic habitat suitable for California red-legged frog breeding. Prior to late-fall application, ground areas subject to spraying would be assessed by a LLNL wildlife biologist. Also, herbicide projects would proceed only after consultation with the wildlife biologist (LLNL 2001c). California red-legged frog populations were lower in areas downwind from areas where agricultural pesticides are applied (Davidson et al. 2001). Herbicide applications would pose minimal risk provided the formulations are applied in accordance with EPA pesticide label instructions; under conditions with little or no wind to avoid herbicide drift; only to the extent necessary; and in accordance with the additional LLNL safeguards.

E.2.2.6.1.1.10 Invasive Species Control

The occasional removal of feral pigs, a known predator and cause of habitat degradation, would have a beneficial effect on California red-legged frogs. No bullfrogs have been observed at Site 300, so bullfrog control measures have not been required.

E.2.2.6.1.1.11 Ground Squirrel Control

The occasional control of ground squirrels with Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations would probably not result in direct mortality of California red-legged frogs, unless conducted in frog habitat. The impact from the application of these rodenticides would be negligible when used in accordance with their EPA pesticide label instructions.

E.2.2.6.1.1.12 Vehicle Traffic

Vehicle traffic at Site 300 could result in mortality of California red-legged frogs found on roads or fire trails. However, the risk is considered low because vehicle traffic at Site 300 would be limited; the majority of traffic would occur during the daylight hours when this species is not typically active; most of the California red-legged frog breeding and nonbreeding areas are in less accessible parts of the site and migrations of this species are infrequent. A large population of California red-legged frogs is in the Advanced Test Acceleration (ATA) drainage ditches, which are adjacent to a road. There would be some potential for frog-vehicle interaction here, although it would be low because most traffic occurs during the day.

E.2.2.6.1.1.13 Explosive Testing

Explosives testing would probably not result in direct mortality of California red-legged frogs. Additionally, the explosives testing areas are not in prime habitat for the California red-legged frog (BioSystems 1986c). Further, explosives testing would be primarily conducted during the daylight hours when this species is not typically active.

E.2.2.6.1.1.14 Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

The California red-legged frog has been observed only at the overflow pond (also referred to as the percolation pond) and not at the sewage oxidation pond (Jones and Stokes 2001, LLNL 2003ab). These ponds provide suboptimal habitat and would not likely adversely affect the California red-legged frog population at Site 300.

E.2.2.6.1.2 Indirect Effects

E.2.2.6.1.2.1 Storm Drainage System Maintenance

Storm drainage system maintenance activities would indirectly benefit the California red-legged frog habitat. Previous drainage maintenance activities at Site 300 involved periodic removal of sediment in catch basins and below culverts. These activities resulted in the creation of deep pools suitable for breeding by the California red-legged frog. The continuation of this maintenance activity would maintain this additional breeding habitat.

Because the Proposed Action activities would not be expected to pose a barrier to movement of frogs during the wet season, no indirect impact to California red-legged frog would be expected (Jones and Stokes 2001).

E.2.2.6.1.2.2 Erosion

Grading of fire trails disturbs sediment that could indirectly affect the California red-legged frog by reducing habitat suitability. During a Site 300 survey in 2002, natural erosion from a fire trail crossing and inadequately designed culvert was noted to have degraded the adjacent aquatic habitat (Wetland 12 in Appendix F of this LLNL SW/SPEIS) and in Lower Draney Canyon. Wetlands in this area no longer have adequate depth to support breeding by the California red-legged frog, although breeding was noted in this area in 1999 (LLNL 2003ab). Erosion from another fire trail is shown in Figure E.2.2.6.1.2.1–1.



Source: LLNL 2003ad.

FIGURE E.2.2.6.1.2.1–1.—*Erosion in Elk Ravine above Building 812*

E.2.2.6.1.3 Mitigation and Avoidance Measures

To protect the California red-legged frog and its habitat, the following avoidance and mitigation measures would be implemented at Site 300 during maintenance activities (Jones and Stokes 2001):

- The loss of breeding habitat for the California red-legged frog at Building 865 would be offset by plans to enhance California red-legged frog habitat onsite (see Section E.2.2.9).

- All storm drainage system maintenance would be performed during the dry season, or when water is not present in the work area. In the four areas scheduled for culvert improvement or installation, a preactivity survey would be conducted within 24 hours of construction. A qualified biologist would be present during construction to examine potential burrow sites within the work zone to determine if they are occupied by the California red-legged frog.

- Prior to fire trail grading, prescribed burning, storm drainage system maintenance, and culvert improvement and installation activities, a qualified biologist would provide worker awareness training to all project personnel. This training would include recognition of California red-legged frog and its habitat.

- Construction personnel and equipment would be confined to designated work areas and approved access roads.

- If the California red-legged frog were encountered during preactivity surveys or during project activities, all work would cease until the frog is removed and relocated or the frog would be temporarily held in a wetted container. Frog collection would be performed by a USFWS-approved biologist.

- Any incidental take would be immediately reported to USFWS at (916) 414-6600.

E.2.2.6.2 *Alameda Whipsnake*

E.2.2.6.2.1 Direct Effects

E.2.2.6.2.1.1 Firetrail Grading

This activity could result in direct mortality of individual snakes from grading equipment during grading. Mitigation measures have been identified to minimize potential for direct impact of this activity on this species (see Section E.2.2.6.2.3) (Jones and Stokes 2001).

E.2.2.6.2.1.2 Storm Drainage System Maintenance, Culvert Improvement/Installation, and Termination of Surface Water Releases

Because these activities would not occur within the Alameda whipsnake habitat, they would not directly affect the Alameda whipsnake or its critical habitat. In addition, there would be no direct effects on the Alameda whipsnake from termination of water supply to the artificially created wetlands at Buildings 865, 801, 851 and 827.

E.2.2.6.2.1.3 Prescribed Burns

Prescribed burns would be anticipated to occur within 400 feet of the nearest edge of sage scrub, the primary constituent habitat elements of the Alameda whipsnake (Figure E.2.2.6.2.1.3–1). At four other locations (along the east boundary), small isolated patches of sage scrub would be close to the burn area boundary, but separated from it by a fire trail. No known fires have encroached on these areas within the past 46 years. Because Alameda whipsnakes are known to use grassland habitat within 400 feet of sage scrub and rock outcrops at Site 300, there would only be a small potential for direct mortality as a result of prescribed burns. No Alameda whipsnake mortality has been observed at Site 300 after a prescribed burn (LLNL 2001a). In addition, because the Alameda whipsnake inhabits fire-dependent communities, the species has probably acquired behavioral adaptations that minimize potential for mortality from fire (Jones and Stokes 2001). A research proposal has been coordinated with the USFWS to investigate, in greater depth, the effects of prescribed burning on the Alameda whipsnake at Site 300 and several other locations (Swaim 2002c). The USFWS has also issued a biological opinion on this project (USFWS 2002a).

E.2.2.6.2.1.4 Construction Related Activities

Under the Proposed Action, construction of the EMPC would result in the disturbance of approximately 40,000 square feet of soil at Site 300. A field reconnaissance of the proposed EMPC site was performed to detect the presence of special status wildlife species and/or their habitats at Site 300. No Alameda whipsnakes were detected in the proposed construction area (LLNL 2003ag). The proposed EMPC site would be some distance from coastal scrub habitat where the Alameda whipsnake has been observed, so it is unlikely that this project would affect this species. The proposed EMPC site is not located in formerly designated critical habitat for the Alameda whipsnake.

E.2.2.6.2.1.5 Decontamination and Demolition of Facilities

It is unlikely that Building 808 decontamination and demolition activities would result in direct mortality of the Alameda whipsnake, because this facility is not located in an area with suitable habitat for this species (see Figure E.2.2.6.2.1.3–1). Therefore, proposed decontamination and demolition would likely have minimal effect on this species. The decontamination and demolition of Building 808 at Site 300 would eliminate approximately 1,500 square feet of developed space after this structure has been demolished and then landscaped for soil retention.

E.2.2.6.2.1.6 Maintenance of Facilities, Paved Roads, and Utilities

The routine maintenance of facilities, paved roads, and utilities at Site 300 would probably not result in direct mortality of the Alameda whipsnake, although a potential for direct impact exists in the southwest portion of the site where suitable habitat for this species exists. Mitigation measures have been identified to minimize the potential for direct effects on the Alameda whipsnake (see Section E.2.2.6.2.3)

E.2.2.6.2.1.7 Landscaping and Grounds Maintenance

Landscaping and grounds maintenance activities at Site 300 would probably not result in direct mortality of the Alameda whipsnake, although a potential for direct impact exists in the southwest portion of the site where suitable habitat for this species exists. Mitigation measures have been identified to minimize the potential for direct effects on the Alameda whipsnake.

E.2.2.6.2.1.8 Herbicide Application and Disking

Herbicide application at the Site 300 would be performed primarily to eliminate vegetation along security fences and on the perimeter of some facilities. Preactivity surveys for the presence of sensitive natural resources would be performed prior to disking, and Site 300 maintenance staff would receive annual training on special status species identification and distribution. The Site 300 maintenance staff would follow mitigation measures established by wildlife biologists to protect sensitive wildlife and habitats from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years. The perimeter-disking project would proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Herbicide formulations would pose minimal risk when applied in accordance with their EPA pesticide labels and under conditions with little or no wind so as to avoid herbicide drift. Herbicides would no be sprayed on habitat suitable for the Alameda whipsnake. Prior to late-Fall application, ground areas subject to spraying would be assessed by LLNL wildlife biologist. Also, herbicide projects would proceed only after consultation with a wildlife biologist (LLNL 2001c).

E.2.2.6.2.1.9 Invasive Species Control

The control of certain invasive plant species during prescribed burns would probably not result in direct mortality of Alameda whipsnakes, as discussed in E.2.2.6.2.1.3 Prescribed Burns. The occasional removal of feral pigs, a known predator and cause of habitat degradation has a beneficial effect on Alameda whipsnakes.

E.2.2.6.2.1.10 Ground Squirrel Control

The occasional control of ground squirrels with Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations would probably not result in direct mortality of the Alameda whipsnake. The impact from the application of these rodenticides would be anticipated to be negligible when used in accordance with their EPA pesticide label instructions.

E.2.2.6.2.1.11 Vehicle Traffic

Vehicle traffic at Site 300 could result in direct mortality of the Alameda whipsnake. However, the risk is considered low because vehicle traffic at Site 300 would be limited and most of the suitable habitat for the Alameda whipsnake is in less accessible parts of the site.

E.2.2.6.2.1.12 Explosive Testing

Explosives testing would probably not result in direct mortality of the Alameda whipsnake, because the test areas are not in areas with suitable habitat for the Alameda whipsnake.

E.2.2.6.2.1.13 Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

Operation of the explosive process water surface impoundments and sewage oxidation pond would probably not result in direct mortality of the Alameda whipsnake, because they are not located in areas with suitable habitat for this species.

E.2.2.6.2.2 Indirect Effects

Prescribed burning would temporarily alter approximately 385 acres of grassland habitat within the formerly designated critical habitat (USFWS 2002b). No suitable coastal sage scrub habitat for the Alameda whipsnake would be affected. Burning would not take place in any of the coastal sage scrub or rock outcrops or in any grassland closer than 400 feet from primary constituent habitat elements for this species.

There would be no indirect effects on the Alameda whipsnake as a result of termination of surface water releases to the artificially created wetlands or from activities associated with storm

drainage system maintenance and culvert improvement/installation. Fire trail grading would not indirectly affect the Alameda whipsnake or whipsnake habitat by creating any barriers to dispersal.

E.2.2.6.2.3 Mitigation and Avoidance Measures

In order to protect the Alameda whipsnake and its habitat during annual burning and grading activities, Site 300 would implement the following mitigation and avoidance measures (Jones and Stokes 2001):

- Prior to fire trail grading and prescribed burning, a qualified biologist would provide worker awareness training to all project personnel; this training would include recognition of the Alameda whipsnake and its habitat.

- If the Alameda whipsnake were encountered during grading, work would cease until the snake is removed and relocated by a USFWS-approved biologist.

- If the Alameda whipsnake were encountered during any project activity, work would cease until the snake is removed and relocated by a USFWS-approved biologist.

- Any incidental take of this species would be immediately reported to USFWS at (916) 414-6600.

E.2.2.6.3 *California Tiger Salamander*

E.2.2.6.3.1 Direct Effects

E.2.2.6.3.1.1 Burning and Fire Trail Grading

Grading of fire trails would be unlikely to result in the direct mortality of individual California tiger salamanders, because this activity would occur during the summer, after individual salamanders have dispersed from breeding pools into upland refugia. Fire trails would be graded along previously disturbed existing trails. Song Pond, a known breeding pool for California tiger salamanders, falls within a prescribed burn area. However, burns would occur during May–July when the California tiger salamander would be below ground, thereby reducing the likelihood of direct effects this activity could have on the California tiger salamander. In addition, because these burns would occur annually and fuel load would be low, impacts associated with this activity would be reduced (Jones and Stokes 2001).

E.2.2.6.3.1.2 Storm Drainage System Maintenance

Storm drainage system maintenance could result in the direct mortality of the California tiger salamander because, these activities could occur in perennial drainages. However, because maintenance activities would be conducted in late summer or fall, it is unlikely that the California tiger salamander would occur within the Proposed Action project areas. Mitigation measures described for the California red-legged frog would further reduce potential to directly affect the California tiger salamander (Jones and Stokes 2001).

E.2.2.6.3.1.3 Culvert Improvement and Installation

These activities could result in the direct mortality of the California tiger salamander, because they could occur in areas of ponded water. However, because improvement and installation work would be conducted after the breeding season, it is unlikely that the California tiger salamander would occur within the Proposed Action project areas. Mitigation measures have been identified to further minimize potential for direct effects on the California tiger salamander or its habitat (Jones and Stokes 2001).

E.2.2.6.3.1.4 Termination of Surface Water Releases

The termination of water from Buildings 865, 851, and 827 would not directly affect the California tiger salamander; these artificial wetlands have been monitored by the Site 300 biologist for 6 years and the California tiger salamander has never been identified at these sites.

E.2.2.6.3.1.5 Construction Related Activities

Under the Proposed Action, construction of the EMPC would result in the disturbance of approximately 40,000 square feet of soil at Site 300. A field reconnaissance of the proposed EMPC site was performed to detect the presence of special status wildlife species and/or their habitats at Site 300. No California tiger salamanders were detected in the proposed construction area (LLNL 2003ah). The proposed EMPC construction would be within the dispersal capability of California tiger salamanders from areas in the southeastern part of Site 300 where this species has been observed. Therefore, a pre-activity survey would be conducted prior to the groundbreaking for the EMPC to avoid injury to California tiger salamanders.

E.2.2.6.3.1.6 Decontamination and Demolition of Facilities

It is unlikely that Building 808 decontamination and demolition activities would result in direct mortality of the California tiger salamander unless individuals of this species are present at the project site. However, this facility is in an upland area that is not typically frequented by California tiger salamanders. The proposed decontamination and demolition would likely have minimal adverse effect on this species. The decontamination and demolition of Building 808 at Site 300 would eliminate approximately 1,500 square feet of developed space after this structure has been demolished and then landscaped for soil retention.

E.2.2.6.3.1.7 Maintenance of Facilities, Paved Roads, and Utilities

The routine maintenance of facilities, paved roads, and utilities at Site 300 would probably not result in direct mortality of California tiger salamanders, because the maintenance of facilities, paved roads, and utilities would be primarily in upland areas, which would pose minimal risk to California tiger salamanders. Additionally, these maintenance activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.3.1.8 Landscaping and Grounds Maintenance

Landscaping and grounds maintenance activities at Site 300 would probably not result in direct mortality of California tiger salamanders, because these activities avoid known wetland areas

inhabited by this species. Additionally, these activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.3.1.9 Herbicide Application and Disking

Herbicide application at Site 300 would be performed primarily to eliminate vegetation along security fences and on the perimeter of some facilities. Preactivity surveys for the presence of sensitive natural resources would be performed prior to disking, and Site 300 maintenance staff would receive annual training on special status species identification and distribution. The Site 300 maintenance staff would follow mitigation measures established by a wildlife biologist to protect sensitive wildlife and habitats (e.g., American badger dens) from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years. The perimeter-disking project would proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Herbicides would not be applied on aquatic habitat suitable for California tiger salamander breeding. Prior to late-fall application, ground areas subject to spraying would be assessed by LLNL wildlife biologists. Also, herbicide projects proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c). Herbicide applications should pose minimal risk to the California tiger salamander provided the formulations are applied in accordance with EPA pesticide label instructions; under conditions with little or no wind to avoid herbicide drift; only to the extent necessary; and in accordance with LLNL safeguards.

E.2.2.6.3.1.10 Invasive Species Control

The occasional removal of feral pigs, a known predator and cause of habitat degradation, would have a beneficial effect on California tiger salamanders. No bullfrogs have been observed at Site 300, so bullfrog control measures have not been required.

E.2.2.6.3.1.11 Ground Squirrel Control

The occasional control of ground squirrels with Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations would probably not result in direct mortality of California tiger salamanders unless conducted in California tiger salamander habitat. The impact from the application of these rodenticides would be negligible when they are used in accordance with their EPA pesticide label instructions.

E.2.2.6.3.1.12 Vehicle Traffic

Vehicle traffic at Site 300 could to result in mortality of California tiger salamanders found on roads or fire trails. However, the risk is considered low because vehicle traffic at Site 300 would be limited in comparison to that at the Livermore Site; the majority of traffic would occur during the daylight hours when this species is not typically active; and migrations of this species are infrequent.

E.2.2.6.3.1.13 Explosive Testing

Explosives testing would probably not result in mortality of California tiger salamanders as the explosives testing areas would not in prime habitat for the California tiger salamander (BioSystems 1986c). Further, explosives testing would be primarily conducted during the daylight hours when this species is not typically active.

E.2.2.6.3.1.14 Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

The California tiger salamander has been observed at the overflow pond (also referred to as the percolation pond) only, and not at the sewage oxidation pond. This species has also been observed at the explosives process water surface impoundments (Jones and Stokes 2001, LLNL 2003ab). These ponds provide suboptimal habitat and would not likely adversely affect the California tiger salamander population at Site 300.

E.2.2.6.3.2 Indirect Effects

Fire trail grading would disturb sediment that could result in an indirect negative impact on the California tiger salamander by reducing habitat suitability. Storm drainage system maintenance would create deep pools, enhancing the California tiger salamander breeding habitat. There would be no indirect effect on this species as a result of prescribed burning, and the prescribed burning would not likely pose a barrier to movement of salamanders during the wet season (Jones and Stokes 2001).

E.2.2.6.3.3 Mitigation and Avoidance Measures

To protect the California tiger salamander and its habitat, Site 300 would implement the same avoidance and mitigation measures discussed for the California red-legged frog (Jones and Stokes 2001).

E.2.2.7 *Interrelated Actions*

Interrelated actions are part of a larger action and dependent upon the larger action for their justification. The Proposed Action operations would not be part of a larger project or plan, although a research project has been coordinated with the USFWS to evaluate the effects of prescribed burns on the Alameda whipsnake at several locations, including Site 300, as discussed in Section E.2.2.6.2.1.3, Prescribed Burns (Swaim 2002c). The USFWS has already issued a separate biological opinion on this research project that is including Site 300 as one of its study locations (USFWS 2002d). There would be no interrelated effects on listed species within the project area with the exception of the Alameda whipsnake investigation.

E.2.2.8 *Cumulative Effects*

The Proposed Action activities at Site 300 would not result in cumulative effects. Typically, cumulative effects under the *Endangered Species Act* would include all future actions "reasonably certain to occur" within the action area. There are no known additional future activities planned at Site 300 that would contribute to cumulative effects on listed species covered in this biological assessment (Jones and Stokes 2001). The incremental effect of the

Proposed Action on biological resources within the area would be positive, particularly in the long term, when taken in the context of continuing conversion of wildlife habitat for agricultural, residential, commercial, and industrial use in the vicinity of Site 300.

E.2.2.9 *Conservation and Mitigation*

One of the Proposed Action projects would remove a maximum of 0.62 acre of wetland habitat, of which the California red-legged frog occupies only 0.55 acre (Table E.2.2.5.5–1). Of the 0.55 acre, 0.003 acre of occupied California red-legged frog breeding habitat would be affected. Approximately 0.07 acre of unoccupied wetland habitat would also be affected (wetlands at Buildings 801, 827, and 851). NNSA proposes to mitigate for the 0.62-acre artificial wetland removed by protecting and enhancing selected area, and increasing breeding opportunities for the California red-legged frog and the California tiger salamander in areas where breeding habitat is limited or nonexistent. These designated areas would be managed and protected for the California red-legged frog and the California tiger salamander. A minimum of 1.86 acres of wetland habitat would be enhanced and protected for the California red-legged frog and the California tiger salamander. Three mitigation sites for potential enhancement are described in detail below.

E.2.2.9.1 *Potential Enhancement Sites*

E.2.2.9.1.1 Oasis Canyon Wetland

The Oasis Canyon wetland, comprising 1.16 acres (see Figure A-l in Appendix A), originates at an abandoned inclined mine shaft seep. In 2001, this wetland was observed to have high-quality breeding and nonbreeding habitat that would be managed (e.g., invasive species control) and protected as a natural drainage in perpetuity for the California red-legged frog (Jones and Stokes 2001). However, no breeding was noted in 2002 at this location due to sedimentation (LLNL 2003ab).

E.2.2.9.1.2 Mid Elk Ravine

Mid Elk Ravine, comprising approximately 1.6 acre, is a perennial drainage vegetated with mature willows, oaks, and cattails. The Site 300 biologist has conducted frog surveys in this drainage since 1996. Nonbreeding California red-legged frogs have been observed in the drainage, but no breeding frogs have been detected in this drainage during surveys. The drainage lacks pooled water areas of sufficient depth to provide suitable breeding habitat.

Enhancement of this drainage by creating one or more ponds in selected areas would increase suitable habitat for breeding frogs in an area where such habitat is limited. The site would allow breeding ponds of about 0.15 acre.

E.2.2.9.1.3 SHARP Facility Seep

A perennial 0.08-acre seep located in the upper Elk Ravine watershed is one of the proposed enhancement areas for the California red-legged frog and the California tiger salamander. The seep is approximately 328 feet west of Building 865 and is currently surrounded by the remains of a concrete structure. Due to close proximity to the Building 865 wetland (occupied by the

California red-legged frog), the SHARP Facility seep could provide an important breeding site for the California red-legged frog. Figure E.2.2.6.1.1.4–1 shows the SHARP Facility enhancement area. At peak capacity, the enhancement area would sustain a pond up to 0.07 acre in area with a maximum depth of approximately 4 to 6 feet. The proposed enhancement of this seep would be conducted prior to the termination of the supplied water to the Building 865 wetland.

E.2.2.9.2 *Creation of Breeding Habitat*

The proposed preservation and management activities are intended to compensate primarily for impacts on 0.55 acre of artificial wetland, part of which provides dispersal and foraging habitat for the California red-legged frog and the California tiger salamander. The first component of these mitigation actions would involve the establishment of a 1.86-acre mitigation area consisting of existing riparian and wetland resources that provide equal or greater habitat value than the affected wetlands. NNSA would permanently set aside this area for the protection and management of the California red-legged frog.

The second component would involve the creation of a minimum of 0.01 acre of breeding habitat at two distinct locations in Site 300. The main goal of this approach is to compensate for impacts on artificial breeding pools by creating pools of equal or greater habitat quality. The two components of the proposed California red-legged frog and the California tiger salamander mitigation actions are summarized in Table E.2.2.5.5–1 and described in detail in the following sections.

Biologists and hydrologists selected two locations in the Elk Ravine watershed for the creation of breeding ponds and associated semipermanent marshes. The two sites will be referred to as the SHARP Facility and Mid Elk Ravine mitigation sites. They were selected largely because the topography and hydrologic conditions at both sites are highly suitable for pond and marsh creation. A general description of existing environmental conditions at each site and a general description of the proposed mitigation approach and associated construction methods are provided below (Jones and Stokes 2001).

E.2.2.9.2.1 The SHARP Facility

The SHARP Facility is located near the headwaters of Elk Ravine on the opposite side of the road from Building 865 (Figure E.2.2.6.1.1.4–1). The seep and surrounding area consist of the lower half of a small, ephemeral drainage trending east-west. This drainage way was altered during the early 1990s when the facility was constructed (Jones and Stokes 2001).

During the late 1990s, a perennial groundwater seep developed, which now surfaces along the northwestern embankment. This seep is associated with subsurface drainage from the west side of Site 300 and, therefore, was sampled for tritium contamination. Low concentrations of tritium, below drinking water standards, have been detected in this water. The exact rate of flow from the seep is unknown, but was estimated to range from 0.25 to 1 gallon per minute during August 2001. This estimate is expected to be representative of flow rates during the summer months, but flow rates may vary considerably throughout the year. Water emanating from the seep flows in a thin stream along the northern embankment of the drainageway, where it currently supports a

small community of cattails, willows, nettles, and other riparian and wetland vegetation. Water from the seep and the surrounding watershed exits the site through a culvert that drains into upper Elk Ravine, just downstream from Building 865. California red-legged frog, have been found using this area; however, the habitat does not contain the proper characteristics for California red-legged frog breeding (Jones and Stokes 2001).

The SHARP Facility drains approximately 25 acres of steep annual grasslands that are underlain almost entirely by the moderately coarse- and medium-textured Entisols of the Wisflat, San Timoteo, and Arburua series. These soils are, in turn, underlain by weathered sandstone and siltstone at depths ranging from 10 to 31 inches. Mean annual precipitation at Site 300 is approximately 10 to 11 inches, with 90 percent of the precipitation occurring as rainfall between November and April. Mean annual reference evapotranspiration for the nearby town of Tracy is 4 inches per month, ranging from a low of 0.7 inch per month in December to a high of 7.9 inches per month in July. The seep does not currently support a breeding population of California red-legged frogs or California tiger salamanders due to the lack of pooled water areas (Jones and Stokes 2001).

The general mitigation approach, construction method, and maintenance procedures for the SHARP Facility breeding pond were addressed in a recent biological assessment and related biological opinion (Jones and Stokes 2001, USFWS 2002b).

E.2.2.9.2.2 Mid Elk Ravine Site

The Mid Elk Ravine site, located immediately south of Building Complex 812, consists of a 200-foot reach of the main channel of Elk Ravine and a section of moderate-to-steep slopes that abut the channel on either side. Most of Elk Ravine is intermittent drainageway, but a perennial seep located approximately 1,200 feet upstream of the site provides a constant, low-volume flow of water, estimated to range from 5 to 10 gallons per minute. This estimate is probably representative of the average flow rate during the summer months, but the rate may vary considerably throughout the year. The seep supports a continuous stand of riparian and wetland vegetation extending several thousand feet downstream from its source.

The subject reach of the Elk Ravine channel is 3 to 7 feet wide and 3 to 8 feet deep, with a gradient of approximately 3 to 5 percent. The channel supports a thick stand of cattails and fewer numbers of associated hydrophytic species. The bed of the channel consists primarily of fine sands, silts, and clays trapped by the cattails. The soil survey of San Joaquin County indicates that the hill slope that bounds the western side of the channel is occupied by soils of the Alo and Vaqueros series, while the hill slope that bounds the eastern side of the project reach is underlain by soils of the Wisflat, Arburua, and San Timoteo series. As described above, the soils of the Wisflat, Arburua, and San Timoteo series are shallow, medium-textured Entisols underlain by sandstone and siltstone bedrock at depths ranging from 10 to 30 inches. Soils of the Alo and Vaqueros series are moderately deep, Vertisols (i.e., expansive clay soils) underlain by shale at depths of 30 inches to more than 6 feet.

The subject reach of Elk Ravine drains a 1,470-acre watershed that consists almost entirely of steep annual grasslands underlain by soils of the Wisflat, Arburua, San Timoteo, Alo, and Vaqueros series. Impervious surfaces, such as roads, buildings, parking lots, and staging areas

comprise an estimated 0.5 percent of the watershed. Precipitation and evapotranspiration characteristics for the Mid Elk Ravine site are identical to those described above for the SHARP Facility (Jones and Stokes 2001).

The general mitigation approach, construction method, and maintenance procedures for the Mid Elk Ravine breeding habitat site were addressed in a recent biological assessment and related biological opinion (Jones and Stokes 2001, USFWS 2002b)

E.2.2.10 *Compensation and Set-Asides*

E.2.2.10.1 *Alameda Whipsnake*

Mitigation measures for impacts on the Alameda whipsnakes would include participation in a 5-year study on the effects of burning on this species. Site 300 has agreed to support and participate in a study proposed by the USFWS Recovery Program on the potential effects of prescribed burns on the Alameda whipsnake (Jones and Stokes 2001).

E.2.2.10.2 *California Red-Legged Frog*

Mitigation for impacts on California red-legged frog habitat would include monitoring the enhancement areas annually for 5 years and semi-annually for the next 5 years to determine whether the ponds are functioning as intended and to determine whether invasive bullfrogs have colonized the enhancement sites. Monitoring would involve spring surveys for the California red-legged frog. If bullfrogs were discovered at the site, the Site 300 biologist would make the necessary effort to remove adults and larvae.

A 5-year report would be prepared and submitted to USFWS. This report would document the results of annual surveys in enhancement areas and evaluate the success of the proposed mitigation plan (Jones and Stokes 2001).

E.2.2.11 *Contingency Plan*

If, after 10 years, the proposed enhancement pond mitigation action were not effective, the Site 300 biologist would discuss the results with USFWS.

E.2.2.12 *Conference*

As noted in Section E.2.2.5.5, a preliminary survey was conducted for the proposed EMPC in March 2003 without detecting any protected or sensitive species. NNSA would like to request a conference with the USFWS to discuss: (a) any plans that the USFWS may have to redesignate critical habitat for the California red-legged frog in the vicinity of the proposed EMPC site at Site 300; and (b) any measures required to address the California tiger salamander at Site 300 in the event the status of this species is elevated from proposed threatened to threatened.

E.2.2.13 *Conclusion and Determination*

With implementation of proposed avoidance, conservation, and mitigation measures, the Proposed Action activities may affect (but are not likely to adversely affect) the Alameda whipsnake, California tiger salamander, and California red-legged frog.

Fire trail grading may indirectly affect the California red-legged frog and California tiger salamander; however, mitigation measures would minimize the potential impact. The Alameda whipsnake may be affected by this activity; however, pre-activity surveys would minimize the potential for incidental take.

Storm drainage system maintenance is likely to provide a long-term, indirect benefit to California red-legged frog and California tiger salamander habitat by creating pools and enhancing breeding habitat. Direct effects would be minimized through implementation of pre-activity surveys. This activity would have no effect on the Alameda whipsnake.

Culvert improvement and installment may affect (but are not likely to adversely affect) the California red-legged frog and California tiger salamander. Direct effects would be mitigated through the implementation of avoidance and mitigation measures. There would be no effect on the Alameda whipsnake as a result of this activity.

The proposed burning of grassland in the Alameda whipsnake critical habitat may affect (but is not likely to adversely affect) the Alameda whipsnake. The impacts on the Alameda whipsnake associated with annual prescribed burning in grassland habitat are unknown. Future conservation of this species would be fostered through a research project conducted by NNSA that would address this impact.

The termination of surface water release may affect the California red-legged frog. NNSA would mitigate for the loss of 0.62 acre of artificial wetlands through the permanent protection and enhancement of a minimum of 1.86 acres of natural wetland habitat. This habitat would be managed and protected for the continued recovery of the California red-legged frog.

Construction-related projects such as the proposed EMPC 300 may affect (but are not likely to adversely affect) the California red-legged frog and California tiger salamander. These species were not observed during a field reconnaissance of the proposed construction site in an upland location. Direct effects would be minimized through implementation of a pre-construction survey. There would be no effect on the Alameda whipsnake.

Demolition of facilities would eliminate approximately 1,500 square feet of developed space, after this structure has been demolished and then landscaped for soil retention. Building 808 is not in an area with suitable habitat for the Alameda whipsnake, so its demolition would have no effect on that species.

Maintenance of facilities, paved roads, and utilities may affect (but are not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. These operations would occur primarily within the developed part of Site 300, be representing less than 5 percent of the total site acreage. Maintenance activities would be routinely reviewed by LLNL wildlife biologists to minimize the potential for direct effects on these species.

Landscaping and grounds maintenance may affect (but are not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. Since the landscaping and grounds maintenance activities would avoid known wetland breeding areas and associated nonbreeding areas, these activities would pose a minimal risk to California red-legged frogs and California tiger salamanders. The impact of these activities on the Alameda whipsnake would likely be minimal due the relatively small amount of suitable habitat for this reptile at Site 300, with much of it not subject to typical landscaping and grounds maintenance.

Herbicide applications may affect (but are not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. Herbicides would likely have minimal impact on these three species when used in accordance with their EPA pesticide label instructions. Also, herbicide projects would proceed only after consultation with a LLNL wildlife biologist.

Ground squirrel control is not likely to affect the California red-legged frog and California tiger salamander since there is presently no active ground squirrel control program anywhere at Site 300. Control is done, on an as needed basis, around the explosive process water surface impoundments using rodenticides in accordance with EPA pesticide label instructions. Ground squirrel control at the surface impoundment would not have an effect on the Alameda whipsnake.

Vehicle traffic may affect (but is not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. However, the potential for impact would be reduced because the majority of traffic would occur during the daylight hours when adults of this species are not typically active; most of the California red-legged frog breeding and nonbreeding areas would be in less accessible parts of the site; and migrations of this species are infrequent. The impact of vehicle traffic on the Alameda whipsnake would likely be minimal due the relatively small amount of suitable habitat for this reptile and its unsuitability for most vehicles.

Explosive testing may affect (but is not likely to adversely affect) the California red-legged frog and California tiger salamander. However, the explosive testing sites are in areas that provide suboptimal habitat for these species. Explosive testing would have no effect on the Alameda whipsnake since these sites are not in areas with suitable habitat for this species.

The sewage oxidation pond may affect (but is not likely to adversely affect) the California red-legged frog and California tiger salamander. These two amphibians have been observed at the overflow pond only and not at the sewage oxidation pond. Further, the pond provides suboptimal habitat for these species.

E.3 REFERENCES

16 U.S.C. § 1536 "Conservation, Endangered Species, Interagency Cooperation," *United States Code*, Title 16, Chapter 35, Section 1536.

16 U.S.C. § 703 et seq. "Taking, killing, or possessing migratory birds unlawful, " *United States Code*, Title 16, Chapter 7, Subchapter II, Sec. 703, July 13, 1918.

32 FR 4001 U.S. Fish and Wildlife Service (USFWS), "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the San Joaquin Kit Fox," *Federal Register*, Vol 32, Pg 4001, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, March 11, 1967.

45 FR 52803 USFWS, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Valley Elderberry Longhorn Beetle," *Federal Register*, Vol 45, Pg 52803, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, August 8, 1980.

50 FR 19374 USFWS, "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Large-flowered Fiddleneck *(Amsinckia grandiflora,"Federal Register*, Vol 50, Pg 19374, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, May 8, 1985.

61 FR 25813 USFWS, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the California Red-Legged Frog," *Federal Register*, Vol, 62 Pgs 25813-25833, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, May 23, 1996.

62 FR 64306 USFWS, "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Callippee Silverspot Butterfly and the Behren's Silverspot Butterfly and Threatened Status for the Alameda Whipsnake," *Federal Register*, Vol. 52, Pg 64306, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, December 5, 1997.

65 FR 58933 — USFWS, "Endangered and Threatened Wildlife and Plants; Final Determination of Critical Habitat for the Alameda Whipsnake (Masticophis lateralis euryxanthus)," *Federal Register*, Vol. 66, Pg 58933, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, October 3, 2000.

66 FR 14626 — USFWS, "Endangered and Threatened Wildlife and Plants, Final Determination of Critical Habitat for the California Red-Legged Frog, Final Rule." *Federal Register*, Vol. 66, Pg 14626, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, March 13, 2001.

68 FR 28649 — USFWS, "Listing of the Central California Distinct Population Segment of the California Tiger Salamander; Reclassification of the Sonoma County and Santa Barbara County Distinct Populations from Endangered to Threatened; Special Rule, Supplementary Information, Background," Vol 51, Pg 28649, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, May 23, 2003.

Arnold 2002 — Arnold, Richard A., *Report on the Threatened Valley Elderberry Longhorn Beetle and its Elderberry Food Plant at the Lawrence Livermore Laboratory – Site 300, Entomological Consulting Services, Ltd.,* Pleasant Hill, CA, September 2002.

Balestreri 1981 — Balestreri, Antonio N., *Status of the San Joaquin Kit Fox at Camp Roberts, California, California Polytechnic State University,* San Luis Obispo, CA, 1981.

Barry 1972 — Barry, W.J., *The Central Valley Prairie, Volume 1. California Prairie Ecosystem,* State of California, The Resources Agency, Department of Parks and Recreations, Sacramento, CA, March 1972.

Bartolome and Gemmil 1981 — Bartolome, J.W. and B. Gemmil, "The Ecological Status of Stipa Pulchra (Poaceae) in California," *Madrono* Vol. 28, Pgs. 172-184, 1981.

BioSystems 1986a — BioSystems Analysis, Inc. (BioSystems), *Vegetation of Site 300, Lawrence Livermore National Laboratory, San Joaquin County, California,* Pleasanton, CA, Novbmer 1986.

BioSystems 1986b — BioSystems, *Wildlife Studies of Site 300 Emphasizing Rare and Endangered Species, Lawrence Livermore National Laboratory, San Joaquin County, California*, Pleasanton, CA, 1986.

BioSystems 1986c — BioSystems, *A Rare Plant Survey of Site 300 LLNL San Joaquin County, California*, Pleasanton, CA, November 1986.

Bloom 2002 — Bloom, P. H, *Breeding Raptor and Loggerhead Shrike Status and Management Recommendations for Site 300 (Draft Report)*, Lawrence Livermore National Laboratory, Livermore, CA, October 31, 2002.

California Fish and Game Code §§ 2050-2098 — *California Fish and Game Code*, "California Endangered Species Act," Division 3, Chapter 1.5, Articles 1-3.5, §§2050-2068, Sacramento, CA.

CC Times 2003 — Contra Costa Times, "Whipsnake loses to growth advocates," Contra Costa Times, Contra Costa, CA, Available online at http://www.bayarea.com/mled/cctimes/5874964.htm, May 16, 2003, Accessed May 16, 2003.

CDFG 2002a — California Department of Fish and Game (CDFG), *State and Federally Listed Endangered and Threatened Animals of California*, CDFG, Sacramento, CA, http://www.dfg.ca.gov/whdab/TEAnimals.pdf, 2002, Accessed October 2002.

CDFG 2002b — California Department of Fish and Game (CDFG), State and Federally Listed Endangered and Threatened Plants of California, CDFG, Sacramento, CA, Available online at http://www.dfg.ca.gov/whdab/TEPlants.pdf, 2002, Accessed October 2002.

Clements 1920 — Clements, F.E., *Plant Indicators-The Relation of Plant Communities to Process and Practice*, Carnegie Institution of Washington Publication, Washington, DC, No. 242, Pgs. 1-512, 1920.

Condor Country Consulting 2002 — Condor Country Consulting, Inc., *2001-2002 Wet Season Branchiopod Survey Report: University of California LLNL Site 300 Alameda and San Joaquin Counties, California*, Condor Country Consulting, Inc., Hayward, CA, prepared for Lawrence Livermore National Laboratory, Livermore, CA, December 3, 2002.

CSUS 2003 — California State University, Stanislaus (CSUS), *Mesocarnivore Surveys on LLNL Site 300, Alameda and San Joaquin Counties California, Stanislaus Endangered Species Recovery Program, CSUS,* Stanislaus, CA, February 21, 2003.

Davidson et al. 2001 — Davidson, Carlos, H. Bradley Shaffer, and Mark R. Jennings, "Declines of the California Red-legged Frog: Climate, UV-B, Habitat, and Pesticides Hypothesis," *Ecological Applications*, The Ecological Society of America, Washington, DC, Vol. 11, No. 2, Pgs. 464-479, 2001.

DOE 1982a — U.S. Department of Energy (DOE), *Final Environmental Impact Statement, Lawrence Livermore National Laboratory and Sandia National Laboratories–Livermore Sites*, DOE/EIS-0028, U.S. Department of Energy, Washington, DC, July 1982.

DOE 2002i — DOE, *Final Environmental Assessment for the East Avenue Security Upgrade at LLNL and Sandia National Laboratories*, DOE/EA-1439, U.S. Department of Energy, Oakland Operations Office, Oakland, CA, September 2002.

DOE 2002j — DOE, Letter from Mr. Ray Corey, DOE/NNSA to Mr. Dan Buford, Chief, Delta-Bay Branch, USFWS, Sacramento Field Office, dated July 22, 2002, regarding the *Bullfrog Management Plan Amendment for Biological Opinion 1-1-97-F-173, Livermore Site, Lawrence Livermore National Laboratory*, U.S. Department of Energy, Oakland Operation Office, Oakland, CA, 2002.

Dowler-Gruman 2003 — Dowler-Gruman, Architects, LLNL EMPC Drawings: Magazine Area Topo Option M7R, Conceptual Floor Plan and Elevation, Proposed Grading Plan, Proposed Utility Plans C1 and C2, Plumbing Site Plan, Plumbing Floor Plan, Proposed Electrical Site Plan, Electrical Conceptual Floor Plan, Proposed Service Yard, Mountain View, CA, May 23, 2003.

Dyer 2002 — Dyer, A.R., "Burning and Grazing Management in a California Grassland: Effect on Bunchgrass See Viability," *Restoration Ecology*, Vol. 10, Issue 1, Pgs. 107-111, 2002.

ESA 1990 — Environmental Science Associates (ESA), *Environmental Field Investigations - Sandia National Laboratories*, 86-6642, Environmental Science Associates, Inc., prepared for Sandia National Laboratories, Livermore, CA, August 15, 1990.

Finlayson et al. 2000 — Finlayson, B.J., R.A. Schnick, R.L. Cailteaux, L. DeMong, W.D. Horton, W. McClay, and C.W. Thompson, *Rotene use in Fisheries Management Administrative and Technical Guidelines Manual*, American Fisheries Society, Fish Management Chemicals Subcommittee, Task Force on Fishery Chemicals, Bethesda, MD, 2000.

Frenkel 1970 — Frenkel, R.E. "Ruderal Vegetation Along Some California Roadsides," *University of California Publications in Geography* 20 (1970):1-163.

Heady 1958 — Heady, H.F., "Vegetational Changes in the California Annual Type," *Ecology*, Vol. 39, Pgs. 402-416, 1958

Heady 1977 — Heady, H.F., "Valley Grasslands," in *Terrestrial Vegetation of California*, Wiley, New York, NY, 1977.

Hull and Muller 1977 — Hull, J.C. and C.H. Muller, "The Potential for Dominance by Stipa pulchra in a California Grassland," *American Midland Nuaturalist*, Vol. 97, Pgs. 47-173, 1977.

Jones and Stokes 1997 — Jones and Stokes Associates, Inc., *Delineation of Waters of the United States for Arroyo Las Positas, prepared for Lawrence Livermore National Laboratory, Alameda County, California*, JSA 97-107, Lawrence Livermore National Laboratory, Livermore, CA, November 7, 1997.

Jones and Stokes 2001 — Jones and Stokes Associates, Inc., *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 Associates, Inc., *Special-Status Plant Species Surveys and Vegetation Mapping at Lawrence Livermore National Laboratory*, prepared for Lawrence Livermore National Laboratory, Livermore, CA, September 2002.

Jones and Stokes 2002b — Jones and Stokes Associates, Inc., *2002 Small Mammal Inventory at Lawrence Livermore National Laboratory Site 300*, prepared for Lawrence Livermore National Laboratory, Livermore, CA, October 2002.

Lass et al. 1999 — L.W. Lass, J.P. McCaffrey, D.C. Thill, and R.H. Callihan, *Yellow Starthistle: Biology and Management in Pasture and Rangeland*, University of Idaho Cooperative Extensivon Service, Moscow, ID, March 1999.

Laughrin 1970 — Laughrin, L.L., *San Joaquin Kit Fox, Its Distribution and Abundance*, Administrative Report No. 70-2, California Department of Fish and Game, Wildlife Management Branch, Sacramento, CA, 1970.

LLNL 1992a — Lawrence Livermore National Laboratory (LLNL), *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence National Laboratory and Sandia National Laboratories,* Vols. 1-5, DOE/EIS-0157, Lawrence Livermore National Laboratory, Livermore, CA, August 1992.

LLNL 1997o — LLNL, *Environmental Impact Report Addendum for the Continued Operation of Lawrence Livermore National Laboratory*, UCRL-CR-125546, Lawrence Livermore National Laboratory, Livermore, CA, September 1997.

LLNL 1998a — LLNL, *Amended Biological Assessment, Arroyo Las Positas Maintenance Project at the Lawrence Livermore National Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, June 1998.

LLNL 2001a — LLNL, *Hazards Analysis Report, Building 153, Microfabrication Facility*, UCRL-AR-143011, Lawrence Livermore National Laboratory, Safety Analysis Team, Livermore, CA, January 2001.

LLNL 2001c — LLNL, *Final Summary Document for Controlled Burning Operations at LLNL Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, April 17, 2001.

LLNL 2001v — LLNL, *2000 Site Annual Site Environmental Report (SAER)*, UCRL-50027-00, Lawrence Livermore National Laboratory, Livermore, CA, September 1, 2001.

LLNL 2001bb — LLNL, *Rare Plant Restoration and Monitoring at Lawrence Livermore National Laboratory Site 300 Project Progress Report, Fiscal Year 2000, October 1999-September 2000*, UCRL-AR-142408, Prepared by Carlsen, Tina, Erin Espeland, and Abigail Smith, Prepared by Unites States Fish and Wildlife Service, Available online at http://www-erd.llnl.gov/library/AR-142408.pdf, February 2001, Accessed 2002.

LLNL 2002d — LLNL, *Landscape Architecture Master Plan,* Lawrence Livermore National Laboratory, Livermore, CA, June 2000.

LLNL 2002ap — LLNL, *CMS Input to 2002 EIS Project*, Lawrence Livermore National Laboratory, Chemistry and Materials Science Assurance Office, Livermore, CA, September 27, 2002.

LLNL 2002bz — LLNL, Personal communication from Bergman, Michele, Manager, Office of Program Planning, Safeguards & Security, to Ross Dimmick, Tetra Tech, NUS, dated December 13, 2002, Lawrence Livermore National Laboratory, Livermore, CA, 2002.

LLNL 2002di — LLNL, *Tricolored Blackbird Distribution and Productivity, Lawrence Livermore National Laboratory, Site 300, Alameda and San Joaquin Counties, California*, Lawrence Livermore National Laboratory, Livermore, CA, December 15, 2002.

LLNL 2002dj — USFWS, *Rare Plant Restoration and Monitoring at Lawrence Livermore National Laboratory Site 300 Project Progress Report, Fiscal Year 2000, October 1999–September 2000,* Available online at http://www.erd.llnl.gov/library?AR-142408-01.pdf, January 2002, Accessed 2002.

LLNL 2003q — LLNL, *Lawrence Livermore National Laboratory Site 300 Explosive Test Facility Prescribed Burn/Smoke Management Plan*, UCRL-AR-154174, Lawrence Livermore National Laboratory, Livermore, CA, April 13, 2003.

LLNL 2003ab — LLNL, *Current and Historical Distribution of Special Status Amphibians at the Livermore Site and Site 300* (Draft), Lawrence Livermore National Laboratory, Livermore, CA, April 2003.

LLNl 2003ac — LLNL, Email from Michael van Hattem, LLNL, to George Pratt, Tetra Tech, Inc. dated October 9, 2003, regarding Willow Flycatcher at Site 300, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003ad — LLNL, Email from Michael van Hattem, LLNL, to Bill Taber, Tetra Tech, NUS, regarding Erosion Pictures at Site 300, dated June 12, 2003, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003ag — LLNL, Email from Jim Woollett, LLNL, to George Pratt, Tetra Tech, Inc., dated June 16, 2003, regarding EMPC Special-Status Biotic Survey Site 300, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003ah — LLNL, Email from Jim Woollett, LLNL, to George Pratt, Tetra Tech, Inc., dated February 11, 2003, regarding *Status of Herbicide Applications and Ground Squirrel Control at Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003ai — LLNL, Email from Jim Woollett, to George Pratt, Tetra Tech, Inc. dated October 13, 2003, regarding *Burrowing Owl Presence at Livermore Site*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003ap — LLNL, "*Population Characteristics of Eschscholzia rhombipetala, Lawrence Livermore National Laboratory, Livermore, CA,"* UCRL-JC-150173, Lawrence Livermore National Laboratory, Livermore, CA, January 2003.

LLNL 2003bh — LLNL, Email from Jennifer Garrison, LLNL to George Pratt, Tetra Tech, Inc., dated July 25, 2003, regarding Preliminary Site 300 Bat Survey, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bi — LLNL, Email from Jennifer Garrison, LLNL, to George Pratt, Tetra Tech, Inc., dated August 28, 2003, regarding *Site 300 Fence Information*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003by — LLNL, *LLNL Avian Monitoring Program: Variable Circular Plot Point Count and Constant Effort Mist Netting Lawrence Livermore National Laboratory, Site 300, Alameda and San Joaquin Counties, CA, Draft Report*, Lawrence Livermore National Laboratory, Livermore, CA, January 15, 2003.

LLNL 2003bz — LLNL, Email to George Pratt, Tetra Tech, Inc., dated February 11, 2003, regarding the *Inventory of Animal and Plants at the Livermore Site in 2001 (includes attachment: 2001 Spring and Fall Fauna and Flora Inventory for Site 300, Livermore, CA)*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003cc — LLNL, *Integrated Safety Management System Description, Version 6.0*, UCRL-AR-132791, Lawrence Livermore National Laboratory, Livermore, CA, March 2003.

LLNL 2003j — LLNL, Revisions to the Hazardous Waste Facility Permit, Part A and Part B, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

NNSA 2003a — NNSA, *Final Site-Wide Environmental Assessment of the Sandia National Laboratories*, NNSA/DOE-AL; DOE/EA-1422, U.S. Department of Energy, National Nuclear Security Administration, January 2003.

O'Farrell and McCue 1981 — O'Farrell, T.P. and P. McCue, *Inventory of San Joaquin Kit Fox on BLM Lands in the Western San Joaquin Valley*, EGG 1183-2416, Goleta, CA, 1981.

O'Farrell et al. 1981 — O'Farrell, T.P., T. Kats, P. McCue, and M.L. Sauls, *Inventory of San Joaquin Kit Fox on BLM Lands in the Southern and Southwestern San Joaquin Valley*, EGG 1183-2400, Goleta, CA. 1981.

Orloff et al. 1986 — Orloff, S.G., Hall, F., and L. Spiegel, "Distribution and habitat requirements of the San JoaquinKit Fox in the Northern Extreme of their Range," *Wildlife Society*, Vol. 22, Pgs. 60-70, 1986.

Pitt 1975 — Pitt, M.D., *The Effect of Site, Season, Weather Patterns, Grazing and Brush of California*, Berkley, CA, 1975.

Pollak and Kan 1998 — Oren Pollak and T. Kan, *The Use of Prescribed Fire to Control Invasive Exotic Weeds at Jepson Prairie Preserve*, Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference, California Native Plant Society, Pgs. 241-249, Sacramento, CA, Available online at http://www.cnps.org/vernalpools/pollak.pdf, 1998, Accessed March 15, 2003.

Robbins 1940 — Robbins, W.W., "Alien Plants Growing without Cultivation in California," *California Agricultural Experiment Station Bulletin*, No. 637, University of California, 1940.

Sproul and Flett 1993 — Sproul, M. J., M. A. Flett, "Status of the San Joaquin Kit Fox in the Northwest Margin of its Range," *Wildlife Society*, Vol. 29, Pgs. 61-69, 1993.

Stebbins 2003 — Stebbins, R.C., *A Field Guide to Western Reptiles and Amphibians*, 3rd Ed., Houghton Mifflin, New York, NY, 2003.

Swaim 2002a — Swaim, K., *Results of surveys for special status reptiles at the Site 300 facilities of Lawrence Livermore National Laboratory*, Swaim Consulting, Livermore, CA, October 30, 2002.

Swaim 2002b — Swaim, Karen, *Biological Consulting. Results of Baseline (Pre Burn) Trapping Survey for the Alameda Whipsnake (Masticophis lateralis euryxanthus) at Lawrence Livermore National Laboratories S300, Alameda and San Joaquin [Counties], California*. Draft Report, Livermore, CA, November 10, 2002.

Swaim 2002c — Swaim, Karen, *Effects of Prescribed Burns on the Alameda Whipsnake (Masticophis lateralis euryxanthus) (Research Proposal)*, Livermore, CA, July 1, 2002.

Talbot et al. 1939 — Talbot, M.W., H.H. Biswell, and Al.L. Hormay, "Fluctuations in the Annual Vegetation of California," *Ecology* Vol. 20, Pgs. 394-402, 1939.

UC 1987 — University of California (UC), *Draft Environmental Impact Report for the University of California Contract with the Department of Energy for Operation and Management of LLNL*, SCH-85112611, July 18, 1987.

USDCDC 2002 — U.S. District Court for the District of Columbia (USDCDC), *Home Builders Associations of Northern California, et al. Versus Gale A. Norton (Secretary o the Department of Interior) and Jumping Frog Institute* (01-1291-RJL), Filed November 6, 2002.

USFWS 1997 — U.S. Fish and Wildlife Service (USFWS), *Formal Consultation on the Proposed Arroyo Maintenance Project on Arroyo Las Positas at Livermore National Laboratory, Alameda County, California*, October 27, 1997.

USFWS 1998 — USFWS, *Amendment to the United States Fish and Wildlife Service Biological Opinion (1-1-97-F-173) on the Arroyo Maintenance Project on Arroyo Las Positas at LLNL, Alameda County, CA*, U.S. Fish and Wildlife Service, 1998.

USFWS 2002a — USFWS, *Formal Intra-Service Endangered Species Consultation on a Research Proposal to Examine Effects of Prescribed Burns and Other Fuels Management on the Alameda Whipsnake (Re-Initiation of),* U.S. Fish and Wildlife Service, 2002.

USFWS 2002b — USFWS, *Formal Consultation on the Routine Maintenance and Operations Projects at the Lawrence Livermore National Laboratory, Site 300 Experimental Test Site, Alameda and San Joaquin Counties* (1-1-02-4-0062), U.S. Fish and Wildlife Service, May 17, 2002.

USFWS 2002d — USFWS, *Species List for Lawrence Livermore National Laboratory Site-Wide Environmental Impact Statement, Livermore-Tracy Area, Alameda and San Joaquin Counties, California,* U.S. Fish and Wildlife Service, October 28, 2002.

USFWS 2002e — USFWS, *Bullfrog Management Plan Amendment for Biological Opinion 1-1-97-F-173, Livermore Site, Lawrence Livermore National Laboratory*. Letter from Cay C. Goude, Assistant Field Supervisor, USFWS Sacramento Field Office to Mr. Ray Corey DOE/NNSA, Oakland Area Office. August 8, 2002.

USFWS 2003 — USFWS, *California Red-legged Frog Recovery (Home Page)*, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. Sacramento, CA, Available online http://sacramento.fws.gov/es/herps/crf.htm, Accessed 2003.

Wilson and McCranie 1994 — Wilson, L.D. and J.R. McCranie, "Rotenone Hazards to Amphibians and Reptiles," *Herpetological Review*, Vol. 25, No. 4, 1994.

Attachment 1 – Agency Correspondence

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825

IN REPLY REFER TO:
1-1-03-SP-0162

October 28, 2002

Thomas R. Grim, Document Manager
Department of Energy
National Nuclear Security Administration
Livermore Site Office
1301 Clay Street
Oakland, California 94612-5208

Subject: Species List for Lawrence Livermore National Laboratory Site-Wide Environmental Impact Statement, Livermore-Tracy Area, Alameda and San Joaquin Counties, California

Dear Mr. Grim:

We are sending the enclosed list in response to your October 21, 2002, request for information about endangered and threatened species (Enclosure A). This list fulfills the requirement of the Fish and Wildlife Service (Service) to provide species lists under section 7(c) of the Endangered Species Act of 1973, as amended (Act).

The animal species on the Enclosure A quad list are those species we believe may occur within, *or be affected by projects within*, the following USGS quads, where your project is planned: Midway and Altamont Quads.

Any plants on the quad list are ones *that have actually been observed* in the project quad(s). Plants may occur in a quad without having been observed there. Therefore we have included a species list for the whole county in which your project occurs. We recommend that you survey for any relevant plants shown on this list.

Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them. Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.

Executive Order 13186, January 17, 2001, directs Federal agencies to take specific steps to conserve migratory birds. *Species of Concern* (see below) are specifically included in this Executive Order. (The Order can be found at www.nara.gov/fedreg/eo.html) Birds are shown on

our species lists regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

If a species has been listed as threatened or endangered by the State of California, but not by us nor by the National Marine Fisheries Service, it will appear on your list as a Species of Concern.

However you must contact the California Department of Fish and Game for official information about these species. Call (916) 322-2493 or write Marketing Manager, California Department of Fish and Game, Natural Diversity Data Base, 1416 Ninth Street, Sacramento, California 95814.

Some of the species listed in Enclosure A may not be affected by the proposed action. A trained biologist or botanist, familiar with the habitat requirements of the listed species, should determine whether these species or habitats suitable for them may be affected. For plants, we recommend using the enclosed Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed and Candidate Species (Enclosure C).

Some pertinent information concerning the distribution, life history, habitat requirements, and published references for the listed species is available upon request. This information may be helpful in preparing the biological assessment for this project, if one is required. Please see Enclosure B for a discussion of the responsibilities Federal agencies have under section 7(c) of the Act and the conditions under which a biological assessment must be prepared by the lead Federal agency or its designated non-Federal representative.

Formal consultation, under 50 CFR § 402.14, should be initiated if you determine that a listed species may be affected by the proposed project. If you determine that a proposed species may be adversely affected, you should consider requesting a conference with our office under 50 CFR § 402.10. Informal consultation may be utilized prior to a written request for formal consultation to exchange information and resolve conflicts with respect to a listed species. If a biological assessment is required, and it is not initiated within 90 days of your receipt of this letter, you should informally verify the accuracy of this list with our office.

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as *critical habitat*. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal. Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, this will be noted on the species list. Maps and boundary descriptions of the critical habitat may be found in the *Federal Register*. The information is also reprinted in the *Code of Federal Regulations* (50 **CFR** 17.95).

Candidate species are being reviewed for possible listing. Contact our office if your biological assessment reveals any candidate species that might be adversely affected. Although they currently have no protection under the Endangered Species Act, one or more of them could be proposed and listed before your project is completed. By considering them from the beginning, you could avoid problems later.

Your list may contain a section called *Species of Concern.* This term includes former *category 2 candidate species* and other plants and animals of concern to the Service and other Federal, State and private conservation agencies and organizations. Some of these species may become candidate species in the future.

If the proposed project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by the U.S. Army Corps of Engineers (Corps), a Corps permit will be required, under section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act. Impacts to wetland habitats require site specific mitigation and monitoring. You may request a copy of the Service's General Mitigation and Monitoring Guidelines or submit a detailed description of the proposed impacts for specific comments and recommendations. If you have any questions regarding wetlands, contact Mark Littlefield at (916) 414-6580.

Please contact Dan Buford at (916) 414-6625, if you have any questions about the attached list or your responsibilities under the Endangered Species Act. For the fastest response to species list requests, address them to the attention of Species Lists at this address. You may fax requests to 414-6712 or 414-6713. You may also email them to harry_mossman@fws.gov.

Sincerely,

for

Jan C. Knight
Chief, Endangered Species Division

Enclosures

Attachment 2.1 – Site 300 (from Jones & Stokes 2002a)

Annotated Checklist of the Vascular Plants of Lawrence Livermore Laboratory Site 300

This list was compiled from Jones & Stokes (J&S) site surveys performed in May and September, 1997, and March and April, 2002. It also incorporates species reported by BioSystems (BS) (1986). Nomenclature follows *The Jepson Manual* (Hickman 1993), except where noted. Synonyms [in brackets] are provided for plant names used in BioSystems' checklist that have been superceded. Common names generally are taken from *The Jepson Manual* or CalFlora (2000). Introduced species are preceded with an asterisk.

Pterophyta (Ferns)

Pteridaceae (Brake Family)

Pellaea andromedifolia (Kaulf.) Fee. At base of rocks in coastal scrub. Local, uncommon. Coffee fern. (BS, J&S)

Pellaea mucronata (D. Eaton) D. Eaton. Bird's-foot fern. Rock outcrops in blue oak woodland. Uncommon. (J&S)

Pentagramma triangularis (Kaulf.) G. Yatskievych, M. D. Wyndham, & E. Wollenweber. Gold-back fern. Rock outcrops in blue oak woodland. Locally common. [*Pityrogramma triangularis* Kaulf.] (BS, J&S)

Coniferophyta (Conifers)

Cupressaceae (Cypress Family)

Juniperus californica Hook. California juniper. Juniper woodland and scrub, juniper-oak woodland, and scattered in grasslands. Widespread, common. (BS, J&S)

Anthophyta--Dicotyledones

Amaranthaceae (Amaranth Family)

**Amaranthus albus* L. Tumbleweed. Wetlands. Uncommon. (J&S)

Amaranthus blitoides Wats. Prostrate amaranth. (BS)

Amaranthus californicus (Moq.) Wats. California amaranth. Wetlands. Uncommon. (J&S)

Anacardiaceae (Sumac Family)

Toxicodendron diversilobum (T. & G.) Greene. Poison-oak. Poison-oak scrub. Local, in one stand on the west side of Site 300. (BS, J&S)

Apiaceae (Carrot Family)

Apiastrum angustifolium Nutt. Wild celery. Blue oak woodland. Local, uncommon. (BS, J&S)

Bowlesia incana Ruiz Lopez & Pav. Bowlesia. At base of rocks in grasslands. Local, uncommon. (BS, J&S)

Lomatium caruifolium (Hook. & Arn.) Coult. & Rose. Caraway-leaved lomatium. Grasslands. Widespread but uncommon. (BS, J&S)

Lomatium utriculatum (T. & G.) Coult. & Rose. Common lomatium. Grasslands. Widespread but uncommon. (BS, J&S)

Sanicula bipinnata Hook. & Arn. Poison sanicle. Blue oak woodland, coastal scrub. Widespread, common. (BS, J&S)

Sanicula bipinnatifida Hook. Purple sanicle. Grasslands. Local, uncommon. (BS, J&S)

Sanicula crassicaulis DC. Pacific sanicle. Elderberry scrub. Local, uncommon. (J&S)

**Torilis nodosa* (L.) Gaertner. Knotted hedge parsley. (BS)

Yabea microcarpa (Hook. & Arn.) Koso-Polj. California hedge-parsley. Blue oak woodland. Local, uncommon. (BS, J&S)

Asclepiadaceae (Milkweed Family)

Asclepias fascicularis Decne. Narrow-leaf milkweed. Grassland. Uncommon. (BS, J&S)

Asteraceae (Sunflower Family)

Achillea millefolium L. Common yarrow. Grasslands, coastal scrub, blue oak woodland. Widespread, common. [var. *californica* (Pollard) Keck] (BS, J&S)

Achyrachaena mollis Schauer. Blow-wives. Grasslands, vernal pool. Widespread but uncommon. (BS, J&S)

Agoseris grandiflora (Nutt.) Greene. Large-flowered agoseris. Grassland. Local, uncommon. (BS, J&S)

Agoseris heterophylla (Nutt.) Greene. Annual agoseris. Grasslands. Widespread but uncommon. (BS, J&S)

Ancistrocarphus filagineus Gray. Woolly fishhooks. Bare soil in grasslands, coastal scrub. Local, uncommon. [*Stylocline filaginea* (Gray) Gray] (BS, J&S)

Artemisia californica Less. California sage. Coastal scrub. Widespread, common. (BS, J&S)

Baccharis pilularis DC. Coyote brush. Blue oak woodland, along drainage. Local, uncommon. [var. *consanguinea* (DC.) Kuntze] (BS, J&S)

Baccharis salicifolius (Ruiz Lopez & Pav.) Pers. Mule fat. Along stream channels. Local, uncommon. [*B. viminea* DC.] (BS, J&S)

Blepharizonia laxa Greene. Viscid big tarplant. Grasslands, ruderal. Uncommon. [*B. plumosa* ssp. *viscida* Keck; see Baldwin et al. 2001 for nomenclature] (J&S)

Blepharizonia plumosa (Kell.) Greene. Big tarplant. Grasslands, ruderal. Widespread, common (see Figure 2). List 1B in CNPS Inventory. (J&S)

**Carduus pycnocephalus* L. Italian thistle. Grasslands. Widespread but uncommon. (BS, J&S)

**Carduus tenuiflorus* Curtis. Slender-flowered thistle. Wetlands, blue oak woodland. Common. (J&S)

Centromadia fitchii (Gray) Greene. Fitch's spikeweed. Ruderal. Local, uncommon. [*Hemizonia fitchii* Gray; see Baldwin 1999 for revised nomenclature] (J&S)

Centromadia pungens (Hook. & Arn.) Greene subsp. ***pungens***. Common spikeweed. Grasslands, ruderal. Local, uncommon. [*Hemizonia pungens* (Hook. & Arn.) T. & G; see Baldwin 1999 for revised nomenclature] (J&S)

****Centaurea melitensis*** L. Tocalote. Grasslands. Local, uncommon. (BS, J&S)

****Centaurea solstitialis*** L. Yellow star-thistle. Grasslands. Uncommon. (BS, J&S)

****Chamomilla suaveolens*** (Greene) Rydb. Pineapple weed. Ruderal. Local, uncommon. (BS, J&S) [*Matricaria matricarioides* (Less.) Porter]

****Cirsium occidentale*** (Nutt.) Jeps. ssp. ***venustum*** (Greene) Jeps. Venus thistle. Grasslands. Local, uncommon. [*C. proteanum* J. Howell] (BS, J&S)

****Cirsium vulgare*** (Savi) Ten. Bull thistle. Freshwater seeps. Local, uncommon. (BS, J&S)

Conyza canadensis (L.) Cronq. Horseweed. Wetlands, ruderal. Uncommon. (BS, J&S)

Coreopsis calliopsidea (DC.) Gray. Leafy-stemmed coreopsis. (BS)

****Cynara cardunculus*** L. Artichoke thistle. Grasslands. Local, uncommon. (J&S)

Deinandra kelloggii (Greene) Greene. Kellogg's tarplant. Grasslands, coastal scrub, ruderal. Common. [*Hemizonia kelloggii* Greene; see Baldwin 1999 for revised nomenclature] (BS, J&S)

Deinandra lobbii (Greene) Greene. Lobb's tarplant. Coastal scrub. Common. [*Hemizonia lobbii* Greene; see Baldwin 1999 for revised nomenclature] (BS, J&S)

****Dittrichia graveolens*** (L.) Greuter. Stinkweed. Ruderal. Local, uncommon. [not in The Jepson Manual; see Preston (1997)] (J&S)

Ericameria linearifolia (DC.) Urb. & J. Wussow. Interior goldenbush. Coastal scrub. Local, uncommon. (BS, J&S)

Erigeron reductus (Cronq.) G. Nesom var. ***angustatus*** (Gray) G. Nesom. California rayless daisy. [*E. inornatus* Gray var. *angustatus* Gray] (BS)

Filago californica Nutt. California filago. Thin soils, coastal scrub. Widespread but uncommon. (BS, J&S)

**Filago gallica* L. Narrow-leaved filago. Grasslands. Local, uncommon. [*Logfia gallica* Coss. & Germ.] (BS, J&S)

Gnaphalium californicum DC. California cudweed. Grasslands. Local, uncommon. (J&S)

Gnaphalium luteo-album L. Weedy cudweed. Along stream channel. Local, uncommon. (J&S)

Gnaphalium palustre Nutt. Marsh cudweed. Vernal pool, freshwater seep. Local, uncommon. (BS, J&S)

Grindelia camporum Greene. Great Valley gumplant. Grasslands, coastal scrub, blue oak woodland; Widespread, common. (BS, J&S)

Gutierrezia californica (DC.) T. & G. California matchweed. Coastal scrub, grasslands. Widespread, common. [*G. bracteata* Abrams] (BS, J&S)

Helianthus annuus L. Common sunflower. Wetlands. Uncommon. (J&S)

Hesperevax caulescens (Benth.) Gray. Hogwallow starfish. Grasslands, with moist, clay soils. One population (See Figure 2). CNPS List 4. [*Evax caulescens* Benth.] (BS, J&S)

Hesperevax sparsiflora (Gray) Greene. Erect evax. [*Evax sparsiflora* Gray] (BS)

Heterotheca grandiflora Nutt. Telegraph weed. Rock outcrops in grassland. Uncommon. (J&S)

Heterotheca sessiflora (Nutt.) Shinn. ssp. ***echioides*** (Benth.) Semple. Goldenaster. Grasslands. Uncommon. [*H. echioides* Benth.] (BS, J&S)

Holocarpha obconica (Clausen & Keck) Keck. San Joaquin tarplant. Grasslands, coastal scrub. Common. (BS, J&S)

Hypochaeris glabra L. Smooth cat's-ear. Grasslands. Widespread but uncommon. (BS, J&S)

Hypochaeris radicata L. Rough cat's-ear. Blue oak woodland, grasslands. Local, uncommon. (BS, J&S)

Lactuca serriola L. Prickly lettuce. Grassland. Common. (BS, J&S)

Lagophylla ramosissima Nutt. Common hareleaf. Grassland, Common. (J&S)

Lasthenia gracilis (DC.) Greene. California goldfields. Thin soil in grasslands, coastal scrub. Widespread but uncommon. [*L. chrysostoma* (Fisch. & Mey.) Greene; recently segregated from *L. californica* Lindley by Chan (2001)] (BS, J&S)

Lasthenia microglossa (A. DC.) Greene. Small-rayed goldfields. Moist areas in grasslands. Widespread, common (BS, J&S)

Lasthenia minor (A. DC.) Ornduff. Woolly goldfields. Grasslands. Widespread but uncommon. (BS, J&S)

Layia gaillardioides (Hook. & Arn.) DC. Woodland layia. Grasslands. Widespread but uncommon. (BS, J&S)

Layia platyglossa (Fisch. & Mey.) Gray. Tidytips. Grasslands. Local, uncommon. (BS, J&S)

Madia gracilis (Smith) Keck. Slender tarweed. (BS)

Malacothrix coulteri Gray. Snake's-head. Grasslands. Widespread but uncommon. (BS, J&S)

Micropus californicus Fisch. & Mey. Slender cottonweed. Grasslands. Local, uncommon. (BS, J&S)

Microseris acuminata E. Greene. Needle microseris. Grasslands. Local, uncommon. (J&S)

Microseris douglasii (DC.) Schultz-Bip subsp. ***douglasii***. Douglas' microseris. Grasslands. Local, uncommon. (J&S)

Microseris douglasii (DC.) Schultz-Bip subsp. ***tenella*** (Gray) Chambers. Small microseris. Grasslands. Local, uncommon. (BS, J&S)

Monolopia major DC. Cupped monolopia. Grasslands. Widespread, common. (BS, J&S)

Pentachaeta alsinoides Greene. Pentachaeta. Grassland. Local, uncommon. (BS, J&S)

****Picris echioides*** L. Bristly ox-tongue. Freshwater seep. Local, uncommon. (BS, J&S)

Psilocarphus brevissimus Nutt. Woolly marbles. (BS)

Psilocarphus tenellus Nutt. Slender woolly marbles. (BS)

Rafinesquia californica Nutt. California chicory. (BS)

Senecio breweri Davy. Brewer's butterweed. Blue oak woodland. Local, uncommon. (BS, J&S)

****Senecio vulgaris*** L. Common groundsel. Grasslands, coastal scrub. Widespread, common. (BS, J&S)

**Silybum marianum* (L.) Gaertner. Milk thistle. In stream channels. Widespread but uncommon. (BS, J&S)

Solidago canadensis L. Canada goldenrod. (BS)

**Sonchus asper* (L.) Hill. Prickly sow-thistle. Freshwater seeps. Uncommon. (BS, J&S)

**Sonchus oleraceus* L. Common sow-thistle. Ruderal. Widespread but uncommon. (BS, J&S)

Stebbinsoseris heterocarpa (Nutt.) Chambers. Derived microseris. Grasslands. Uncommon. (J&S)

Stephanomeria virgata Benth. var. *pleurocarpa* (Greene) Gottlieb. Tall stephanomeria. Grasslands. Uncommon. (J&S)

Stylocline gnaphaloides Nutt. Everlasting nest straw. Rock outcrops in coastal scrub. Local, uncommon. (BS, J&S)

**Taraxacum officinale* Wigg. Common dandelion. (BS)

Uropappus lindleyi (DC.) Nutt. Silver puffs. Grasslands, coastal scrub. Widespread but uncommon. [*Microseris lindleyi* (DC.) Gray] (BS, J&S)

Xanthium strumarium L. Common cocklebur. Freshwater seeps, along stream channels. Uncommon. [var. *canadense* (Miller) T. & G.] (BS, J&S)

Boraginaceae (Borage Family)

Amsinckia eastwoodiae J. F. Macbr. Eastwood's fiddleneck. Moist areas in grasslands. Widespread but uncommon. (J&S)

Amsinckia grandiflora Gray. Large-flowered fiddleneck. Blue oak woodland. Restricted to a single population (see Figure 2). Federally-listed as endangered. (BS, J&S).

Amsinckia lycopsoides Lehm. Tarweed fiddleneck. Grasslands, blue oak woodland. Widespread, common. (J&S)

Amsinckia menziesii (Lehm.) Nels. & Macbr. var. *intermedia* (Fisch. & Mey.) Ganders. Common fiddleneck. Grasslands, coastal scrub, blue oak woodland. Widespread, common. (BS, J&S)

Amsinckia menziesii (Lehm.) Nels. & Macbr. var. *menziesii*. Menzies' fiddleneck. Grasslands. Widespread but uncommon. (BS, J&S)

Amsinckia tessellata Gray var. ***tessellata***. Devil's lettuce. Grasslands, oak woodland, coastal scrub. Widespread, common. (BS, J&S)

Amsinckia vernicosa Hook. & Arn. Green fiddleneck. Clay barrens. Uncommon. (BS)

Cryptantha flaccida (Lehm.) Greene. Weak-stemmed cryptantha. Rock outcrops in grassland. Uncommon. (BS, J&S)

Cryptantha intermedia (Gray) Greene. Common cryptantha. Rock outcrops in grassland. Uncommon. (BS, J&S)

Cryptantha microstachys (Gray) Greene. Tejon cryptantha. (BS)

Heliotropium curassavicum L. Salt heliotrope. Freshwater seeps. Uncommon. [var. *oculatum* (Heller) Jtn.] (BS, J&S)

Pectocarya penicillata (Hook. & Arn.) A. DC. Winged pectocarya. Coastal scrub. Widespread but uncommon. (BS, J&S)

Plagiobothrys bracteatus (T. J. Howell) Jtn. Bracted popcorn flower. Vernal pool. Local, uncommon. (J&S)

Plagiobothrys canescens Benth. Soft popcorn flower. Grasslands. Widespread, common. (BS, J&S)

Plagiobothrys stipitatus (Greene) Jtn. var. ***micranthus*** (Piper) Jtn. Small-flowered popcorn flower. Vernal pool. Local, uncommon. (BS, J&S)

Plagiobothrys tenellus (Nutt.) Gray. Grasslands. Local, uncommon. (BS, J&S)

Brassicaceae (Mustard Family)

Athysanus pusillus (Hook.) Greene. Petty athysanus. Rock outcrops in grassland. Widespread but uncommon. (BS, J&S)

****Brassica nigra*** (L.) Czernov. Black mustard. Grasslands. Uncommon. (BS, J&S)

****Capsella bursa-pastoris*** (L.) Medik. Shepherd's purse. Blue oak woodland. Widespread, common. (BS, J&S)

****Cardaria pubescens*** (C. Meyer) Jarmol. White-top. (BS)

****Descurainia sophia*** (L.) Webb. Tansy mustard. Grasslands. Local, uncommon. (BS, J&S)

Erysimum capitatum (Dougl.) Greene. Western wallflower. (BS)

Guillenia flavescens (Hook.) Greene. Yellow-flowered guillenia. Grasslands. Local, uncommon. Flower color varies from pale yellow to lilac within Site 300. Hoover (1936) treated the lilac- to purple-flowered forms as *Streptanthus lilacinus*. [*Caulanthus flavescens* (Hook.) Pays.] (BS, J&S)

Guillenia lasiophylla (Hook. & Arn). Greene. California mustard. Grasslands. Widespread, common. [*Caulanthus lasiophyllus* (Hook. & Arn.) Greene] (BS, J&S)

**Hirschfeldia incana* (L.) Lagr.-Foss. Mediterranean mustard. Grasslands, coastal scrub, ruderal. Widespread, common. [*Brassica geniculata* (Desf.) Ball] (BS, J&S)

Lepidium nitidum (Nutt.) T. & G. Shining peppergrass. Grasslands. Widespread, common. [var. *insigne* Greene] (BS, J&S)

Nasturtium officinale R. Br. Watercress. Freshwater seeps. Local, uncommon. [*Rorippa nasturtium-aquaticum* (L.) Hayek; see Al-Shehbaz & Price (1998) for nomenclature] (BS, J&S)

**Sinapis arvensis* L. Charlock. Grasslands. Uncommon. (J&S)

**Sisymbrium altissimum* L. Tumble mustard. (BS)

**Sisymbrium officinale* L. Hedge mustard. (BS)

**Sisymbrium orientale* L. Oriental mustard. Outcrops in coastal scrub, grasslands. Locally common. (J&S)

Tropidocarpum gracile Hook. Dobie pod. Grasslands. Widespread but uncommon. (J&S)

Thysanocarpus curvipes Hook. var. *curvipes*. Lacepod. Blue oak woodland, grasslands. Widespread, common. (BS, J&S)

Thysanocarpus curvipes Hook. var. *elegans* (Fisch. & Mey.) Rob. Fringepod. Grasslands. Local, uncommon [*T. elegans* Fisch. & Mey.] (BS, J&S)

Callitrichaceae (Water Starwort Family)

Callitriche marginata Torr. California water-starwort. Vernal pool. Local, uncommon. (J&S)

Callitriche verna L. Vernal water-starwort. (BS)

Campanulaceae (Bluebell Family)

Downingia insignis Greene. Cupped downingia. Vernal pool. Local, uncommon. (BS, J&S)

Caprifoliaceae (Honeysuckle Family)

Lonicera interrupta Benth. Chaparral honeysuckle. Along stream, in blue oak woodland. Local, uncommon. (BS, J&S)

Sambucus mexicana C. Presl. Blue elderberry. Elderberry scrub, scattered along stream channels, or at base of rock outcrops. Local, uncommon. (BS, J&S)

Caryophyllaceae (Pink Family)

**Cerastium glomeratum* Thuill. Mouse-ear chickweed. Grasslands, coastal scrub. Local, uncommon. (BS, J&S)

**Herniaria hirsuta* L. ssp. *cinerea* (DC.) Cout. Gray herniaria. Coastal scrub. Widespread but uncommon. (BS, J&S)

Loeflingia squarrosa Nutt. California loeflingia. (BS)

Minuartia californica (Gray) Mattf. California sandwort. Thin soils in coastal scrub. Local, uncommon (BS, J&S)

Minuartia douglasii (T. & G.) Mattf. Douglas' sandwort. (BS)

Sagina apetala Ard. Dwarf pearlwort. Rock outcrop in grasslands. Local, uncommon. (J&S)

Sagina decumbens (Elliot) T. & G. var. *occidentalis* (Wats.) G. Crow. Western pearlwort. (BS)

Silene antirrhina L. Snapdragon catchfly. Grasslands, coastal scrub. Uncommon. (BS, J&S)

**Silene gallica* L. Common catchfly. Grasslands, coastal scrub. Widespread but uncommon. (BS, J&S)

Spergularia marina (L.) Griseb. Saltmarsh sand-spurry. (BS)

**Stellaria media* (L.) Villars. Common chickweed. Grasslands, blue oak woodland, coastal scrub. Widespread but uncommon. (BS, J&S)

Stellaria nitens Nutt. Shining chickweed. Rock outcrops in grassland, coastal scrub. Widespread but uncommon. (BS, J&S)

Chenopodiaceae (Goosefoot Family)

Atriplex patula L. Spear oracle. (BS)

**Atriplex rosea* L. Tumbling oracle. Ruderal. Uncommon. (J&S)

**Atriplex semibaccata* R. Br. Australian saltbush. Ruderal, grasslands. Local, uncommon. (BS, J&S)

Atriplex serenana Nels. Bractscale. Ruderal. Uncommon. (J&S)

**Chenopodium album* L. Pigweed. Ruderal. Uncommon. (J&S)

Chenopodium californicum (Wats.) Wats. California goosefoot. Grasslands; uncommon. (BS, J&S)

**Chenopodium murale* L. Nettle-leaved goosefoot. Rock outcrops in grasslands. Uncommon. (J&S)

Chenopodium rubrum L. Red goosefoot. (BS)

**Chenopodium vulvaria* L. Stinking goosefoot. (BS)

Monolepis nuttalliana (Schultes) Greene. Poverty weed. (BS)

**Salsola tragus* L. Russian thistle. Grasslands, ruderal. Widespread, common. [*S. kali* L.] (BS, J&S)

Convolvulaceae (Morning-glory Family)

**Convolvulus arvensis* L. Field bindweed. Grasslands. Uncommon. (J&S)

Crassulaceae (Stonecrop Family)

Crassula connata (Ruiz Lopez & Pav.) Berger. Pygmyweed. Rock outcrops in grasslands, coastal scrub. Widespread, common. [*C. erecta* (Hook. & Arn.) Berger] (BS, J&S)

Cucurbitaceae (Gourd Family)

Marah fabaceus (Naudin) Greene. California manroot. Grasslands. Widespread, common. [var. *agrestis* (Greene) K. M. Stocking] (BS, J&S)

Euphorbiaceae (Spurge Family)

Chamaesyce ocellata (Durand & Hilg.) Millsp. Valley spurge. Grasslands. Uncommon. (J&S)

Croton setigerus Hook. Turkey mullein. Grasslands, ruderal. Common. [*Eremocarpus setigerus* (Hook.) Benth.; see Webster (1992) for nomenclature] (BS, J&S)

Euphorbia spathulata Lam. Reticulate-seeded spurge. Blue oak woodland. Local, uncommon. (BS, J&S)

Fabaceae (Pea Family)

Astragalus asymmetricus E. Sheldon. Rattleweed. Grasslands. Widespread but uncommon. (BS, J&S)

Astragalus didymocarpus Hook. & Arn. Two-seeded milkvetch. Grassland, coastal scrub. Widespread but uncommon. (BS, J&S)

Astragalus gambelianus E. Sheldon. Grasslands. Widespread but uncommon. (J&S)

Lotus humistratus Greene. Hairy lotus. Grasslands, coastal scrub. Widespread but uncommon. (BS, J&S)

Lotus wrangellianus Fisch. & Mey. Chile lotus. Grasslands. Widespread, common. [*L. subpinnatus* Lagasca] (BS, J&S)

Lupinus albifrons Benth. Bush lupine. Blue oak woodland, coastal scrub. Widespread, common,. often dominant in small stands. (BS, J&S)

Lupinus benthamii Heller. Spider lupine. Grasslands. Uncommon. (BS, J&S)

Lupinus bicolor Lindley. Miniature lupine. Grasslands, coastal scrub, oak woodland. Widespread, common. [var. *umbellatus* (Greene) D. Dunn] (BS, J&S)

Lupinus microcarpus Sims var. ***densiflorus*** (Benth.) Jeps. Chick lupine. Grasslands, blue oak woodland. Widespread, common. [*L. densiflorus* Benth. var. *aureus* (Kell.) Munz and var. *lacteus* (Kell.) C.P. Smith] (BS, J&S)

Lupinus microcarpus Sims var. ***microcarpus***. Chick lupine. [*L. densiflorus* Benth. var. *palustris* (Kell.) C.P. Smith] (BS)

Lupinus succulentus Koch. Arroyo lupine. Grasslands. Widespread, common. (BS, J&S)

****Medicago polymorpha*** L. California bur-clover. Grasslands. Widespread, common. (BS, J&S)

****Melilotus alba*** Medik. White sweet-clover. Ruderal. Uncommon. (BS, J&S)

****Melilotus indica*** (L.) All. Indian sweet-clover. Ruderal. Widespread but uncommon. (BS, J&S)

Trifolium albopurpureum T. & G. var. ***albopurpureum***. Common Indian clover. Grasslands. Widespread but uncommon. (BS, J&S)

Trifolium albopurpureum T. & G. var. ***dichotomum*** (Hook. & Arn.) Isely. Branched Indian clover. [*T. dichotomum* Hook. & Arn.] (BS)

Trifolium ciliolatum Benth. Tree clover. Grasslands. Local, uncommon. (J&S)

Trifolium depauperatum Desv. var. ***amplectans*** (T. & G.) L.F. McDermott. Pale sac clover. [*T. amplectans* T. & G.] (BS)

Trifolium depauperatum Desv. var. ***truncatum*** (E. Greene) Isely. Narrow-leaved sac clover. Grasslands. Local, uncommon. (J&S)

Trifolium gracilentum T. & G. Pinpoint clover. Grasslands, coastal scrub. Widespread, common. (BS, J&S)

****Trifolium hirtum*** All. Rose clover. Grasslands, ruderal. Local, uncommon. (J&S)

Trifolium microcephalum Pursh. Small-headed clover. Grasslands. Local, uncommon. (J&S)

Trifolium microdon Hook. & Arn. Valparaiso clover. (BS)

Trifolium oliganthum Steudel. Few-flowered clover. Coastal scrub. (BS)

Trifolium willdenovii Sprengel. Tomcat clover. Grasslands; coastal scrub, oak woodland. Widespread, common. [*T. tridentatum* Lindley] (BS, J&S)

****Vicia sativa*** L. Common vetch, Grassland. Uncommon. (J&S)

****Vicia tetrasperma*** (L.) Schreber. Slender vetch. (BS)

****Vicia villosa*** Roth ssp. ***varia*** (Host) Corbiere. Winter vetch. (BS)

****Vicia villosa*** Roth ssp. ***villosa***. Hairy vetch. Grassland. Uncommon. (J&S)

Fagaceae (Beech Family)

Quercus douglasii Hook. & Arn. Blue oak. Blue oak woodland, juniper oak woodland. Widespread, common. (BS, J&S)

Quercus lobata Nee. Valley oak. Valley oak woodland, blue oak woodland. Local, uncommon. (BS, J&S)

Geraniaceae (Geranium Family)

****Erodium botrys*** (Cav.) Bertol. Big heronbill. Grassland, coastal scrub. Widespread, common. (BS, J&S)

****Erodium brachycarpum*** (Godron) Thell. Heronbill. Grasslands. Widespread, uncommon. (BS, J&S)

****Erodium cicutarium*** (L.) L'Her. Red-stemmed filaree. Grasslands, coastal scrub, oak woodland. Widespread, common. (BS, J&S)

Erodium macrophyllum Hook. & Arn. Round-leaved filaree. Grassland, on friable clay soil. Restricted to a single population (see Figure 2). CNPS List 2. (J&S)

****Erodium moschatum*** (L.) L'Her. White-stemmed filaree. Grasslands. Local, uncommon. (BS, J&S)

****Geranium dissectum*** L. Cut-leaf geranium. Grasslands. Uncommon. (J&S)

**Geranium molle* L. Dove's-foot geranium. (BS)

Grossulariaceae (Gooseberry Family)

Ribes quercetorum Greene. Oak gooseberry. Elderberry scrub. Local, uncommon. (J&S)

Ribes malvaceum Smith. Chaparral current. Elderberry scrub. local, uncommon. (BS, J&S)

Hippocastanaceae (Buckeye Family)

Aesculus californicus (Spach) Nutt. California buckeye. Blue oak woodland. Local, uncommon. (BS, J&S)

Hydrophyllaceae (Waterleaf Family)

Emmenanthe penduliflora Benth. var. ***penduliflora***. Whispering bells. Coastal scrub. Local, uncommon. (J&S)

Eriodictyon californicum (Hook. & Arn.) Torr. Yerba santa. Coastal scrub. Local, uncommon. (BS, J&S)

Nemophila menziesii Hook. & Arn. Baby blue-eyes. Grasslands. Local, uncommon. (BS, J&S)

Nemophila pedunculata Dougl. Spreading nemophila. (BS)

Phacelia ciliata Benth. Great Valley phacelia. Grasslands. Widespread, common. (BS, J&S)

Phacelia distans Benth. Common phacelia. Rock outcrops in grasslands, coastal scrub. Widespread, common. (BS, J&S)

Phacelia douglasii (Benth.) Torr. Douglas' phacelia. Coastal scrub. Local, uncommon. (BS, J&S)

Phacelia imbricata Greene. Imbricate phacelia. Rock outcrops in grasslands, coastal scrub. Local, uncommon. (BS, J&S)

Phacelia tanacetifolia Benth. Tansy phacelia. Rock outcrops in grasslands, coastal scrub. Widespread, common. (BS, J&S)

Pholistoma membranaceum (Benth.) Constance. White fiesta-flower. Blue oak woodland, base of rock outcrops in grasslands. Local, uncommon. (BS, J&S)

Lamiaceae (Mint Family)

****Lamium amplexicaule*** L. Henbit. (BS)

****Marrubium vulgare*** L. Horehound. Coastal scrub, freshwater seep, ruderal. Widespread but uncommon. (BS, J&S)

****Mentha pulegium*** L. Pennyroyal. Freshwater seep. Local, uncommon. (J&S)

Pogogyne serpylloides (Torr.) Gray. Thyme-like pogogyne. Elderberry scrub. Local, uncommon. (BS, J&S)

Salvia columbariae Benth. Chia. Coastal scrub. Locally common. (BS, J&S)

Salvia mellifera Greene. Black sage. Coastal scrub. Local, uncommon. (BS, J&S)

Stachys albens Gray. White hedgenettle. Freshwater seep. Local, uncommon. (BS, J&S)

Trichostema lanceolatum Benth. Vinegar curls. Grasslands. Common. (BS, J&S)

Linaceae (Flax Family)

Hesperolinon californicum (Benth.) Small. California dwarf flax. Grasslands. Uncommon. (BS, J&S)

****Linum usitatissimum*** L. Common flax. Grassland, ruderal. Uncommon. (J&S)

Loasaceae (Loasa Family)

Mentzelia affinis Greene. Hydra stick-leaf. Rock outcrops. Local, uncommon. (BS, J&S)

Mentzelia dispersa Wats. Small-flowered mentzelia. Rock outcrops in grasslands, coastal scrub. Local, uncommon. (J&S)

Malvaceae (Mallow Family)

Eremalche parryi (Greene) Greene. Parry's mallow. Grasslands, on lower canyon slope. Local, uncommon. (BS, J&S)

**Malva parviflora* L. Cheeseweed. Blue oak woodland. Uncommon. (BS, J&S)

Malvella leprosa (Ortega) Krapov. Alkali mallow. Freshwater seep, grasslands, ruderal. Uncommon. (BS, J&S)

Oleaceae (Olive Family)

Forestiera pubescens Nutt. Desert olive. Along stream. Single stand on west side of Site 300. [*F. neomexicana* Gray] (BS, J&S)

Onagraceae (Evening Primrose Family)

Camissonia boothii (Dougl.) Raven ssp. *decorticans* (Hook. & Arn.) Raven. Shredding evening primrose. Coastal scrub. Local, uncommon. (BS, J&S)

Camissonia contorta (Dougl.) Raven. Plains evening primrose. Coastal scrub. Local, uncommon. [*Camissonia cruciata*, an unpublished name based on *Oenothera cruciata* (Wats.) Munz] (BS, J&S)

Camissonia graciliflora (Hook. & Arn.) Raven. Slender-flowered primrose. Open area in grasslands. Local, uncommon. (BS, J&S)

Camissonia hirtella (Greene) Raven. Hairy sun-cups. Coastal scrub. Widespread but uncommon. (BS, J&S)

Camissonia intermedia Raven. Intermediate sun-cups. Coastal scrub. Local, uncommon. (J&S)

Clarkia affinis H. Lewis & M. Lewis. Clarkia. Blue oak woodland, grasslands. Common. (BS, J&S)

Clarkia purpurea (Curtis) Nels. & Macbr. ssp. *purpurea*. Purple clarkia. Grasslands. Uncommon. (BS, J&S)

Clarkia temblorensis Vasek. Temblor clarkia. Blue oak woodland. Uncommon. (BS, J&S)

Clarkia unguiculata Lindley. Elegant clarkia. Blue oak woodland. Uncommon. (BS, J&S)

Epilobium brachycarpum C. Presl. Panicled willow-herb. Grasslands. Uncommon. (BS, J&S) [*E. paniculatum* T. & G.]

Epilobium canum (Greene) Raven. California fuschia. Coastal scrub. Local, uncommon. [ssp. *mexicana* (C. Presl) Raven] (BS, J&S)

Epilobium cleistogamum (Curran) P. Hoch & Raven. Cleistogamous spike primrose. Vernal pool. Local, uncommon. (J&S)

Epilobium pygmaeum (Speg.) P. Hoch & Raven. Smooth spike-primrose. Vernal pool. (BS)

Orobanchaceae (Broomrape Family)

Orobanche californica Cham. & Schldl. ssp. ***jepsonii*** (Munz) Heckard. Jepson's broom-rape. Coastal scrub. Local, uncommon. (BS, J&S)

Orobanche uniflora L. Naked broom-rape. Grassland, parasitic on *Saxifraga californica*. Local, uncommon. [var. *minuta* (Suksd.) D. B. Achey] (BS, J&S)

Papaveraceae (Poppy Family)

Eschscholzia californica Cham. California poppy. Grasslands. Widespread, common. (BS, J&S)

Eschscholzia rhombipetala Greene. Diamond-petaled poppy. Grasslands. Restricted to two small occurrences (see Figure 2). CNPS List 1B. (J&S)

Papaver californicum A. Gray. Fire poppy. Grasslands. Local, uncommon. (J&S)

Platystemon californicus Benth. Cream cups. Grasslands. Widespread, common. (BS, J&S)

Stylomecon heterophylla (Benth.) G. C. Taylor. Wind poppy. Moist areas in grasslands. Widespread, common. (BS, J&S)

Plantaginaceae (Plantain Family)

Plantago elongata Pursh. Annual coast plantain. [*Plantago bigelovii* Gray] (BS)

Plantago erecta E. Morris. California plantain. Grasslands, coastal scrub. Widespread, common. (BS, J&S)

Plantago lanceolata L. English plantain. (BS)

Platanaceae (Sycamore Family)

Platanus racemosa Nutt. Western sycamore. (BS)

Polemoniaceae (Phlox Family)

Allophyllum divericatum (Nutt.) A.D. Grant & V. Grant. Straggling gilia. (BS)

Eriastrum pluriflorum (Heller) Mason. Many-flowered eriastrum. Grasslands. Local, uncommon. (BS, J&S)

Gilia capitata Sims ssp. ***staminea*** (Greene) V. Grant. Blue field gilia. Rock outcrops in coastal scrub. Widespread, common. (BS, J&S)

Gilia clivorum (Jeps.) V. Grant. Many-stemmed gilia. Grasslands, coastal scrub. Widespread but uncommon. (J&S)

Gilia tricolor Benth. Bird's-eye gilia. Grasslands. Widespread, common. (BS, J&S)

Linanthus bicolor (Nutt.) Greene. Bicolored linanthus. Coastal scrub. Widespread, common (BS, J&S)

Linanthus dichotomus Benth. Evening snow. Coastal scrub. (BS)

Navarretia nigelliformis Greene. Adobe navarretia. Grasslands. Uncommon. (BS, J&S)

Navarretia pubescens (Benth.) Hook. & Arn. Downy navarretia. Grasslands. Uncommon. (J&S)

Phlox gracilis Hook. Slender phlox. Moist areas in grasslands. Widespread, common. (BS, J&S)

Polygonaceae (Buckwheat Family)

Eriogonum angulosum Benth. Angle-stemmed buckwheat. Open areas in grasslands, coastal scrub. Widespread, common. (BS, J&S)

Eriogonum fasciculatum Benth. var. ***polifolium*** (A. DC.) T. & G. California buckwheat. Coastal scrub. Widespread, common. (BS, J&S)

Eriogonum gracile Benth. Slender woolly wild buckwheat. Grasslands. Uncommon. (J&S)

Eriogonum nudum Benth. var. ***pauciflorum*** Benth. Naked-stemmed buckwheat. Grassland. coastal scrub. Widespread, common. According to Professor James Reveal (pers. comm.), var. *pauciflorum* is a southern California entity, and the *Eriogonum nudum* from the Coast Ranges between Mount Diablo and Santa Barbara County may be an undescribed taxon. He suggested that we treat our material as var. *pauciflorum* until he is able to determine whether it is sufficiently distinct to warrant describing it as a new variety. (BS, J&S)

Eriogonum wrightii Benth. var. ***subscaposum*** Wats. Wright's buckwheat. Coastal scrub. Local, uncommon. (J&S)

Eriogonum wrightii Benth. var. ***trachygonum*** (Benth.) Jeps. Wright's buckwheat. (BS)

****Polygonum arenastrum*** Boreau. Common knotweed. (BS)

Pterostegia drymarioides Fisch. & Mey. Pterostegia. At base of rock outcrops and under shrubs, in blue oak woodland, coastal scrub, and grasslands. Widespread, common. (BS, J&S)

****Rumex conglomeratus*** Murray. Whorled dock. (BS)

****Rumex crispus*** L. Curly dock. Freshwater seep. Local, uncommon. (BS, J&S)

Rumex salicifolius J. A. Weinm. var. ***denticulatus*** Torr. Willow dock. Freshwater seep. Local, uncommon. (BS, J&S)

Portulacaceae (Purslane Family)

Calandrinia ciliata (Ruiz Lopez & Pav.) DC. Red maids. Grasslands, ruderal. Widespread, common. (BS, J&S)

Claytonia exigua T. &. G. Common montia. Rock outcrops. Local, uncommon. [*C. spathulata* Dougl. var. *exigua* (T. & G.) Robinson and var. *tenuifolia* (T. & G.) Munz] (BS, J&S)

Claytonia parviflora Hook. var. ***parviflora***. Narrow-leaved miner's lettuce. Blue oak woodland. Widespread but uncommon. (BS, J&S)

Claytonia perfoliata Willd. Miner's lettuce. Blue oak woodland, coastal scrub. Widespread, common. (BS, J&S)

Claytonia rubra (Howell) Tidestrom. Red miner's lettuce. Grasslands. Uncommon. (J&S)

Primulaceae (Primrose Family)

Androsace elongata L. ssp. ***acuta*** (Greene) G. Robb. California androsace. Moss-covered rock outcrops and open areas in adjacent grassland. Widespread and common, but restricted to highly localized microhabitat sites (see Figure 2). CNPS List 4. (BS, J&S)

Dodecatheon hendersonii Gray. Mosquito bills. Grasslands. Locally common. (BS, J&S)

Ranunculaceae (Buttercup Family)

Delphinium gypsophilum Ewan ssp. ***gypsophilum***. Gypsum-loving larkspur. Grasslands. Restricted to several occurrences along the east side of Site 300 (see Figure 2). CNPS List 4. (BS; J&S)

Delphinium hesperium Gray. Western larkspur. (BS)

Delphinium hesperium Gray ssp. ***pallescens*** (Ewan) H. Lewis & Epling. Pale western larkspur. Blue oak woodland, grasslands. Common. (J&S)

Delphinium parryi Gray. Parry's larkspur. Blue oak woodland, grasslands. Common. (J&S)

Delphinium patens Benth. Coastal scrub, oak woodland. Spreading larkspur. Widespread, common. (BS, J&S)

Ranunculus canus Benth. Sacramento Valley buttercup. Grasslands. Local, uncommon. [var. *laetus* (Greene) Benson] (BS, J&S)

Ranunculus hebecarpus Hook. & Arn. Pubescent-fruited buttercup. (BS)

**Ranunculus muricatus* L. Prickle-fruited buttercup. Wetlands. Uncommon. (J&S)

Ranunculus sceleratus L. Celery-leaved buttercup. (BS)

Rosaceae (Rose Family)

Aphanes occidentalis (Nutt.) Rydb.. Western ladies'-mantle. Grasslands, oak woodland. Widespread but uncommon. (BS, J&S)

Heteromeles arbutifolia (Lindley) Roemer. Toyon. Blue oak woodland. Local, uncommon. (BS, J&S)

Prunus virginiana L. var. *demissa* (Nutt.) Torr. Western choke-cherry. Elderberry scrub. Local, uncommon. (BS, J&S)

Rubus leucodermis Torr. & Gray. Blackcap raspberry. (BS)

Rubus ursinus Cham. & Schldl. California blackberry. Elderberry scrub. Local, uncommon. (J&S)

Rubiaceae (Madder Family)

Galium aparine L. Common bedstraw. Blue oak woodland, grasslands. Widespread but uncommon. (BS, J&S)

**Galium parisiense* L. Wall bedstraw. Ruderal, grasslands. Widespread but uncommon. (J&S)

Galium porrigens Dempster var. *tenue* (Dempster) Dempster. Climbing bedstraw. Blue oak woodland. Local, uncommon. (BS, J&S)

Salicaceae (Willow Family)

Populus fremontii Wats. Fremont cottonwood. Fremont cottonwood riparian forest, valley oak woodland. Local, uncommon. (BS, J&S)

Salix laevigata Bebb. Red willow. Great Valley willow scrub, Fremont cottonwood riparian forest . Local, uncommon. (BS, J&S)

Salix lasiolepis Benth. Arroyo willow. Great Valley willow scrub. Local, uncommon. (J&S)

Saxifragaceae (Saxifrage Family)

Lithophragma affine Gray. Woodland star. (BS)

Lithophragma parviflorum (Hook.) Torrey & A. Gray var. ***parviflorum***. Moist areas in grasslands. Widespread, common. (J&S)

Saxifraga californica Greene. California saxifrage. Moist areas in grasslands. Widespread, common. (BS, J&S)

Scrophulariaceae (Figwort Family)

Castilleja attenuata (Gray) Chuang & Heckard. Valley tassels. Grasslands. Local, uncommon. [*Orthocarpus attenuatus* Gray] (BS, J&S)

Castilleja exerta (Heller) Chuang & Heckard. Purple owl's-clover. Grasslands, coastal scrub, blue oak woodland. Widespread, common. [*Orthocarpus purpurascens* Benth.] (BS, J&S)

Castilleja foliolosa Hook. & Arn. Ash-grey Indian paintbrush. Coastal scrub. Local, uncommon. (BS, J&S)

Collinsia heterophylla Buist. Chinese houses. Blue oak woodland. Locally common. (BS, J&S)

Collinsia sparsiflora Fisch. & Mey. Few-flowered blue-eyed Mary. (BS)

Collinsia sparsiflora Fisch. & Mey. var. ***collina*** (Jeps.) V. Newsom. Remote-flowered blue-eyed Mary. Rock outcrops and open, moist areas in grasslands. Widespread, common. (BS, J&S)

Linaria canadensis (L.) Dum.-Cours. Blue toadflax. [*L. texana* Scheele] (BS)

Mimulus aurantiacus Curtis. Bush monkey flower. Elderberry scrub. Local, uncommon. (BS, J&S)

Mimulus guttatus DC. Seep-spring monkey flower. Freshwater seep, vernal pool. Uncommon. [*M. nasutus* Greene] (BS, J&S)

Mimulus latidens (Gray) Greene. Broad-toothed monkey flower. (BS)

Scrophularia californica Cham. & Schldl. California figwort. Rock outcrops in blue oak woodland, elderberry scrub. Local, uncommon. (BS, J&S)

Veronica peregrina L. ssp. *xalapensis* (Kunth) Pennel. Purslane speedwell. Vernal pool. Local, uncommon. (BS, J&S)

Solanaceae (Nightshade Family)

Datura wrightii Regel. Jimson weed. Ruderal, Great Valley willow scrub. Uncommon. (J&S)

**Nicotiana acuminata* Hook. var. *multiflora* (Philippi) Reiche. Many-flowered tobacco. Freshwater seep. Uncommon. (J&S)

**Nicotiana glauca* Graham. Tree tobacco. Along streams. Local, uncommon. (BS, J&S)

Nicotiana quadrivalvis Pursh. Indian tobacco. [*N. bigelovii* (Torr.) Wats.] (BS)

Solanum americanum Miller. Small-flowered nightshade. Ruderal. Uncommon. [*S. nodiflorum* Jacq.] (BS, J&S)

Solanum umbelliferum Eschsch. Blue witch. Grasslands. Uncommon. (BS, J&S)

Urticaceae (Nettle Family)

Hesperocnide tenella Torr. Western nettle. Rock outcrops in grasslands, coastal scrub. Local, uncommon. (BS, J&S)

Urtica dioica L. subsp. *holosericea* (Nutt.) Thorne. Hoary nettle. Freshwater seep. Local, uncommon. (BS, J&S)

**Urtica urens* L. Dwarf nettle. Ruderal, blue oak woodland. Local, uncommon. (BS, J&S)

Valerianaceae (Valerian Family)

Plectritis brachystemon Fischer & C. Meyer. Short-spurred plectritis. Moist areas in grasslands. Local, uncommon. (J&S)

Plectritis ciliosa (Greene) Jeps. subsp. ***insignis*** (Suksd.) D. Morey. Long-spurred plectritis. Blue oak woodland, grasslands. Widespread but uncommon. (BS, J&S)

Plectritis congesta (Lindley) A. DC. Pink plectritis. (BS)

Plectritis macrocera Torrey & A. Gray. White plectritis. Grasslands. Local, uncommon. (J&S)

Verbenaceae (Vervain Family)

Verbena bracteata Lagasca & J.D. Rodriguez. Prostrate vervain. Vernal pool. Local, uncommon. (J&S)

Violaceae (Violet Family)

Viola pedunculata T. &. G. Johnny jump-up. Grasslands. Local, uncommon. (J&S)

Viola purpurea Kell. ssp. ***quercetorum*** (M. Baker & J. Clausen) R. J. Little. Foothill violet. [*V. quercetorum* M. Baker & J. Clausen] (BS)

Viscaceae (Mistletoe Family)

Phoradendron villosum (Nutt.) Nutt. Oak mistletoe. Blue oak woodland. Local, uncommon. (BS, J&S)

Vitaceae (Grape Family)

Vitus californica Benth. California wild grape. Along stream in blue oak woodland. Local, uncommon. (J&S)

Anthophyta--Monocotyledones

Cyperaceae (Sedge Family)

Cyperus eragrostis Lam. Umbrella sedge. Vernal pool. Local, uncommon. (BS, J&S)

Eleocharis macrostachya Britton. Creeping spikerush. Vernal pool. Local, uncommon. [*E. palustris* (L.) Roemer & Schultes] (BS, J&S)

Scirpus acutus Bigelow. Hard-stem bulrush. (BS)

Scirpus fluviatilis (Torr.) Gray. River bulrush. (BS)

Iridaceae (Iris Family)

Sisyrinchium bellum Wats. Blue-eyed grass. Grasslands. Local, uncommon. (J&S)

Juncaceae (Rush Family)

Juncus balticus Willd. Baltic rush. Freshwater seep. Local, uncommon. (BS, J&S)

Juncus bufonius L. Toad rush. Freshwater seep. Local, uncommon. (BS, J&S)

Juncus occidentalis (Cov.) Wieg. Western rush. [*Juncus tenuis* Willd. var. *congestus* Engelm.] (BS)

Juncus oxymeris Engelm. Pointed rush. (BS)

Juncus patens E. Meyer. Spreading rush. Freshwater seep. Local, uncommon. (BS, J&S)

Juncus xiphioides E. Meyer. Iris-leaved rush. Freshwater seep. Local, uncommon. (J&S)

Juncaginaceae (Arrowgrass Family)

Lilaea scilloides (Poiret) Hauman. Flowering quillwort. Vernal pool. Local, uncommon. (BS, J&S)

Lemnaceae (Duckweed Family)

Lemna miniscula Herter. Least duckweed. [*L. minuta* Kunth] (BS)

Liliaceae (Lily Family)

Allium crispum Greene. Crinkled onion. Grasslands. Local, uncommon. (BS, J&S)

Allium serra D. McNeal & F. Ownbey. Serrated onion. Grasslands, blue oak woodland. Widespread, common. [*A. serratum* Wats.] (BS, J&S)

Brodiaea elegans Hoover. Harvest brodiaea. Grasslands. Common. (BS, J&S)

Calochortus clavatus Wats. ssp. ***pallidus*** (Hoov.) Munz. Mariposa lily. Grasslands. Uncommon. (BS, J&S)

Calochortus venustus Benth. Mariposa lily. Grasslands. Uncommon. (BS, J&S)

Chlorogalum pomerideanum (DC.) Kunth. Soap plant. Grasslands. Widespread, common (BS, J&S)

Dichelostemma capitata Alph. Wood. Blue dicks. Grasslands, blue oak woodland. Widespread, common. Rolf Berg (1996) argues that this species should be treated as *Dipterostemon capitatus* (Benth.) Rydb. on the basis of its distinctive embryogenesis. [*D. pulchellum* (Salisb.) Heller] (BS, J&S)

Fritillaria agrestis Greene. Stinkbells. Grasslands. Local, uncommon (see Figure 2). CNPS list 4. (BS, J&S)

Triteleia hyacinthina (Lindley) Greene. White hyacinth. Grasslands. Uncommon. (BS, J&S)

Triteleia laxa Benth. Ithuriel's spear. Grasslands, blue oak woodland, coastal scrub. Widespread, common. (BS, J&S)

Poaceae (Grass Family)

Alopecurus carolinianus Walter. Carolina foxtail. Vernal pool. Local, uncommon. (J&S)

Alopecurus saccatus Vasey. Pacific foxtail. Vernal pool. Local, uncommon. [*A. howellii* Vasey] (BS, J&S)

**Avena barbata* Link. Slender wild oat. Grasslands, coastal scrub, blue oak woodland. Widespread, common. (BS, J&S)

**Avena fatua* L. Wild oat. Grasslands. Widespread but uncommon. (BS, J&S)

**Bromus arenarius* Labill. Australian brome. Grasslands. Uncommon. (BS, J&S)

Bromus carinatus Hook. & Arn. California brome. Blue oak woodland, grasslands. Local, uncommon. [*B. marginatus* Steudel] (BS, J&S)

**Bromus diandrus* Roth. Ripgut brome. Grasslands, coastal scrub, blue oak woodland. Widespread, common. (BS, J&S)

**Bromus hordeaceus* L. Soft chess. Grasslands, coastal scrub, blue oak woodland. Widespread, common. [*B. mollis* L., *B. molliformis* Godron] (BS, J&S)

**Bromus japonicus* Murr. Japanese brome. (BS)

**Bromus madritensis* L. subsp. *madritensis*. Foxtail chess. Grasslands, blue oak woodland. Widespread but uncommon. (BS, J&S)

**Bromus madritensis* L. subsp. *rubens* (L.) Husnot. Red brome. Grasslands, coastal scrub, blue oak woodland. Widespread, common. [*B. rubens* L.] (BS, J&S)

**Bromus sterilis* L. Poverty brome. (BS)

**Bromus tectorum* L. Cheat grass. Grasslands. Uncommon. (BS, J&S)

**Crypsis schoenoides* (L.) Lam. Swamp timothy. Vernal pool. Local, uncommon. (J&S)

**Cynodon dactylon* (L.) Pers. Bermuda grass. Freshwater seep, ruderal. Local, uncommon. (J&S)

Deschampsia danthonioides (Trin.) Benth. Annual hairgrass. Vernal pool. Local, uncommon. (BS, J&S)

Distichlis spicata (L.) Greene. Saltgrass. Grasslands, Freshwater seep. Local, uncommon. [var. *stricta* (Torr.) Beetle] (BS, J&S)

Elymus elymoides (Raf.) Swezey. Squirreltail. [*Sitanion hystrix* (Nutt.) J. G. Smith] (BS)

Elymus glaucus Buckley. Blue wildrye. Oak woodlands. Local, uncommon. (BS, J&S)

Elymus multisetus (J. G. Smith) Davy. Big squirreltail. Grasslands, blue oak woodland. Common. [*Sitanion jubatum* J. G. Smith] (BS, J&S)

****Gastridium ventricosum*** (Gouan) Schinz & Thell. Nitgrass. Grasslands. Local, uncommon. (J&S)

Hordeum depressum (Scribner & J. G. Smith) Rydb. Low barley. Swale in grasslands. Local, uncommon. (BS, J&S)

****Hordeum marinum*** Hudson ssp. ***gussoneanum*** (Parl.) Thell. Mediterranean barley. Vernal pool. Local, uncommon. [*H. geniculatum* All.] (BS, J&S)

****Hordeum murinum*** L. ssp. ***leporinum*** (Link) Arcang. Foxtail barley. Grasslands. Widespread, common. [*H. leporinum* Link] (BS, J&S)

Koeleria macrantha (Ledeb.) J. A. Schultes. Prairie junegrass. Grasslands. Local, uncommon. [*K. cristata* (L.) Pers., *K. nitida* Nutt.] (BS, J&S)

****Koeleria phleoides*** (Villars) Pers. Bristly junegrass. Open, thin-soiled areas in grasslands, coastal scrub. Local, uncommon. [*K. gerardii* (Villars) Shinners] (BS, J&S)

****Lamarckia aurea*** (L.) Moench. Goldentop. Coastal scrub. Widespread but uncommon. (BS, J&S)

Leymus triticoides (Buckley) Pilger. Creeping wildrye. Grasslands, freshwater seep. Common. [*Elymus triticoides* Buckley] (BS, J&S)

****Lolium multiflorum*** Lam. Italian ryegrass. Grasslands, vernal pool. Common. (BS, J&S)

****Lolium perenne*** L. Perennial ryegrass. Swale in grasslands. Local, uncommon. (J&S)

Melica californica Scribner. California melic. Rock outcrops in grasslands, blue oak woodland. Local, uncommon (BS, J&S)

Nassella cernua (Stebbins & Love) Barkworth. Nodding needlegrass. Grasslands. Common. [*Stipa cernua* Stebbins & Love] (BS, J&S)

Nassella pulchra (A. Hitchc.) Barkworth. Purple needlegrass. Grasslands. Common. [*Stipa pulchra* A. Hitchc.] (BS, J&S)

****Phalaris paradoxa*** L. Paradox canary grass. Swale in grasslands; Local, uncommon. (J&S)

****Poa annua*** L. Annual bluegrass. Grasslands. Local, uncommon. (BS, J&S)

****Poa bulbosa*** L. Bulbous bluegrass. Grasslands. Local, uncommon. (BS, J&S)

Poa secunda J. S. Presl. One-sided bluegrass. Grasslands. Widespread, common. [*P. scabrella* (Thurb.) Vasey] (BS, J&S)

****Polypogon interruptus*** Kunth. Ditch beard grass. Freshwater seep. Local, uncommon. (BS, J&S)

****Polypogon monspeliensis*** (L.) Desf. Annual rabbit's-foot grass. Freshwater seep, vernal pool. Local, uncommon. (BS, J&S)

****Schismus arabicus*** Nees. Arabian grass. Rock outcrops in grasslands, ruderal. Widespread but uncommon. (BS, J&S)

****Schismus barbatus*** (L.) Thell. Mediterranean grass. Coastal scrub. Widespread but uncommon. (J&S)

****Taeniatherum caput-medusae*** (L.) Nevski. Medusa-head. (BS)

****Vulpia bromoides*** (L.) S. F. Gray. Foxtail fescue. Grasslands. Uncommon. (J&S)

Vulpia microstachys (Nutt.) Benth. var. ***ciliata*** (Beal) Leonard & Gould. Ciliate fescue. Blue oak woodland, grasslands. Widespread but uncommon. (J&S)

Vulpia microstachys (Nutt.) Benth. var. ***confusa*** (Piper) Leonard & Gould. Hairy-leaved fescue. Grasslands. Widespread but uncommon. (BS, J&S)

Vulpia microstachys (Nutt.) Benth. var. ***pauciflora*** (Beal) Leonard & Gould. Few-flowered fescue. Grasslands. Widespread but uncommon. (BS, J&S)

****Vulpia myuros*** (L.) C. Gmelin. Rattail fescue. Grasslands. Widespread but uncommon. (BS, J&S)

Vulpia octoflora (Walter) Rydb. var. ***hirtella*** (Piper) Henrard. Eight-weeks fescue. Coastal scrub. Local, uncommon. (BS, J&S)

Potamogetonaceae (Potamogeton Family)

**Potamogeton crispus* L. Crispate-leaved pondweed. (BS)

Typhaceae (Cattail Family)

Typha angustifolia L. Narrow-leaved cattail. Cattail wetland, freshwater seep. Local, uncommon. (BS, J&S)

Typha domingensis Pers. Southern cattail. (BS)

Typha latifolia L. Broad-leaved cattail. Cattail wetland, freshwater seep. Local, uncommon. (BS, J&S)

Excluded Species

BioSystems' survey included a number of taxa from Site 300 that appear to be erroneously reported. These taxa include:

Alyssum alyssoides (L.). This species does not occur in central western California; possibly a misidentification of erect-fruited *Lepidium nitidum* T. & G.

Fritillaria bicolor Lindley. Misidentification of *Fritillaria agrestis* Greene.

Gilia capitata Sims ssp. *abrotanifolia* (Greene) V. Grant. This is a southern California subspecies; probably a misidentification of ssp. *staminea*.

Hordeum pusillum Nutt. This is a synonym of *H. intercedens* Nevski, a southern California species; possibly a misidentification of *H. depressum*.

Lagophylla glandulosa Gray. This is a late summer- to fall-blooming species that does not occur in central western California; probably a misidentification of *Lagophylla ramosissima*.

Plagiobothrys hystriculus (Piper) Jtn. This species, which is presumed to be extinct, is endemic to Solano County; possibly a misidentification of *Plagiobothrys acanthocarpus* (Piper) Jtn.

Plagiobothrys tener (Greene) Jtn. This species does not occur in central western California; possibly a misidentification of *Plagiobothrys trachycarpus* (Gray) Jtn. or a typographic error for *P. tenellus* (Nutt.) Gray.

Plantago eriopoda Torr. This species does not occur in central western California; possibly a misidentification of *Plantago lanceolata*.

Poa palustris L. This is a montane species that does not occur in central western California; possibly a misidentification of *Poa pratensis* L.

Ribes divericatum Dougl. This species is coastal and does not occur in the interior foothills; probably a misidentification of *R. quercetorum* Greene.

Thelypodium lemmonii Greene. This species occurs in the central to southern South Coast Ranges but not as far north as Alameda County. Probably a misidentification of *Guillenia flavescens*.

Triteleia elegans. This is not a valid name; probably a typographic error for *Brodiaea elegans*.

References

Al-Shehbaz, I. A., and R. A. Price. 1998. Delimitation of the genus Nasturtium (Brassicaceae). *Novon* 8: 124-126.

Baldwin, B. G. 1999. New combinations and new genera in the North American tarweeds. *Novon* 9: 462-471.

Baldwin, B. G., R. E. Preston, B. L. Wessa, and M. Wetherwax. 2001. A biosystematic and phylogenetic assessment of sympatric taxa in *Blepharizonia* (Compositae-Madiinae). *Systematic Botany* 26: 184-194.

Berg, R. Y. 1996. Development of ovule, embryo sac and endosperm in *Dipterostemon* and Dichelotemma (Alliaceae) relative to taxonomy. *American Journal of Botany* 83: 790-801.

BioSystems Analysis, Inc. 1986b. A rare plant survey of Site 300, Lawrence Livermore National Laboratory, San Joaquin County, California. November 1986. Santa Cruz, CA. Prepared for Science Applications International Corporation, Pleasanton, CA.

CalFlora: Information on California plants for education, research and conservation. [web application]. 2000. Berkeley, California: The CalFlora Database [a non-profit organization]. Available: http://www.calflora.org/.

Chan, R. 2001. Taxonomic changes and a new species in *Lasthenia* Sect. *Amphiachaena* (Compositae: Heliantheae sensu lato). *Madroño* 48(3): 205-210.

Hickman, J. C. (ed.). 1993. *The Jepson manual*. University of California Press, Berkeley, CA.

Hoover, R. F. 1936. *New California plants*. Leaflets of Western Botany 1:225–232.

Preston, R. E. 1997. *Dittrichia graveolens* (Asteraceae), new to the California weed flora. *Madroño* 44: 200-203.

Reveal, James. Professor. University of Maryland, College Park. October 15, 1997 - E-mail.

Webster, G. L. 1992. Realignment in American *Croton*. *Novon* 2: 269-273.

Attachment 2.2 – Livermore Site (from Jones & Stokes 2002a)

Table B-2. Checklist of Plant Species Observed in Arroyo Seco, Lawrence Livermore National Laboratory, June 27, 2002

Scientific Name	Common Name
Aesculus californica	California buckeye
Artemisia douglasiana	mugwort
Artemisia californica	California sagebrush
Avena fatua	wild oat
Baccharis salicifolius	mulefat
Bromus diandrus	ripgut brome
Bromus catharticus	rescue brome
Carduus pycnocephalus	Italian thistle
Carpobrotus sp.	ice-plant
Cirsium vulgare	bull thistle
Cynodon dactylon	Bermuda grass
Cyperus eragrostis	umbrella sedge
Epilobium canum	California fuschia
Epilobium brachycarpum	panicled willow-herb
Epilobium ciliatum	hairy willow-herb
Eschscholzia californica	California poppy
Euphorbia spathulata	reticulate-seeded spurge
Foeniculum vulgare	sweet fennel
Geranium dissectum	cut-leaved geranium
Grindelia camporum	Great Valley gumplant
Heliotropium curassavicum	salt heliotrope
Hirschfeldia incana	Mediterranean mustard
Hordeum murinum subsp. *leporinum*	foxtail barley
Juglans sp.	black walnut
Lactuca serriola	prickly lettuce
Lepidium latifolium	perennial peppercress
Leymus triticoides	creeping wildrye
Ligustrum lucidum	glossy privet

Table B-2. Continued

Scientific Name	Common Name
Lolium multiflorum	Italian ryegrass
Malva sp.	cheeseweed
Marrubium vulgare	horehound
Nicotiana glauca	tree tobacco
Oxalis corniculatus	creeping wood sorrel
Panicum capillare	witchgrass
Paspalum dilatatum	Dallisgrass
Piptatherum miliaceum	smilo grass
Plantago lanceolata	English plantain
Polypogon monspeliensis	annual rabbit's-foot grass
Prunus dulcis	almond
Pyracantha sp.	firethorn
Quercus sp.	oak
Raphanus sativus	wild radish
Rumex salicifolius var. *denticulatus*	willow dock
Rumex crispus	curly dock
Salix lasiolepis	arroyo willow
Senecio vulgaris	common groundsel
Silybum marianum	milk thistle
Sonchus oleraceus	common sow-thistle
Tragopogon porrifolius	salsify
Urtica dioica subsp. *holosericea*	hoary nettle
Vitis vinifera	cultivated grape
Xanthium strumarium	common cocklebur

Attachment 3 – Species Accounts

SPECIES ACCOUNTS

San Joaquin Kit Fox (*Vulpes macrotis mutica*)

The San Joaquin kit fox is the smallest fox in North America, standing 9 to 12 inches at the shoulder (USFWS 2003a). An adult fox has a body length of approximately 20 inches and a tail length of approximately 12 inches, with relatively long legs and large ears and a slender build. The males weigh about 5 pounds, and females slightly less (4.6 pounds) (CDFG 2000). San Joaquin kit fox fur is tan during the summer and silver-gray in the winter. The tip of the tail is black (Brown et al. 1997).

Status

The San Joaquin kit fox was listed as endangered under the *Endangered Species Act* of 1967 and threatened in the State of California in 1971 (USFWS 2003a).

Threats

The most important threats to San Joaquin kit fox populations are habitat loss and fragmentation, reduction of prey populations through rodent control programs, and use of pesticides and rodenticides (USFWS 1998). Other carnivores may compete with and predate on San Joaquin kit fox, including native species such as the coyote (*Canis latrans)* and bobcat (*Felis rufus*) and nonnative species such as red fox *(Vulpes vulpes)* and domestic dogs (*Canis familiaris*) (USFWS 1998).

Range, Habitat, and Life History

Range: San Joaquin kit fox prior to 1930 ranged over most of the San Joaquin Valley from southern Kern County north to eastern Contra Costa County and eastern Stanislaus County (Grinnell et al. 1937, Brown et al. 1997, USFWS 1998). No recent extensive surveys have been conducted in the historical range. However, based on small-scale surveys and sightings, kit fox are thought to inhabit suitable habitat in the San Joaquin Valley and surrounding foothills and the Sierra Nevada and Tehachapi mountains. Kit fox have been found in Kern, Tulare, Kings, Fresno, Madera, San Benito, Merced, Stanislaus, San Joaquin, Alameda, and Contra Costa counties. They are also known from Monterey, San Benito, San Luis Obispo, Ventura, Santa

Barbara, San Luis Obispo, and possibly Santa Clara counties (USFWS 1998). Observations of San Joaquin kit fox in the 1980s and early 1990s are known from areas near Site 300, including the Carnegie New Town in northwestern San Joaquin county and Midway Substation on the San Joaquin and Alameda counties border, Bethany Reservoir, and Los Vaqueros Reservoir/Altamont Pass area (Orloff et al. 1986, Sproul and Flett 1993). Additionally, a kit fox has been observed at Brushy Peak north of the Livermore Site.

Habitat: San Joaquin kit foxes use grassland and scrubland, oak woodland, alkali sink scrubland, vernal pool, and alkali meadow communities. San Joaquin kit fox dig dens for temperature regulation, shelter, reproduction, and escape from predators (USFWS 1998). They may dig their own dens or modify dens constructed by other species such as ground squirrels, badgers, and coyotes (Morrell 1972, Berry et al. 1987). Loose-textured soils are preferred for den construction. San Joaquin kit fox may also use human-made structures such as culverts, pipelines, and banks in sumps or roadbeds (USFWS 1998). Home ranges vary from 1 square mile to approximately 12 square miles, depending on prey abundance (Morrell 1972, USFWS 1998).

Life History: San Joaquin kit fox are primarily nocturnal but can also be seen during the day on occasion, and are active throughout the year. Kit fox feed on small mammals, birds, insects, and vegetation. Common prey items include California ground squirrels, harvest and pocket mice, kangaroo rats, Jerusalem crickets, and black-tailed hares (Orloff et al. 1986, USFWS 1998). Kit foxes reach sexual maturity at one year of age, but may not breed their fist year of adulthood (Morrell 1972). Pairs usually remain together all year, although they may not occupy the same den (USFWS 1998). Female kit foxes begin preparing a natal pupping den in September and October. Mating occurs between December and March. Gestation takes between 48 to 52 days, and litters are usually born in February and March (Morrell 1972, USFWS 1998). Litters generally consist of two to six pups. Pups emerge aboveground at around one month of age, and disperse after 4 to 5 months, usually in August or September. Reproductive success depends on abundance of prey (USFWS 1998). Drought may lead to low reproductive success by reducing prey abundance. Kit foxes may live up to 10 years, but generally do not live that long in the wild, as adult mortality is high. Adult mortality may be as high as 50 percent, and juvenile

mortality may be around 70 percent (Berry et al. 1987). Predation by larger carnivores such as coyote may account for the majority of kit fox mortality (USFWS 1998).

Large-Flowered Fiddleneck (*Amsinckia grandiflora*)

Status

Large-flowered fiddleneck *(Amsinckia grandiflora)* was federally listed as endangered in 1985. On May 8, 1985, 160 acres of Site 300 surrounding the native large-flowered fiddleneck population in the Drop Tower Canyon, was designated critical habitat by the United States Fish and Wildlife Service (USFWS). In 1997, the USFWS published the final recovery plan for the species (USFWS 1997). On April 28, 2000, the Secretary of the United States Department of Energy established the *Amsinckia grandiflora* reserve on the 160 acres of critical habitat and signed a memorandum of agreement with the USFWS, describing technical services, management, and access to the reserve (USDOE 2000).

Range, Habitat, and Life History

Large-flowered fiddleneck (Gray) Kleeb. ex Greene (Boraginaceae), is a rare annual forb native to the California winter annual grasslands. Large-flowered fiddleneck has been recently known from only three natural populations containing individuals numbering from fewer than 30 to several thousand. All natural populations occur on steep, well-drained, north-facing slopes in the Altamont Hills of the Diablo range, about 19 miles southeast of San Francisco, California. The populations occur at low elevations, approximately 950 feet, and border on blue oak woodland and coastal sage scrub communities. Two of the natural populations occur on Site 300, a high-explosive testing facility operated by the University of California for the United States Department of Energy. The two natural populations at Site 300 are known as the Drop Tower population and the Draney Canyon population. Located in the north/southwest-trending Drop Tower Canyon, the Drop Tower population is the larger of the two populations at Site 300 and was the only known population of large-flowered fiddleneck up through 1987. In 1987, the Draney Canyon population was discovered in a north/southwest-trending canyon west of the Drop Tower Canyon. This population is now believed to have been eliminated. In 1993, a large large-flowered fiddleneck population, known as the Carnegie Canyon population, was discovered on private rangelands near the southeast border of Site 300.

Attempts at establishing two experimental populations have also occurred near Site 300. An ecological reserve, owned by the California Department of Fish and Game (CDFG), is located adjacent to the southeast border of Site 300. An attempt was made to establish an experimental population of large-flowered fiddleneck at this site (known in Pavlik 1994 as the Corral Hollow population), but no reproductive plants have been observed at this site in recent years, suggesting the establishment was not successful. A second experimental population was attempted at the Connolly Ranch, a privately owned ranch near the southwest border of Site 300. This attempt failed, paossibly as a result of extremely high rodent activity (Pavlik 1994).

Restoration efforts began in 1988 by researchers from Mills College. These efforts focused on determining the factors necessary for the successful establishment of additional populations of large-flowered fiddleneck (Pavlik 1988a, 1988b) and have resulted in the establishment of at least one apparently successful experimental population at Lougher Ridge in the Black Diamond Mines East Bay Regional Park (Pavlik 1994). Between 1993 and 1995, using funds obtained through a grant from LLNL's Laboratory Directed Research and Development Program, LLNL researchers teamed with researchers from Mills College to further investigate the causes of large-flowered fiddleneck rarity and to establish an additional population at Site 300. The experimental population was established near the Drop Tower native population on a north-facing slope on the eastern fork of the Drop Tower Canyon where it splits in two around the Drop Tower facility parking lot. This population is known as the Drop Tower experimental population.

Research on the Drop Tower experimental population, the Lougher Ridge experimental population, and data from management of the Drop Tower natural population indicated that competition from exotic annual grasses was contributing to the decline of *A. grandiflora.* In addition, long-term management proved necessary to reduce exotic annual grass cover and restore and maintain the native perennial bunch grass community to ensure the persistence of this species (Pavlik et al. 1993, Pavlik 1994, Carlsen et al. 2000). Long-term financial support is being provided through LLNL Site 300 management.

The goal of the ongoing management of the Site 300 large-flowered fiddleneck populations is to control the cover of exotic annual grasses while developing techniques to restore native perennial

grasslands (Carlsen et al. 2003). The use of controlled burning is being investigated as a tool for developing and maintaining perennial grasslands. Finally, the impact of seed predation is being investigated to determine its impact on the population dynamics of *A. grandiflora*.

The low numbers of large-flowered fiddleneck plants observed over the past several years at Site 300 have also been observed in other existing natural and experimental populations of the fiddleneck throughout its existing range. Encroachment of bush lupine (*Lupinus albifrons*) has been observed both at the native population at Site 300 and the experimental population at Lougher Ridge. A significant level of spring and summer seed predation has been observed at the Site 300 experimental population, although its magnitude does not appear to correlate with plant establishment the following year. To enhance the experimental population at Site 300 and Lougher Ridge, LLNL began a rapid seedbank enhancement project in October 2003 with funding provided by the United States Bureau of Reclamation.

Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*)

The valley elderberry longhorn beetle is a stout-bodied beetle with long antennae. Males range from 1/2 to 1 inch in length and have antennae as long as their bodies. Females are slightly larger, ranging from 3/4 to 1 inch, with shorter antennae. Adult males have red-orange wing covers with four elongated dark spots, while females have dark colored wing covers (USFWS 1999a).

Status

The valley elderberry longhorn beetle was listed in 1980 as threatened under the United States *Endangered Species Act* (USFWS 1999a).

Threats

The primary threats to valley elderberry longhorn beetles are habitat loss (destruction of riparian forests and associated elderberry trees), invasive insect species such as the Argentine ant, and insecticide and herbicide use. Activities that threaten individual beetles include dewatering or flooding, pesticide application, trimming of plants, and ant invasions (Huxel 2000, Collinge et al. 2001).

Range, Habitat, and Life History

Range: The valley elderberry longhorn beetle is found in the Central Valley of California from Shasta County in the north to Kern County in the south (Barr 1991) and east into the foothills of the Sierra Nevada (Arnold 2002). Adult valley longhorn elderberry beetles have been observed at Site 300 and at the neighboring CDFG site southeast of Site 300 (Arnold 2002).

Habitat: Valley elderberry longhorn beetles use riparian forests and adjacent upland habitats (USFWS 1999a). They are primarily associated with elderberry (*Sambucus* species) trees and shrubs (Arnold 2002, USFWS 1999b). The beetle requires elderberry shrubs with a basal diameter greater than 1 inch (Barr 1991).

Life History: In the spring (April/May), female valley elderberry longhorn beetles lay eggs in crevices in the bark of living elderberry plants. Eggs hatch in a few days and the larvae bore into the pith of the elderberry stem, trunk, or roots (Arnold 2002). The larvae feed on the pith until metamorphosis, which occurs one to two years after hatching (Arnold 2002). Prior to metamorphosis, the larvae chew an exit hole in the trunk of the elderberry, anywhere from ground level to 25 feet or more (Barr 1991). The exit holes are generally between 0.15 and 0.4 inches in diameter. Adults emerge when the host plant begins to flower (Barr 1991). Adult elderberry beetles appear to feed on elderberry flowers and foliage (Arnold 2002). Elderberry beetles are not strong fliers, tend not to leave their host plant, and do not seem to disperse between drainages (Collinge et al. 2001).

California Red-Legged Frog (*Rana aurora draytonii)*

The California red-legged frog is a large frog, reaching up to 5.5 inches from snout to vent in length, with a prominent dorsolateral fold. It is predominantly brown to reddish brown, with moderate-sized dark brown to black spots that sometimes have light centers (Jennings and Hayes 1994). It often has red to orange coloration to the belly and undersurfaces of the thighs, legs, and feet. However, distribution of the red coloration is highly variable. Some individuals have red pigment extending over all undersurfaces and upper surfaces of the body; other individuals lack

red pigment entirely or have it restricted to the feet (Jennings and Hayes 1994). There is a whitish stripe along the jaw (Stebbins 2003).

Status

The California red-legged frog was listed in 1996 as threatened under the *Endangered Species Act* (61 FR 25813). Critical habitat was designated for the California red-legged frog in March 2001, although most has been rescinded due to a recent court decision (USFWS 2002a).

Range, Habitat, and Life History

Range: The current range of the California red-legged frog includes Pacific slope drainages from Napa and Sonoma counties to Baja California. Isolated populations are also found in the Sierra Nevada foothills north of Sacramento (USFWS 2002b). Historically, the California red-legged frog was known from 46 counties but now has been eliminated from at 24 of these (61 FR 25813). The California red-legged frog is found at both Site 300 and at the Livermore Site (van Hattem 2003a).

Habitat: The California red-legged frog is found in a variety of aquatic, riparian, and upland habitats in areas below 4,900 feet. Aquatic systems used by California red-legged frogs include dune swales, ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, permanent ponds, perennial creeks, man-made ponds, and virtually any aquatic system that is in close proximity to some permanent water source (USFWS 2001, 2002b). California red-legged frogs have been observed in streams up to 2 miles from breeding habitat and in riparian vegetation adjacent to streams (USFWS 2002b). In heavily grazed areas, adult California red-legged frogs often are observed hundreds of feet from breeding ponds, presumably foraging, seeking appropriate microhabitats or dispersing (van Hattem 2003). California red-legged frogs often use California ground squirrel burrows, deep desiccation cracks, or woody vegetation as thermal refuge during both dry and cold periods of the year. Breeding adults are frequently associated with relatively deep, greater than 2 feet, slow-moving water in areas of dense riparian vegetation, although breeding frogs are found in areas without dense emergent or riparian vegetation in water depths less than 2 feet (USFWS 2001, 2002b).

Life History: Adult California red-legged frogs have a variable diet including invertebrates, small mammals, and other amphibians (Arnold and Halliday 1986, Hayes and Tennant 1986). Larvae are thought to be algae eaters (Jennings and Hayes 1994). California red-legged frogs can complete their entire life cycle in one pond or use a mosaic of habitat types (USFWS 2001). The breeding period for California red-legged frogs is from late November to late April, although most frogs lay their eggs in March (Jennings and Hayes 1994, USFWS 2002b). Emergent vegetation, twigs, and roots are typically used for oviposition sites. Eggs develop into larvae in 20 to 22 days. Although over-wintering tadpoles have been observed in some areas, tadpoles typically develop into frogs in 11 to 20 weeks (USFWS 2002b). During periods of wet weather, California red-legged frogs can move over upland habitats to other aquatic habitats. During dry periods, California red-legged frogs can disperse from breeding habitat to forage or to seek summer habitat in response to declining water levels. A radio-tagged California red-legged frog in the Guadalupe Dunes of California was observed to move approximately 1.75 miles through upland and aquatic habitats over the course of a wet season (Rathbun and Schneider 2001). The California red-legged frog recovery plan (USFWS 2002b) describes unpublished research conducted in Santa Cruz County indicating that California red-legged frogs traveled distances of 0.25 to 2 miles without regard to topography, vegetation type, or riparian corridors.

Alameda Whipsnake (*Masticophis lateralis euryxanthus*)

The Alameda whipsnake is a slender, fast moving snake with a narrow neck and a relatively broad head with large eyes (Swaim 2002). Its dorsal side is sooty black, with yellow-orange dorso-lateral stripes. The anterior portion of the underside is orange to rufus (Stebbins 2003, Swaim 2002). Adult snakes reach up to 5 feet in long (Swaim 2002).

Status

The Alameda whipsnake was listed in 1997 as threatened under the *Endangered Species Act* and threatened in the State of California in 1971 (USFWS 2003c).

Threats

The main threats to the Alameda whipsnake are habitat alteration such as loss of chaparral and coastal sage scrub and fire suppression, which allows vegetation to overgrow its preferred open habitat. Habitat fragmentation has lead to isolation of populations (USFWS 2003c).

Range, Habitat, and Life History

Range: Alameda whipsnakes are found in the inner coast range in western and central Contra Costa and Alameda counties (USFWS 2003). The Alameda whipsnake is found at Site 300 (Swaim 2002).

Habitat: Alameda whipsnakes are found in chaparral, sage scrub, northern coyote brush scrub, and riparian scrub (Swaim 2002). They also use grasslands and oak woodlands adjacent to scrub habitats (Swaim 1994). Rocky outcrops appear to be important to the whipsnake as a source of cover and increased density of prey items such as lizards (Stebbins 1985, Swaim 1994).

Life History: Alameda whipsnakes are active during the day, during spring and summer. In the winter and early spring (November – March), they often remain in a hibernaculum (shelter), although they may be active for short periods of time (USFWS 2003). Mating occurs in late March through mid-June. Little is known about oviposition sites. Whipsnakes feed primarily on western fence lizards (*Sceloporus occidentalis*). They also feed on skinks, frogs, snakes, and birds (USFWS 2003c).

California Tiger Salamander *(Ambystoma californiense)*

The California tiger salamander is a large black salamander with large pale yellow to white spots, growing up to 5 inches from snout to vent (Stebbins 2003). Undersurfaces are highly variable, ranging from uniform white or pale yellow to variegated white or pale yellow and black (Jennings and Hayes 1994). California tiger salamander larvae are yellowish gray to olive above with dark mottling on the back and have large feathery gills (Stebbins 2003).

Status

The California tiger salamander is a state species of special concern and has been proposed for listing as threatened under the *Endangered Species Act* (USFWS 2003a). The Santa Barbara County population was listed as endangered in 2000, and the Sonoma County population was listed as endangered in 2003 (USFWS 2000, 2003b).

Threats

The most important threat to California tiger salamander populations is habitat loss and fragmentation, especially due to urban expansion and conversion of aquatic and upland habitat to agriculture (USFWS 2000). Additional significant population threats include predation by introduced species such as fish and bullfrogs (*Rana catesbeiana*) (Shaffer et al. 1993), vehicle-related mortality during breeding migrations (Gibbs 1998), and rodent control programs (Loredo et al. 1996).

Range, Habitat, and Life History

Range: The California tiger salamander is found in the Central Valley and adjacent foothills and coastal grasslands of California (Loredo and van Vuren 1996). The range of this California endemic extends from Sonoma County and the Colusa-Yolo County border in the north, south through the Central Valley and the Coast Range to Santa Barbara and Tulare counties (Shaffer et al. 1993, Jennings and Hayes 1994). Alameda and Contra Costa counties are among the remaining regions that support the greatest concentration of California tiger salamanders (Shaffer et al. 1993). California tiger salamanders are found at Site 300 (van Hattem 2003a).

Habitat: California tiger salamanders inhabit grasslands and open woodlands with available small mammal burrows and breeding sites (Jennings and Hayes 1994) in areas with a Mediterranean climate of cool wet winters and hot dry summers (Loredo and van Vuren 1996). California tiger salamanders require standing water for breeding (Petranka 1998).

Life History: California tiger salamanders breed in temporary rain pools and permanent waters of grasslands and open woodland of low hills and valleys (Stebbins 1985). Breeding sites can include both natural (vernal pools) and artificial (stock ponds) lentic environments. California tiger salamanders spend much of the year underground, in the burrows of ground squirrels

(*Spermophilus beecheyi*), pocket gophers (*Thomys bottae*), and badgers (*Taxidea taxus*). They usually emerge for only brief periods to breed (Stebbins 1985), typically after the first rains of the year in November or December (Jennings and Hayes 1994, Loredo and van Vuren 1996) and sometimes through April (Petranka 1998). The larval period lasts from 3 to 6 months (Petranka 1998) and, because of this, California tiger salamanders require breeding pools to remain hydrated for at least this length of time. Metamorphosis of salamander larvae begins in late spring or early summer and is followed by the dispersal of metamorphs from their natal ponds into terrestrial habitat (Holland et al. 1990, Loredo et al. 1996). Trenham (2001) recorded adult California tiger salamanders using burrows up to 814 feet from release points adjacent to breeding pools and juvenile salamanders have been reported to use burrows up to 0.75 mile from breeding sites (Jennings and Hayes 1994).

Swainson's Hawk (*Buteo swainsoni*)

The Swainson's hawk is a buteo of the plains, proportioned like a red-tailed hawk but with wings that are a slightly more pointed. When gliding, wings are held slightly above horizontal (Peterson 1990). Adult females weigh 28 to 34 ounces and males weigh 25 to 31 ounces (CDFG 2003d).

Status

The Swainson's hawk was listed as threatened in the State of California on April 17, 1983 (CDFG 2003d).

Threats

Threats to the Swainson's hawk include the destruction of California native grasslands as well as the loss of agricultural lands to various residential and commercial developments throughout California (CDFG 2003a, 2003d).

Range, Habitat, and Life History

Range: During the early 1900s, the Swainson's hawk nested in lowlands throughout most of California. By 1980, the population of this species had dwindled to approximately 110 pairs with

about two-thirds of the California population present in the southern Sacramento Valley and northern San Joaquin Valley (CDFG 2003e).

Habitat: The Swainson's hawk breeds in stands with few trees in juniper-sage flats, riparian areas, and in oak savannah in the Central Valley. The Swainson's hawk forages in grasslands suitable grain or alfalfa fields, or livestock pastures adjacent to breeding stands (CDFG 2003e).
Life History: The Swainson's hawk is diurnal. Common prey include mice, gophers, ground squirrels, rabbits, large arthropods, amphibians, reptiles, birds, and, rarely, fish. It soars at low and high levels in search of prey. It also may walk on the ground to catch invertebrates and other prey and catches insects and bats in flight. Breeding occurs from late March to late August, with peak activity in late May through July. The Swainson's hawk nests on a platform of sticks, bark, and fresh leaves in a tree, bush, or utility pole from 4 to 100 feet above ground. It nests in open riparian habitat, in scattered trees or small groves, in sparsely vegetated flatlands. Its clutch size is usually 2 or 3 eggs, which incubate in 25 to 28 days (CDFG 2003e).

Willow Flycatcher (*Empidonax traillii*)

The willow flycatcher is a member of several small (approximately 5.75 inches long), drab flycatchers in the Empidonax complex and share the characteristics of light eye-ring and two pale wing bars. During breeding, these birds are separated by voice, habitat, and manner of nesting. (Peterson 1990).

Status

The willow flycatcher was listed as endangered in the State of California on January 2, 1991 (CDFG 2003a).

Threats

Loss and degradation of riparian habitat is the principal reason for the decline of the willow flycatcher population and the decrease in geographic range of the species. Impacts of livestock grazing to both the habitat and nests of breeding birds have also been implicated in the decline of the species. Nest parasitism by brown-headed cowbirds has contributed to population reductions (CDFG 2003a).

Range, Habitat, and Life History

Range: The willow flycatcher was formerly a common summer resident throughout California. The species has now been eliminated as a breeding bird from most of its former range in California. Only small, scattered populations remain in isolated meadows of the Sierra Nevada and along the Kern, Santa Margarita, San Luis Rey, and Santa Ynez rivers in Southern California. The smallest of these populations consists of about five pairs and the largest about 50 pairs (CDFG 2003a).

Habitat: The willow flycatcher's breeding range in California formerly extended wherever extensive willow thickets occurred. Dense willow thickets are required for nesting and roosting. Low, exposed branches are used for singing posts and hunting perches. In the Sierra Nevada, the willow flycatcher is consistently absent from otherwise apparently suitable areas where the lower branches of willows have been browsed heavily by livestock (CDFG 2003a).

Life History: The willow flycatcher is diurnal in nature. It arrives from Central and South American wintering grounds in May and June and departs in August; transients are noted through mid-September (CDFG 2003f). Willow fly catcher nests are frequently parasitized by the brown-headed cowbird. Willow flycatchers are monogamous, with peak egg laying occurring in June. The incubation period is 12 to 13 days, with clutches averaging 3 or 4 eggs. The fledging age for this bird is 13 to 14 days (CDFG 2003f).

References

61 FR 25813	Federal Register (FR), Vol. 61, No. 101, Endangered and Threatened Wildlife and Plants, final Determination of Threatened Status for the California Red-legged from, pp. 25813-25833, May 23, 1996
Arnold 2002	Arnold, R.A. 2002. Report on the threatened valley elderberry longhorn beetled and its elderberry food plant at the Lawrence Livermore National Laboratory – Site 300. Prepared for the Lawrence Livermore National Laboratory. Sept. 2002.
Arnold and Halliday 1986	Arnold, S. J., and T. Halliday. 1986. Life history notes: *Hyla regilla*, predation. Herpetological Review 17(2):44.
Barr 1991	Barr, C.B. 1991. The distribution, habitat, and status of the valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* Fisher (Insecta: Coleoptera: Ceramycidae). U.S. Fish and Wildlife Service. Sacramento, CA. 133 pp.
Berry et al. 1987	Berry, W.H., Scrivner, J.H., O'Farrell, T.P., Harris, C.E., Kato, T.T., and P.M. McCue. 1987. Sources and rates of mortality of the San Joaquin kit fox, Naval Petroleum Reserve #1, Kern County, CA, 1980-1986. Rep. No. EGG 10282-2154, EG&G Energy Measurements, Goleta, CA. 34 pp.
Brown et al. 1997	Brown, N.L., Johnson, C.D., Kelley, P.A., and D.F. Williams. 1997. San Joaquin kit fox (*Vulpes macrotis mutica*). *In:* Endangered Species Recovery Program website, California State University, Stanislaus. Available online at: http://arnica.csustan.edu/esrpp/sjkfprof.htm
Carlsen et al. 2000	Carlsen, T. M., J. W. Menke and B. M. Pavlik. 2000. Reducing competitive suppression of a rare annual forb by restoring native perennial grasslands. Restoration Ecology 8: 18-29.
Carlsen et al. 2003	Carlsen, T. M., E. K. Espeland and L. E. Paterson. 2003. Rare plant restoration and monitoring at Lawrence Livermore National Laboratory Site 300. Lawrence Livermore National Laboratory, Livermore, CA.
CDFG 2000	California Department of Fish and Game. 2000. San Joaquin kit fox. *In*: The Status of Rare, Threatened, and Endangered Animals and Plants of California. Available online at http://www.dfg.ca.gov/hcpb/cgi-bin/more_info.asp?idKey=ssc_tespp&specy=mammals&query=Vulpes%20macrotis%20mutica
CDFG 2003a	California Department of Fish and Game. 2003. State and federally listed endangered and threatened animals of California. Available online at: http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml

CDFG 2003d	California's Threatened and Endangered Species, Swainson's Hawk. Available online at: http://www.dfg.ca.gov/te_species/index/classification/birdslist/swainhawk.html.
CDFG 2003e	California Wildlife Habitat Relationships Systems, Swainson's Hawk. Available online at: http://www.dfg.ca.gov/whdab/html/B121.html.
CDFG 2003f	California Wildlife Habitat Relationships Systems, Willow Flycatcher. Available online at: http://www.dfg.ca.gov/whdab/html/B315.html.
Collinge et al. 2001	Collinge, S.K., Holyoak, M., Barr, C.B., and J.T. Marty. 2001. Riparian habitat fragmentation and population persistence of the threatened valley elderberry longhorn beetle in Central California. Biological Conservation 100: 103-113.
Grinnell et al. 1937	Grinnell, J., Dixon, J.S., and J.M. Linsdale. 1937. Fur-bearing mammals of California. Vol. 2. University of California Press, Berkeley.
Hayes and Tennant 1986	Hayes, M. P., and M. R. Tennant. 1986. Diet and feeding behavior of the California red legged frog, *Rana aurora draytonii* (Ranidae). The Southwestern Naturalist 30(4):601- 605.
Huxel 2000	Huxel, G.R. 2000. The effect of the Argentine ant on the threatened valley elderberry longhorn beetle. Biological Invasions 2:81-85.
Jennings and Hayes 1994	Jennings, M.R., and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Prepared for the California Department of Fish and Game. 255 pp. Available online at http://www.dfg.ca.gov/hcpb/info/info.shtml.
Loredo and van Vuren 1996	Loredo, I. D. and D. van Vuren. 1996. Reproductive ecology of a population of the California tiger salamander. Copeia 4:895-901.
Loredo et al. 1996	Loredo, I., D. van Vuren and M.L. Morrison. 1996. Habitat use and migration behavior of the California tiger salamander. J. Herpetology 30(2):282-285.
Morrell 1972	Morrell, S.H. 1972. Life history of the San Joaquin kit fox. California Fish and Game 58: 162-174.
Orloff et al. 1986	Orloff, S.G., Hall, F., and L. Spiegel. 1986. Distribution and habitat requirements of the San Joaquin kit fox in the northern extreme of their range. Trans. West. Sect. Wildl. Soc. 22:60-70.

Pavlik 1988a — Pavlik, B.M. 1988a. Nutlet production and germination of Amsinckia grandiflora. I. Measurements from cultivated populations. California Department of Fish and Game, Endangered Plant Program, Sacramento, CA.

Pavlik 1988b — Pavlik, B.M. 1988b. Habitat characterization and selection of potential sites for establishment of new populations of Amsinckia grandiflora. California Department of Fish and Game, Endangered Plant Program, Sacramento, CA.

Pavlik 1994 — Pavlik, B. M. 1994. Tales of success and failure: trends in natural and reintroduced populations of A. grandiflora under different management regimes. Prepared for the Endangered Plant Program, California Department of Fish and Game, Sacramento, CA, USA.

Pavlik et al. 1993 — Pavlik, B. M., D. L. Nickrent and A. M. Howald. 1993. The recovery of an endangered plant. I. Creating a new population of Amsinckia grandiflora. Conservation Biology 7(3):510-526.

Peterson 1990 — Peterson, R.T. 1990. A field guide to western birds. Third edition. Houghton Mifflin Co, Boston. 432 pp.

Petranka 1998 — Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C.

Rathbun and Schneider 2001 — Rathbun, G. B. and J. Schneider. 2001. Translocation of California red-legged frogs *(Rana aurora draytonii).* Wildl Soc Bull 29(4):1300-1303.

Shaffer et al. 1993 — Shaffer, H. B., R.N. Fisher, and S.E. Stanley. 1993. Status report; The California tiger salamander *(Ambystoma californiense).* Final report for the California Department of Fish and Games. 36pp. Plus figures and tables.

Sproul and Flett 1993 — Sproul, M. J., M. A. Flett. 1993. Status of the San Joaquin kit fox in the northwest margin of its range. Trans. West. Sect. Wildl. Soc. 29:61-69.

Stebbins 1985 — Stebbins, R.C. 1985. A field guild to western reptiles and amphibians. Houghton Mifflin Company, Boston, MA. 336 pp.

Stebbins 2003 — Stebbins, R. C. 2003. A field guide to western reptiles and amphibians. 3rd edition. Houghton Mifflin, New York. 533 pp.

Swaim 1994 — Swaim, K. 1994. Aspects of the ecology of the Alameda whipsnake (*Masticophis lateralis euryxanthus*). Masters Thesis, California State University, Hayward, CA. 140 pp.

Swaim 2002 — Swaim, K. 2002. Results of surveys for special status reptiles at the Site 300 facilities of Lawrence Livermore National Laboratory. Prepared for Lawrence Livermore National Laboratory by Swaim Consulting. October 30, 2002. 10 pp.

Trenham 2001 — Trenham, P.C. 2001. Terrestrial habitat use by adult California tiger salamanders. J. Herpetology 35:343-346.

USDOE 2000 — USDOE. 2000. Memorandum of Agreement between the US Department of the Interior and the US Department of Energy for the A. grandiflora Reserve at Lawrence Livermore National Laboratory Site 300 Experimental Test Facility San Joaquin and Alameda Counties, California.

USFWS 1997 — USFWS. 1997. Large-flowered Fiddleneck (*Amsinckia grandiflora*) Recovery Plan. US Fish and Wildlife Service, Portland, OR. 44pp.

USFWS 1998 — U.S. Fish and Wildlife Service. 1998. Recovery plan for upland species of the San Joaquin Valley, California. U.S. Fish and Wildlife Service, Portland, OR. Pp 122-132.

USFWS 1999a — U.S. Fish and Wildlife Service. 1999a. Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*). Species account. Prepared by the Endangered Species Division, Sacramento Fish and Wildlife office, U.S. Fish and Wildlife Service. Available online at: http://sacramento.fws.gov/es/animal_spp_acct/valley_elderberry_longhorn_beetl.htm.

USFWS 1999b — U.S. Fish and Wildlife Service. 1999b. Conservation guidelines for the valley elderberry longhorn beetle. Sacramento, CA. 13 pp. Available online at: http://sacramento.fws.gov/es/documents/velb_conservation.htm.

USFWS 2000 — U.S. Fish and Wildlife Service. 2000. Endangered and threatened wildlife and plants; listing the Santa Barbara County distinct population segment of the California Tiger Salamander as Endangered; Final Rule. Federal Register 65(184): 57242-57264.

USFWS 2001 — U.S. Fish and Wildlife Service. 2001. Final determination of critical habitat for the California red-legged frog. Federal Register 66(49): 14626-14758.

USFWS 2002a — U. S. Fish and Wildlife Service. 2002a. Sacramento Fish and Wildlife Office California red-legged frog recovery. Available online at: http://sacramento.fws.gov/es/herps/crf.htm.

USFWS 2002b — U. S. Fish and Wildlife Service. 2002b. Recovery plan for the California red-legged frog *(Rana aurora draytonii)*. Region 1, U. S. Fish and Wildlife Service Portland, Oregon. Available online at: http://sacramento.fws.gov/es/herps/crf.htm.

USFWS 2003a — U.S. Fish and Wildlife Service. 2003. San Joaquin Kit Fox (*Vulpes macrotis mutica*) species account. Prepared by Endangered Species Div., Sacramento Fish & Wildlife Office. Available online at: http://sacramento.fws.gov/es/animal_spp_acct/sj_kit_fox.htm.

USFWS 2003b — U.S. Fish and Wildlife Service. 2003b. Endangered and threatened wildlife and plants; determination of endangered status for the Sonoma County distinct population segment of the California tiger salamander; final rule. Federal Register 68(53): 13498-13520.

USFWS 2003c — U.S. Fish and Wildlife Service. 2003. Alameda whipsnake (*Masticophis lateralis euryxanthus*). Species account. Prepared by Endangered Species Div., Sacramento Fish & Wildlife Office, U.S. Fish & Wildlife Service. Available online at: http://sacramento.fws.gov/es/animal_spp_acct/alameda_whipsnake.htm.

van Hattem 2003a — van Hattem, M.G. 2003. The current and historical distribution of special status amphibians at the Livermore Site and Site 300. Lawrence Livermore National Laboratory, Alameda and San Joaquin Counties, California. Draft Report. April 2003.

ENCLOSURE A

Endangered and Threatened Species that May Occur in or be Affected by Projects in the Area of the Following California Counties

Reference File No. 1-1-03-SP-0162

October 28, 2002

ALAMEDA COUNTY

Listed Species

Mammals

- San Joaquin kit fox, *Vulpes macrotis mutica* (E)
- riparian (San Joaquin Valley) woodrat, *Neotoma fuscipes riparia* (E) *
- riparian brush rabbit, *Sylvilagus bachmani riparius* (E) *
- salt marsh harvest mouse, *Reithrodontomys raviventris* (E)

Birds

- California brown pelican, *Pelecanus occidentalis californicus* (E)
- California clapper rail, *Rallus longirostris obsoletus* (E)
- California least tern, *Sterna antillarum (=albifrons) browni* (E)
- bald eagle, *Haliaeetus leucocephalus* (T)

Reptiles

- Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)
- Critical habitat, Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

Amphibians

- California red-legged frog, *Rana aurora draytonii* (T)
- California tiger salamander, *Ambystoma californiense* (C/E)
- Critical habitat, California red-legged frog, *Rana aurora draytonii* (T)

Fish

- Central California Coastal steelhead, *Oncorhynchus mykiss* (T) NMFS
- Central Valley spring-run chinook salmon, *Oncorhynchus tshawytscha* (T) NMFS
- Critical habitat, winter-run chinook salmon, *Oncorhynchus tshawytscha* (E) NMFS
- Sacramento splittail, *Pogonichthys macrolepidotus* (T)
- coho salmon - central CA coast, *Oncorhynchus kisutch* (T) NMFS
- delta smelt, *Hypomesus transpacificus* (T) *
- tidewater goby, *Eucyclogobius newberryi* (E)
- winter-run chinook salmon, *Oncorhynchus tshawytscha* (E) NMFS

Invertebrates

- bay checkerspot butterfly, *Euphydryas editha bayensis* (T)
- callippe silverspot butterfly, *Speyeria callippe callippe* (E)
- longhorn fairy shrimp, *Branchinecta longiantenna* (E)

vernal pool fairy shrimp, *Branchinecta lynchi* (T)

vernal pool tadpole shrimp, *Lepidurus packardi* (E)

Plants

California sea blite, *Suaeda californica* (E) *

Contra Costa goldfields, *Lasthenia conjugens* (E)

Presidio clarkia, *Clarkia franciscana* (E)

Santa Cruz tarplant, *Holocarpha macradenia* (T) *

large-flowered fiddleneck, *Amsinckia grandiflora* (E)

pallid manzanita (=Alameda or Oakland Hills manzanita), *Arctostaphylos pallida* (T)

palmate-bracted bird's-beak, *Cordylanthus palmatus* (E)

robust spineflower, *Chorizanthe robusta var. robusta* (E) *

showy Indian clover, *Trifolium amoenum* (E) *

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Invertebrates

Critical habitat, vernal pool invertebrates, *See Federal Register 67:59883* (PX)

Plants

Critical habitat, vernal pool plants, *See Federal Register 67:59883* (PX)

Candidate Species

Fish

Central Valley fall/late fall-run chinook salmon, *Oncorhynchus tshawytscha* (C) NMFS

Critical habitat, Central Valley fall/late fall-run chinook, *Oncorhynchus tshawytscha* (C) NMFS

Species of Concern

Mammals

Alameda Island mole, *Scapanus latimanus parvus* (SC)

Berkeley kangaroo rat, *Dipodomys heermanni berkeleyensis* (SC) *

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)

San Francisco dusky-footed woodrat, *Neotoma fuscipes annectens* (SC)

San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Yuma myotis bat, *Myotis yumanensis* (SC)

fringed myotis bat, *Myotis thysanodes* (SC)

greater western mastiff-bat, *Eumops perotis californicus* (SC)

long-eared myotis bat, *Myotis evotis* (SC)

long-legged myotis bat, *Myotis volans* (SC)

salt marsh vagrant shrew, *Sorex vagrans halicoetes* (SC)

small-footed myotis bat, *Myotis ciliolabrum* (SC)

Birds

Alameda (South Bay) song sparrow, *Melospiza melodia pusillula* (SC)
Aleutian Canada goose, *Branta canadensis leucopareia* (D)
Allen's hummingbird, *Selasphorus sasin* (SC)
American bittern, *Botaurus lentiginosus* (SC)
American peregrine falcon, *Falco peregrinus anatum* (D)
Bell's sage sparrow, *Amphispiza belli belli* (SC)
California thrasher, *Toxostoma redivivum* (SC)
Costa's hummingbird, *Calypte costae* (SC)
Lawrence's goldfinch, *Carduelis lawrencei* (SC)
Lewis' woodpecker, *Melanerpes lewis* (SC)
Vaux's swift, *Chaetura vauxi* (SC)
bank swallow, *Riparia riparia* (CA)
black rail, *Laterallus jamaicensis coturniculus* (CA)
common loon, *Gavia immer* (SC)
ferruginous hawk, *Buteo regalis* (SC)
grasshopper sparrow, *Ammodramus savannarum* (SC)
hermit warbler, *Dendroica occidentalis* (SC)
little willow flycatcher, *Empidonax traillii brewsteri* (CA)
loggerhead shrike, *Lanius ludovicianus* (SC)
long-billed curlew, *Numenius americanus* (SC)
oak titmouse, *Baeolophus inornatus* (SLC)
olive-sided flycatcher, *Contopus cooperi* (SC)
rufous hummingbird, *Selasphorus rufus* (SC)
saltmarsh common yellowthroat, *Geothlypis trichas sinuosa* (SC)
short-eared owl, *Asio flammeus* (SC)
tricolored blackbird, *Agelaius tricolor* (SC)
western burrowing owl, *Athene cunicularia hypugaea* (SC)
white-faced ibis, *Plegadis chihi* (SC)
white-tailed (=black shouldered) kite, *Elanus leucurus* (SC)

Reptiles

California horned lizard, *Phrynosoma coronatum frontale* (SC)
San Joaquin coachwhip (=whipsnake), *Masticophis flagellum ruddocki* (SC)
northwestern pond turtle, *Clemmys marmorata marmorata* (SC)
silvery legless lizard, *Anniella pulchra pulchra* (SC)
southwestern pond turtle, *Clemmys marmorata pallida* (SC)

Amphibians

foothill yellow-legged frog, *Rana boylii* (SC)

western spadefoot toad, *Spea hammondii* (SC)

Fish

Pacific lamprey, *Lampetra tridentata* (SC)

green sturgeon, *Acipenser medirostris* (SC)

longfin smelt, *Spirinchus thaleichthys* (SC)

river lamprey, *Lampetra ayresi* (SC)

Invertebrates

Bridges' Coast Range shoulderband snail, *Helminthoglypta nickliniana bridgesi* (SC)

California linderiella fairy shrimp, *Linderiella occidentalis* (SC)

Fairmont (=Lum's) microblind harvestman, *Microcina lumi* (SC)

Opler's longhorn moth, *Adela oplerella* (SC)

Ricksecker's water scavenger beetle, *Hydrochara ricksecker*i (SC)

San Francisco lacewing, *Nothochrysa californica* (SC)

curved-foot hygrotus diving beetle, *Hygrotus curvipes* (SC)

Plants

Ben Lomond buckwheat (= naked buckwheat), *Eriogonum nudum var. decurrens* (SC)

Choris's (=artist's) popcorn-flower, *Plagiobothrys chorisianus var chorisianus* (SLC) *

Congdon's tarplant, *Hemizonia parryi ssp. congdonii* (SC)

Diablo helianthella (=rock-rose), *Helianthella castanea* (SC)

Hall's bush mallow, *Malacothamnus hallii (=M. fasciculatus)* (SLC)

Hoover's button-celery, *Eryngium aristulatum var. hooveri* (SC)

Hoover's cryptantha, *Cryptantha hooveri* (SLC)

Kellogg's horkelia, *Horkelia cuneata ssp. sericea* (SC) *

Lemmon's jewelflower, *Caulanthus coulteri var lemmonii* (SLC) *

Livermore tarplant, *Deinandra bacigalupii* (SC)

Loma Prieta hoita, *Hoita strobilina* (SC) *

Mason's lilaeopsis, *Lilaeopsis masonii* (SC)

Mt. Hamilton coreopsis, *Coreopsis hamiltonii* (SC)

Mt. Hamilton thistle, *Cirsium fontinale var. campylon* (SC)

Napa western flax, *Hesperolinon serpentinum* (SC)

Pacific cordgrass (=California cordgrass), *Sparina foliosa* (SLC)

San Francisco Bay spineflower, *Chorizanthe cuspidata var. cuspidata* (SC) *

San Francisco popcornflower, *Plagiobothrys diffusus* (CA)

San Joaquin spearscale (=saltbush), *Atriplex joaquiniana* (SC)

Sharsmith's onion, *Allium sharsmithae* (SC)

South Bay clarkia (=Santa Clara red ribbons), *Clarkia concinna ssp. automixa* (SC)
Tiburon buckwheat, *Eriogonum caninum* (SLC)
adobe sanicle, *Sanicula maritima* (SC) *
alkali milk-vetch, *Astragalus tener var. tener* (SC)
bent-flowered fiddleneck, *Amsinckia lunaris* (SLC)
big tarplant, *Blepharizonia plumosa ssp. plumosa* (SC)
big-scale (=California) balsamroot, *Balsamorhiza macrolepis var macrolepis* (SLC)
brittlescale, *Atriplex depressa* (SC)
caper-fruited tropidocarpum, *Tropidocarpum capparideum* (SC) *
chaparral harebell (=bellflower), *Campanula exigua* (SLC)
delta tule-pea, *Lathyrus jepsonii var. jepsonii* (SC)
diamond-petaled California poppy, *Eschscholzia rhombipetala* (SC)
fragrant fritillary (= prairie bells), *Fritillaria liliacea* (SC)
hairless allocarya (=popcornflower), *Plagiobothrys glaber* (SC) **
heartscale, *Atriplex cordulata* (SC)
hispid bird's-beak, *Cordylanthus mollis ssp. hispidus* (SC)
interior California (Hospital Canyon) larkspur, *Delphinium californicum ssp. interius* (SC)
large-flowered (=flower) linanthus, *Linanthus grandiflorus* (SC)
little mousetail, *Myosurus minimus ssp. apus* (SC)
most beautiful (uncommon) jewelflower, *Streptanthus albidus ssp. peramoenus* (SC)
northcoast (=Point Reyes) bird's-beak, *Cordylanthus maritimus ssp. palustris* (SC) *
prostrate navarretia (=prostrate pincushionplant), *Navarretia prostrata* (SC) *
recurved larkspur, *Delphinium recurvatum* (SC)
robust monardella (=robust coyote mint), *Monardella villosa ssp globosa* (SLC)
salt marsh owl's clover (=johnny-nip), *Castilleja ambigua ssp. ambigua* (SLC)
serpentine bedstraw, *Galium andrewsii ssp. gatense* (SLC)
stinkbells, *Fritillaria agrestis* (SLC)
talus fritillary, *Fritillaria falcata* (SC)
water sack (=saline) clover, *Trifolim depauperatum var. hydrophilum* (SC)
western leatherwood, *Dirca occidentalis* (SLC)

SAN JOAQUIN COUNTY

Listed Species

Mammals

San Joaquin kit fox, *Vulpes macrotis mutica* (E)
riparian (San Joaquin Valley) woodrat, *Neotoma fuscipes riparia* (E)
riparian brush rabbit, *Sylvilagus bachmani riparius* (E)

Birds

bald eagle, *Haliaeetus leucocephalus* (T)

Reptiles

Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

Critical habitat, Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

giant garter snake, *Thamnophis gigas* (T)

Amphibians

California red-legged frog, *Rana aurora draytonii* (T)

California tiger salamander, *Ambystoma californiense* (C/E)

Critical habitat, California red-legged frog, *Rana aurora draytonii* (T)

Fish

Central Valley steelhead, *Oncorhynchus mykiss* (T) NMFS

Critical habitat, delta smelt, *Hypomesus transpacificus* (T)

Critical habitat, winter-run chinook salmon, *Oncorhynchus tshawytscha* (E) NMFS

Sacramento splittail, *Pogonichthys macrolepidotus* (T)

delta smelt, *Hypomesus transpacificus* (T)

winter-run chinook salmon, *Oncorhynchus tshawytscha* (E) NMFS

Invertebrates

Conservancy fairy shrimp, *Branchinecta conservatio* (E)

longhorn fairy shrimp, *Branchinecta longiantenna* (E)

valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

vernal pool fairy shrimp, *Branchinecta lynchi* (T)

vernal pool tadpole shrimp, *Lepidurus packardi* (E)

Plants

Critical habitat, large-flowered fiddleneck, *Amsinckia grandiflora* (E)

Greene's tuctoria (=Orcutt grass), *Tuctoria greenei* (E) *

large-flowered fiddleneck, *Amsinckia grandiflora* (E)

palmate-bracted bird's-beak, *Cordylanthus palmatus* (E) *

succulent (=fleshy) owl's-clover, *Castilleja campestris ssp. succulenta* (T)

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Invertebrates

Critical habitat, vernal pool invertebrates, *See Federal Register 67:59883* (PX)

Plants

Critical habitat, vernal pool plants, *See Federal Register 67:59883* (PX)

Candidate Species

Birds

Western yellow-billed cuckoo, *Coccyzus americanus occidentalis* (C) *

Fish

Central Valley fall/late fall-run chinook salmon, *Oncorhynchus tshawytscha* (C) NMFS

Critical habitat, Central Valley fall/late fall-run chinook, *Oncorhynchus tshawytscha* (C) NMFS

Species of Concern

Mammals

Merced kangaroo rat, *Dipodomys heermanni dixoni* (SC)

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)

San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Yuma myotis bat, *Myotis yumanensis* (SC)

fringed myotis bat, *Myotis thysanodes* (SC)

greater western mastiff-bat, *Eumops perotis californicus* (SC)

long-eared myotis bat, *Myotis evotis* (SC)

long-legged myotis bat, *Myotis volans* (SC)

small-footed myotis bat, *Myotis ciliolabrum* (SC)

Birds

Aleutian Canada goose, *Branta canadensis leucopareia* (D)

American bittern, *Botaurus lentiginosus* (SC)

American peregrine falcon, *Falco peregrinus anatum* (D)

Bell's sage sparrow, *Amphispiza belli belli* (SC)

California thrasher, *Toxostoma redivivum* (SC)

Lawrence's goldfinch, *Carduelis lawrencei* (SC)

Lewis' woodpecker, *Melanerpes lewis* (SC)

Nuttall's woodpecker, *Picoides nuttallii* (SLC)

Swainson's hawk, *Buteo Swainsoni* (CA)

bank swallow, *Riparia riparia* (CA)

black rail, *Laterallus jamaicensis coturniculus* (CA)

black tern, *Chlidonias niger* (SC)

common loon, *Gavia immer* (SC)

ferruginous hawk, *Buteo regalis* (SC)

grasshopper sparrow, *Ammodramus savannarum* (SC)

greater sandhill crane, *Grus canadensis tabida* (CA)

little willow flycatcher, *Empidonax traillii brewsteri* (CA)

loggerhead shrike, *Lanius ludovicianus* (SC)

long-billed curlew, *Numenius americanus* (SC)
oak titmouse, *Baeolophus inornatus* (SLC)
olive-sided flycatcher, *Contopus cooperi* (SC)
rufous hummingbird, *Selasphorus rufus* (SC)
short-eared owl, *Asio flammeus* (SC)
tricolored blackbird, *Agelaius tricolor* (SC)
western burrowing owl, *Athene cunicularia hypugaea* (SC)
white-faced ibis, *Plegadis chihi* (SC)
white-tailed (=black shouldered) kite, *Elanus leucurus* (SC)

Reptiles

California horned lizard, *Phrynosoma coronatum frontale* (SC)
San Joaquin coachwhip (=whipsnake), *Masticophis flagellum ruddocki* (SC)
northwestern pond turtle, *Clemmys marmorata marmorata* (SC)
silvery legless lizard, *Anniella pulchra pulchra* (SC)
southwestern pond turtle, *Clemmys marmorata pallida* (SC)

Amphibians

foothill yellow-legged frog, *Rana boylii* (SC)
western spadefoot toad, *Spea hammondii* (SC)

Fish

Kern brook lamprey, *Lampetra hubbsi* (SC)
Pacific lamprey, *Lampetra tridentata* (SC)
green sturgeon, *Acipenser medirostris* (SC)
longfin smelt, *Spirinchus thaleichthys* (SC)
river lamprey, *Lampetra ayresi* (SC)

Invertebrates

Antioch Dunes anthicid beetle, *Anthicus antiochensis* (SC)
California linderiella fairy shrimp, *Linderiella occidentalis* (SC)
Midvalley fairy shrimp, *Branchinecta mesovallensis* (SC)
Sacramento anthicid beetle, *Anthicus sacramento* (SC)
curved-foot hygrotus diving beetle, *Hygrotus curvipes* (SC)
moestan blister beetle, *Lytta moesta* (SC)
molestan blister beetle, *Lytta molesta* (SC)

Plants

Boggs Lake hedge-hyssop, *Gratiola heterosepala* (CA)
Hoover's cryptantha, *Cryptantha hooveri* (SLC)
Lemmon's jewelflower, *Caulanthus coulteri var lemmonii* (SLC)
Livermore tarplant, *Deinandra bacigalupii* (SC)

Mason's lilaeopsis, *Lilaeopsis masonii* (SC)
San Joaquin spearscale (=saltbush), *Atriplex joaquiniana* (SC) *
Suisun Marsh aster, *Aster lentus* (SC)
alkali milk-vetch, *Astragalus tener var. tener* (SC) *
big tarplant, *Blepharizonia plumosa ssp. plumosa* (SC) *
caper-fruited tropidocarpum, *Tropidocarpum capparideum* (SC) *
delta coyote-thistle (=button-celery), *Eryngium racemosum* (CA) *
delta tule-pea, *Lathyrus jepsonii var. jepsonii* (SC)
heartscale, *Atriplex cordulata* (SC) *
interior California (Hospital Canyon) larkspur, *Delphinium californicum ssp. interius* (SC)
showy (=golden) madia, *Madia radiata* (SC) *
slough thistle, *Cirsium crassicaule* (SC)
valley sagittaria (=Sanford's arrowhead), *Sagittaria sanfordii* (SC)

KEY:

(E)	*Endangered*	Listed (in the Federal Register) as being in danger of extinction.
(T)	*Threatened*	Listed as likely to become endangered within the foreseeable future.
(P)	*Proposed*	Officially proposed (in the Federal Register) for listing as endangered or threatened.
(PX)	*Proposed Critical Habitat*	Proposed as an area essential to the conservation of the species.
(C)	*Candidate*	Candidate to become a *proposed* species.
(SC)	*Species of Concern*	Other species of concern to the Service.
(SLC)	*Species of Local Concern*	Species of local or regional concern or conservation significance.
(D)	*Delisted*	Delisted. Status to be monitored for 5 years.
(CA)	*State-Listed*	Listed as threatened or endangered by the State of California.
NMFS	NMFS species	Under jurisdiction of the National Marine Fisheries Service. Contact them directly.
*	*Extirpated*	Possibly extirpated from the area.
**	*Extinct*	Possibly extinct
	Critical Habitat	Area essential to the conservation of a species.

ENCLOSURE A

Endangered and Threatened Species that May Occur in
or be Affected by Projects in the Selected Quads Listed Below
Reference File No. 1-1-03-SP-0162
October 28, 2002

QUAD: 445A MIDWAY

Listed Species

Mammals

riparian (San Joaquin Valley) woodrat, *Neotoma fuscipes riparia* (E) *

riparian brush rabbit, *Sylvilagus bachmani riparius* (E) *

San Joaquin kit fox, *Vulpes macrotis mutica* (E)

Birds

bald eagle, *Haliaeetus leucocephalus* (T)

Reptiles

Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

Critical habitat, Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

giant garter snake, *Thamnophis gigas* (T)

Amphibians

California tiger salamander, *Ambystoma californiense* (C/E)

California red-legged frog, *Rana aurora draytonii* (T)

Critical habitat, California red-legged frog, *Rana aurora draytonii* (T)

Fish

Critical habitat, delta smelt, *Hypomesus transpacificus* (T)

delta smelt, *Hypomesus transpacificus* (T)

Central Valley steelhead, *Oncorhynchus mykiss* (T) NMFS

Sacramento splittail, *Pogonichthys macrolepidotus* (T)

Invertebrates

longhorn fairy shrimp, *Branchinecta longiantenna* (E)

vernal pool fairy shrimp, *Branchinecta lynchi* (T)

valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

vernal pool tadpole shrimp, *Lepidurus packardi* (E)

Plants

Critical habitat, large-flowered fiddleneck, *Amsinckia grandiflora* (E)

large-flowered fiddleneck, *Amsinckia grandiflora* (E)

showy Indian clover, *Trifolium amoenum* (E) *

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Candidate Species

Fish

Central Valley fall/late fall-run chinook salmon, *Oncorhynchus tshawytscha* (C) NMFS

Species of Concern

Mammals

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)

greater western mastiff-bat, *Eumops perotis californicus* (SC)

small-footed myotis bat, *Myotis ciliolabrum* (SC)

long-eared myotis bat, *Myotis evotis* (SC)

fringed myotis bat, *Myotis thysanodes* (SC)

long-legged myotis bat, *Myotis volans* (SC)

Yuma myotis bat, *Myotis yumanensis* (SC)

San Francisco dusky-footed woodrat, *Neotoma fuscipes annectens* (SC)

San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Birds

tricolored blackbird, *Agelaius tricolor* (SC)

grasshopper sparrow, *Ammodramus savannarum* (SC)

Bell's sage sparrow, *Amphispiza belli belli* (SC)

short-eared owl, *Asio flammeus* (SC)

western burrowing owl, *Athene cunicularia hypugaea* (SC)

oak titmouse, *Baeolophus inornatus* (SLC)

ferruginous hawk, *Buteo regalis* (SC)

Costa's hummingbird, *Calypte costae* (SC)

Lawrence's goldfinch, *Carduelis lawrencei* (SC)

Vaux's swift, *Chaetura vauxi* (SC)

black tern, *Chlidonias niger* (SC)

white-tailed (=black shouldered) kite, *Elanus leucurus* (SC)

little willow flycatcher, *Empidonax traillii brewsteri* (CA)

American peregrine falcon, *Falco peregrinus anatum* (D)

greater sandhill crane, *Grus canadensis tabida* (CA)

loggerhead shrike, *Lanius ludovicianus* (SC)

Lewis' woodpecker, *Melanerpes lewis* (SC)

long-billed curlew, *Numenius americanus* (SC)

rufous hummingbird, *Selasphorus rufus* (SC)

Allen's hummingbird, *Selasphorus sasin* (SC)

California thrasher, *Toxostoma redivivum* (SC)

Reptiles

silvery legless lizard, *Anniella pulchra pulchra* (SC)

northwestern pond turtle, *Clemmys marmorata marmorata* (SC)

southwestern pond turtle, *Clemmys marmorata pallida* (SC)

San Joaquin coachwhip (=whipsnake), *Masticophis flagellum ruddocki* (SC)

California horned lizard, *Phrynosoma coronatum frontale* (SC)

Amphibians

foothill yellow-legged frog, *Rana boylii* (SC)

western spadefoot toad, *Spea hammondii* (SC)

Fish

green sturgeon, *Acipenser medirostris* (SC)

river lamprey, *Lampetra ayresi* (SC)

Pacific lamprey, *Lampetra tridentata* (SC)

longfin smelt, *Spirinchus thaleichthys* (SC)

Invertebrates

curved-foot hygrotus diving beetle, *Hygrotus curvipes* (SC)

California linderiella fairy shrimp, *Linderiella occidentalis* (SC)

Plants

big tarplant, *Blepharizonia plumosa ssp. plumosa* (SC)

Lemmon's jewelflower, *Caulanthus coulteri var lemmonii* (SLC)

Livermore tarplant, *Deinandra bacigalupii* (SC) ?

diamond-petaled California poppy, *Eschscholzia rhombipetala* (SC)

showy (=golden) madia, *Madia radiata* (SC) *

caper-fruited tropidocarpum, *Tropidocarpum capparideum* (SC) **

QUAD: 445B ALTAMONT

Listed Species

Mammals

riparian (San Joaquin Valley) woodrat, *Neotoma fuscipes riparia* (E) *

riparian brush rabbit, *Sylvilagus bachmani riparius* (E) *

San Joaquin kit fox, *Vulpes macrotis mutica* (E)

Birds

bald eagle, *Haliaeetus leucocephalus* (T)

Reptiles

Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

Critical habitat, Alameda whipsnake, *Masticophis lateralis euryxanthus* (T)

Amphibians

California tiger salamander, *Ambystoma californiense* (C/E)

California red-legged frog, *Rana aurora draytonii* (T)

Critical habitat, California red-legged frog, *Rana aurora draytonii* (T)

Fish

delta smelt, *Hypomesus transpacificus* (T)

Central California Coastal steelhead, *Oncorhynchus mykiss* (T) NMFS

Central Valley steelhead, *Oncorhynchus mykiss* (T) NMFS

Sacramento splittail, *Pogonichthys macrolepidotus* (T)

Invertebrates

longhorn fairy shrimp, *Branchinecta longiantenna* (E)

vernal pool fairy shrimp, *Branchinecta lynchi* (T)

Plants

palmate-bracted bird's-beak, *Cordylanthus palmatus* (E)

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Invertebrates

Critical habitat, vernal pool invertebrates, *See Federal Register 67:59883* (PX)

Plants

Critical habitat, vernal pool plants, *See Federal Register 67:59883* (PX)

Candidate Species

Fish

Central Valley fall/late fall-run chinook salmon, *Oncorhynchus tshawytscha* (C) NMFS

Species of Concern

Mammals

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)

greater western mastiff-bat, *Eumops perotis californicus* (SC)

small-footed myotis bat, *Myotis ciliolabrum* (SC)

long-eared myotis bat, *Myotis evotis* (SC)

fringed myotis bat, *Myotis thysanodes* (SC)

long-legged myotis bat, *Myotis volans* (SC)

Yuma myotis bat, *Myotis yumanensis* (SC)

San Francisco dusky-footed woodrat, *Neotoma fuscipes annectens* (SC)

San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Birds

- tricolored blackbird, *Agelaius tricolor* (SC)
- grasshopper sparrow, *Ammodramus savannarum* (SC)
- Bell's sage sparrow, *Amphispiza belli belli* (SC)
- short-eared owl, *Asio flammeus* (SC)
- western burrowing owl, *Athene cunicularia hypugaea* (SC)
- oak titmouse, *Baeolophus inornatus* (SLC)
- ferruginous hawk, *Buteo regalis* (SC)
- Costa's hummingbird, *Calypte costae* (SC)
- Lawrence's goldfinch, *Carduelis lawrencei* (SC)
- Vaux's swift, *Chaetura vauxi* (SC)
- black tern, *Chlidonias niger* (SC)
- white-tailed (=black shouldered) kite, *Elanus leucurus* (SC)
- little willow flycatcher, *Empidonax traillii brewsteri* (CA)
- American peregrine falcon, *Falco peregrinus anatum* (D)
- greater sandhill crane, *Grus canadensis tabida* (CA)
- loggerhead shrike, *Lanius ludovicianus* (SC)
- Lewis' woodpecker, *Melanerpes lewis* (SC)
- long-billed curlew, *Numenius americanus* (SC)
- rufous hummingbird, *Selasphorus rufus* (SC)
- Allen's hummingbird, *Selasphorus sasin* (SC)
- California thrasher, *Toxostoma redivivum* (SC)

Reptiles

- silvery legless lizard, *Anniella pulchra pulchra* (SC)
- northwestern pond turtle, *Clemmys marmorata marmorata* (SC)
- southwestern pond turtle, *Clemmys marmorata pallida* (SC)
- San Joaquin coachwhip (=whipsnake), *Masticophis flagellum ruddocki* (SC)
- California horned lizard, *Phrynosoma coronatum frontale* (SC)

Amphibians

- foothill yellow-legged frog, *Rana boylii* (SC)
- western spadefoot toad, *Spea hammondii* (SC)

Fish

- green sturgeon, *Acipenser medirostris* (SC)
- river lamprey, *Lampetra ayresi* (SC)
- Pacific lamprey, *Lampetra tridentata* (SC)
- longfin smelt, *Spirinchus thaleichthys* (SC)

Invertebrates

curved-foot hygrotus diving beetle, *Hygrotus curvipes* (SC)

California linderiella fairy shrimp, *Linderiella occidentalis* (SC)

Plants

bent-flowered fiddleneck, *Amsinckia lunaris* (SLC)

alkali milk-vetch, *Astragalus tener var. tener* (SC) *

heartscale, *Atriplex cordulata* (SC)

brittlescale, *Atriplex depressa* (SC)

San Joaquin spearscale (=saltbush), *Atriplex joaquiniana* (SC)

big-scale (=California) balsamroot, *Balsamorhiza macrolepis var macrolepis* (SLC)

big tarplant, *Blepharizonia plumosa ssp. plumosa* (SC)

hispid bird's-beak, *Cordylanthus mollis ssp. hispidus* (SC)

Livermore tarplant, *Deinandra bacigalupii* (SC)

little mousetail, *Myosurus minimus ssp. apus* (SC)

hairless allocarya (=popcornflower), *Plagiobothrys glaber* (SC) **

water sack (=saline) clover, *Trifolim depauperatum var. hydrophilum* (SC)

caper-fruited tropidocarpum, *Tropidocarpum capparideum* (SC) **

KEY:

(E)	*Endangered*	Listed (in the Federal Register) as being in danger of extinction.
(T)	*Threatened*	Listed as likely to become endangered within the foreseeable future.
(P)	*Proposed*	Officially proposed (in the Federal Register) for listing as endangered or threatened.
(PX)	*Proposed Critical Habitat*	Proposed as an area essential to the conservation of the species.
(C)	*Candidate*	Candidate to become a *proposed* species.
(SC)	*Species of Concern*	May be endangered or threatened. Not enough biological information has been gathered to support listing at this time.
(SLC)	*Species of Local Concern*	Species of local or regional concern or conservation significance.
(MB)	*Migratory Bird*	Migratory bird
NMFS	NMFS species	Under the jurisdiction of the National Marine Fisheries Service. Contact them directly.
(D)	*Delisted*	Delisted. Status to be monitored for 5 years.
(CA)	*State-Listed*	Listed as threatened or endangered by the State of California.
(*)	*Extirpated*	Possibly extirpated from this quad.
(**)	*Extinct*	Possibly extinct.
	Critical Habitat	Area essential to the conservation of a species.

Enclosure B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: (1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species; (2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and (3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment-Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat is present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirement; interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; an analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of indirect effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, and problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

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[1]A construction project (or other undertaking having similar physical impacts) which is a major federal action significantly affecting the quality of the human environment as referred to in NEPA (42 U.S.C. 4332(2)C).

[2]"Effects of the action" refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

Enclosure C

GUIDELINES FOR CONDUCTING AND REPORTING BOTANICAL INVENTORIES FOR FEDERALLY LISTED, PROPOSED AND CANDIDATE PLANTS

(September 23, 1996)

These guidelines describe protocols for conducting botanical inventories for federally listed, proposed and candidate plants, and describe minimum standards for reporting results. The Service will use, in part, the information outlined below in determining whether the project under consideration may affect any listed, proposed or candidate plants, and in determining the direct, indirect, and cumulative effects.

Field inventories should be conducted in a manner that will locate listed, proposed, or candidate species (target species) that may be present. The entire project area requires a botanical inventory, except developed agricultural lands. The field investigator(s) should:

1. Conduct inventories at the appropriate times of year when target species are present and identifiable. Inventories will include all potential habitats. Multiple site visits during a field season may be necessary to make observations during the appropriate phenological stage of all target species.

2. If available, use a regional or local reference population to obtain a visual image of the target species and associated habitat(s). If access to reference populations(s) is not available, investigators should study specimens from local herbaria.

3. List every species observed and compile a comprehensive list of vascular plants for the entire project site. Vascular plants need to be identified to a taxonomic level which allows rarity to be determined.

4. Report results of botanical field inventories that include:

   a. a description of the biological setting, including plant community, topography, soils, potential habitat of target species, and an evaluation of environmental conditions, such as timing or quantity of rainfall, which may influence the performance and expression of target species.

   b. a map of project location showing scale, orientation, project boundaries, parcel size, and map quadrangle name.

   c. survey dates and survey methodology(ies).

   d. if a reference population is available, provide a written narrative describing the target species reference population(s) used, and date(s) when observations were made.

   e. a comprehensive list of all vascular plants occurring on the project site for each habitat type.

   f. current and historic land uses of the habitat(s) and degree of site alteration.

g. presence of target species off-site on adjacent parcels, if known.

h. an assessment of the biological significance or ecological quality of the project site in a local and regional context.

5. If target species is(are) found, report results that additionally include:

   a. a map showing federally listed, proposed and candidate species distribution as they relate to the proposed project.

   b. if target species is (are) associated with wetlands, a description of the direction and integrity of flow of surface hydrology. If target species is (are) affected by adjacent off-site hydrological influences, describe these factors.

   c. the target species phenology and microhabitat, an estimate of the number of individuals of each target species per unit area; identify areas of high, medium and low density of target species over the project site, and provide acres of occupied habitat of target species. Investigators could provide color slides, photos or color copies of photos of target species or representative habitats to support information or descriptions contained in reports.

   d. the degree of impact(s), if any, of the proposed project as it relates to the potential unoccupied habitat of target habitat.

6. Document findings of target species by completing California Native Species Field Survey Form(s) and submit form(s) to the Natural Diversity Data Base. Documentation of determinations and/or voucher specimens may be useful in cases of taxonomic ambiguities, habitat or range extensions.

7. Report as an addendum to the original survey, any change in abundance and distribution of target plants in subsequent years. Project sites with inventories older than 3 years from the current date of project proposal submission will likely need additional survey. Investigators need to assess whether an additional survey(s) is (are) needed.

8. Adverse conditions may prevent investigator(s) from determining presence or identifying some target species in potential habitat(s) of target species. Disease, drought, predation, or herbivory may preclude the presence or identification of target species in any year. An additional botanical inventory(ies) in a subsequent year(s) may be required if adverse conditions occur in a potential habitat(s). Investigator(s) may need to discuss such conditions.

9. Guidance from California Department of Fish and Game (CDFG) regarding plant and plant community surveys can be found in Guidelines for Assessing the Effects of Proposed Developments on Rare and Endangered Plants and Plant Communities, 1984. Please contact the CDFG Regional Office for questions regarding the CDFG guidelines and for assistance in determining any applicable State regulatory requirements.

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APPENDIX F: FLOODPLAIN AND WETLANDS ASSESSMENT

F.1 INTRODUCTION

This appendix is prepared to provide an analysis of the potential impacts on floodplains and wetlands from the No Action Alternative, Proposed Action, and Reduced Operation Alternative. See Chapter 3 of the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS). It is also prepared to demonstrate U.S. Department of Energy (DOE) 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, respectively. Figure F.1–1 illustrates the relationship of Appendix F to other LLNL appendices and sections of the text in this LLNL SW/SPEIS, and DOE requirements.

F.2 FLOODPLAIN EFFECTS

F.2.1 Methods

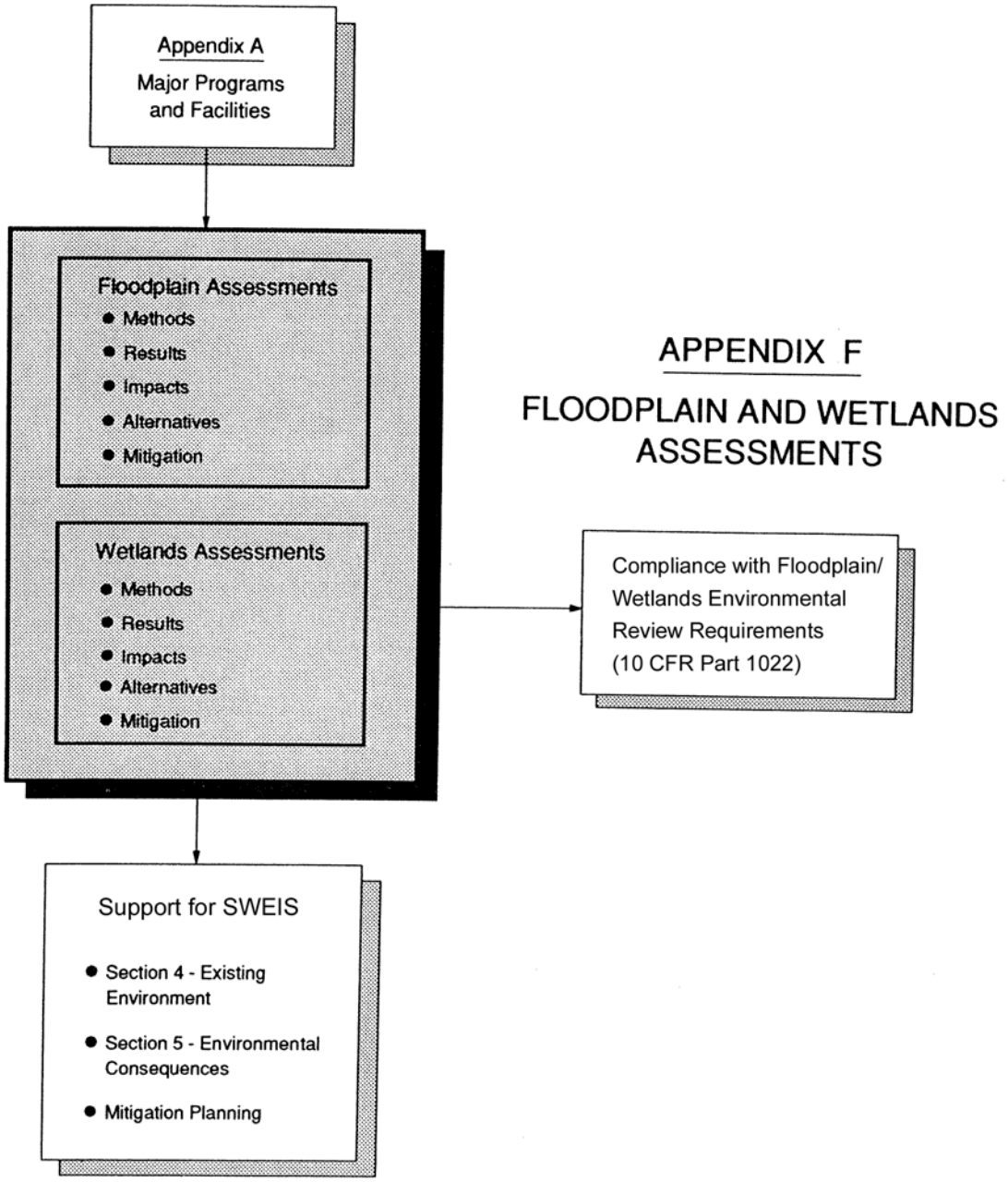
Livermore Site

The 100-year floodplain at the Livermore Site was identified from studies performed in 1981 and 1997 by the Federal Emergency Management Agency (FEMA) to determine flood hazards in the Alameda County area. These floodplains were incorporated into the Flood Insurance Rate Maps (FEMA 1997a, FEMA 1997b, FEMA 1981) and are shown in Figure F.2.1–1.

Since completion of the FEMA studies, DOE has modified the banks and channel of the Arroyo Las Positas. Specifically, a berm was constructed along the southern bank of the arroyo to ensure that the 100-year flood event would not inundate the Livermore Site.

Site 300

Site 300 includes several large canyons that drain into Corral Hollow Creek. The Flood Insurance Rate Map for Corral Hollow Creek was used to characterize the 100-year floodplain in the area adjacent to the Site 300 (Figure F.2.1–2). Because FEMA did not map other areas within the Site 300 boundaries in their studies, DOE conducted modeling for the 1992 Lawrence Livermore National Laboratory (EIS/EIR) to characterize the 100-year floodplain for the canyons at Site 300. Three drainages (Oasis/Draney Canyon, Elk Ravine, and Middle Canyon) were used as representative drainages for the analysis. Peak runoff was computed using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center Flood Hydrograph Package (USACE 1981). Model parameters, which represented average conditions within the drainage basins, included drainage area, rainfall, precipitation loss factor, and unit hydrograph and flood routing parameters. The computed hydrographs at the outlet of each basin provide the peak flows for the 100-year flood event. The 500-year event was not examined because there is no 500-year floodplain in the Corral Hollow Creek area at Site 300.



Source: Original.

FIGURE F.1–1.—*Appendix F Interface with Site-wide Environmental Impact Statement Sections, Appendix A, and Regulatory Reviews*

As part of this LLNL SW/SPEIS, site-specific rainfall data from 1996 through 2002 were examined and compared to data used for the 1992 modeling effort. Rainfall intensities and amounts during this period were generally comparable to data used for the 1992 modeling effort; i.e., an average of about 10 inches per year, with most precipitation occurring in the winter months, with the exception of 1998 when almost 19 inches of precipitation were recorded at Site 300.

F.2.2 Results

Livermore Site

At the time of the FEMA mapping effort, the 100-year floodplain of the Arroyo Las Positas primarily extended north of the channel, but did extend south of the banks of the Arroyo Las Positas for a short distance. However, as previously discussed, the berm constructed for the Arroyo Las Positas Maintenance Project has effectively confined the 100-year floodplain to the buffer zone north of the Livermore Site. Thus, the southerly extent of the 100-year floodplain is no longer as depicted on Figure F.2.1–1.

As shown on Figure F.2.1–1, the 100-year and 500-year floodplains do encroach on the far eastern boundary of the Livermore Site. No structures are located within either the 100-year or 500-year floodplains in this area.

The Arroyo Seco crosses the Livermore Site at the far southwestern corner for a distance of about 1,800 feet. As shown on Figure F.2.1–1, the 100-year and 500-year floods are contained within the channel; therefore, Arroyo Seco poses no threat of flooding to the Livermore Site.

Site 300

As shown on Figure F.2.1–2, the 100-year floodplain of Corral Hollow Creek, as mapped by FEMA, is located adjacent to the General Services Area (GSA) area along Corral Hollow Road. Parts of Corral Hollow Road in this area are within the 100-year floodplain and would, therefore, be inundated during a 100-year event.

The results of DOE's modeling indicated peak flows of 91 cubic feet per second for Middle Canyon (13.9 feet wide), 368 cubic feet per second for Elk Ravine (19.5 feet wide), and 355 cubic feet per second for Oasis/Draney Canyon (19.6 feet wide). Depth of flow ranged from 1 to 2.4 feet. These results indicate that the 100-year flood elevation is contained within the channels; therefore, no 100-year floodplains exist at Site 300 (LLNL 1992a).

F.2.3 Impacts of the Proposed Action

Livermore Site

Because no structures are proposed to be located within the 100-year or 500-year floodplain at the Livermore Site under the Proposed Action, there would be no impact to the 100-year or 500-year floodplain from implementing the Proposed Action. Maintenance activities within the channel of the Arroyo Las Positas would continue. The impacts from these activities are

discussed in the project-specific environmental assessment prepared for that maintenance project (DOE 1998b).

The 1992 LLNL EIS/EIR assessed flooding of Livermore Valley by a postulated seismic failure of Del Valle Dam. It was concluded that under such a scenario, the Livermore Site would not be flooded. Similarly, a postulated seismic failure of the Patterson Reservoir or the nearby South Bay Aqueduct would not flood the Livermore Site because the floodwaters would flow into and be contained within Arroyo Las Positas and Arroyo Seco (LLNL 2001ay).

Site 300

Because there are no 100-year floodplains at Site 300, the Proposed Action would not affect 100-year floodplains. Furthermore, because the 100-year storm event is contained within the channels of the canyons and ravines at Site 300, activities at Site 300 would not be affected by the 100-year storm event.

F.3 WETLAND EFFECTS

Wetland delineations for 3 small wetland areas along Arroyo Las Positas at the Livermore Site and 16 wetlands at Site 300 were included in the 1992 LLNL EIS/EIR (LLNL 1992a). Subsequently, additional wetland delineations have been performed at the Livermore Site in 1997 and at Site 300 in August 2001 and July 2002 (Jones and Stokes 1997, 2002c). Text from the wetland delineation reports prepared in 1997 for Arroyo Las Positas and in 2002 for Site 300 have been incorporated into this appendix with little change to retain the nature of agreements between LLNL, DOE, and USACE regarding jurisdictional wetlands subject to Section 404 of the *Clean Water Act* (Jones and Stokes 1997, 2002c).

In January 2003, USACE and the U.S. Environmental Protection Agency (EPA) jointly released a request for agency and public comment on the definition of "waters of the U.S.," particularly the definition for isolated wetlands that are both intrastate and non-navigable (68 FR 1991). Depending on the terminology adopted for the revised definition of "waters of the U.S.," some of the wetlands currently anticipated to qualify as jurisdictional wetlands, listed in Table F.3.2.2–1, may become exempt from jurisdictional wetland regulation under Section 404 of the *Clean Water Act*. However, those wetlands may still qualify for protection under California law.

F.3.1 Livermore Site

F.3.1.1 *Methods*

Jurisdictional wetlands and other waters of the U.S. were delineated using the routine onsite determination procedure from the USACE wetland delineation manual (USACE 1987). The manual provides technical guidelines and methods for determining the boundaries of jurisdictional wetlands, based on three parameters:

- Hydrophytic vegetation
- Hydric soils

- Wetland hydrology

A wetland delineation was performed of Arroyo Las Positas on August 5, 1997. Sample plots were established in representative locations in each plant community present: six in wetland plant communities and one in the upland plant community. At each sample point, the dominant plant species were recorded (Jones and Stokes 1997).

Because flowing water was present in the Arroyo Las Positas channel, wetland hydrology was determined to be present by direct observation of inundation or saturation. Wetland hydrology is defined by the USACE to occur when an "area is inundated either permanently or periodically at mean water depths less than or equal to 6.6 feet, or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation" (USACE 1987). Under the USACE classification of wetland hydrologic regimes, wetlands typically are inundated or saturated for more than 12.5 percent of the growing season, although areas inundated or saturated between 5 percent and 12.5 percent of the time may also qualify as wetlands (Jones and Stokes 1997).

The growing season in Livermore is between 250 and 255 days (Welch et al. 1966); therefore, inundation or saturation for 31 days or more is characteristic of wetlands in the Livermore area, although areas inundated or saturated for more than 12.5 days may also qualify as wetlands.

Hydric soils were assumed to be present from an aquic moisture regime. An aquic moisture regime is one of the primary indicators of hydric soils (USACE 1987). This situation occurs when the soil is saturated by groundwater or water of the capillary fringe and respiration by microorganisms, roots, and soil fauna removes oxygen from the soil, creating reducing conditions. A peraquic moisture regime occurs when soils are permanently saturated. Areas potentially qualifying as wetlands or other waters of the U.S. which are subject to USACE jurisdiction, were mapped (Figures F.3.1.1–1, F.3.1.1–2, and F.3.1.1–3). Routine wetland determination forms were completed during the field delineation (Jones and Stokes 1997).

Approximately 900 feet of Arroyo Seco is on LLNL property. In July 2001, a wetland delineation survey was performed. Potential wetland areas are shown in Figure F.3.1.1–4 (LLNL 2001ap).

F.3.1.2 *Results and Discussion*

Arroyo Las Positas on the Livermore Site is an approximately trapezoidal channel. The channel is concrete-lined and riprapped at two locations where the channel makes 90-degree bends. Several other small concrete spillways occur in the channel and along the southern bank, where drainage outfalls occur. Most of the channel is vegetated, although several small areas of open, standing water are present. A total of 0.171 acre of open water habitat is present in the channel. A description of the plant communities present and an assessment of the hydrology and soils are presented below (Jones and Stokes 1997).

Vegetation

A total of 1.963 acres of wetland habitat is present in the Arroyo Las Positas channel. Three wetland plant communities were identified: ruderal wetland, freshwater marsh, and riparian scrub. The locations of the wetland plant communities are displayed in Figures F.3.1.1–1, F.3.1.1–2, and F.3.1.1–3. An upland plant community of annual grassland was present on the upper channel banks and in the fields north of the channel (Jones and Stokes 1997).

The scientific names and wetland indicator status of plant species mentioned in the text are provided in Table F.3.1.2–1. The wetland indicator status of plants has been determined under the following scheme: species that occur in wetlands 99 percent of the time are called obligate species; those that occur in wetlands 67 to 99 percent of the time are facultative-wet species; those equally likely to occur in wetlands or nonwetlands are facultative plant species; and those that occur 67 to 99 percent of the time in nonwetlands are facultative-upland species. Hydrophytic vegetation is defined as "macrophytic plant life growing in water, soil, or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content." An area has hydrophytic vegetation when, under normal circumstances, more than 50 percent of the vegetation is obligate, facultative-wet, or facultative species (Jones and Stokes 1997).

Ruderal Wetland

Ruderal plant species are adapted to colonizing recently disturbed soils. Ruderal wetland species colonize disturbed soils in areas with wetland hydrology, such as along streams, irrigation canals, and drainage ditches, and in pastures and irrigated cropland. The dominant species in the ruderal plant community along Arroyo Las Positas are tall flatsedge (*Cyperus eragrostis*), bristly ox-tongue (*Picris echioides*), bearded sprangletop (*Leptochloa fasciculata*), Bermuda grass (*Cynodon dactylon*), and barnyard grass (*Echinochloa crus-gallii*). Nearly half (45.9 percent) of the 37 species observed in the Arroyo Las Positas channel were nonnative ruderal species (Jones and Stokes 1997).

Freshwater Marsh

Freshwater marsh is a wetland plant community dominated by perennial, emergent monocots, typically cattails (*Typha*) or bulrushes (*Scirpus*). A freshwater marsh along Arroyo Las Positas is dominated by narrow-leaved cattail (*T. angustifolia*), broad-leaved cattail (*T. latifolia*), and alkali bulrush (*Scirpus robustus*). Many of the ruderal wetland species occurring in the channel are also associated with the freshwater marsh plant community (Jones and Stokes 1997).

Riparian Scrub

Riparian scrub is a streamside wetland plant community dominated by woody shrubs, typically willows (*Salix*). Most of the riparian scrub along Arroyo Las Positas is dominated by narrow-leaved willow (*S. exigua*). Goodding's willow (*S. gooddingii*), arroyo willow (*S. lasiolepis*), and red willow (*S. laevigata*) also occur along the channel. A small stand of cottonwoods (*Populus*), progeny of trees planted along the north side of the channel, is also becoming established in the channel (Jones and Stokes 1997).

TABLE F.3.1.2–1.—*Plant Species Observed in Arroyo Las Positas, Lawrence Livermore National Laboratory*

Scientific Name	Common Name	Channel Position		Wetland Indicator Status
		Upper Bank	Lower Bank and Channel Bottom	
Atriplex semibaccata	Australian saltbush	X		FAC
Atriplex triangularis	Halberd-leaved saltbush		X	FACW
Avena fatua	Wild oats	X		- -
Azolla filiculoides	Mosquito fem		X	OBL
Bromus diandrus	Ripgut brome	X		- -
Baccharis salicifolius	Mule fat		X	FACW
Bromus hordeaceus	Soft chess	X		FACU
Casuarina sp.	Beefwood		X	- -
Centaurea solstitialis	Yellow star-thistle	X		- -
Cirsium vulgare	Bull thistle		X	FACU
Convolvulus arvensis	Field bindweed	X		- -
Conyza bonariensis	South American horseweed	X		- -
Conyza canadensis	Canada horseweed	X	X	FAC
Crypsis schoenoides	Swamp timothy		X	OBL
Cynodon dactylon	Bermuda grass	X	X	FAC
Cyperus eragrostis	Tall flatsedge		X	FACW
Distichlis spicata	Saltgrass	X	X	FACW
Echinochloa crus-gallii	Barnyard grass		X	FACW
Epilobium brachycarpum	Panicled willow-herb	X	X	- -
Epilobium ciliatum	Hairy willow-herb		X	FACW
Eremocarpus setigerus	Turkey mullein	X		- -
Eschscholzia californica	California poppy	X		- -
Gnaphalium luteo-album	Weedy cudweed		X	FACW
Hemizonia fitchii	Fitch's spikeweed	X		- -
Hirschfeldia incana	Mediterranean mustard	X		- -
Leptochloafasciculata	Bearded sprangletop		X	OBL
Lolium multiflorum	Italian ryegrass	X	X	FAC
Lotus corniculatus	Bird's-foot trefoil		X	FAC
Lythrum hyssopifolium	Hyssop loosestrife		X	FACW
Malvella leprosa	Alkali mallow	X	X	FAC
Medicago polymorpha	California bur-clover	X		- -
Melilotus indica	Indian sweetclover	X		FAC
Oenothera biennis	Common evening-primrose		X	- -
Phalaris aquatica	Harding grass	X		FAC
Picris echioides	Bristly ox-tongue	X	X	FAC
Plantago lanceolata	English plantain	X		FAC
Polygonum persicaria	Lady's thumb		X	FACW
Polypogon monspeliensis	Annual rabbit's-foot grass		X	FACW
Populus fremontii	Fremont cottonwood		X	FACW

TABLE F.3.1.2–1.—*Plant Species Observed in Arroyo Las Positas, Lawrence Livermore National Laboratory (continued)*

Scientific Name	Common Name	Channel Position		Wetland Indicator Status
		Upper Bank	Lower Bank and Channel Bottom	
Ranunculus sceleratus	Celery-leaved buttercup		X	OBL
Rorippa nasturtium-aquaticum	Watercress		X	OBL
Rumex conglomeratus	Clustered dock		X	FACW
Rumex crispus	Curly dock	X	X	FACW
Salix exigua	Narrow-leaved willow		X	OBL
Salix gooddingiana	Black willow		X	OBL
Salix laevigata	Red willow		X	- -
Salix lasiolepis	Arroyo willow		X	FACW
Scirpus robustus	Alkali bulrush		X	OBL
Tragopogon porrifolius	Salsify	X		- -
Typha angustifolia	Narrow-leaved cattail		X	OBL
Typha latifolia	Broad-leaved cattail		X	OBL
Veronica anagallis-aquatica	Water speedwell		X	OBL
Vicia villosa	Winter vetch	X		- -
Xanthium strumarium	Common cocklebur		X	FAC

Source: Jones and Stokes 1997.
Wetland indicator status (USFWS 1988).
OBL = obligate, 99% occurrence in wetlands; FACW = Faculative Wetland, 66-99% occurrence in wetlands; FAC = Faculative, 33-66% occurrence in wetlands; FACU = Faculative upland, 1-33% occurrence in wetlands; -- = no indicator status, assumed to be upland species.

Annual Grassland

Annual grassland on the upper Arroyo Las Positas channel bank and outside of the channel is an upland plant community dominated by annual grasses and forbs. The dominant species on the site are wild oats (*Avena barbata*) and brome grasses (*Bromus*). Associated species include alkali mallow (*Malvella leprosa*) and yellow star-thistle (*Centaurea soltitialis*) (Jones and Stokes 1997).

Hydrology

An ordinary high watermark was not readily apparent in the Arroyo Las Positas channel. Evidence such as scour, watermarks, or sediment and debris deposits, was lacking. A small flow of water was observed in the channel where it enters the Livermore Site at its eastern boundary. This offsite source of water was not investigated. The flow of water was not continuous in the channel, and some sections of the channel were not inundated. Most of the water observed in the channel appeared to be treated groundwater that Livermore releases regularly into the channel. Because seasonal streams in California are dry during the summer months and because of the presence of perennial wetland vegetation in the stream channel, water is assumed to be present in the channel on a permanent or semipermanent basis. Because no ordinary high watermark was evident, the extent of saturated soil was used to distinguish the limit of wetland hydrology (Jones and Stokes 1997).

Soils

The present channel of Arroyo Las Positas on the Livermore Site was excavated in areas mapped as Rincon loam (zero- to 3-percent slopes), San Ysidro loam, and Rincon clay loam (3- to 7-percent slopes) (Welch et al. 1966). None of these soils are listed as hydric. Soils in the channel bottom and lower portion of the bank were assessed as hydric, based on the presence of a peraquic moisture regime. Soil characteristics in the channel were not examined, but hydric soil characteristics may have formed following redirection of the stream flow (Jones and Stokes 1997).

Jurisdictional Assessment

Approximately 2.13 acres are likely to be waters of the U.S., subject to USACE jurisdiction. Table F.3.1.2–2 shows wetlands and other waters by type and acreage (Jones and Stokes 1997). These delineations are preliminary and subject to verification by the USACE.

TABLE F.3.1.2–2.—*Wetland Acres, by Type and Size*

Habitat Type	Size (acres)
Open water	0.171
Ruderal wetland	1.224
Freshwater marsh	0.649
Riparian scrub	0.090
Total	**2.134**

Source: Jones and Stokes 1997.

In July 2001, a wetland delineation survey was performed along approximately 1,800 feet of Arroyo Seco on LLNL property. Within the arroyo, six vegetated areas were determined to be potential jurisdictional wetlands with a total area of 0.04 acre. These occur on the channel bottom with three of the areas associated with storm drain outfalls (LLNL 2001ap).

F.3.2 Site 300

F.3.2.1 *Methodology*

Wetlands were delineated using the routine onsite determination procedure described in the USACE Wetlands Delineation Manual (USACE 1987). Although the study site is larger than 5 acres, the routine determination procedure was used, rather than the comprehensive determination procedure, because the areas of potential wetlands were small and widely scattered across the site. Sampling along regular transects would not have been an effective or efficient means for determining wetland boundaries (Jones and Stokes 2002c).

During the vegetation mapping study conducted by Jones and Stokes in August 2001, field surveys were done to characterize the vegetation types and verify the map unit boundaries. The wetlands identified during the previous 1991 study were visited to verify their presence and to re-map their boundaries. Additional wetlands were identified by consulting with LLNL wildlife biologists familiar with Site 300 and by walking transects along the canyons. To delineate the

wetlands more accurately, global positioning system (GPS) data recorders were used to collect point locations and to record linear features and map unit polygons. Wetland boundaries were identified in the field on the basis of the plant community present. Areas of hydrophytic vegetation, composed of green, growing perennials, were readily differentiated from the adjacent upland vegetation composed of brown, dried annual grasses.

Additional information on wetland soils was collected on July 3, 2002. Because of the overall similarity of wetlands at Site 300, only a limited number of representative sample points were examined. At each data point, paired soil pits were excavated: one on the wetland side of the wetland boundary and the other on the upland side of the boundary. Each shallow soil pit was excavated by hand to compare soil characteristics with the mapped units and to determine whether soils exhibited redoximorphic features. Data from each sample point were recorded on standard data forms. Geographic information system (GIS) files were created from field-delineated maps, and the GPS data were differentially corrected and the topology was cleaned for positional errors (Jones and Stokes 2002c).

F.3.2.2 *Results And Discussion*

Forty-six wetlands were identified during this study, with a total area of 8.605 acres. Wetlands appearing to meet the USACE criteria for jurisdictional wetlands total 4.388 acres. The delineation is shown in Figures F.3.2.2–1 through F.3.2.2–31 at the end of this appendix. The wetlands include vernal pools, freshwater seeps, and seasonal ponds. Table F.3.2.2–1 provides information on the type, size, and characteristic plant species of each wetland and a preliminary jurisdictional assessment (Jones and Stokes 2002c).

The previous delineation (LLNL 1992a) identified 6.76 acres of wetlands at Site 300, including 5.80 acres of herbaceous wetlands, 0.64 acre of woody riparian wetland, and 0.32 acre of vernal pool wetland. Of these wetlands, 1.88 acres were characterized as artificial. Most of these wetlands are still present and were delineated in 2001 (Jones and Stokes 2002c).

An artificial wetland that was mapped near Building 827 and that was supported by cooling tower water, is no longer present. Some of the areas mapped as creeping ryegrass-dominated wetlands, such as one near the pistol range, no longer exhibit wetland characteristics. Many wetlands were mapped in 2001 that were not mapped in the previous delineation, including the larger vernal pool (Wetland 1) and many small wetlands supported by seeps. The greater number of wetlands delineated in the 2001 study probably reflects a greater familiarity with Site 300 developed by LLNL wildlife biologists since the previous delineation (Jones and Stokes 2002c).

A description of the wetland types at Site 300 is presented below. The scientific names and wetland indicator status of plant species mentioned in the text are provided in Table F.3.2.2–2.

Vernal Pools

Vegetation

Vernal pools provide habitat for numerous endemic plant species and are known for their colorful spring floral displays. Vernal pools at Site 300 are not typical and do not fit any of the current vernal pool classifications. Unlike typical vernal pools, in which many of the species are endemic to vernal pool habitats, the three vernal pools at Site 300 (Wetlands 1 through 3) have vegetation composed mostly of wetland generalists that are often found in, but not restricted to, vernal pools, including stipitate-popcorn flower (*Plagiobothrys stipitatus*), annual hairgrass (*Deschampsia danthonioides*), cleistogamous spike-primrose (*Epilobium cleistogamum*), and creeping spikerush (*Eleocharis macrostachya*). The dominant plants in the vernal pools are usually or almost always found in wetlands. The smaller pool appears to have a much shorter period of inundation, as Mediterranean barley (*Hordeum marinum*) is the dominant species. Therefore, vernal pools meet the hydrophytic vegetation criterion (Jones and Stokes 2002c).

Soils

The vernal pools at Site 300 are located in small basins where the soils are mapped as Diablo clay, 30- to 45-percent slopes. The texture, structure, and low chroma matrix of the soil at data point 2A are characteristics of the Diablo clay soil, which is a well-drained, nonhydric Vertisol. However, when considered in conjunction with the topography and landscape position of the vernal pool features, the low matrix chroma was considered sufficient to qualify the soil at data point 2A as hydric. The soil matrix at data point 2B also has a low chroma, but was determined to be hydric based primarily on the presence of redoximorphic iron-oxide concentrations; i.e., mottles, in the surface horizon (Jones and Stokes 2002c).

Hydrology

Wetland hydrology in vernal pools is dependent on rainfall. Vernal pools typically are inundated for 4 to 12 weeks. However, berms have been constructed at the outlet end of each vernal pool at Site 300, an action that has resulted in deeper water and a longer period of inundation. The two larger pools (Wetlands 1 and 2) are inundated for a period sufficient for the breeding of the California tiger salamander; the larger pool remains inundated long enough to provide breeding habitat for the California red-legged frog (Jones and Stokes 2001). The longer inundation regime is likely responsible for the prevalence of wetland generalist plants, rather than vernal pool endemics. The smaller pool (Wetland 3), which occurs where a swale was bermed by a fire trail, appears to have a shorter period of inundation because the vegetation is less hydrophytic (Jones and Stokes 2002c).

Seasonal Ponds

Seasonal ponds at Site 300 have seasonal wetland hydrology, similar to vernal pools, but vernal pool endemics and wetland generalist species characteristic of vernal pools are absent. These seasonal pools are Wetlands 16, 26, 40, 41, and 46. Vegetation in the seasonal ponds is absent to sparse and is composed of ruderal hydrophytic species, including annual rabbit's foot grass (*Polypogon monspeliensis*), horseweed (*Conyza Canadensis*), perennial peppercress (*Lepidium latifolium*), and salt heliotrope (*Heliotropium curassavicum*). Wetland hydrology in the seasonal

ponds is dependent on rainfall. Two of the seasonal ponds (Wetlands 16 and 26) were formed where fire trails bermed swales. Wetland 46 was originally constructed as an overflow pond for the sewage treatment facility, but now ponds independently. Wetlands 40 and 46 are inundated for a period sufficient for the breeding of the California red-legged frog (Jones and Stokes 2001). Soils in these wetlands were not investigated but were presumed to be hydric on the basis of an aquic moisture regime present during the rainy season (Jones and Stokes 2002c).

Freshwater Seeps and Springs

Vegetation

Vegetation in the freshwater seeps is generally dominated by herbaceous perennial hydrophytes, although riparian scrub is also associated with seeps at several locations. Where perennial soil moisture is present, the dominant species is usually narrow-leaved cattail (*Typha angustifolia*), although broad-leaved cattail (*Typha lalifolia*) is also present. Other common species in the seeps include creeping wild rye (*Leymus triticoides*), hoary nettle (*Urtica dioica*), saltgrass (*Distichlis spicata*), Baltic rush (*Juncus balticus*), white hedgenettle (*Stachys albens*), and annual rabbit's-foot grass. Woody vegetation is associated with freshwater seeps in some areas. Red willows (*Salix laevigata*) are present along Wetland 31, in Elk Ravine. Scattered Fremont cottonwood *(Populus fremontii)* and willows are present along the downstream portion of Wetland 20, and valley oak (*Quercus lobata*) and Fremont cottonwood are present adjacent to the upstream end of Wetland 12. Mulefat (*Baccharis salicifolius*) is present at scattered locations in seeps that occur along the bottoms of drainages (Jones and Stokes 2002c).

Soils

Information on soils in seeps was collected at four sites (Data Points 1A, 1C, 3A, 4A, 4C, and 5B) (Jones and Stokes 2002c). Soils in seeps at Site 300 consist of sandy loams, silt loams, clay loams, silty clay loams, and clays that frequently contain accumulations of carbonate salts below the surface soil horizon. Soils in seep wetlands were determined to be hydric, based on the presence of gleyed or low chroma matrix colors and the presence of redoximorphic iron-oxide concentrations; i.e., mottles.

Soils at Data Points 4A and 4C were problematic. Although soils at these points exhibited no hydric soil indicators, the points were placed where the vegetation was clearly hydrophytic and either in a stream channel (4A) or in a hillside swale (4C). A possible explanation for the absence of redoximorphic features may be that water flows primarily aboveground at these locations and remains relatively well oxygenated.

Hydrology

Wetland hydrology in many of the wetlands at Site 300 is provided by natural seeps and springs that occur where water-bearing sandstone crops out in the canyon bottoms. Other seeps are associated with superficial slope failures or “slumps” induced, in part, by excess moisture where the water-bearing bedrock is near the surface. Most of these wetlands are confined to small areas immediately adjacent to the seeps. Flows at the seeps appear to vary throughout the year; some seeps were dry during surveys, and others exhibited saturated soils in only part of the seep (Jones and Stokes 2002c).

In contrast, more extensive wetlands are present where perennial springs provide water for wetlands that extend for a considerable distance downstream from the spring source. Perennial springs are present in portions of Wetlands 4, 7, 12, 28, and 31. Wetland 12 is supported by a spring that flows from an abandoned mine shaft. The spring at Wetland 28 was exposed during excavation of sediments and bedrock during construction of a facility in a small canyon at that location. The spring at Wetland 31 in Elk Ravine is a natural groundwater spring that occurs where the bed of the stream channel intercepts a groundwater aquifer (Jones and Stokes 2002c).

Uplands

Vegetation

Uplands adjacent to the wetlands consist of annual grassland dominated by wild oats (*Avena fatus*) and brome grasses (Jones and Stokes 2002c).

Soils

Information on soils in uplands adjacent to wetlands was collected at Data Points 1B, 3B, 4B, and 5A (Jones and Stokes 2002c). Upland soils located adjacent to vernal pools and seep wetlands at Site 300 consisted of silt loams, sandy loams, and clays that were found to be nonhydric based on topography, landscape position, and the absence of hydric soil indicators.

Hydrology

No evidence of wetland hydrology was found outside of the vernal pools and seeps. Annual grasslands are usually not inundated and have saturated soils only for short periods during or immediately following rainfall. This period of saturation is not sufficiently long to inhibit the growth of upland species or to promote the growth of plants adapted to grow under saturated soil conditions (Jones and Stokes 2002c).

Jurisdictional Assessment

This section provides an assessment of the aquatic habitats that may be subject to regulation by USACE. USACE regulates many wetlands, streams, and water bodies. It generally regulates wetlands that cross state boundaries and have an interstate or foreign commerce connection, that are adjacent to regulated waters, or that are habitat for endangered species. It may make a nonjurisdictional determination for wetlands that are isolated, that lack an interstate or foreign commerce connection, or that are artificial. Such artificial features include nontidal drainage and irrigation ditches excavated on dry land or artificial lakes created by excavating and/or diking dry land to collect water used exclusively for such purposes as stock watering, irrigation, settling basins, or rice growing (Jones and Stokes 2002c).

Almost all of the wetlands on Site 300 appear to be isolated (Jones and Stokes 2002c). The streams at Site 300 are ephemeral, and most lack an ordinary high watermark. Only Corral Hollow Creek, an intermittent stream that crosses the southeastern edge of Site 300 in the Ecological Reserve, possesses an ordinary high watermark. Water typically is present in the channels only after storms or where seeps and springs are present. Most of the streams lack a channel confluent with Corral Hollow Creek; stream flows drain into the soil before reaching the

end of the channels. Only Elk Ravine and the unnamed stream in the western portion of the site have channels confluent with Corral Hollow Creek. Wetlands in Elk Ravine (Wetland 31) are supported by a perennial spring, but stream flows sufficient to reach Corral Hollow Creek do not ordinarily occur. The unnamed stream on the west side of Site 300 has a well-defined bed and banks, but stream flow primarily occurs in Wetland 12, which is supported by a perennial spring. Therefore, only Wetlands 4, 5, 7, and 12 appear to be associated with a stream tributary to regulated water.

Wetlands 1, 40, and 46 and portions of Wetlands 7, 12, and 27 are known breeding sites for the California red-legged frog, which is listed under the Federal *Endangered Species Act* as threatened (Jones and Stokes 2001). Wetlands 2, 4, 20, and 26 and portions of Wetlands 12,17, and 31 are known nonbreeding sites for the California red-legged frog (Jones and Stokes 2001, 2002c).

Several wetlands at Site 300 are artificial. Wetland 27 was originally created by releases of cooling tower water at Building 865 and is currently maintained with potable water. Wetlands 14 and 15 appear to be maintained by runoff from Building 825, and Wetlands 29 and 30 appear to be maintained by runoff from Building 801. These wetlands would likely not persist if their artificial water source was discontinued. Wetlands 3, 16, and 26 were formed by impoundment of water in swales behind berms created by fire trails. These wetlands would likely persist as long as the berms remain intact. Wetland 46 was excavated on dry land to retain wastewater overflow. This pond persists as a seasonal pond, although it is no longer used for wastewater retention (Jones and Stokes 2002c).

Table F.3.2.2–1 indicates which wetlands may be subject to USACE regulation. This assessment is preliminary and subject to verification by USACE, which may make jurisdictional determinations on a case-by-case basis (Jones and Stokes 2002c).

In January 2003, USACE and EPA jointly released a request for agency and public comment on the definition of "waters of the U.S.," particularly the definition for isolated wetlands that are both intrastate and nonnavigable (68 FR 1991). Depending on the terminology adopted for the revised definition of "waters of the U.S.," some of the wetlands currently anticipated to qualify as jurisdictional wetlands in Table F.3.2.2–1 may become exempt from jurisdictional wetland regulation under Section 404 of the *Clean Water Act*. However, those wetlands may still qualify for protection under California law.

F.4 REFERENCES

68 FR 1991 — United States Department of the Army, Corps of Engineers (USACE), "Advanced Notice of Proposed Rulemaking on the Clean Water Act, Regulatory Definition of Waters of the United States," *Federal Register*, Vol. 68 Pgs.1991-1998, Office of the Federal Register National Archives and Records Administration, United States Government Printing Office, Washington, DC, January 15, 2003.

EO 11988 — Executive Order 11988, "Floodplain Management," Issued on May 24, 1977 by President Jimmy Carter.

EO 11990 — Executive Order 11990, "Protection of Wetlands," Issued on May 24, 1977 by President Jimmy Carter.

DOE 1998b — DOE, *Draft Environmental Assessment Arroyo Las Positas Maintenance Project at Lawrence Livermore National Laboratory's Livermore Site*, DOE/EA-1272, United States Department of Energy, Oakland Operations Office, Oakland, CA, September 30, 1998.

FEMA 1981 — Federal Emergency Management Agency (FEMA), *National Flood Insurance Program, Flood Insurance Rate Map, Alameda County, California, Panel 230*, Federal Emergency Management Agency, Washington, DC, 1981.

FEMA 1997a — FEMA, *National Flood Insurance Program, Flood Insurance Rate Map, Alameda County, California, Panel 210*, Federal Emergency Management Agency, Washington, DC, 1997.

FEMA 1997b — FEMA, *National Flood Insurance Program, Flood Insurance Rate Map, City of Livermore, California, Panel 10*, Federal Emergency Management Agency, Washington, DC, 1997.

Jones and Stokes 1997 — Jones and Stokes Associates, Inc., *Delineation of Waters of the United States for Arroyo Las Positas, prepared for Lawrence Livermore National Laboratory, Alameda County, California*, JSA 97-107, Lawrence Livermore National Laboratory, Livermore, CA, November 7, 1997.

Jones and Stokes 2001 — Jones and Stokes Associates, Inc., *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 2002c — Jones and Stokes Associates, Inc., *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.

LLNL 1992a — Lawrence Livermore National Laboratory (LLNL), *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence National Laboratory and Sandia National Laboratories,* Vols. 1-5, DOE/EIS-0157, Lawrence Livermore National Laboratory, Livermore, CA, August 1992.

LLNL 2001ap — LLNL, *Arroyo Seco Draft Wetland Delineation Report*, prepared by Questa Engineering Corporation for Lawrence Livermore National Laboratory, Livermore, CA, July 30, 2001.

LLNL 2001ay — LLNL, *Building 231 Vault Flood Hazard Analysis 2001* (UCNI), UCRL-ID-146099, Lawrence Livermore National Laboratory, Livermore, CA, 2001.

USACE 1981 — USACE, *HEC-1 Flood Hydrograph Package User's Manual*, United States Army Corps of Engineers, 1981.

USACE 1987 — USACE, *United States Army Corps of Engineers Wetlands Delineation Manual*, Technical Report Y-87-1, United States Army Corps of Engineers, Environmental Laboratory, Vicksburg, MS, 1987.

USFWS 1988 — United States Fish and Wildlife Service (USFWS), *Amendment to the United States Fish and Wildlife Service Biological Opinion (1-1-97-F-173) on the Arroyo Maintenance Project on Arroyo Las Positas at LLNL, Alameda County, CA*, United States Fish and Wildlife Service, 1998.

Welch et al. 1966 — Welch, L. E., R. C. Huff, R. A. Dierking, T. D. Cook, L. A. Bates, and W. F. Andrews, *Soil survey of the Alameda Area, California*, United States *Department of Agriculture, Soil Conservation Service*, March 1966.

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APPENDIX G: SUPPLEMENTAL INFORMATION FOR PREHISTORIC AND HISTORIC CULTURAL RESOURCES AND NATIVE AMERICAN CONSULTATION

This appendix presents additional information on the prehistoric and historic cultural resources management and Native American consultation conducted at Lawrence Livermore National Laboratory (LLNL) for the Livermore Site and Site 300. Section G.1 describes the significance criteria used in evaluating prehistoric and historic cultural resources for eligibility to the National Register of Historic Places (NRHP). Section G.2 contains a copy of the California Native American Heritage Commission response letter with the tribal contact list for the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS). Section G.3 has copies of consultation letters sent to agencies and Native American Contacts regarding preparation of the Programmatic Agreement. This is followed by the Final Programmatic Agreement in Section G.4.

G.1 FEDERAL SIGNIFICANCE CRITERIA FOR PREHISTORIC AND HISTORIC CULTURAL RESOURCES

Criteria for including properties in the NRHP, pursuant to 36 *Code of Federal Regulations* (CFR) 60.4, are as follows:

- Association with events that have made a significant contribution to the broad patterns of our history
- Association with the lives of persons significant to our past
- Resources that embody the distinctive characteristics of a type, period, or method of construction or that represent the work of a master or that possess high artistic values or that represent a significant and distinguishable entity whose component may lack individual distinction
- Resources that have yielded or may be likely to yield information important in prehistory or history

G.2 LETTER FROM THE CALIFORNIA NATIVE AMERICAN HERITAGE COMMISSION WITH THE TRIBAL CONTACT LIST

STATE OF CALIFORNIA — Gray Davis, Governor

NATIVE AMERICAN HERITAGE COMMISSION
915 CAPITOL MALL, ROOM 364
SACRAMENTO, CA 95814
(916) 653-4082
Fax (916) 657-5390

December 23, 2002

Thomas Grim
Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, CA 94612-5208

RE: Native American Contacts/Lawrence Livermore National Laboratory
#AMNSEIS:020011

Dear Mr. Grim:

I recommend that you contact the Native Americans contacts on the attached list for this project. They may be able to provide input concerning the project site and assist in the mitigation measures. It is with the understanding that the list is to be used only to determine possible areas of cultural sensitivity

The Commission makes no recommendation or preference of a single individual, or group over another. This list should provide a starting place in locating areas of potential adverse impact within the proposed project area. I suggest that all of those indicated be contacted, if they cannot supply information, they may recommend others with specific knowledge. A minimum of two weeks must be allowed for responses after notification.

If you receive notification of change of addresses and phone numbers from any these individuals or groups, please notify me. With your assistance we are able to assure that our lists contain current information. If you have any questions or need additional information, please contact me at (916) 653-4038.

Sincerely,

Debbie Pilas-Treadway
Environmental Specialist III

Post-it® Fax Note 7671	Date	# of pages ▶ 4
To T. GRIM	From D. TREADWAY	
Co./Dept.	Co.	
Phone #	Phone # 916/653-4038	
Fax # 925/422-1776	Fax #	

NATIVE AMERICAN CONTACTS
Alameda County
December 23, 2002

Jakki Kehl
720 North 2nd Street
Patterson , CA 95363
(209) 892-2436
(209) 892-2435 - Fax
jakki@bigvalley.net

Ohlone/Costanoan

Thomas P. Soto
Howard S. Soto
P.O. Box 56802
Hayward , CA 94541
(530) 889-2444
sotoland@sbcglobal.net
(510) 733-6158 Fax
hss001@aol.com

Ohlone/Costanoa

Katherine Erolinda Perez
1234 Luna Lane
Stockton , CA 95206
(209) 462-2680

Ohlone/Costanoan
Northern Valley Yokut
Bay Miwok

Trina Marine Ruano Family
Ramona Garibay, Representative
37974 Canyon Hts. Drive
Fremont , CA 94536
(510) 792-1642
(510) 673-5029 - Cell

Ohlone/Costanoa

Ella Rodriguez
PO Box 1411
Salinas , CA 93902
(831) 632-0490

Ohlone/Costanoan
Esselen

Amah/Mutsun Tribal Band
Michelle Zimmer
4952 McCoy Avenue
San Jose , CA 95130
(408) 378-3934

Ohlone/Costanoa

Marjorie Ann Reid
19235 Pinnacle Court
Redding , CA 96003

Ohlone/Coastanoan

Amah/MutsunTribal Band
Irene Zwierlein, Chairperson
789 Canada Road
Woodside , CA 94062
(650) 851-7747 - Home
(650) 851-7489 - Fax
(408) 364-1393 - Cell

Ohlone/Costanoa

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regards to the cultural assessmet for the proposed consultation Lawrence Livermore National Laboratory, Alameda County.

NATIVE AMERICAN CONTACTS
Alameda County
December 23, 2002

Indian Canyon Mutsun Band of Costanoan
Ann Marie Sayer, Chairperson
P.O. Box 28 Ohlone/Costanoan
Hollister , C A 95024
(510) 637-4238

The Ohlone Indian Tribe
Andrew Galvan
PO Box 3152 Ohlone/Costanoan
Mission San Jose , C A 94539
(510) 656-0787 - Voice
(510) 882-0527 - Cell
(510) 656-0780 - Fax
chochenyo@AOL.com

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regards to the cultural assessmet for the proposed consultation Lawrence Livermore National Laboratory, Alameda County.

NATIVE AMERICAN CONTACTS
San Joaquin County
December 23, 2002

Katherine Erolinda Perez
1234 Luna Lane
Stockton , C A 95206
(209) 462-2680

Ohlone/Costanoan
Northern Valley Yokut
Bay Miwok

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regards to the cultural assessment for the proposed consultation Lawrence Livermore National Laboratory, San Joaquin County.

G.3 LETTERS TO AGENCIES AND THOSE POTENTIALLY INTERESTED IN THE DEVELOPMENT OF A PROGRAMMATIC AGREEMENT

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

AUG 15 2002

Dr. Knox Mellon
State Historic Preservation Officer
Office of Historic Preservation
Department of Parks and Recreation
P.O. Box 942896
Sacramento, CA 94296-0001

SUBJECT: National Historic Preservation Act Programmatic Agreement Regarding Operation of Lawrence Livermore National Laboratory (LLNL)

Dear Dr. Mellon:

The Department of Energy, National Nuclear Security Administration, (DOE/NNSA) Oakland Operations Office with assistance from Lawrence Livermore National Laboratory will develop an historic context and complete cultural resource evaluations on lands it controls in Alameda and San Joaquin Counties, California. We have already initiated a dialog with your staff on the scope of these efforts, and I believe they will produce results that can serve as a foundation for effective management of important resources and for a sound implementation plan for these approaches. The context development and resource evaluations are a multi-year commitment for LLNL.

I believe we should consider an agreement that both documents the intent of the Laboratory to complete the work and provides an interim standard for the DOE/NNSA to meet National Historic Preservation Act Section 106 responsibilities. I also would propose that this document should establish a timetable for development of the LLNL cultural resource management plan and for its implementation by agreement. To these ends I enclose a preliminary draft Programmatic Agreement that may serve as a basis for discussion. I request your initial comment on this document along with your suggestions for the best approach to work together to finalize an agreement.

I have written to the Advisory Council on Historic Preservation to announce our intent to consult and, since the Council participated in our past efforts to develop an agreement, I have invited their continued participation. In addition, I have contacted all the Native American points of contact for Alameda and San Joaquin Counties, which were recommended by staff of the California Native American Heritage Commission, to determine interest in the consultation. Please inform me if you believe we should involve additional parties and, if you have a recommendation, provide contact information.

AUG 15 2002

You can contact me by telephone at (510)637-1813 if you require additional information to assist you in your deliberations. Mr. Paul McGuff, LLNL, can also answer questions and can be reached at (925)422-9547.

Sincerely,

Original signed by:

Janet M. Neville
Historic Preservation Officer
Environment, Safety, and Health
Division

Enclosure:
Preliminary Draft Programmatic Agreement

cc:
C. Carter, LEPD, L-293 w/encl
P. Hill, LSOD, L-293 w/encl
T. Kato, LLNL, L-627 w/o encl
P. McGuff, LLNL, L-627 w/o encl

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

AUG 15 2002

Ms. Jane M. Crisler
Advisory Council on Historic Preservation
Western Office of Federal Agency Programs
1236 West Bayaud Avenue
Suite 330
Lakewood, Colorado 80228

SUBJECT: National Historic Preservation Act Programmatic Agreement Regarding Operation of Lawrence Livermore National Laboratory (LLNL)

Dear Ms. Crisler:

The Department of Energy, National Nuclear Security Administration, (DOE/NNSA) last communicated with you concerning an agreement for Lawrence Livermore National Laboratory (LLNL) several years ago. Recently we have made new progress in the historic preservation program and I am pleased to report that LLNL will develop an historic context and complete cultural resource evaluations on lands owned by the DOE/NNSA and maintained by LLNL in Alameda and San Joaquin Counties, California. We've already initiated a dialog with the State Historic Preservation Office Staff on the scope of these efforts, and believe the results of investigations will serve as a foundation for effective management of resources. The context-development and resource evaluations are a multi-year commitment for LLNL.

I believe we should consider an agreement that documents the intent of the Laboratory to complete the work and provide an interim standard for the DOE/NNSA to meet National Historic Preservation Act Section 106 responsibilities. I also would propose that this agreement should establish a timetable for development of the LLNL cultural resource management plan and for its implementation by agreement. The Advisory Council was an active participant in our efforts to develop an agreement several years ago and I would welcome your continued participation in this renewed effort. I request that you inform me of the role the Advisory Council will take in this consultation.

For your information I enclose a preliminary draft Programmatic Agreement that may serve as a basis for discussion. Should the Council decide to actively participate in the consultation, I request your initial comment on this document along with your suggestions for the best approach to work together to finalize an agreement.

I have also written to the California State Historic Preservation Office and Native American points of contact recommended by staff of the California Native American Heritage Commission.

AUG 1 5 2002

You can contact me by telephone at (510) 637-1813 if you require additional information. Mr. Paul McGuff, LLNL, can also answer questions and can be reached at (925)422-9547.

Sincerely,

Original signed by:

Janet M. Neville
Historic Preservation Officer
Environment, Safety, and Health
Division

Enclosure:
Preliminary Draft Programmatic Agreement

cc w/o encl:
C. Carter, LEPD, L-293
P. Hill, LSOD, L-293
T. Kato, LLNL, L-627
P. McGuff, LLNL, L-627

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

AUG 15 2002

IDENTIFICAL LETTER SENT TO ATTACHED LIST

Ms. Ella Rodriquez
P. O. Box 1411
Salinas, CA 93902

SUBJECT: National Historic Preservation Act Programmatic Agreement Regarding Operation of Lawrence Livermore National Laboratory (LLNL)

Dear Ms. Rodriquez:

The Department of Energy, National Nuclear Security Administration (DOE/NNSA) wants to take steps that will improve cultural resource management at Lawrence Livermore National Laboratory (LLNL). The steps include completion of a historic context for the period after 1941, an evaluation of cultural resources including known archeological sites, and implementation of an agreement. The agreement would document the commitment for context development and evaluation, specify a timetable to write a new agreement based upon the results of evaluation, and define a process for management of resources until the context, assessment, and new agreement are complete.

I am writing to you because I believe you could have interest in our plans. If so, I would like to know whether you have a desire to participate in the planning and to what degree. In addition to sending this letter, Paul McGuff from LLNL will attempt to call you in the next few weeks with the purpose of providing you a direct opportunity to ask questions or state your interest. Please feel free to call him if you have not received a phone call or for any other reason.

You may have little familiarity with LLNL. LLNL is a DOE/NNSA research laboratory and maintains lands at two separate locations in Alameda and San Joaquin counties, California. The nature of research at LLNL requires high security and limitations on access. I have enclosed a map that provides an idea of the location and relative size of the two sites.

The LLNL Livermore Site covers 821 acres and functions as a main campus for research. It is located about 40 miles east of San Francisco in Alameda County, California. Operations at the site occupy about six million gross square feet of facilities. This space is spread among approximately 500 buildings and structures, of which approximately 250 are temporary. This site has very little undeveloped land and no undisturbed lands.

AUG 15 2002

The 7000-acre LLNL Site 300 is primarily a non-nuclear high explosives test facility. It is located 15 miles southeast of Livermore in the hills of the Diablo Range, and is in San Joaquin and Alameda counties, California. Operations at the site occupy approximately 400,000 gross square feet of facilities. This space is spread among approximately 200 buildings and structures of which few are temporary. This site has considerable undeveloped land. The lands received an archeological survey several years ago. The acreage has no flowing streams and archeological site density is low. Twenty-five archeological sites are recorded on the property and all but eight of them date to the late-Nineteenth or early-Twentieth centuries. The eight older sites are small occupation areas and isolated artifacts identified by stone and bone tools and debris.

I have also written to the California State Historic Preservation Office and to the Advisory Council on Historic Preservation concerning our programmatic plans.

You can contact me by telephone at (510) 637-1813 or Mr. Paul McGuff, LLNL at (925) 422-9547, if you require additional information.

Sincerely,

Original signed by!

Janet M. Neville
Historic Preservation Officer
Environment, Safety, and Health Division

Enclosure:
LLNL Location Map

cc:
C. Carter, LEPD, L-293 w/encl
P. Hill, LSOD, L-293 w/encl
T. Kato, LLNL, L-627 w/o encl
P. McGuff, LLNL, L-627 w/o encl

ADDRESS LIST:

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Michelle Zimmer
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San Jose, CA 95130

Amah/Mutsun Tribal Band
Irene Zwierlein, Chairperson
789 Canada Road
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Indian Canyon Mutsun Band of Costanoan
Ann Marie Sayer, Chairperson
PO Box 28
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The Ohlone Indian Tribe
Andrew Galvan
PO Box 3152
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Thomas P. Soto
Howard S. Soto
PO Box 56802
Hayward, CA 94541

Trina Marine Ruano Family
Ramona Garibay, Representative
37974 Canyon Heights Drive
Fremont, CA 94536

G.4 FINAL PROGRAMMATIC AGREEMENT REGARDING OPERATION OF LAWRENCE LIVERMORE NATIONAL LABORATORY

Department of Energy
National Nuclear Security Administration
Livermore Site Office
PO Box 808, L-293
7000 East Avenue
Livermore, California 94551-0808

RECEIVED
JUL 11 2003
PERMITS & REGULATORY AFFAIRS GROUP

JUN 30 2003

Mr. Hans Kreutzberg
Chief, Project Review Unit
Office of Historic Protection
Department of Parks and Recreation
PO Box 942896
Sacramento, CA 94296-0001

Subject: National Historic Preservation Act Programmatic Agreement Regarding Operation of Lawrence Livermore National Laboratory

Dear Mr. Kreutzberg:

The Department of Energy, National Nuclear Security Administration (NNSA) is pleased to provide a Programmatic Agreement implementing the National Historic Preservation Act (NHPA) Section 106 responsibilities at Lawrence Livermore National Laboratory (LLNL). The enclosed Programmatic Agreement has been signed by both the University of California and NNSA. We have worked informally with you to reach consensus on the content of this agreement. Based on these recent efforts, we believe that this agreement is ready for signature by Dr. Mellon as the California State Historic Preservation Officer. We request that you endorse the agreement and send it to him for execution.

The agreement documents both the intent of NNSA and LLNL to follow the protocols described in the agreement and provides an interim standard for meeting NHPA Section 106 requirements. It also establishes a timetable for development of the LLNL cultural resource management plans and for their implementation by a future agreement.

Thank you for your assistance with this agreement. You can contact me at (925) 423-7061 if you require additional information. Mr. Paul McGuff of LLNL at (925) 422-9547 can also assist. After July 31, 2003, Karin King will be the acting Historic Preservation Officer for the NNSA – Livermore Site Office and can be reached at (925) 422-0756.

Sincerely,

Michael Brown, Deputy Director
Environmental Stewardship Division

Enclosure

cc: K. Folks, LLNL
T. Kato, LLNL
P. McGuff, LLNL
A. Galvan, Ohlone/Costanoan
H. Soto, Ohlone/Costanoan

PROGRAMMATIC AGREEMENT
AMONG
THE DEPARTMENT OF ENERGY—NATIONAL NUCLEAR SECURITY ADMINISTRATION—,
THE UNIVERSITY OF CALIFORNIA,
AND THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER
REGARDING OPERATION OF
LAWRENCE LIVERMORE NATIONAL LABORATORY

WHEREAS, the United States Department of Energy, National Nuclear Security Administration (NNSA), owns Lawrence Livermore National Laboratory (LLNL) in Alameda and San Joaquin Counties, California (Attachment 1), whose facilities have been used in highly technical and scientific research since the 1950s; and

WHEREAS, the University of California (UC) operates LLNL for NNSA under a contract that requires UC to assist NNSA's compliance with federal historic preservation laws and regulations; and

WHEREAS, NNSA has determined that the operation of LLNL (Undertaking) involves routine management activities suitable for programmatic treatments and other actions that may result in effects to properties included in and eligible for inclusion in the National Register of Historic Places (NRHP) (historic properties); and

WHEREAS, pursuant to 36 CFR 800, regulations implementing Section 106 of the National Historic Preservation Act (NHPA) (16 USC 470f), NNSA has consulted with the California State Historic Preservation Officer (SHPO) regarding the Undertaking in accordance with 36 CFR § 800.6(a), notified the Advisory Council on Historic Preservation (ACHP) pursuant to 36 CFR § 800.6(a)(1)(i)(C), and intends to execute this Programmatic Agreement (PA) pursuant to 36 CFR § 800.6(b)(1) because the ACHP has declined to participate in the consultation pursuant to 36 CFR § 800.6(a)(1)(iii-iv); and

WHEREAS, NNSA seeks through execution of this PA to permit UC to carry out, on NNSA's behalf, certain responsibilities as specified herein; and

WHEREAS, UC has participated in the consultation and has been invited by NNSA and the SHPO to become a signatory to this PA;

NOW, THEREFORE, NNSA, SHPO, and UC agree that NNSA and UC shall implement the Undertaking in accordance with the following stipulations in order to take into account the effects of the Undertaking on historic properties at LLNL, and that these stipulations shall govern NNSA compliance with Section 106 of the NHPA for this Undertaking until this PA expires or is terminated.

STIPULATIONS

NNSA, in cooperation with UC, shall ensure that the following stipulations are carried out:

I. Inventory and Assessment for Historic Properties.

a. Not later than the end of February 2005, NNSA and UC will complete the following inventory and assessment tasks:

i. Develop an historic context for the period between 1942 and the present. The standards for the historic context include conformity with *Archeology and Historic Preservation: Secretary of the Interior's Standards and Guidelines* (effective September 29, 1983), a publication of the National Park Service, as amended and annotated—specifically standards and guidelines for preservation planning, identification, and evaluation. The standards also include conformity with guidance in the following National Register Bulletins: 15 (*How to Apply National Register Criteria for Evaluation*), 18 (*How to Evaluate and Nominate Designed Historic Landscapes*), 21 (*How to Establish Boundaries for National Register Properties*), 22 (*Guidelines for Evaluating and Nominating Properties That Have Achieved Significance within the Last Fifty Years*), 32 (*Guidelines for Evaluating and Documenting Properties Associated with Significant Persons*), and 39 (*Researching a Historic Property*).

ii. Use the historic context as a decision framework and complete NRHP determinations on the inventory of buildings, structures, districts, and objects at LLNL.

iii. Although NNSA and UC have an archeological survey of all LLNL land surfaces with the potential for archeological discovery, the archeological-site forms documenting that effort are not adequate for a current evaluation of site integrity and significance. Therefore, NNSA and UC will visit previously recorded archeological sites at LLNL and update site information on the California DPR 523 form to revise the current baseline information on the archeological resources.

iv. Consider updated archeological site information to make NRHP determinations on recorded archeological sites.

b. NNSA will submit the context, site form updates, and NRHP determinations to the SHPO pursuant to 36 CFR § 800.4(c)(1) and (2). If NNSA and the SHPO are unable to resolve any disagreement on NRHP eligibility determinations, NNSA shall obtain a determination of eligibility pursuant to 36 CFR § 800.4(c)(2) and 36 CFR 63.

II. Review Process for Activities Proposed Prior to Implementation of Cultural Resource Management Planning Decisions under Subsequent Agreement.

a. UC may apply the screening criteria in Attachment 2 so long as this PA is in effect. These screening criteria will be used to determine what activities covered by this PA have no reasonably foreseeable potential to affect historic properties (36 CFR § 800.3[a][1]) and are, therefore, exempt from further review under this PA, and what activities have that potential and, therefore, require further consultation.

b. The following activities are exempt from further review under this PA:

   i. Ground-disturbing activities in areas sensitive for archeological discoveries when a qualified professional monitors these activities as defined in Stipulation IV.a. of this PA.

   ii. Ground-disturbing activities located 300 feet or more away from the known exterior boundaries of archeological sites that either have been determined eligible for inclusion in the NRHP, or that have not been evaluated for NRHP eligibility pursuant to Stipulations I.a.iv. and I.b of this PA.

   iii. Ground-disturbing activities that affect archeological sites determined ineligible for inclusion in the NRHP pursuant to Stipulation I.b of this PA.

   iv. Demolition of post-1960 buildings or trailers that, according to appropriately conducted research, functioned only in administrative or facilities-operations/maintenance roles.

c. NNSA will consult with the SHPO pursuant to 36 CFR 800 for all individual activities covered by this PA when such activities both have the potential to affect historic properties and are identified for Part 800 consultation by application of the screening criteria in Attachment 2.

III. Consultation Following Completion of Inventory and Assessment for Historic Properties.

No later than the end of August 2005, NNSA and UC will consult with the SHPO and the ACHP pursuant to 36 CFR § 800.14(b) to develop a new PA for LLNL operations. Such consultation shall take into account the results obtained from the implementation of Stipulation I of the present PA and address cultural resource management approaches suitable to those results. A suitable response depends upon the revealed individual character and the total complexity of the significant resource base and upon the concerns and comments that arise from the consultation. It may end in implementation of a cultural resource management plan by agreement, or, if requirements are relatively straightforward, in an agreement that itself embodies management commitments.

IV. Administrative Stipulations.

a. Professional Qualifications. All actions prescribed by this PA that involve the identification, evaluation, analysis, recordation, and monitoring of historic properties shall be carried out by, or under the direct supervision of, a person or persons meeting at a

minimum, the *Secretary of the Interior's Professional Qualifications Standards* for archeology, history, or architectural history, as appropriate (48 FR 44739).

b. Resolution of Objections.

i. Should the SHPO object in writing to NNSA or UC regarding the manner in which the terms of this PA are carried out, NNSA and UC would immediately consult with the SHPO to resolve the objection. NNSA shall establish a reasonable timeframe for such consultation.

ii. If the objection is resolved through consultation, NNSA and UC may proceed with the action subject to objection in accordance with the terms of such resolution.

iii. If, after initiating such consultation, NNSA determines that the objection cannot be resolved through consultation, it shall forward all documentation relevant to the objection to the ACHP, including NNSA's proposed response to the objection. Within 30 days after receipt of all pertinent documentation, the ACHP shall exercise one of the following options:

1. Advise NNSA that the ACHP concurs in NNSA's proposed response to the objection; whereupon NNSA will respond to the objection accordingly; or

2. Provide NNSA with recommendations, which NNSA shall take into account in reaching a final decision regarding its response to the objection; or

3. Notify NNSA that the objection will be referred for comment pursuant to 36 CFR § 800.7(a)(4) and proceed to refer the objection and comment. In this event, NNSA shall ensure that the Agency Official is prepared to take the resulting comment into account in accordance with 36 CFR §800.7(c)(4).

iv. Should the ACHP not exercise one of the above options within 30 days after receipt of the pertinent documentation, NNSA may assume the ACHP's concurrence in its proposed response to the objection.

v. NNSA shall take into account any ACHP recommendation or comment and any comment from the other signatories to this PA in reaching a final decision regarding the objection. NNSA's responsibility to carry out all actions under this PA that are not the subjects of the objection shall remain unchanged.

vi. NNSA shall provide all other signatories to this PA with a written copy of its final decision regarding any objection addressed pursuant to this Stipulation IV.b.

vii. NNSA may authorize any action subject to objection under Items i through vi, inclusive of this Stipulation IV.b, to proceed, provided the objection has been resolved in accordance with the terms of Items i through vi, inclusive of this Stipulation IV.b.

viii. Should a member of the public raise an objection to the manner in which the terms of this PA are implemented, NNSA and UC shall advise the SHPO of the objection and consult with the objecting party to consider the objection. NNSA will render a decision regarding the objection and respond in writing to the objecting party, also advising the SHPO of the result. NNSA's decision regarding the objection will be final unless the SHPO has joined the objection at the initial notification. Following issuance of its final decision, NNSA may authorize the action subject to objection to proceed in accordance with the terms of that decision.

c. Standard for Subsequent Agreements. Execution of this PA does not prohibit NNSA from developing other agreement documents to govern the management of historic properties at LLNL; that is, provided that subsequent agreements meet the intent of this PA and that any subsequent PA clearly states whether or not it supersedes this PA in whole or specific part.

d. Amendment.

i. Any signatory may at any time propose amendment of this PA, whereupon all signatories shall consult to consider such amendment pursuant to 36 CFR §§ 800.6(c)(7) and 800.6(c)(8). This PA may be amended only upon written concurrence of the signatories.

ii. NNSA and UC may add sensitive areas or archeological sites to lists and maps that are historic compliance screening tools. Such additions shall not require consultation with the SHPO. Following consultation with the SHPO, NNSA and UC may delete sensitive areas or archeological sites from lists and maps that are historic compliance screening tools without amending the PA.

e. Discoveries and Unanticipated Effects. UC will notify NNSA and the SHPO at the earliest possible time if it appears that an activity covered by this PA will affect a previously unidentified property that may be eligible for the NRHP, or affect a known historic property in an unanticipated manner. NNSA may assume for purposes of this PA that the affected property is eligible for inclusion in the NRHP. NNSA and UC will consult with the SHPO to develop actions that take the effects of the activity into account. Any consultation carried out hereunder shall not exceed ten days. NNSA will provide the SHPO with written recommendations reflecting the consultation and will modify the scope of work as necessary to implement these recommendations.

f. Termination.

i. NNSA or SHPO may terminate this PA. If this PA is not amended as provided for in paragraph d above of this stipulation, or if any NNSA or SHPO proposes termination of this PA for other reasons, the signatory proposing termination shall notify the other signatories in writing, explain the reasons for proposing termination, and consult with the other signatories for no more than a 30-day period to seek alternatives to termination. If the objection is resolved through such consultation,

the action in dispute may be carried out in accordance with the terms of such a resolution.

ii. Should such a consultation fail, the signatory proposing termination may terminate this PA by promptly notifying the other signatories in writing.

iii. Should this PA be terminated, then NNSA shall either consult in accordance with 36 CFR § 800.14(b) to develop a new PA or request the comments of the ACHP pursuant to 36 CFR 800.

iv. Beginning with the date of termination, NNSA shall ensure that until and unless a new PA is executed for the undertakings covered by this PA, such undertakings shall undergo individual review in accordance with 36 CFR §§ 800.4 through 800.6.

g. Emergencies

i. In the event that natural disasters, fires, spill events, or other emergencies occur, UC may take actions that may affect historic properties without consultation. These actions would protect life and safety, or stabilize historic properties, or prevent further property damage. UC will undertake such emergency-response work in a manner that seeks to avoid or minimize effects on historic properties to the extent possible.

ii. Should historic properties be discovered during emergency repair or response activity, work in the immediate area of the discovery will cease if UC has determined that a work stoppage at the site will not impede emergency-response activities. As early as possible given the nature of the emergency, UC will provide telephonic or email notification of the discovery to NNSA and the SHPO. Notification will include the steps taken to address the emergency, a description of the discovered property and its apparent significance, and a description of the emergency work and the potential effects on the discovered property. Within 30 calendar days following this notification, UC will provide NNSA and the SHPO with a written report documenting the actions taken to avoid or minimize effects, the present status of the discovered property, and planned treatment of the said property.

h. Confidentiality. All signatories acknowledge that information about historic properties, prospective historic properties, or properties considered historic for purposes of this PA are or may be subject to the provisions of Section 304 of the NHPA relating to the disclosure of sensitive information, and having so acknowledged, will ensure that all actions and documentation prescribed by this PA are, where necessary, consistent with the requirements of Section 304 of the NHPA.

i. Anti-Deficiency Act. The Anti-Deficiency Act, 31 USC 1341, prohibits federal agencies from incurring an obligation of funds in advance of or in excess of available appropriations. Accordingly, all signatories agree that any requirement for the obligation of funds arising from the terms of this PA shall be subject to the availability of appropriated funds for that

purpose, and that this PA shall not be interpreted to require the obligation or expenditure of funds in violation of the Anti-Deficiency Act.

V. Effective Date and Duration.

a. This PA is effective on the date that it has been signed by NNSA, UC, and SHPO.

b. This PA remains in effect until December 1, 2005, if not superseded.

EXECUTION OF THIS PA by NNSA, UC, and SHPO, its transmittal by NNSA to the ACHP in accordance with 36 CFR § 800.6(b)(1)(iv), and subsequent implementation of its terms, shall evidence pursuant to 36 CFR § 800.6(c), that this PA is an agreement with the ACHP for purposes of Section 110(1) of the NHPA, and shall further evidence that the NNSA has afforded the ACHP an opportunity to comment on the Undertaking and its effects on historic properties, that NNSA has taken into account the effects of the Undertaking on historic properties, and that NNSA has satisfied its responsibilities under Section 106 of the National Historic Preservation Act and its implementing regulations codified at 36 CFR 800.

SIGNATORIES:

U.S. DEPARTMENT OF ENERGY, NATIONAL NUCLEAR SECURITY ADMINISTRATION

Camilla Yuan-Soo Ho DATE: 6/30/03

LAWRENCE LIVERMORE NATIONAL LABORATORY, UNIVERSITY OF CALIFORNIA

Dennis K. Fisher DATE: 4/28/03

CALIFORNIA STATE HISTORIC PRESERVATION OFFICER

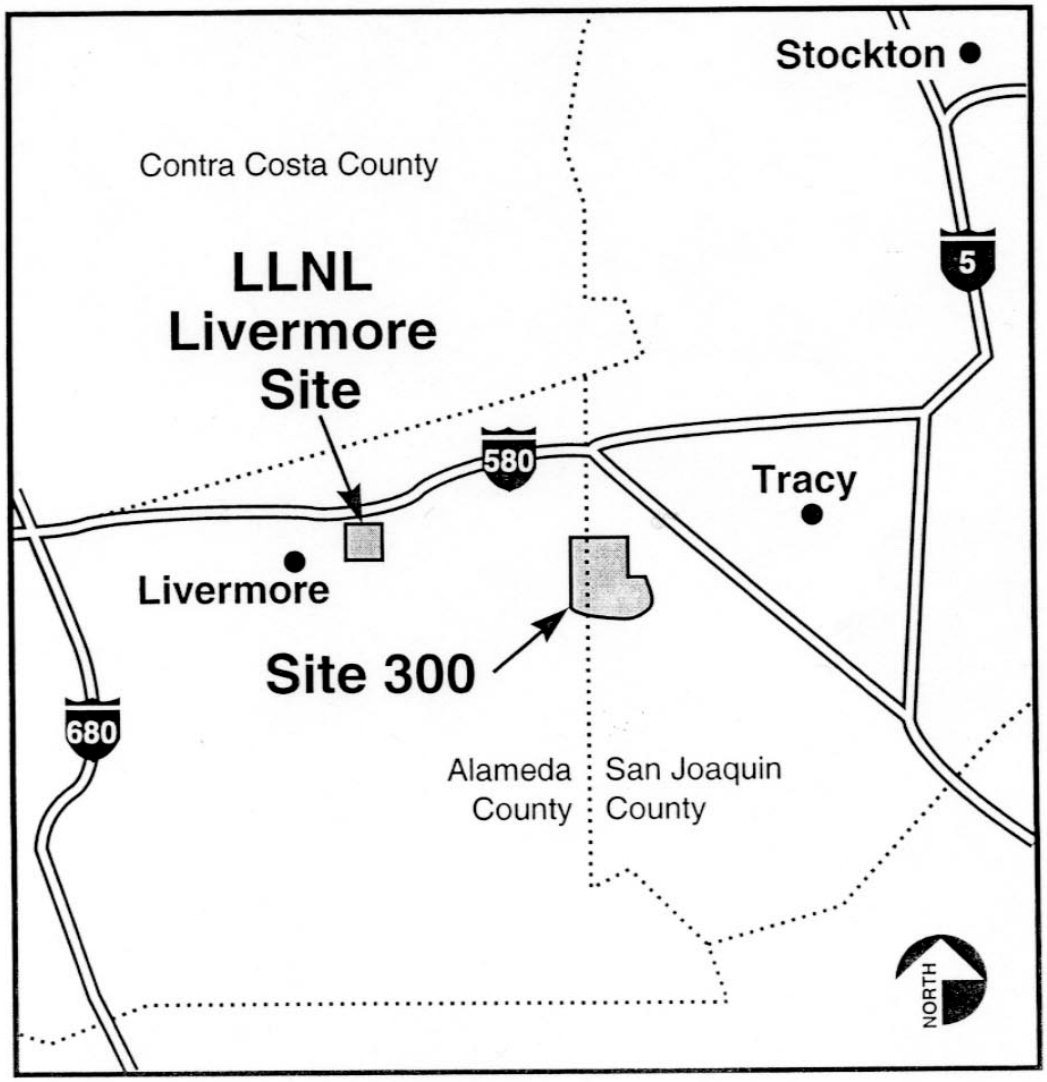
Steph D. Mikesell DATE: 7-11-03
DSH/PO

G.5 REFERENCES

36 CFR §60.4 Department of the Interior, "Parks, Forests and Public Property, National Register of Historic Places," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

Interim PA for LLNL Operation

ATTACHMENT 1: Map Locating LLNL Real Estate.



ATTACHMENT 2:

HISTORIC REVIEW SCREENING CRITERIA FOR ENVIRONMENTAL DISCIPLINES

References:

1. Maps of known archeological sites and areas sensitive to archeological/paleontological discovery at Main Site and Site 300.

2. Lists of buildings included in LLNL plans for demolition projects.

Screening Criteria:

1. Does the proposed work involve a building demolition?

2. Is any ground disturbance anticipated on areas sensitive to archeological discovery, or within 300 feet of known archeological sites?

If the answer to any of the questions was "yes," forward the work proponent's name, phone number, and available project information to Paul McGuff, L-627, or call 925-422-9547, for further review.

ATTACHMENT 2, REFERENCE 1. Maps of known archeological sites and areas sensitive to archeological discovery at Main Site and Site 300.

As provided for in Section 304 of the National Historic Preservation Act, exact information on the location of archeological sites and areas sensitive to archeological discovery is for official use only.

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Figure H–3 Map of the East San Francisco Bay Area showing characterization of active and potentially active faults in the vicinity of the LLNL. Teeth indicate dip direction of thrust and reverse faults. Mt. Diablo thrust and Livermore Fault are blind; traces shown represent the buried upper tips of these faults. H-7

APPENDIX H: SEISMICITY

H.1 INTRODUCTION

The purpose of this appendix is to present detailed information on the latest study of seismic hazards at the Livermore Site. Excerpts from the most recent study (LLNL 2002dk), the *Lawrence Livermore National Laboratory Site Seismic Safety Program: Summary of Findings* (LLNL 2002dk), or Summary of Findings, are presented to supplement the discussion of seismic hazard in Section 4.8 of the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS). The studies of seismic hazards for Site 300 have not been updated and the calculations presented in the 1992 *Lawrence Livermore National Laboratory Environmental Impact Statement/Environmental Impact Report* (LLNL EIS/EIR) are still used.

The 1992 LLNL EIS/EIR discussed the potential impacts associated with the seismic risks at the Livermore Site and Site 300. It stated that the siting of facilities in areas subject to strong ground shaking at the Livermore Site and Site 300 may result in structural damage and increased exposure to risks associated with ground shaking. Engineering and administrative measures would be taken to prevent and/or mitigate releases of hazardous substances resulting from strong ground shaking at any given facility. This effort was integrated into the safety program at LLNL as part of the analysis and mitigation of all accident risks for buildings and operations at LLNL.

H.2 LAWRENCE LIVERMORE NATIONAL LABORATORY SEISMIC SAFETY PROGRAM

At LLNL, seismic upgrades, retrofits, and a comprehensive furniture and equipment tie-down program are part of an ongoing effort to minimize risks to personnel, the environment, and the public at the laboratory due to a moderate to strong earthquake.

In 1994, Executive Order (EO) 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings," required all federally owned and leased buildings that did not meet current seismic design and construction standards be identified and modified or retrofitted if necessary. Application of the seismic safety screening requirements of EO 12941 and associated standards resulted in the identification of 108 buildings at LLNL as having potential seismic difficulties. The need for seismic upgrading of these buildings was prioritized based on a scoring approach that incorporated building vulnerability, failure consequence, and mission essential factors. The seismic upgrade of the following high priority buildings and facilities are in different stages of planning, approval, design, and implementation.

- B131: Upgrades completed
- B151: Seismic upgrades are in progress
- B216: Upgrades completed
- B231: Upgrades completed

- B241: Seismic retrofit; work in progress. Scheduled for completion by June 2004
- B298: Work in progress. Scheduled completion, January 2004
- B321: Work in progress. Schedule completion, September 2008
- B381/B391: Seismic upgrade necessary to safely optimize use of prime lab space; FY2006
- B511: Work in progress. Scheduled completion, January 2004

LLNL continues to evaluate laboratory facilities in accordance with new seismic and engineering understanding and changing safety requirements. Seismic evaluations performed to date indicate that approximately 88 percent of buildings comply with the federal seismic "life safety" standards and require no further evaluation or mitigation. Of the remaining 12 percent (63 buildings), 22 have been evaluated and identified to have unacceptable seismic risks; 41 still require detailed evaluations to determine their seismic risk levels.

H.3 EXCERPTS FROM *LAWRENCE LIVERMORE NATIONAL LABORATORY SITE SEISMIC SAFETY PROGRAM: SUMMARY OF FINDINGS*

H.3.1 Overview

The *Lawrence Livermore National Laboratory Site Seismic Safety Program: Summary of Findings* (LLNL 2002dk) presents an assessment of the seismic hazard to the LLNL site and employees. Portions of the following text are excerpted from that document, shown here in italicized text. The references cited in the excerpts are from the original document (LLNL 2002dk) and listed in the back of this appendix. Likewise, acronyms and technical terms are not defined in the glossary of this LLNL SW/SPEIS.

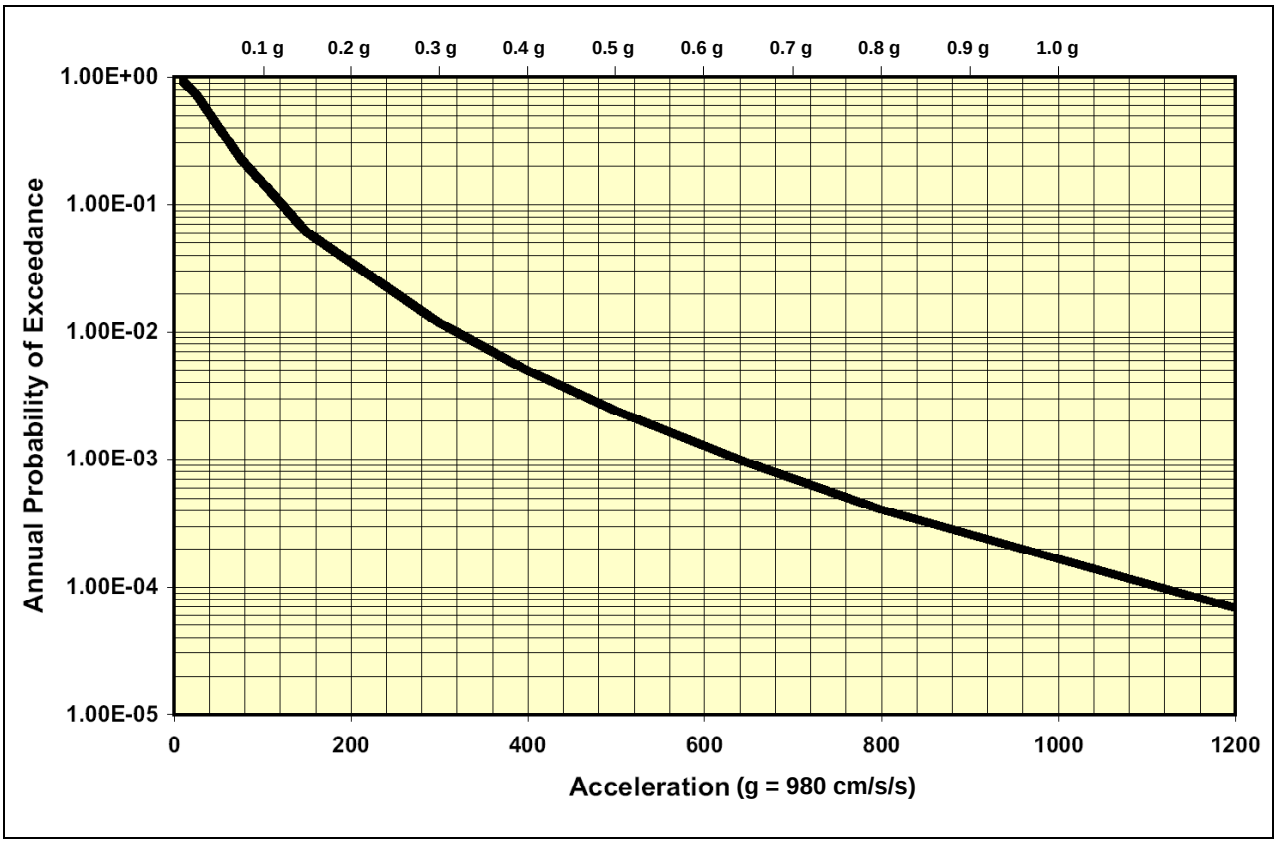
The Summary of Findings presents *the latest assessment of seismic hazard at LLNL, and includes a new estimate of peak ground acceleration to be used for design and evaluation of facilities at the site.*

The last such estimate was based on knowledge, technology, and methodologies that had been developed in the late 1970s. This new assessment is based on the information on the geology and tectonics of the region available in 2001. The assessment includes information from recent and ongoing studies of earthquake potential in the San Francisco Bay Region (SFBR) performed by the United States Geological Survey and other agencies, and fault modeling approaches developed by LLNL jointly with the Southern California Earthquake Center. This update follows the most recent methodology for performing probabilistic seismic hazard analysis, as recommended in the U.S. Department of Energy (DOE) standards (1020 Series) and documented in NUREG/CR-6372, Recommendation for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts (Budnitz et al. 1997).

The new assessment shows that the Greenville Fault system dominates these new seismic estimates, followed by the Calaveras and the Corral Hollow fault systems; then, by an order of magnitude less, it is followed by the Springtown and Mount Diablo thrust, and finally by the Las Positas Fault. This is primarily due to the distance of these faults from the Livermore Site.

Although these new estimates are the result of a completely new and independent analysis, there are virtually no differences between the new mean hazard curves and those of the 1991 study.

The results are presented in Figure H–1 showing the estimated mean hazard curve in terms of the annual probability of exceedance of the peak ground acceleration (average of the two horizontal orthogonal components) at the LLNL site, assuming that the local site conditions are similar to those of a generic soil. This assessment of the peak ground acceleration does not take into account engineering factors that reduce the accelerations that would be experienced by individual facilities and their contents.



Source: LLNL 2002dk.

FIGURE H–1.—*Peak Ground Acceleration Hazard Curve for LLNL Site, Generic Soil Conditions*

H.3.2 Seismic Hazard Evaluation Process

There are five steps involved in deriving the distribution of seismic hazard.

Step 1: Evaluation of seismic sources.

Step 2: Assessment of earthquake recurrence and maximum magnitude.

Step 3: Ground motion attenuation.

Step 4: Mathematical model to calculate seismic hazard.

Step 5: Presentation of the hazard results.

The evaluation of the seismic sources, or, faults and fault systems, (Step 1) and a discussion of the associated earthquake recurrence rates and magnitudes (Step 2) are presented below. The calculations associated with attenuation (Step 3) and the modeling of the seismic hazard are (Step 4) described in detail in the Summary of Findings (LLNL 2002dk) and are not described here. The presentation of the results (Step 5) is in Section H.3.3 below.

Evaluation of the Seismic Sources and Assessment of Earthquake Recurrence

Fault geometries for the source model are constrained using available geological mapping and seismicity and geophysical data. Geologic slip rates are estimated from paleoseismic results together with fault kinematic models, within overall geodetic and tectonic plate velocity constraints. Data and interpretations were obtained by a comprehensive review of published and unpublished literature and by elicitation of several experts on SFBR geology and tectonics during several workshops and individual interviews. This process was greatly facilitated by membership (Foxall) on the overview panel of 1999 Working Group (WG99). Historical seismicity data are taken from Bakun (1999), and the U.S. Geological Survey and UC Berkeley catalogs of instrumentally located earthquakes were obtained through the Northern California Earthquake Data Center. The LLNL seismic network provides important data for characterizing sources and recurrence close to the Livermore Site, where numerous small events have occurred.

Selection of Seismic Sources

Figures H–2 and H–3 show the SFBR faults included in the source characterization model. In general, these faults show evidence for Holocene (within the last 8,000 years) and late Quaternary (within the last 15,000 years) *activity of potential significance to hazard at the LLNL site. The sources are divided into two groups: (1) regionally significant faults that are included in the WG99 source characterization (Table H–1); and (2) local and other faults of significance to LLNL site hazard (Table H–2). Group 2 includes the Greenville Fault and Mt. Diablo thrust. These two faults are part of the WG99 characterization, but are dealt with separately and characterized in detail in the present study because of their proximity to the site. Group 2 also includes smaller or slower slip rate faults in the immediate vicinity of the site (Figure H–4), and other potentially significant faults that are not included in WG99. The Ortigalita Fault is relatively long and has an estimated slip rate on the order of 1 millimeter per year. However, it*

is distant from the site and does not make a significant contribution to the hazard, and so is not described further in this report.

Local and Other Sources

***Greenville Fault**: The Greenville fault is the easternmost member of the NW-striking right lateral San Andreas Fault system in the SFBR. Although, based on data presently available, it is considered to have the lowest slip rate of the faults of this system, it makes the largest contribution to the hazard at LLNL because it approaches to within 1 kilometer of the site.*

Characterization of the Greenville fault follows the two-segment model adopted by WG99, but its geometry and slip rate distributions are defined in considerably more detail than is required in that study.

The definition of the source geometry is based on recent detailed geomorphic and structural mapping of the fault by Unruh and Sawyer (1998), which built upon earlier investigations (e.g., Herd 1977; Dibblee 1980a; Hart 1981; Sweeney and Springer 1981). The fault segments are shown in Figure H–3, and segment parameters are given in Table H–2. WG99 defines the boundary between the north and south Greenville Fault segments at the fault's intersection with the Las Positas Fault, based upon the change in the general character and structural setting of the Greenville Fault in this vicinity (T. Sawyer, written communication, February 10, 2000). However, the location of this boundary is subject to large uncertainty, which, because of its proximity to the site, translates to significant hazard uncertainty. When the exact location of a fault is undetermined, the characteristics of the fault are also undetermined. This leads to a higher uncertainty in predictions of the fault's behavior.

Data presently available to constrain the Greenville slip rate are sparse. Earlier estimates (e.g., Sweeney 1982 and Wright et al. 1982) are in the range 0.2–0.7 millimeters per year. This is based upon observations that yield slip rate estimates averaged over widely varying time intervals ranging from tens of millions to 100–200 thousand years. However, the well-defined morphology of the fault zone is consistent with a Quaternary slip rate of 1 millimeter per year or greater (Unruh and Sawyer 1998). This has yet to be verified by data. Sawyer and Unruh (2000) found evidence for one Holocene earthquake in three trenches on Crane Ridge, southeast of LLNL, but were unable to estimate a definitive slip rate. If, as assumed by Sawyer and Unruh, this is the most recent event and using their co-seismic slip estimate of 1.25 ± 0.25 meters, then carbon-14 dating of bulk samples suggests a maximum slip rate in the range 0.25–0.5 millimeters per year; however, this is very tentative.

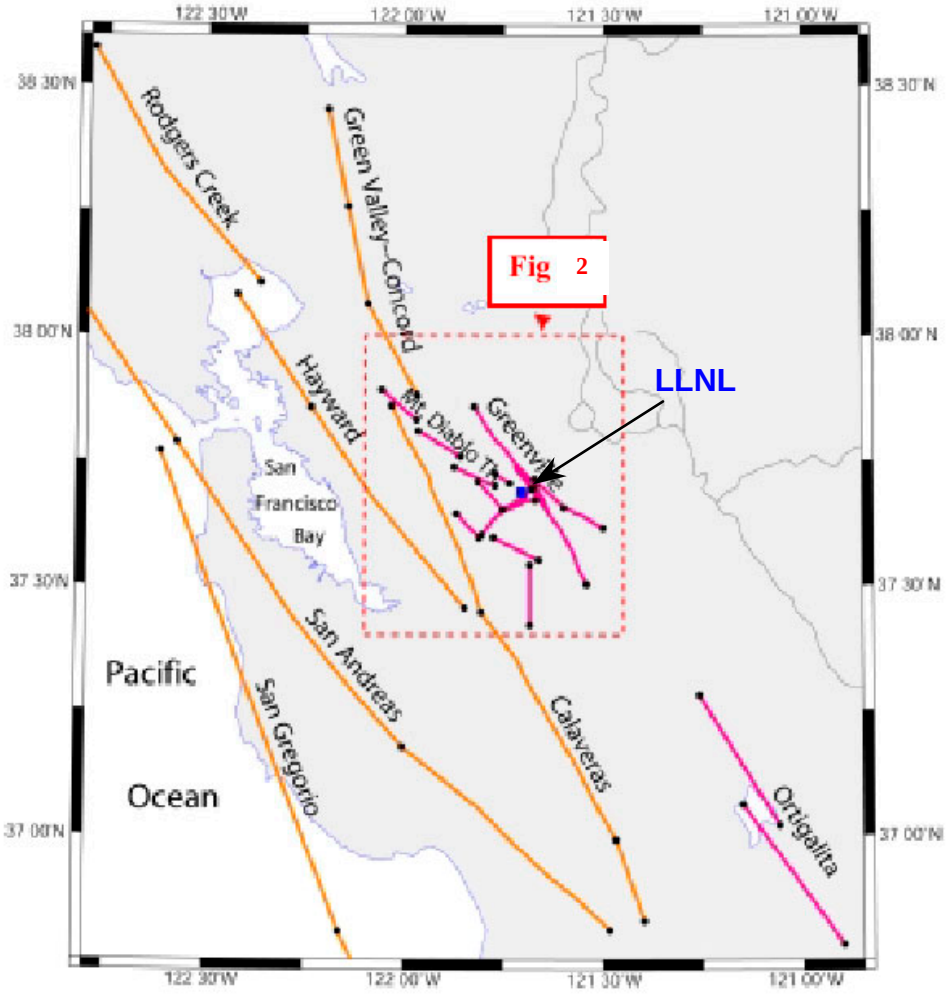


FIGURE H–2.— ***Map of the San Francisco Bay Region showing characterization of faults of significance to seismic hazard at the LLNL. The LLNL is represented by the blue square, and major right-lateral strike slip faults included in the WG99 source characterization (Schwartz 2002) are shown in orange. Significant local and other faults are shown in magenta.***

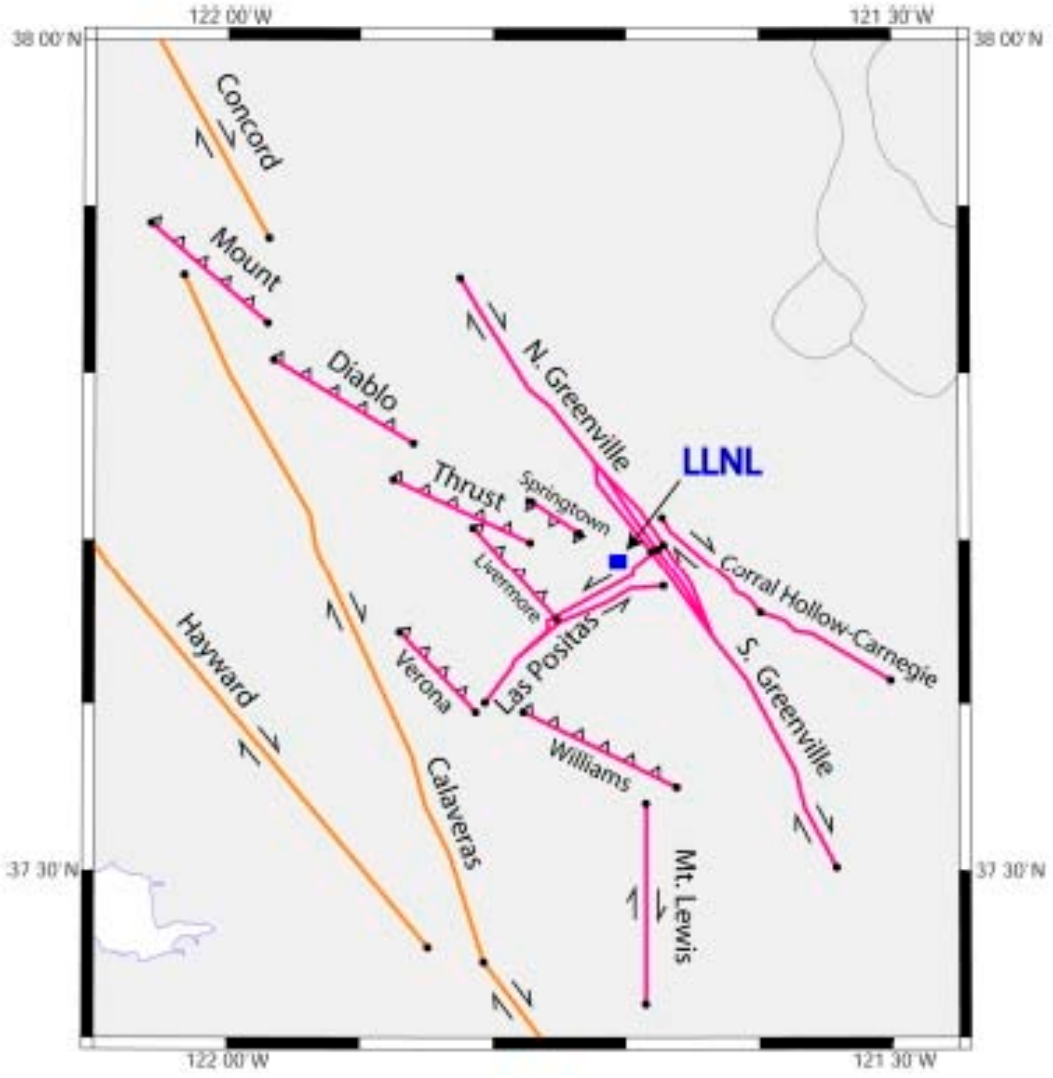


FIGURE H–3.—*Map of the East San Francisco Bay Area showing characterization of active and potentially active faults in the vicinity of the LLNL. Teeth indicate dip direction of thrust and reverse faults. Mt. Diablo thrust and Livermore Fault are blind; traces shown represent the buried upper tips of these faults.*

TABLE H–1.—*WG99 Earthquake Sources*

Fault System and Fault Segment(s)		Slip Rate (mm/yr)
San Andreas	Offshore	24 ±3
	N. Coast	24 ±3
	Peninsular	17 ±4
	Santa Cruz	17 ±4
Rodgers Creek		9 ±2
Hayward	North	9 ±2
	South	9 ±2
Calaveras:	North	6 ±2
	Central	15 ±3
	South	15 ±3
Green-Valley	North	5 ±3
	South	5 ±3
Concord		4 ±2
San Gregorio	North	7 ±3
	South	3 ±2

TABLE H–2.—*Local Earthquake Sources*

Fault Segment		Slip Rate (mm/yr)
Greenville	North	2.0 +2.5/-1.8
	South	2.0 +2.5/-1.8
Las Positas		0.6 +1.0/-0.5
Mt. Diablo Th.	NW	2.5 ±1.5
	Cent.	2.5 ±1.5
	SE	2.5 ±1.5
Verona		0.7 +0.7/-0.6
Williams		0.2 +1.1/-0.2
Corral Hollow		0.7 +1.3/-0.65
Carnegie		0.7 +1.3/-0.65
Livermore		1.0 +0.5/-0.9
Springtown		1.0 +0.5/-0.9
Mt. Lewis		1.0 +1.0/-0.9
Ortigalita	North	1.5 +0.6/-1.0
	South	0.5 +0.5/-0.4

In 2001, Sawyer and Unruh opened four new trenches across the fault at Laughlin Road, north of LLNL, where their working hypothesis of a stream channel offset across the fault suggests a slip rate of 1–2 millimeters per year or greater. Age dating of samples from these trenches is currently being carried out at the LLNL Center for Accelerator Mass Spectroscopy. An alternative way of estimating the Greenville slip rate is by inferring it from the transpressional kinematic model proposed by Unruh and Sawyer (1997) and Unruh (2000). In this model, slip is transferred from the Greenville to the Concord–Green Valley Fault via the blind Mt. Diablo thrust (see Figure H–4, and below), so that estimates of the slip rates on the Concord Fault and Mt. Diablo thrust can be used to infer the slip rate on the Greenville Fault. This yields an estimate in the range of 1 to 4 millimeters per year.

Mt. Diablo Thrust. *Unruh and Sawyer (1997) propose that the Mt. Diablo blind thrust underlying the Livermore and Sycamore valleys is the source of the major fold structures in the area, including Mt. Diablo and the Mt. Diablo and Tassajara anticlines. Unruh and Sawyer modeled these anticlinal structures as fault-propagation folds over the blind tip of the proposed Mt. Diablo thrust. The folds, and hence the underlying fault, are assumed to be active because they deform late Pleistocene (within the last 100,000 to 200,000 years) and early Holocene sediments (Unruh and Sawyer 1997, Unruh 2000). The geometry and slip rate on the thrust are inferred largely from structural modeling, although the existence of the thrust is consistent with seismic reflection data from the southeastern Tassajara Hills (Unruh 2000). This blind thrust is the only fault included in the WG99 characterization that is not part of the right-lateral San Andreas system, and is a significant new local source for the LLNL Probabilistic Seismic Hazard Assessment (PSHA). Mt. Diablo Thrust fault's contribution to the seismic hazard had not been considered in earlier studies.)*

The Mt. Diablo Thrust is identified by Unruh and Sawyer as part of what they term the Mt. Diablo fold and thrust belt, which includes the surface Williams and Verona faults southwest of the Livermore Valley, and the Livermore and Springtown structures in the immediate vicinity of the LLNL site (see Figure H–3 and below). Unruh and Sawyer hypothesize that this system formed in a left-stepping transpressional step-over between the right lateral Greenville and Concord–Green Valley faults, and propose a kinematic model in which slip on the Greenville Fault is transferred via the Mt. Diablo Thrust to the Concord Fault. Present modeling results constrain estimates only of the minimum slip rate on the Mt. Diablo Thrust averaged over several million years, which depend upon the timing of initiation of folding. The maximum age of initiation is estimated to be between 6.2 million years ago (Ma) and 3.3 Ma, which yields a minimum slip rate in the range of 1.3 to 2.4 millimeters per year (Unruh 2000). According to the Unruh and Sawyer transpressional model, this range is generally consistent with the 4 to 2 millimeters per year slip rate estimate for the Concord Fault assigned by WG99. At present, there is no evidence to constrain the minimum age of the onset of folding; if this occurred later than 3.3 Ma, then the average slip rate would be greater than 2.4 millimeters per year.

Las Positas Fault*. Based on its estimated area and slip rate, the Las Positas Fault appears capable of generating relatively infrequent moderate earthquakes. However, it makes a substantial contribution to the hazard because it passes within 1 kilometer of the Livermore Site. Characterization of the Las Positas Fault is based largely on the original mapping of Herd (1977), fault evaluation reports by the California Division of Mines and Geology (T.C. Smith 1981, Hart 1981), and particularly on the extensive field geological and geophysical*

investigations and analyses by LLNL Geosciences (Carpenter and Clark 1982, Carpenter et al. 1984). There is moderately strong evidence for latest Pleistocene–Holocene activity, and equivocal evidence that the fault may have experienced historical events (Carpenter et al. 1984, Hart 1981). However, despite the detailed field investigations carried out by LLNL, the fault remains poorly understood and its slip rate uncertain although apparently low (in the range ~0.1 to ~1 millimeters per year).

Characterization of the Las Positas Fault requires consideration of its structural and kinematic relationships to the Greenville, Verona, and Williams faults and to the hypothesized Livermore and Springtown blind reverse faults. However, these relationships are largely a matter of conjecture, since the subsurface geometries of all the faults except the Greenville are unconstrained. One interpretation (T. Sawyer personal communication 2001) is that the assumed subvertical, left-lateral Las Positas Fault acts as a tear fault separating the thrust/reverse Williams and Verona faults, in which case the slip rates on the individual faults have to be kinematically balanced. Alternatively, the Verona and Williams faults may be continuous below some depth, in which case the Las Positas Fault is a hanging wall structure, antithetical to the Greenville Fault, and its slip rate is not directly coupled to the underlying thrust. Each of these alternatives forms a separate branch in the logic tree input to the hazard calculations.

***Verona and Williams Faults**. The Verona Fault was the subject of considerable debate in the late 1970s, yet it remains very poorly understood (Rice et al. 1979). There is still insufficient information to definitely identify the structure as tectonic (Herd and Brabb 1980), rather than a massive landslide feature. California Division of Mines and Geology designated the northernmost 5.65 kilometers of the feature as mapped by Herd (1977) as an active fault according to the State of California Alquist–Priolo Act. The favored interpretation (Herd and Brabb 1980) is that the fault dips gently northeast, although the sub-surface geometry is unconstrained. Splays of the fault displace Holocene material. The only slip rate estimate for the Verona Fault is 0.12 millimeters per year (Jahns and Harding 1982), but this is highly uncertain. The trace geometry shown in Figure H–3 is based on the original Herd (1977) map.*

The Williams Fault is even more poorly understood. There is no definitive evidence for Holocene activity, although the fault cuts Quaternary sediments. The appearance (Dibblee 1980b) that the Williams trace continues the trend of the Verona Fault suggests one plausible model is that the Verona and Williams traces are the surface expressions of a single fault at depth. If this fault dips gently northeast, as suggested by near-surface splays of the Verona Fault, then this thrust could be a component of the Mt. Diablo fold and thrust belt of Unruh and Sawyer (1998) and Unruh (2000). On a more local scale, T. Sawyer (personal communication 2001) hypothesizes that the Verona, Williams, Las Positas, Livermore, and Springtown faults are components of a "Verona thrust system." As described earlier, the Las Positas Fault would be either a hanging wall or tear fault within this system, depending on whether the slip rates of the Verona and Williams faults are assumed to be equal or not. Another alternative is that the Williams Fault (and/or the Verona Fault) is inactive; note that D.P. Smith (1981, reported in Carpenter et al. 1984) interpreted the trace geometry and geomorphology of the Williams Fault to suggest a southwest dip and right-normal displacement. Slip rates on the Verona–Williams system are estimated indirectly from the sparse data available for the Las Positas Fault and the Springtown blind fault (see below) according to the different structural/kinematic interpretations of the Verona fold and thrust system.

***Livermore and Springtown Faults**: The existence and activity of the Livermore Fault have been the subjects of some debate since the fault was proposed by the California Department of Water Resources (CDWR 1966, 1974; reported in Carpenter et al. 1984), based primarily on a groundwater barrier and an apparent outcrop in Plio-Pleistocene sediments at Oak Knoll in Livermore. California Department of Water Resources (CDWR 1979, reported in Carpenter et al. 1984) also proposed that the fault extends to the southeast to Del Valle reservoir, based on observed shears within Plio-Pleistocene sediments (but not overlying colluvium). However, this interpretation is in conflict with the more compelling evidence for the activity of the Las Positas Fault, since the postulated Livermore Fault would cut across the Las Positas without offset. California Division of Mines and Geology does not consider the fault active for Alquist–Priolo zoning. An alternative possibility is that the Livermore Fault exists only north of the Las Positas Fault. To our knowledge, no estimates of either the sense of slip or slip rate have been attached to the fault as postulated by California Department of Water Resources, although right-lateral displacement is suggested based on the strike, which is subparallel to the Greenville Fault.*

An entirely different interpretation was proposed by Sawyer (1998) in the context of the Mt. Diablo fold and thrust belt. The Livermore trend is characterized by uplifted alluvial surfaces cut by wind gaps that Sawyer interprets as ancestral courses of Arroyo Mocho. The elevations of the wind gaps decrease progressively from southeast to northwest. A plausible explanation of these observations is that the Livermore trend is an active anticline that is growing laterally and deflecting Arroyo Mocho to the northwest. The anticline is truncated (or offset) on the southeast by the Las Positas Fault. Like the large-scale active folds, Sawyer proposes that the anticline is a fault propagation fold above the blind tip of an active northeast-dipping reverse fault. Similarly, the active Springtown anticline (Unruh and Sawyer 1997, Sawyer 1998) is interpreted as a fault propagation fold above a blind southwest-dipping backthrust off the Livermore Fault. These anticlines/faults are relatively short and are considered to be secondary structures within the fold and thrust belt. Like the Verona and Williams faults, the subsurface geometries of the postulated Livermore and Springtown faults are unconstrained; depending on the dip of each fault, the Livermore Fault could root into the Verona/Williams Fault, extend to the base of the seismogenic crust, or splay off the Greenville Fault.

A single carbon-14 date yields a maximum estimate of the Holocene uplift rate on the Springtown anticline of 0.7 to 0.9 millimeters per year (Unruh and Sawyer 1997), suggesting a maximum dip slip rate of about 1 millimeters per year. The average late Quaternary slip rate is estimated as 0.1 to 0.25 millimeters per year. This long-term average is consistent with a tentative uplift and slip rate estimate on the order of 0.1 millimeters per year for the Livermore Fault, based on the stream incision rate for Arroyo Mocho (Sawyer 1998).

***Corral Hollow and Carnegie Faults**. The Corral Hollow–Carnegie Fault zone as mapped by Dibblee (1980c) and Crane (1995) passes about 3 kilometers east of LLNL at its closest approach. Carpenter et al. (1991) found evidence for repeated movement during the Pleistocene and Holocene on a fault strand within Site 300, between the mapped traces of the Corral Hollow and Carnegie faults, and suggested that the fault zone as a whole should be considered potentially active. Dibblee (1980) mapped the Corral Hollow Fault as a right-lateral fault sub-parallel to and east of the Greenville Fault, and shows it offsetting the Corral Hollow syncline in a right-lateral sense. Age control on slip rates by Carpenter et al. (1991) was based on soil stratigraphy, so estimates have large uncertainties. Schlemon (Appendix B in Carpenter et al.*

[1991]) speculates that an earthquake may have ruptured the fault zone during the past few hundred years, which would imply a slip rate of 1 to 2 millimeters per year, comparable to that of the Greenville Fault. Longer-term average estimates over the last 60–70 thousand years, however, are very low, in the range 0.05–0.07 millimeters per year.

***Mt. Lewis Fault**. Characterization of the Mt. Lewis Fault is based on the March 31, 1986, ML5.7 earthquake and its immediate aftershock distribution (Zhou et al. 1993), which sharply delineates a 16-kilometer long north–south trend, consistent with the right-lateral focal mechanism of the main shock. The background microseismicity suggests that the fault may extend as far north as the Williams Fault. A cross-section through the seismicity clearly defines a sub-vertical plane to a depth of about 10 kilometers. The fault had not been recognized before the 1986 event, although it corresponds to a lineament on Landsat images (D. Schwartz, personal communication 2000). There are no direct observations to constrain the slip rate on this fault. Kinematic modeling of geodetic data suggests a slip rate on the order of 1 millimeter per year.*

H.3.3 Comparison with Previous Results

Compared with the 1991 results, *the mean hazard estimates in the generic soil case are essentially identical for the two studies. However, it must be noted that the uncertain estimates are different. The 5th and 95th percentiles provided in the Rev. 1, 1991, study define a larger band of uncertainty than the 5th to 95th percentiles in the new (Rev 2) study; the 95th percentiles are approximately equal. Therefore, this study narrowed down the estimates of the uncertainties by eliminating the alternatives that would lead to very low estimates of the seismic hazard. Our estimates of the uncertainties in the dispersion of the ground motion from the predictions with the attenuation models (the "sigma" values) are smaller than in the previous studies. The same is true for some of the occurrence models. We have included a more realistic representation of the uncertainties in the geometry of the dominant faults, as well as a number of conceptually different alternatives for the general tectonics of the region. The addition of the Mount Diablo thrust as a series of three possibly disjoint segments also contributed to raising the hazard as well as increasing the overall uncertainty.*

In the end, these effects have worked in opposition to finally provide a set of estimates of the mean hazard that is close to the results of the 1991 study, in spite of the different approach to the treatment of the uncertainties, the different set of alternative tectonic models, and the large quantity of new information that was generated in the last decade. This new study provides more insights into the identification of the dominant seismic sources, and it determines the ground motion in terms of uniform hazard response spectra.

H.4 REFERENCES

EO 12941 Executive Order 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings," issued December 1, 1994 by President William J. Clinton.

LLNL 2002dk Lawrence Livermore National Laboratory (LLNL), *Lawrence Livermore National Laboratory Site Seismic Safety Program: Summary of Findings*, UCRL-53674, Rev. 2, Lawrence Livermore National Laboratory, Livermore, CA, April 2002.

References excerpted from the *Lawrence Livermore National Laboratory Site Seismic Safety Program's Summary of Findings*

Bakun, W.H. (1999), Seismicity Activity of the San Francisco Bay Region, *Bull. Seismol. Soc. Am*. 89, 764–784.

Budnitz, R.J., G. Apostolakis, D.M. Boore, L.S. Cluff, K.J. Coppersmith, C.A. Cornell, and P.A.Morris (1997), *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*, Vol. 1, U.S. Nuclear Regulatory Commission, Washington, DC, NUREG/CR-6372, 256 p.

Carpenter, D.W. and R.J. Clark (1982), Seismic Studies for Seismic Hazard Assessment, Las Positas Fault Zone, in *Proc. Conf. on Earthquake Hazards in the Eastern San Francisco Bay Area, California*, E.W. Hart, S.E. Hirschfeld, and S.S. Schulz, eds., Calif. Div. Mines Geol. Spec. Pub. 62, 147–154.

Carpenter, D.W., J.R. Copland, A.L. Lamarre, R.S. Mateik, M.J. Taffet, and E.M. Wade (1991), *Investigation of Holocene Faulting Near Closed Landfill Pit 6, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-ID-106316.

Carpenter, D.W., J.J. Sweeney, P.W. Kasameyer, N.R. Burkhard, K.G. Knauss, and R.I. Shlemon (1984), *Geology of the Lawrence Livermore National Laboratory Site and Adjacent Areas*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53316, 150 p.

Crane, R.C. (1995), Geologic Map of the Midway Quadrangle, California, scale 1:24,000.

Dibblee, T.W. (1980a), Preliminary Geological Map of the Cedar Mountain Quadrangle, Alameda and San Joaquin Counties, California, U.S. Geol. Surv. Open File Rep. 80-850, scale 1:24,000.

Dibblee, T.W. (1980b), Preliminary Geological Map of the La Costa Valley Quadrangle, Alameda County, California, U.S. Geol. Surv. Open File Rep. 80-833a, scale 1:24,000.

Dibblee, T.W. (1980c), Preliminary Geological Map of the Midway Quadrangle, Alameda and San Joaquin Counties, California, U.S. Geol. Surv. Open File Rep. 80-535, scale 1:24,000.

Hart, E.W. (1981), *Recently Active Strands of the Greenville Fault, Alameda, Contra Costa, and Santa Clara Counties, California*, Calif. Div. Mines Geol. Open File Rep. 81-8.

Herd, D. G. (1977), Geologic Map of the Las Positas, Greenville, and Verona Faults, Eastern Alameda County, California, U.S. Geol. Surv. Open-File Rep. 77-689.

Herd, D.G. and E.E. Brabb (1980), *Faults at the General Electric Test Reactor Site, Vallecitos Nuclear Center, Pleasanton, California: A Summary Review of their Geometry, Age of Last Movement, Recurrence, Origin, and Tectonic Setting and the Age of the Livermore Gravels*, U.S. Geol. Surv. Administrative Rep., 77 p.

Jahns, R.H. and R.C. Harding (1982), Evaluation of the Inferred Verona Fault in the Vallecitos Valley, California (abs.), in *Proc. Conf. On Earthquake Hazards in the Eastern San Francisco Bay Area, California*, E.W. Hart, S.E. Hirschfeld, and S.S. Schulz, eds., Calif. Div. Mines Geol. Spec. Pub. 62, 185.

Rice, S., E. Stephens, and C. Real (1979), *Geologic Evaluation of the General Electric Test Reactor Site Vallecitos, Alameda County, California*, Calif. Div. Mines Geol. Spec. Pub. 56, 19 p.

Sawyer, T.L. (1998), *Assessment of Contractile Deformation Rates of the Mt. Diablo Fold and Thrust Belt, Eastern San Francisco Bay Region, Northern California*, Tech. Rep., National Earthquake Hazards Reduction Prog. Award No. 98-HQ-GR-1006, U.S. Geol. Surv., Reston, VA, 7 p.

Sawyer, T.L. and Unruh, J.R. (2000), Paleoseismic Investigation of the Central Greenville Fault, Eastern San Francisco Bay Region, California, *Geol. Soc. Am. Abstracts and Programs* 32, A-442.

Schwartz, D.P. (2002), U.S. Geological Survey, Menlo Park, CA, personal communication (part of WG99 study, in preparation).

Smith, T.C. (1981), *Fault Evaluation Rep. FER-112*, Calif. Div. Mines. Geol., 18 p.

Sweeney, J.J. (1982), Magnitudes of Slip Along the Greenville Fault in the Diablo Range and Corral Hollow Areas, in *Proc. Conf. on Earthquake Hazards in the Eastern San Francisco Bay Area, California*, E.W. Hart, S.E. Hirschfeld, and S.S. Schulz, eds., Calif. Div. Mines Geol. Spec. Pub. 62, 137–145.

Sweeney, J.J. and J.E. Springer (1981), *Geology of the Southeastern Livermore Valley, Alameda County, California*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53220 Rev. 1, 54 p.

Unruh, J.R. (2000), *Characterization of Blind Seismic Sources in the Mt. Diablo–Livemore Region, San Francisco Bay Area, California*, Final Tech. Rep., National Hazards Reduction Prog. Award No. 99-HQ-GR-0069, U.S. Geol. Surv., Menlo Park, CA, 30 p.

Unruh, J.R., and T.L. Sawyer (1997), *Assessment of Blind Seismogenic Sources, Livermore*

Valley, Eastern San Francisco Bay Region, Final Tech. Rep., National Earthquake Hazards Reduction Prog. Award No. 1434-95-G-2611, U.S. Geol. Surv., Reston, VA, 88 p.

Unruh, J.R., and T.L. Sawyer (1998), *Paleoseismic Investigation of the Northern Greenville Fault, Eastern San Francisco Bay Area, California*, Final Tech. Rep., National Hazards Reduction Prog. Award No. 1434-HQ-97-GR-03146, U.S. Geol. Surv., Menlo Park, CA, 34 p.

Working Group on California Earthquake Probabilities (2002), *Earthquake Probabilities in the San Francisco Bay Region: 2002-2031*, U.S. Geol. Surv., Menlo Park, CA, in preparation.

Wright, R.H., D.H. Hamilton, T.D. Hunt, M.L. Traubenik, and R.L. Schlemon (1982), Character and Activity of the Greenville Structural Trend, in *Proc. Conf. on Earthquake Hazards in the Eastern San Francisco Bay Area, California*, E.W. Hart, S.E. Hirschfeld, and S.S. Schulz, eds., Calif. Div. Mines and Geol. Spec. Pub. 62, 187–196.

Zhou, Y.Z., K.C. McNally, and T. Lay (1993), Analysis of the 1986 Mt. Lewis, California, Earthquake: Preshock Sequence–Mainshock–Aftershock Sequence, *Phys. Earth Planetary Interiors* 75, 267–288.

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APPENDIX I: EMERGENCY PLANNING AND RESPONSE

The purpose of this appendix is to summarize emergency planning and response activities established to mitigate the consequences of major emergencies and natural disasters at the Lawrence Livermore National Laboratory (LLNL). This summary covers the following topics: regulatory background, which identifies the Federal regulations upon which the emergency-preparedness programs are based; Federal, state, and local interfaces and responsibilities, which describes LLNL involvement with state and local emergency planning organizations as well as the responsibilities of government agencies; and LLNL emergency preparedness, which discusses the emergency management team, emergency categorization, notifications and communications, facilities and equipment, and transportation-related emergency response.

I.1 REGULATORY BACKGROUND

Federal regulations require establishing emergency planning and response to radiological or hazardous incidents. These regulations include 40 *Code of Federal Regulations* (CFR) Parts 355 and 265 and §302.6, and 29 CFR §1910.120, which deal with *Superfund Amendments and Reauthorization Act* (SARA) Title III, emergency planning and notification, contingency planning, release reporting, hazardous waste operation, and emergency response. In addition, the U.S. Department of Energy (DOE) provides specific direction in DOE O 151.1A and 232.1A for implementing emergency preparedness for a variety of events, including earthquakes.

To meet Federal requirements, LLNL has developed site-wide emergency preparedness plans to integrate all aspects of response.

I.2 FEDERAL, STATE, AND LOCAL INTERFACES AND RESPONSIBILITIES

In the event of an emergency at LLNL, a number of resources are available for mitigation, re-entry, and recovery activities associated with the response. This section briefly describes those Federal, state, and local agencies that may be involved in a response. In addition, the interfaces between LLNL and these agencies are discussed, including formally documented agreements.

The LLNL Fire Department is the primary point of contact with offsite agencies for emergency planning, preparedness, and response. The LLNL Fire Department has frequent ongoing contacts with local response agencies, through mutual-aid agreements and actual response. These contacts include, but are not limited to, offsite planning coordination with LLNL, interagency meetings, and information transfer. The LLNL Public Affairs Office is the primary point of contact with offsite agencies in the areas of public education.

Memorandums of Understanding (MOUs) and mutual-aid agreements exist among specific functional LLNL organizations and departments and their counterparts. The Safeguards and Security Department develops and signs security/law enforcement-related MOUs for LLNL. The LLNL Fire Department develops and signs MOUs related to the fire/emergency medical services/hazardous materials (HAZMAT) arena. The Hazards Control Department and the Health Services Department develop and sign MOUs associated with local medical facilities.

In addition, the National Nuclear Security Administration (NNSA) maintains a number of emergency response assets and interagency agreements with other Federal agencies that may be called upon for support.

I.2.1 National Nuclear Security Administration

NNSA is the lead Federal agency for emergencies at LLNL, except for certain security situations when the Federal Bureau of Investigation (FBI) may be the lead. The resources available from NNSA are extensive and include those from Federal agencies that are part of the Federal Radiological Emergency Response Plan. These assets include:

- Aerial Monitoring System
- Atmospheric Release Advisory Capability
- Accident Response Group
- Federal Radiological Monitoring and Assessment Center
- Nuclear Emergency Search Team
- Radiological Assistance Program
- Radiation Emergency Assistance Center/Training Site

The LLNL Emergency Director initiates the request for support of NNSA/Livermore Site Office assets, depending upon the nature and severity of the event. These requests are approved by NNSA/DOE-Headquarters via NNSA/Livermore Site Office.

I.2.2 Other Federal Agencies

The FBI maintains primary jurisdiction under the *Atomic Energy Act* (42 U.S.C. §2011) for incidents involving the protection of special nuclear material and any crime involving Federal property. In an emergency situation involving security incidents, the FBI will be notified, as required, by the Safeguards and Security Department and may be provided workspace in the Emergency Operations Center (EOC) or the Tactical Operations Center (TOC).

I.2.3 State Government

The State of California will be notified when an operational emergency is declared at LLNL. The state has resources and personnel to assist LLNL during a major emergency that involves the release of hazardous or radioactive materials to offsite locations. The Alameda County Office of Emergency Services takes the lead for offsite response and would coordinate with the state for assistance and resources.

The State of California's emergency assistance is based on a statewide mutual aid system designed to ensure that additional resources are provided to and among local jurisdictions whenever their own resources are committed or inadequate. The basis for this system is the

California Disaster and Civil Defense Master Mutual Aid Agreement (Office of Emergency Services 1950). This agreement was developed in 1950 and adopted by California's incorporated cities and 58 counties. It creates a formal structure coordinated by the state within which each local jurisdiction retains control of its own personnel and facilities but can give and receive assistance whenever it is needed. State agencies are obligated to provide available resources to assist local jurisdictions in emergencies at the direction of the Governor's Office of Emergency Services (OES).

The State of California instituted the Standardized Emergency Management System on December 1, 1996 (California Code of Regulations, Title 10, Division 2, Chapter 1). This system is used for coordinating state and local emergency response in California. Under the Standardized Emergency Management System, the state's assistance is accessed by requesting resources through the operational area coordinator and the Alameda County Sheriff's OES. Fire and mutual-aid resources are requested through the local and state mutual aid system.

The California Governor's OES is the lead state agency in any response to assist Alameda County and is responsible for making statewide resources available.

The California State Department of Health Services provides trained personnel to assist with monitoring and decontaminating personnel, evaluating the extent of any contamination, and monitoring offsite ingestion pathways.

I.2.3.1 *Governor's Office of Emergency Services*

LLNL has several MOUs with the Governor's OES. These MOUs include an agreement for California disaster and civil defense, an agreement for temporary transfer of vehicular equipment, and an agreement for use of radio equipment (LLNL 2003a).

Coordinators, designated by state agencies, assist California's emergency management staff headed by the director of OES or a designated representative. OES is the lead state agency for all aspects of emergency management, including planning, response coordination, recovery coordination, mitigation efforts, and training.

I.2.3.2 *California Highway Patrol*

Upon request, the California Highway Patrol (CHP) supports the Safeguards and Security Department by responding with personnel and equipment, including helicopter support, when warranted. The CHP, when responding to an emergency request for assistance to LLNL, will render support to the Safeguards and Security Department by maintaining traffic supervision and control over roadways to LLNL, operating under a Joint Incident Command System. The nature of the Emergency Response Agreement between LLNL and the CHP includes assistance calls and assistance requests under the state Law Enforcement Mutual Aid Plan (Office of Emergency Service 2003).

I.2.4 Local Organizations

I.2.4.1 *Alameda County Sheriff's Office of Emergency Services*

The Alameda Country Sheriff's OES is the lead offsite response coordination agency for major emergency and disaster situations at or affecting the Livermore Site. The fire chief at LLNL is the point of contact for those requests for resources for mutual aid systems, such as fire or law-enforcement mutual aid.

If the emergency situation requires that the general public be warned, the emergency public information is issued by the cognizant local agency, such as the cities of Livermore or Tracy or counties of Alameda or San Joaquin, depending upon the area affected by the incident.

I.2.4.2 *County Sheriff's Department*

Upon request, the Alameda County Sheriff's Department responds with personnel and equipment, including a special response unit when warranted, to support the Safeguards and Security Department. Support activities are coordinated by the Safeguards and Security Department representative in the TOC and may include assistance in responding to security threats and assistance in evacuating the site. The emergency response agreement between the Alameda County Sheriff's Department and LLNL covers assistance calls and assistance requests under the state Law Enforcement Mutual Aid Plan.

I.2.4.3 *San Joaquin County Office of Emergency Services*

The San Joaquin County OES serves in the same capacity as the Alameda County OES for Site 300.

I.2.4.4 *San Joaquin County Sheriff's Department*

Upon request, the San Joaquin County Sheriff's Department responds with personnel and equipment to support a Site 300 emergency or an immediate officer rescue or backup. The emergency response agreement between the San Joaquin County Sheriff's Department, LLNL, and Site 300 managers covers assistance calls and assistance requests under the state Law Enforcement Mutual Aid Plan.

I.2.4.5 *Twin Valley Agreement for Mutual Fire Assistance*

In addition to the State of California master mutual-aid agreement for fire services and the Alameda County fire mutual aid response plan, LLNL is a signatory to the Twin Valley agreement for mutual fire assistance. This agreement confirms that, upon request, the associated fire services will respond with personnel and equipment to support LLNL emergencies. These agencies, in responding to an emergency request for assistance, render support to the Livermore-Pleasanton Fire Department (LLNL 2003a).

I.2.4.6 *Livermore-Pleasanton Fire Department*

The Livermore-Pleasanton Fire Department is responsible for coordinating disaster planning and emergency response activities for the city of Livermore. The Livermore-Pleasanton Fire Department coordinates its activities with the Alameda County OES, the primary offsite agency for emergencies involving radioactive material. The Livermore-Pleasanton Fire Department assists other responding agencies in locating and providing needed equipment and resources and in updating city officials. In addition, if the primary communication links become unavailable, the Livermore-Pleasanton Fire Department assists in the activation of the amateur radio emergency services (ARES) network.

I.2.4.7 *Livermore Police Department*

The Livermore Police Department may be requested to support a LLNL emergency or an immediate officer rescue or backup. In responding to an emergency request for assistance, they render support to the Safeguards and Security Department by responding to security threats, controlling traffic, controlling facility access, and assisting with evacuation of the site. The Safeguards and Security Department representative, or designee, in the TOC coordinates support activities. The law enforcement assistance agreement between Livermore Police Department and LLNL covers assistance calls and assistance requests under the state Law Enforcement Mutual Aid Plan.

I.2.4.8 *Tracy Fire Department*

The Tracy Fire Department is responsible for coordinating disaster planning and emergency response activities for the city of Tracy. The Tracy Fire Department coordinates its activities with the San Joaquin County OES, the primary offsite agency for emergencies involving radioactive material in San Joaquin County.

I.2.4.9 *Offsite Medical Facilities*

MOUs are in place with Valley Care Medical Center and Eden Medical Center to provide medical support and to assist the LLNL Health Services Facility, if needed. These facilities have the capability to assist in the treatment of contaminated or injured victims resulting from a hazardous material release at LLNL (LLNL 2003a).

I.2.4.10 *Valley Emergency Preparedness Working Group*

The Valley Emergency Preparedness Working Group has been reorganized to facilitate the sharing of emergency preparedness and planning information among LLNL and those offsite agencies and entities responsible for emergency response and protection of the public and the environment, with whom LLNL may interact during emergency situations.

The mission of the Valley Emergency Preparedness Working Group is to share information and discuss common solutions to challenges in planning for response to scenarios resulting from, or potentially affecting, NNSA operations at LLNL, including Site 300.

I.3 LAWRENCE LIVERMORE NATIONAL LABORATORY EMERGENCY PREPAREDNESS

The LLNL Emergency Plan (LLNL 2003a) documents the emergency management procedures and responsibilities for the Livermore Site. The Site 300 Emergency Plan (LLNL 2003c) documents the emergency management procedures and responsibilities for Site 300. The focus of emergency planning and preparedness outlined in these manuals is to provide a coordinated response to incidents involving more than one of the basic emergency service elements or incidents that may be a threat to the health and safety of personnel and the general public. These incidents include, but are not limited to, civil disturbance, fire, explosion, incidents involving hazardous materials and waste, natural disasters, terrorism, and bomb threats.

I.3.1 Emergency Management Team Organization and Resources

I.3.1.1 *Emergency Management Team*

The LLNL director is responsible for the safe operation of LLNL. Two deputy directors, a laboratory executive officer, 12 associate directors, and a chief financial officer assist the director in the mission to provide guidance and direction for LLNL. The LLNL Director has the authority and responsibility to ensure LLNL complies with applicable DOE orders and regulations as well as other Federal, state, and local regulations.

The Director has delegated responsibility for operational activities, including emergency management, to the Deputy Director for Operations. The Safety and Environmental Protection Associate Director, as chair of the Emergency Preparedness Management Committee, is responsible for management oversight of emergency preparedness and integration with other environment, safety, and health (ES&H) activities, including emergency management.

The Hazards Control Department head is responsible for ensuring that emergency planning, including procedures and tracking systems, training, drills, readiness and maintenance of the EOC, hazard surveys and assessments, and other planning aspects, are in place. Directorate organizations are responsible for commitments, closure of commitments, and corrective actions.

The LLNL Director has also delegated to the LLNL emergency duty officers (LEDOs) the responsibility for protecting the health and safety of LLNL employees, the public, and the environment and for maintaining the security of the facility during any emergency.

LEDOs are senior LLNL managers who have accepted the responsibility for managing emergencies requiring more than a single-facility response. During emergencies, field operations will be under the authority of the incident commander, typically the LLNL Fire Department senior officer initially responding to the scene, who will consult with a LEDO.

The Emergency Preparedness Program addresses strategic emergency planning, preparedness, response, resource management, readiness assurance, and associated maintenance activities at LLNL. The organization specifically responsible for the initial response, ongoing response, and mitigation of an operational emergency at LLNL is the emergency management team, composed of senior managers from various LLNL departments. This organization assembles and becomes operational at the direction of the on-duty LEDO.

I.3.1.2 *Emergency Direction and Control*

During an emergency, defined for this purpose as an event requiring activation of the EOC, the lead is taken by the on-duty LEDO who becomes the emergency director. The first off-duty LEDO to arrive becomes the response manager. The balance of the emergency management team is comprised of department heads from Environmental Protection, Hazards Control, Plant Engineering, Public Affairs, Safeguards and Security, and Health Services. The emergency management team will support the incident commander, and keep the Director's office informed of the event. The emergency management team is supported by the Operation Support Centers (OSCs), described in Section I.3.1.5.

I.3.1.3 *Emergency Management Operations*

When the emergency management center is activated, the emergency management team and staff from the OSC will be assembled and become the emergency management team organization. The emergency management team is led by the on-duty LEDO, who maintains contact with the LLNL Director and staff. The emergency management team organization supports the incident commander.

Declaration of an Emergency

An operational emergency will be declared when the LLNL Fire Department duty chief determines events or conditions require time-urgent response from outside the immediate or affected site or facility or area of the incident. Such events or conditions cause, or have the potential to cause, serious health and safety impacts to workers or the public, serious detrimental effects on the environment, direct harm to people or the environment as a result of degradation of security or safeguard conditions, or loss of control over hazardous materials. The LEDO is responsible for activating the EOC.

Activation of the Emergency Operations Center

The LEDO will activate the EOC by notifying the Fire Dispatch Center. The on-duty dispatcher will engage the communicator, a digital call/paging system, to call the requested resources. A backup paging system is also available if the communicator becomes disabled. The LEDO declares the EOC operational when the required minimum staff has reported.

Emergency Response

Resources available to the incident commander, LEDO, and emergency management team vary according to the parameters of the event.

Re-entry

The incident commander will determine when a scene is stable and re-entry can occur. The incident commander will have support from the appropriate safety team.

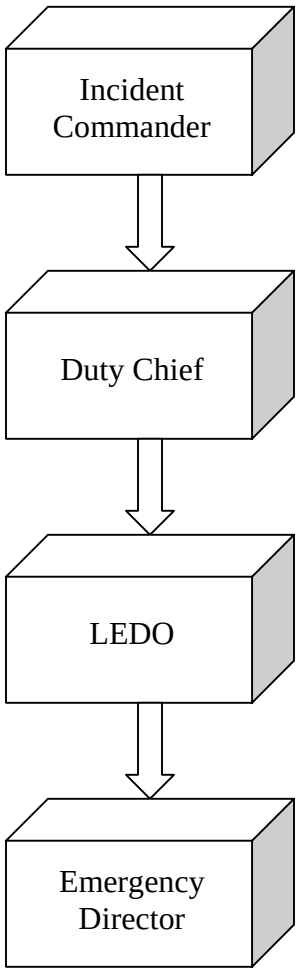
Emergency Termination

The emergency will be terminated when the emergency condition is stabilized and/or the emergency management team and incident commander determine there is no longer a threat to employee safety, public safety, and the environment.

I.3.1.4 *Emergency Management Personnel*

Incident Commander/Duty Chief

The incident commander/duty chief gathers information sufficient to determine the categorization/classification of the event or situation, implement initial protective actions, and, if required, provide protective action recommendations to appropriate offsite authorities (Figure I.3.1.4–1).



Incident Commander – Typically, the LLNL Fire Department senior officer initially responding to scene. Responsible for protecting life, property, and assets; establishing incident objectives and goals, selecting the appropriate strategy, and performing those tactical directions until the goal is achieved.

Duty Chief – The LLNL Fire Department battalion chief or above. Assumes the role of emergency director. Initial responsibilities are to categorize/classify the event, implement protective actions, make protective action recommendations, and complete official notifications. Maintains emergency director role until relieved by emergency director in emergency operations center. Duty chief may assume incident commander role.

LEDO – LLNL Emergency duty officer is a direct representative of the LLNL Director and is responsible for managing institutional response during an emergency.

Emergency Director – The emergency director has absolute, unilateral authority and responsibility to implement the facility/site emergency plan and exercise overall emergency management responsibility at all times during response to an operational emergency. Assumes responsibilities for categorization/classification, protective actions/protective action recommendations, and notifications from duty chief when emergency operations center has been declared "operational."

Source: LLNL 2003a.

FIGURE I.3.1.4–1.—*Emergency Response Command and Control*

Upon categorization of an operational emergency, the incident commander/duty chief activates the appropriate level of the emergency response operation, initiates appropriate notifications, including the LEDO, and manages the emergency as the emergency director until relieved by the on-duty LEDO. A designated incident commander/duty chief is onsite or on call at all times and is responsible for managing institutional response during an emergency.

Laboratory Emergency Duty Officer/Emergency Director

Upon activation of the EOC and appropriate OSCs, the on-duty LEDO serves as the emergency director. The LEDO/emergency director has full authority to provide management direction and response for the mitigation, recovery, and termination of all operational emergencies.

During localized operational emergencies at Site 300, the Site 300 manager or designated alternate serves as the emergency director. This emergency director coordinates the emergency activities of site personnel and equipment and keeps the LEDO apprised at all times. The relationship between Livermore Site and Site 300 command and control is shown in Figure I.3.1.4–2.

Emergency Management Team

An emergency management team is assembled at the EOC at the discretion of the LEDO. The team manages emergency operations and resources under the emergency director. Senior LLNL managers from each emergency service organization are designated to serve on the emergency management team. Operations commanders at their respective OSCs support the emergency management team.

Emergency management team members are described in the following sections.

Response Manager

The response manager coordinates the emergency management team as directed by the emergency director. This person, who reports directly to the emergency director, is the first available off-duty LEDO.

Environmental Protection Department Representative

A senior member of Environmental Protection Department (EPD) management advises the emergency director on environmental issues.

Hazards Control Department Representative

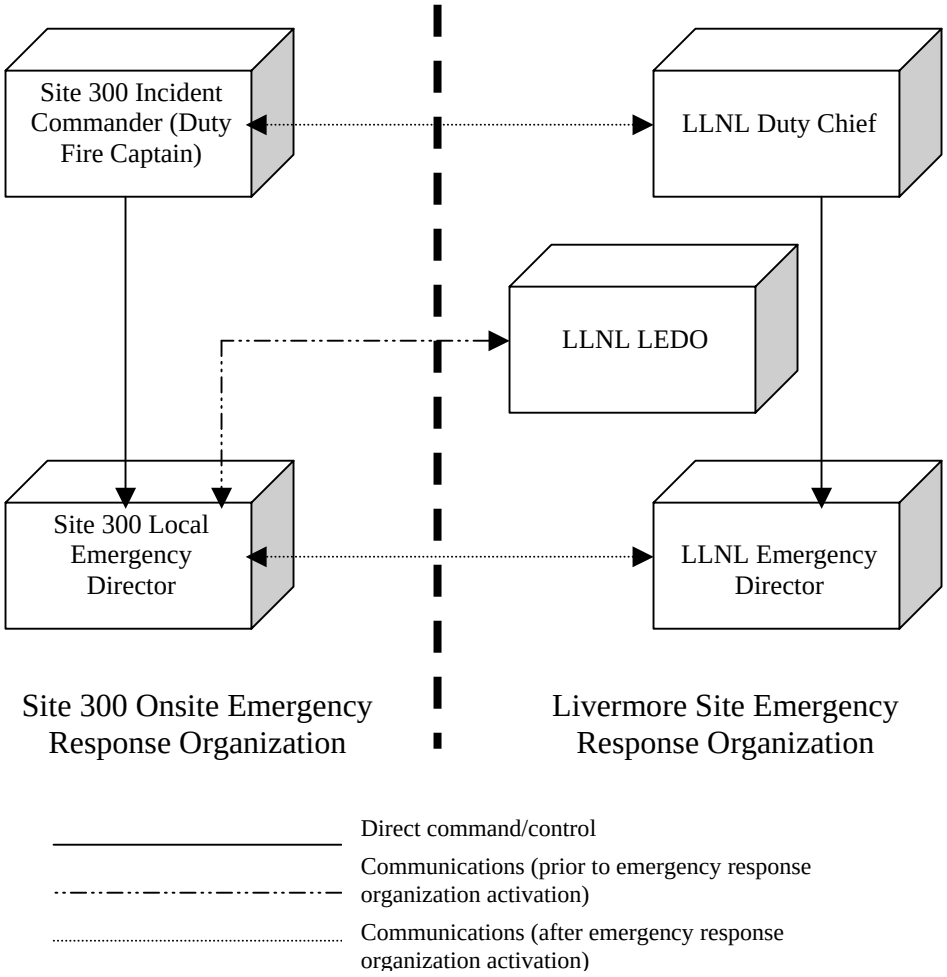
A senior Hazards Control manager advises the emergency director on life-safety matters, hazards and effects, and LLNL policy as it relates to safety.

Plant Engineering Department Representative

A senior Plant Engineering manager will advise the emergency director on general plant operations of LLNL.

Public Affairs Department Representative

A senior Public Affairs Office official, normally the public affairs office manager, will advise the emergency director on LLNL employee information, concerns, and announcements to onsite personnel. This official will also advise the emergency director on public information policy, liaison with offsite organizations with public affairs responsibilities, and preparation and release of statements. When the EOC is activated, this representative becomes the internal/external public affairs manager.



Source: LLNL 2003c.

FIGURE I.3.1.4–2.—*Site 300 and Livermore Site Commend and Control*

Safeguards and Security Department Representative

A senior Safeguards and Security Department manager will advise the emergency director on general security policy and operations.

United States Department of Energy

A senior manager from the NNSA/Livermore Site Office will serve as an advisor to the emergency management team.

Emergency Operations Center Staff

The EOC staff provides administrative/clerical support for the operation of the center. The staff consists of an EOC coordinator, a WebEOC operator, and administrative support.

I.3.1.5 *Operation Support Centers*

The OSCs are LLNL's technical support offices. They provide this support to their respective members of the emergency management team and manage their field and/or regulatory responses from these centers, which are located at various sites throughout LLNL. These centers are connected with the EOC via multiple communication systems. Individual OSC plans outline the operations specific to each OSC's response activities.

Environmental Protection Department

The EPD staff is responsible for evaluating the emergency situation to determine potential or actual impacts to the environment; meeting regulatory reporting requirements; marshaling necessary personnel to assist in the response, cleanup, and disposal of hazardous substances; and notifying Federal, state, and local agencies on environmental issues.

Hazards Control Department

The Hazards Control Department provides response teams with expertise in explosives safety, fire protection, radiation safety, industrial hygiene, industrial safety, and criticality safety. Action and status information is summarized and relayed to and from the EOC.

Health Services Department

The Health Services Department provides medical management of incident casualties, including medical decontamination.

Plant Services

The Plant Services Department coordinates and controls personnel, equipment, and resources for plant maintenance and utilities. Action and status information is summarized and relayed to and from the EOC.

Public Affairs Office

The Public Affairs Office coordinates and directs the release of information to employees and the public. It also functions as the focal point for outside media inquiries associated with the emergency and coordinates activities at the joint information center, if activated.

Safeguards and Security Department

The TOC supports LLNL's emergency management team in operational emergency response. If the emergency is security driven, the center serves as the primary focal point for the incident commander. The TOC also serves as the point of contact for outside law enforcement agencies.

Site 300

The Site 300 EOC coordinates the activities of Site 300 and reports those results to the LEDO, or the emergency director if the Livermore Site EOC is operational. In addition to the emergency response resources integral to Site 300, additional support may be drawn from the Livermore Site.

National Nuclear Security Administration/Livermore Site Office Emergency Communications Center

The emergency communications center (ECC) oversees the site response and provides support, assistance, and guidance to the EOC. The ECC also provides information to NNSA/Livermore Site Office management, the NNSA/DOE-Headquarters EOC, and members of the press and coordinates with other Federal agencies on a local level, as necessary.

I.3.1.6 *Other Emergency Response Assets*

Field Monitoring Teams

When required, the Hazards Control Department and the EPD provide onsite (outside the immediate incident scene) and offsite monitoring capabilities through the use of a pool of team members. When an emergency classification of site area emergency or general emergency is declared, the field monitoring team will be called in to supply real-time monitoring data to verify the results of the analytical models. Field monitoring data are also used to support the adequacy of emergency response actions taken to protect employees and the public. The emergency director and/or consequence assessment analyst will request the activation of the field monitoring team through the Hazards Control Department OSC.

Technical Support

A LLNL health services representative may be requested to advise the emergency management team on issues including health implications of emergency situations, triage, treatment, and transport of injured individuals.

The National Atmospheric Release Advisory Center (NARAC) may be requested to advise the emergency management team on the implications of toxic or radiological releases. NARAC, a part of LLNL's Energy and Environment Directorate, supports DOE, the U.S. Department of Defense (DoD), and LLNL programs and operations, including the LLNL emergency response organization.

Using professional staff, numerical models, computer systems, and network links about the country, NARAC can transmit information about an accident, exercise, or potential accident in

the form of graphic plots of contours of dose and/or air concentration and ground deposition of toxic materials. This service can also be used to support a DOE-authorized offsite response.

Credibility Assessment

A credibility assessment team member may advise the emergency management team through the Safeguards and Security Department manager about the credibility of any potential incident such as terrorist activities or bomb threats.

I.3.1.7 *Offsite Response Interfaces*

Formal and informal relationships exist between LLNL and external emergency planning and response agencies and organizations. Where possible, interrelationships with Federal, state, and local organizations are prearranged and documented in formal plans, agreements, and understandings for mutual assistance detailing the emergency support to be provided.

These agencies and organizations include:

- DOE
- FBI
- California Governor's OES
- California Department of Health Services
- CHP
- Alameda County OES
- Alameda County Sheriff's Office
- San Joaquin County OES
- San Joaquin County Sheriff's Department
- Twin Valley Agreement Mutual Fire Assistance
- Livermore/Pleasanton Fire Department
- Livermore Police Department
- Offsite medical facilities

I.3.2 Emergency Categorization and Classification

I.3.2.1 *Operational Emergencies*

Operational emergencies are unplanned, significant events or conditions that require time-urgent response from outside the immediate affected site, facility, or area of the incident. Such emergencies are caused by, involve, or affect LLNL facilities, sites, or activities.

I.3.2.2 *Operational Emergencies That Require Further Classification*

Operational emergencies are classified as indicated below, in order of increasing severity. They indicate a specific threat to workers and the public due to the release or potential release of significant quantities of radiological and nonradiological hazardous materials from LLNL.

Alert

An alert would be declared when events are predicted, are in progress, or have occurred that result in one or more of the following:

- An actual or potential substantial degradation in the level of control over hazardous materials, radiological and nonradiological, such that the radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material would exceed the applicable protective action guide (PAG) value beyond 100 feet but not greater than the facility boundary (about 330 feet).

- An actual or potential substantial degradation in the level of safety of a facility or process that could, with further degradation, produce a site area emergency or general emergency.

Site Area Emergency

A site area emergency would be declared when events are predicted, in progress, or have occurred that result in one or more of the following situations:

- An actual or potential major failure of functions necessary for the protection of workers or the public. The radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material that would exceed the applicable PAG or emergency response planning guideline (ERPG) values beyond the facility boundary or exclusion zone boundary. The PAG or ERPG value would not be exceeded at or beyond the site boundary.

- Actual or potential major degradation in the level of safety or security of a facility or process that could, with further degradation, produce a general emergency.

General Emergency

A general emergency would be declared when events are predicted, in progress, or have occurred that result in one or more of the following situations:

- Actual or imminent catastrophic reduction of facility safety or security systems with potential for the release of large quantities of radiological or nonradiological hazardous materials to the environment.

- The radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material would exceed the applicable PAG or ERPG value at or beyond the site boundary.

I.3.2.3 *Operational Emergencies Not Requiring Further Classification*

In some cases, an event may occur that, while it does not meet the criteria for a classifiable operational emergency, does pose a concern for personnel health and safety, environmental impact, or security. In general, an operational emergency not requiring further classification is defined as a health and safety, environmental, safeguards and security, or offsite transportation event that does not meet the criteria for an alert, as described above. An example would be discovery of hazardous material contamination from past NNSA operations that is causing or may reasonably be expected to cause uncontrolled personnel exposures exceeding protective action criteria.

I.3.3 Notifications and Communications

Protocols are in place for the prompt initial notification of LLNL emergency response personnel, onsite personnel, and offsite emergency response personnel/organizations, including NNSA/Livermore Site Office, NNSA/DOE-Headquarters, and other Federal, state, and local organizations. Communication systems are also in place to provide for continuing effective communication among the emergency response organizations, both offsite and onsite, throughout an operational emergency.

I.3.3.1 *Notifications*

Onsite/Offsite Notifications

When a potential operational emergency not involving hazardous materials occurs, the fire incident commander or security watch commander is responsible for notifying emergency response personnel and potentially affected onsite personnel of initial protective actions and providing the LLNL Fire Department duty chief with a briefing. The duty chief may declare an operational emergency and initiate notifications, including appropriate offsite authorities and the LEDO.

If the operational emergency involves or has the potential to involve hazardous materials, the duty chief may further classify the event as an alert, site area emergency, or general emergency, brief the LEDO, call out the emergency response organization, and initiate offsite agency notifications. The LEDO notifies the LLNL Director's office and other applicable senior LLNL and University of California Office of the President management.

If a site area emergency or general emergency has been declared, the entire emergency response organization and all supporting emergency response facilities, with the exception of the joint information center (at site area emergency), will be automatically activated. If an operational

emergency not requiring further classification or alert has been declared, the level of activation will be determined by the LEDO. The emergency response organization will be called out via the communicator, a personal computer (PC)-based, digital system that activates both telephones and pagers. A manual call-out backup system, using fire dispatch and/or the occurrence reporting duty officer, is also available. The duty chief, acting as the emergency director, has the responsibility for offsite notifications until the EOC has been declared "operational" and the on-duty LEDO has assumed the role of emergency director and accepts responsibility for all subsequent notifications.

Offsite Agency Notification

The offsite agencies in the following listing will be notified within 15 minutes of the declaration of an operational emergency involving hazardous materials (alert, site area emergency, or general emergency). In an operational emergency not involving hazardous materials, offsite agency notifications will be accomplished within 30 minutes.

Offsite notifications are made to:

- NNSA/Livermore Site Office duty officer
- Livermore Police Department
- Livermore/Pleasanton Fire Department
- Alameda County OES
- San Joaquin County OES
- State of California OES Warning Center
- Sandia National Laboratories/California
- NNSA/DOE-Headquarters EOC duty officer
- Tracy Fire Department
- Tracy Police Department

Followup notifications will be provided on an hourly basis (from the previous notification), or whenever the classification of the emergency event changes, protective action recommendations are revised, or the emergency has been terminated.

Each of the agencies listed above has provided primary and backup numbers to be called for initial notifications, in addition to facsimile numbers to receive followup hard copy. These numbers are reviewed and verified on a quarterly basis.

Initial notifications are made by the duty chief using the communicator. Typically, the duty chief will complete the notification form, and transmit the information into the communicator, which

sends the information simultaneously to all offsite agencies. If the communicator malfunctions, the duty chief can verbally provide the notification information to fire dispatch and it can be manually transmitted to designated agencies.

After the EOC has been declared "operational," the emergency director assumes responsibility for subsequent notifications. The EOC coordinator will oversee the notification process within the EOC.

When notified of an emergency at the Livermore Site, the Alameda County OES notifies other appropriate State of California entities. The Alameda County OES also coordinates and authorizes use of the State of California's emergency broadcast system.

When notified of an emergency at Site 300, the San Joaquin County OES notifies other appropriate State of California entities. The San Joaquin County OES also coordinates and authorizes use of the State of California's emergency broadcast system.

Department of Energy Assets

When there is a need for existing DOE assets to support the emergency response, the emergency director or response manager will make a request through the NNSA/Livermore Site Office emergency management team member or duty officer.

National Nuclear Security Administration Field and Headquarter Notifications

Upon categorization of an operational emergency and/or declaration of a classified emergency, the NNSA/Livermore Site Office duty officer and the DOE-Headquarters EOC duty officer are notified, via the communicator, as a part of the official offsite notification process. The NNSA/Livermore Site Office duty officer and NNSA/DOE-Headquarters will continue to receive subsequent notifications and updates throughout the emergency.

I.3.3.2 *Communications*

Reliable and redundant communications systems provide LLNL the means to notify Federal, state, and local response agencies and provide direction and control of the emergency response organization. LLNL EOC and ECC have the capability for secure communications with the NNSA/DOE-Headquarters EOC.

Communications with Offsite Agencies

The primary communications system for official offsite notifications is the communicator. This is a PC-based digital communications system. If the communicator fails, independent telephone systems allow for completion of notifications. The communicator is also used to call LLNL emergency response organization personnel via pager and/or telephone.

Other Lawrence Livermore National Laboratory Communications Systems

Communications requirements fall into three general categories:

- Emergency instructions to onsite workers
- Initial notifications of emergency response organizations
- Operational communications between command centers and field response elements

The dedicated evacuation voice/alarm system is the primary communications tool used to notify LLNL workers of expected protective actions and additional general information. Site 300 notifications are through the administrative building page system or trunked radio.

Other communications systems include the LLNL telephone system, a building paging system, the LLNL radio station, a digital paging system, an emergency vehicle public address system, and other computer communications systems. Communications among emergency responders and from the incident scene to the incident commander/duty chief are maintained.

When the emergency response facilities are operational, communications between the EOC and the OSCs, including the joint information center will be established to allow participants to review information in real time. LLNL maintains backup communications systems for intra-facility communications.

Each communications system or network is maintained in a state of readiness through regularly scheduled operational tests. These tests and their periodicity, as well as communications issues identified during tests, drills, and exercises, are documented in action reports and tracked to resolution.

I.3.4 Emergency Facilities and Equipment

I.3.4.1 *Emergency Facilities*

LLNL has emergency facilities and equipment to support the planning for, response to, and mitigation of operational emergencies.

Emergency Operations Center

The EOC is the coordination and control point for all operational emergency efforts. It provides a location and a system from which the emergency director and emergency management team assess, evaluate, coordinate, and direct emergency response activities. It is the focal point for emergency notifications and reports and for liaison with Federal, state, and local response organizations.

Emergency Response Facilities

LLNL maintains two fire stations, which are staffed 24 hours a day. Fire Station No. 1 is located on the Livermore Site, just inside the South Main Gate in Building 323. The station houses 14 pieces of fire apparatus; 24 firefighters, 8 on duty each shift; the Emergency Management Division administration; occurrence reporting; and support staff. Fire Station No. 2 is located at Site 300 in Building 890. The facility houses 3 pieces of fire apparatus and 12 firefighters, 4 on duty each shift.

Operations Support Centers

The OSCs provide support to their respective members of the emergency management team and manage their field and/or regulatory responses from these centers.

Decontamination Center

The health services facility houses a decontamination center.

Medical Facilities

The Livermore Site has an occupational medical center with a decontamination facility. This facility is staffed Monday through Friday during normal working hours. LLNL Fire Department paramedics are on duty 24 hours a day. A satellite clinic at Site 300 is staffed by a registered nurse during normal working hours. The registered nurse provides basic health services and first aid.

Security Tactical Operations Center

In the event of an emergency, security will activate the TOC, a master coordination and control point for all security-related operational emergency efforts.

I.3.4.2 *Emergency Equipment*

Communications Equipment

The LLNL Fire Department and the Safeguards and Security Department operate dispatch centers and monitor one another's systems. All security personnel and firefighters are connected to their dispatch centers via hand-held radios and on mobile vehicle radios.

Heavy Construction Equipment

A complete list of heavy construction equipment is available from the Plant Engineering Department office or, during an emergency, from the Plant Engineering Department OSC. Plant Engineering's master equipment list includes this heavy construction equipment list.

Alarm Equipment

The Emergency Management Division emergency dispatch center and the Safeguards and Security central alarm center each monitor site-wide alarm systems.

Rescue Team Equipment

Rescue equipment maintained by the LLNL Fire Department meets National Fire Protection Association standards.

Sanitation and Survival Equipment

Each assembly point is equipped with basic first-aid supplies and additional supplies as determined by each programmatic organization.

Transportation Equipment

The Emergency Management Division operates three ambulances. Mini-motor coaches, operated by the Laboratory Fleet Management Department, can be used to transport injured employees if requested by the incident commander or the emergency director.

Personal Protective Equipment

Personal protective equipment meets National Fire Protection Association standards.

Gas- and Liquid-Monitoring Equipment

Air particulate samplers, air vapor samplers, hand-held combustible gas analyzers, and other equipment are maintained on site by the Hazards Control Department, EPD, and Plant Engineering Department.

Damage Containment Equipment

During an emergency, the incident commander and the Plant Engineering OSC have access to information on the availability of specific damage containment equipment.

Fire-Fighting Equipment

Fire-fighting equipment meets National Fire Protection Association standards. A complete list is maintained by the LLNL fire department.

Emergency Power Equipment

Buildings containing systems that may be needed during a power outage are supplied with emergency generators. Portable generators are available through both the Emergency Management Division and UTel Department.

Logistic Support Equipment

Logistic support equipment is maintained and supplied by the various emergency management team organizations and is available through the incident commander or OSC.

I.3.5 Transportation-Related Emergency Response

LLNL has emergency response plans and procedures for onsite transportation-related incidents involving hazardous and radioactive materials and wastes. Supplements to LLNL's ES&H Manual also address specific transportation concerns such as shipping of explosives and radioactive substances.

The Emergency Plan (LLNL 2003a) details specific activities for first response and evaluation of a hazardous spill, actual cleanup, records keeping, and subsequent followup to eliminate, if possible, repeat incidents. They also identify administrative roles and responsibilities, lines of authority for coordinating emergency response, and requirements for cleanup after a transportation-related accident.

Packaging and Other Requirements

Compliance with the U.S. Department of Transportation (DOT) and DOE requirements for packaging hazardous and radioactive materials reduces the impacts of any release of any hazardous or radioactive materials resulting from an accident. Packaging requirements for hazardous and radioactive shipments are detailed in DOT (49 CFR Parts 109–199) and Nuclear Regulatory Commission (10 CFR Part 71) regulations. These requirements apply to shipments of hazardous and radioactive materials and wastes from LLNL.

In addition, hazardous and radioactive material packages are labeled and transport vehicles are placarded. Shipping papers and documentation requirements also provide necessary information for emergency response. These requirements are specifically identified in DOT regulations (49 CFR §172.600).

I.4 REFERENCES

10 CFR Part 71 — Nuclear Regulatory Commission (NRC), "Energy, Packaging and Transportation of Radioactive Material." *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

29 CFR Part 1910.120 — U.S. Department of Labor (DOL), "Labor, Occupational Safety and Health Standards, Hazardous Waste Operations and Emergency Response," Code of Federal Regulations, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

40 CFR Part 265 — U.S. Environmental Protection Agency (EPA), "Protection of the Environment, Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

40 CFR Part 302.6 — EPA, "Protection of the Environment, Designation, Reportable Quantities, and Notification, Notification requirements," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

40 CFR § 355 — EPA, "Protection of the Environment, Emergency Planning and Notification," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

49 CFR Parts 109-199 — United States Department of Transportation (DOT), "Hazardous Materials Regulations," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised October 21, 2003.

49 CFR §172.600 — DOT, "Transportation, Hazardous Materials Table, Special Provisions, Hazardous Material Communications, Emergency Response Information, and Training Requirements," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, revised October 21, 2003.

42 U.S.C. §2011	"Atomic Energy Act," *United States Code*, Title 42, Chapter 23, §§2011 - 2259.
California Code of Regulations, Title 10, Division 2, Chapter 1	California Code of Regulations, *Office of Emergency Services, Adopted Regulations*, Office of Emergency Services, Sacramento, CA.
DOE O 151.1A	U.S. Department of Energy (DOE), *Comprehensive Management System*, U.S. Department of Energy, Washington, DC, November 1, 2000.
DOE O 232.1A	DOE, *Occurrence Reporting and Processing of Operations Information*, U.S. Department of Energy, Washington, DC, July 21, 1997.
LLNL 2003a	Lawrence Livermore National Laboratory (LLNL), *Emergency Plan*, UCRL-MA-113311, Rev. 6, Lawrence Livermore National Laboratory, Livermore, CA, January 2003.
LLNL 2003c	LLNL, *Site 300 Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA, January 2003.
Office of Emergency Services 1950	Office of Emergency Services, *California Disaster and Civil Defense Master Mutual Aid Agreement*, California Governor's Office of Emergency Services, Sacramento, CA, Attested November 15, 1950.
Office of Emergency Services 2003	Office of Emergency Services, *Law Enforcement Mutual Aid Plan*, California's Governor's Office of Emergency Services, Sacramento, CA, 2003 ed.

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APPENDIX J: RADIOLOGICAL TRANSPORTATION ANALYSIS METHODOLOGY

J.1 SHIPMENT SCENARIOS

J.1.1 Proposed Action and Alternatives for Transportation

The No Action Alternative, Proposed Action, and Reduced Operation Alternative, as described in Chapter 3 of the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS), include transportation of radioactive materials. Low-level radioactive waste would be shipped from the Lawrence Livermore National Laboratory (LLNL) to the Nevada Test Site. Transuranic (TRU) waste would be shipped to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. Other radioactive materials for research or weapons stockpile stewardship would be sent to LLNL from other U.S. Department of Energy (DOE) and National Nuclear Security Administration (NNSA) facilities and from LLNL to these same facilities. There are occasional shipments of radioactive materials that do not fit into these categories.

J.1.2 Materials Shipped

The materials shipped are described as follows.

Low-Level Waste

For purposes of analysis, all low-level waste shipments are assumed to go to either the Nevada Test Site or the PermaFix Facility in Kingston, Tennessee. Other destinations are possible, including privately operated facilities in Barnwell, South Carolina, and Clive, Utah, and several mixed-waste treatment facilities. One such example, the low-level wastes contaminated with chemicals identified in the *Toxic Substance Control Act* (TSCA), would be shipped to DOE's TSCA incinerator at Oak Ridge, Tennessee, with the ash returned to LLNL. Low-level waste shipments throughout DOE complex were analyzed in the *Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997f), but are calculated and reported in this LLNL SW/SPEIS to give a complete picture of radiological transportation impacts for LLNL.

Transuranic Waste

For many years, LLNL had been accumulating TRU waste because there was no disposal site or because facilities used to characterize and package the waste were not available at LLNL. LLNL plans to ship nearly 1,000 TRU waste drums to the WIPP, DOE's designated repository for TRU waste since 1999. This one-time shipment of TRU waste backlog is analyzed separately in Section J.6.3 of this appendix. Another one-time shipment analyzed in this LLNL SW/SPEIS is the shipment of 14 drums of TRU and mixed TRU waste from the Lawrence Berkeley National Laboratory (LBNL) to LLNL for characterization and ultimate shipment to the WIPP. Finally, this LLNL SW/SPEIS also analyzes the continuing shipment of TRU waste generated as a result of LLNL operations. TRU waste shipments from LLNL to the WIPP were analyzed in the *Waste*

Isolation Pilot Plant Final Supplemental Environmental Impact Statement (WIPP SEIS) (DOE 1997e), but are calculated and reported in this LLNL SW/SPEIS to give a complete picture of radiological transportation impacts for LLNL.

Special Nuclear Materials

Special nuclear materials used at LLNL are primarily plutonium and some enriched uranium in the metal or oxide forms. Many of these shipments were analyzed in the *Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (DOE 1996a) and the *Surplus Plutonium Disposition Environmental Impact Statement* (DOE 1999c). The shipments are to or from other NNSA weapons facilities.

Tritium

Illumination devices containing tritium are shipped to LLNL for tritium recycling. Tritium targets are sent from Los Alamos National Laboratory (LANL), New Mexico, to LLNL for National Ignition Facility (NIF) experiments, and tritium gas is sent from the Savannah River Site to LLNL for various other experiments. Tritium does not emit radiation from its packaging; therefore, it does not have any incident-free radiological impacts. Section J.4 addresses the consequences of a transportation accident involving tritium gas.

Miscellaneous Radioactive Materials

A search of DOE's Enterprise Transportation Analysis System identified a number of shipments not included in any of the categories above. These shipments are made to DOE and private laboratories across the nation. Most shipments are small, commercial-carrier shipments with no measurable dose rate. The radiological impacts of these shipments are not quantified.

J.1.3 Packaging

For purposes of this analysis, NNSA used two general package types: Type A and Type B packaging. Type A packaging is designed to protect and retain its contents under normal transport conditions and maintain sufficient shielding to limit radiation exposure to handling personnel. These packages are used to transport low-level waste. Type B packages are used to transport material with the highest radioactivity levels and to protect and retain their contents under transportation accident conditions. TRU waste and special nuclear materials are shipped in Type B packages.

DOE adopts Nuclear Regulatory Commission (NRC) standards for Type B packages, which include certification of packages against stringent testing standards (10 CFR Part 71). The testing or other analysis must certify that the contents of the package will not be released under the following tests:

- Free Drop—The package/cask drops 30 feet onto a flat, horizontal, unyielding surface so that it strikes at its weakest point.

- Puncture—The package/cask drops 40 inches onto a 6-inch-diameter steel bar at least 8 inches long. The bar strikes the cask at its most vulnerable spot.

- Fire—After the impact tests, the cask is totally engulfed in a 1,475-degree Fahrenheit (°F) thermal environment for 30 minutes. The cask is then completely submerged under at least 40 inches of water for 8 hours. Undamaged packages must withstand more severe immersion tests.

There are numerous designs of Type B packages that NNSA uses for transporting radioactive materials. NNSA selects packages that are appropriate for the purpose and contents for which they will be used. NNSA typically uses the TRU package transporter (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.

Type B packages for special nuclear materials are shipped in specially designed safe secure trailers/safeguards transports (SST/SGT). The SST/SGT contains enhanced structural and security features that are classified. They operate under operational security procedures and emergency plans that include armed escort, satellite tracking, and advanced communications.

J.2 ROUTING AND DEMOGRAPHICS

NNSA used the computer code, Transportation Routing Analysis Geographic Information System (TRAGIS) (ORNL 2000), to determine representative routes for the transportation indicated in Table J.2–1. Designed by the Oak Ridge National Laboratory, TRAGIS gives routes from an origin to a destination based on user-selected criteria. NNSA-selected criteria are consistent with transport of radioactive material by preferred routes such as those described in 49 CFR Part 397, Subpart D; i.e., highway route-controlled quantities.

TABLE J.2–1.—*Unique TRAGIS Runs*

Origin-Destination Pair (between LLNL and -)	Material Shipped
Los Alamos National Laboratory	Special nuclear material, tritium, depleted uranium
Pantex	Special nuclear material
Nevada Test Site	Low-level waste, special nuclear material
Savannah River Site	Special nuclear material, tritium
Argonne National Laboratory – West	Special nuclear material
Rocky Flats Environmental Technology Site	Special nuclear material
Atomic Weapons Establishment (United Kingdom)[a]	Special nuclear material
Hanford Site	Special nuclear material
Oak Ridge National Laboratory	Special nuclear material, TSCA waste
PermaFix	Mixed low-level waste
Waste Isolation Pilot Plant	TRU waste
Lawrence Berkeley National Laboratory	TRU waste and mixed TRU waste

Source: Original.
[a] Shipments to the United Kingdom were modeled by truck to the shipping terminal in Charleston, South Carolina.
LLNL = Lawrence Livermore National Laboratory; TRU = transuranic; TSCA = *Toxic Substance Control Act.*

TRAGIS provides route information such as nodes, segments, miles per segment, miles per state, miles per highway type, miles per population density category, population within 800 meters of the route, and other parameters of interest. Some of the output is specifically designed for direct input into the RADTRAN 5 computer code (Section J.3).

TRAGIS runs were performed for the unique origin-destination pairs required under the Proposed Action. Pairs already represented by a reverse-direction pair were eliminated. Unique TRAGIS runs were reduced to those in Table J.2–1.

J.3 INCIDENT-FREE ANALYSIS

NNSA used RADTRAN 5 (SNL 2000) to calculate collective dose from incident-free transportation of radioactive materials by truck. RADTRAN 5 was developed and is maintained by Sandia National Laboratories. It is capable of analyzing both incident-free and accident impacts for highway, rail, ship and barge, and air transport. For incident-free analysis, the code calculates collective doses to persons along the route, such as residents; persons sharing the route; persons at stops; and drivers. Important inputs to RADTRAN 5 are the demographic and route data described in Section J.2, the dose rate 1 meter from the truck, and other parameters.

Microshield® (Grove Engineering 1996) calculations of arrays of special nuclear material packages placed into SST/SGTs yielded very low dose rates. For conservatism, NNSA selected a larger dose rate to model, 1 millirem per hour. Years of experience shipping weapons-related fissile materials have demonstrated that the 1-millirem-per-hour dose rate is not likely to be exceeded. Dose rates for TRU waste were not calculated but taken from the WIPP SEIS (DOE 1997e) as 4 millirems per hour. Low-level waste was assumed to have a dose rate of 1 millirem per hour, based on information in the Waste Management Programmatic EIS (DOE 1997f).

Individual RADTRAN 5 runs for one shipment were conducted for the analysis, and their results are indicated in Table J.3–1, identified with case numbers. These results can be aggregated into values for the No Action Alternative, Proposed Action, and Reduced Operation Alternative, depending on numbers of shipments. NNSA also performed a cumulative impacts analysis of radiological shipments converging on LLNL area from shipments to and from Sandia National Laboratories/California (SNL/CA). The route was assumed to be 3.5 miles in LLNL vicinity with a speed of 25 miles per hour, commensurate with heavy traffic.

TABLE J.3–1.—*Unique RADTRAN 5 Runs for Incident-Free Transport*

Case Number[a]	Origin-Destination Pair	Material Shipped	Collective Dose to Drivers	Collective Dose to Members of the Public (person-rem)			
				Along Route	Sharing Route	At Stops	Total Public
1	LLNL-LANL	SNM	9.3×10^{-3}	5.7×10^{-4}	7.3×10^{-3}	4.0×10^{-3}	1.2×10^{-2}
2	LLNL-PANTEX	SNM	8.3×10^{-3}	6.1×10^{-4}	8.1×10^{-3}	4.0×10^{-3}	1.3×10^{-2}
3	LLNL-NTS	SNM	4.3×10^{-3}	4.1×10^{-4}	5.8×10^{-3}	2.4×10^{-3}	8.6×10^{-3}
4	LLNL-SRS	SNM	1.8×10^{-2}	2.0×10^{-3}	1.8×10^{-2}	8.0×10^{-3}	2.8×10^{-2}
5	LLNL-ANL-W	SNM	6.1×10^{-3}	6.1×10^{-4}	7.0×10^{-3}	2.4×10^{-3}	1.0×10^{-2}
6	LLNL RFETS	SNM	7.7×10^{-3}	6.3×10^{-4}	7.9×10^{-3}	3.2×10^{-3}	1.2×10^{-2}
7	LLNL-AWE	SNM	1.9×10^{-2}	2.3×10^{-3}	1.9×10^{-2}	8.8×10^{-3}	3.0×10^{-2}
8	LLNL-NTS	LLW	6.6×10^{-2}	8.1×10^{-4}	1.2×10^{-2}	4.8×10^{-3}	1.7×10^{-2}
9	LLNL-PERMA FIX	MLLW	2.5×10^{-1}	3.1×10^{-3}	2.8×10^{-2}	1.5×10^{-2}	4.6×10^{-2}
10	LLNL-OAK RIDGE	TSCA	2.5×10^{-1}	3.1×10^{-3}	2.8×10^{-2}	1.5×10^{-2}	4.6×10^{-2}
11	LLNL- OAK RIDGE	TSCA	3.0×10^{-2}	2.8×10^{-4}	2.6×10^{-3}	1.3×10^{-3}	4.2×10^{-3}
13	LLNL-WIPP	TRU	8.6×10^{-3}	1.0×10^{-3}	1.3×10^{-2}	5.8×10^{-3}	1.9×10^{-2}
14	SRS-LLNL	SNM	2.4×10^{-2}	3.4×10^{-3}	3.0×10^{-2}	1.4×10^{-2}	4.7×10^{-2}
15	LLNL-LANL	SNM	1.1×10^{-2}	8.2×10^{-5}	1.0×10^{-3}	5.7×10^{-4}	1.7×10^{-3}
16	LLNL-SRS	SNM	2.4×10^{-2}	3.4×10^{-3}	3.0×10^{-2}	1.4×10^{-2}	4.7×10^{-2}
17	LLNL-LBNL	TRU and Mixed TRU	1.3×10^{-3}	2.3×10^{-5}	4.1×10^{-4}	(b)	4.4×10^{-4}

TABLE J.3–1.—*Unique RADTRAN 5 Runs for Incident-Free Transport (continued)*

Case Number[a]	Origin-Destination Pair	Material Shipped	Collective Dose to Drivers	Collective Dose to Members of the Public (person-rem)			
				Along Route	Sharing Route	At Stops	Total Public
28	HANFORD-LLNL	TRU	8.1×10^{-3}	1.5×10^{-3}	1.4×10^{-2}	6.7×10^{-3}	2.2×10^{-2}
29	LLNL-LANL	SNM	8.1×10^{-3}	1.5×10^{-3}	1.4×10^{-2}	5.4×10^{-3}	2.1×10^{-2}
33	LLNL-PANTEX	SNM	9.3×10^{-3}	3.3×10^{-4}	4.2×10^{-3}	2.3×10^{-3}	6.9×10^{-3}
34	LLNL-NTS	SNM	8.7×10^{-3}	1.0×10^{-3}	1.3×10^{-2}	4.8×10^{-3}	1.8×10^{-2}
35	LLNL-SRS	SNM	8.7×10^{-3}	1.0×10^{-3}	1.3×10^{-2}	4.8×10^{-3}	1.8×10^{-2}
36	LLNL-LLNL	SNM	1.1×10^{-2}	8.2×10^{-5}	1.0×10^{-3}	5.7×10^{-4}	1.7×10^{-3}
37	LLNL-LLNL	SNM	9.3×10^{-3}	9.7×10^{-4}	1.2×10^{-2}	2.3×10^{-3}	2.0×10^{-2}
38	LLNL-WIPP	SNM	8.7×10^{-3}	1.0×10^{-3}	1.3×10^{-2}	4.8×10^{-3}	1.8×10^{-2}
39	LLNL-WIPP	TRU	8.7×10^{-3}	1.0×10^{-3}	1.3×10^{-2}	4.8×10^{-3}	1.8×10^{-2}
40	LLNL-LLNL	SNM	6.1×10^{-5}	8.9×10^{-6}	1.5×10^{-4}	8.8×10^{-5}	2.5×10^{-4}
41	LLNL-LLNL	SNM	6.1×10^{-5}	8.9×10^{-6}	1.5×10^{-4}	8.8×10^{-5}	2.5×10^{-4}
42	LLNL-LLNL	Tritium	0	0	0	0	0
43	LANL-LLNL	Depleted Uranium	6.1×10^{-5}	8.9×10^{-6}	1.5×10^{-4}	8.8×10^{-5}	2.5×10^{-4}

Source: Original.

[a] Cases 12, 18-27, and 30-32 are no longer used in this analysis.

[b] There were no stops on this short route.

ANL/W = Argonne National Laboratory – West; AWE = Atomic Weapons Establishment; LBNL = Lawrence Berkeley National Laboratory; LLW = low-level waste; LANL = Los Alamos National Laboratory; MLLW = mixed low-level waste; NTS = Nevada Test Site; ORR = Oak Ridge Reservation ; RFETS = Rocky Flats Environmental Technology Site; SNM = special nuclear material, various load sizes and compositions; SRS = Savannah River Site; TSCA = *Toxic Substance and Control Act*; WIPP = Waste Isolation Pilot Plant.

J.4 ACCIDENT ANALYSIS

NNSA examined the shipment campaigns under the No Action Alternative, Proposed Action, and Reduced Operation Alternative to identify bounding transportation accidents for each of four radiological shipment types: special nuclear material, TRU waste, low-level waste, and tritium. As with the incident-free analysis, NNSA used RADTRAN 5 to calculate collective dose to the public from potential transportation accidents. The routing and packaging were the same as those for the same shipments under the incident-free analysis. The general methodology is described in NUREG 0170 (NRC 1977a), using eight accident severity categories. Parameters for release fractions, aerosolized fractions, and respirable fractions were taken from the RADTRAN User Guide (SNL 2000). Table J.4-1 describes the four shipments that were analyzed.

TABLE J.4–1.—*Candidate Bounding Radiological Transportation Accidents*

Material	Origin-Destination	Description
Special nuclear material	LANL - LLNL	This is a fine oxide powder consisting mostly of plutonium isotopes and is a byproduct of the ITP process (see Appendix N). The accident would involve 25 Type B containers being transported in an SST/SGT. There would be three shipments per year of this material.
TRU waste	LLNL - WIPP	The TRU waste would originate in the ITP process and consist primarily of plutonium isotopes. The waste would be packaged into forty-two 55-gallon drums that would be placed into three TRUPACT-IIs. There would be one shipment per year of this particular type of TRU waste.
Low-level waste	LLNL - NTS	The low-level waste would consist mostly of plutonium isotopes at concentrations that are less than those needed to classify the waste as TRU. It would be packaged into eighty 55-gallon drums and transported by a standard tractor-trailer truck. There would be 80 shipments per year of this low-level waste.
Tritium	SRS - LLNL	Up to 10 grams of gaseous tritium would be transported in Type B containers. Under accident conditions, the gaseous tritium is assumed to totally oxidize. Tritium in this quantity would be shipped four times per year.

Source: Original.
ITP = Integrated Technology Project; LANL = Los Alamos National Laboratory; NTS = Nevada Test Site; SRS = Savannah River Site; SST/SGT = Safe secure trailers/safeguards transportation; TRU = transuranic; TRUPACT = transuranic package transporter; WIPP = Waste Isolation Pilot Plant.

The impacts of the accidents reported in Table J.4–2 are based on the assumption that the accidents would occur in the most populous regions along the route. Accidents in less populated regions or of lower collision impact could occur, resulting in smaller impacts. The accident probabilities were multiplied by the numbers of shipments. The lower consequence accidents would likely have larger probabilities of occurrence.

TABLE J.4–2.—*Impacts from Candidate Bounding Radiological Transportation Accidents*

Material	Collective Dose (person-rem)	Latent Cancer Fatalities	Probability (per year)
Special nuclear material	2.7×10^{4}	16	5.3×10^{-11}
TRU waste	4.6×10^{4}	28	2.1×10^{-11}
Low-level waste	44	0.026	3.5×10^{-6}
Tritium	340	0.20	9.9×10^{-10}

Source: Original.

The bounding offsite radiological transportation accident under the Proposed Action would be the TRU waste accident associated with the ITP. The probability of this accident is so low that it is not considered reasonably foreseeable. Under the No Action Alternative and Reduced Operation Alternative, the bounding accident would be the tritium accident.

J.5 FORMATION OF ALTERNATIVES

The RADTRAN 5 results presented in Section J.3 must be combined, as follows.

J.5.1 Current Operations

Radiological transportation under current operations includes shipments of special nuclear material, tritium, low-level and mixed low-level waste, TSCA-contaminated low-level waste, TRU waste backlog, and miscellaneous radioactive materials. No cases for tritium or miscellaneous radioactive materials have been quantified because the incident-free impacts are insignificant compared to the quantified shipments.

Therefore, the following RADTRAN 5 runs comprise the current operations analysis (see Table J.3–1):

- 11 shipments under RADTRAN 5 case 1
- 41 shipments under RADTRAN 5 case 8
- 4 shipments under RADTRAN 5 case 9
- 11 shipments under RADTRAN 5 case 10
- 2 shipments under RADTRAN 5 case 11

J.5.2 No Action Alternative

Radiological transportation under the No Action Alternative would include shipments of special nuclear material, tritium, low-level and mixed low-level waste, TRU waste, and miscellaneous radioactive materials. No cases for tritium or miscellaneous radioactive materials have been quantified because the incident-free impacts are insignificant compared to the quantified shipments.

Therefore, the following RADTRAN 5 runs comprise the No Action Alternative analysis (see Table J.3–1):

- 118 shipments under RADTRAN 5 case 1
- 14 shipments under RADTRAN 5 case 2
- 68 shipments under RADTRAN 5 case 3
- 39 shipments under RADTRAN 5 case 4

- 6 shipments under RADTRAN 5 case 5
- 10 shipments under RADTRAN 5 case 7
- 52 shipments under RADTRAN 5 case 8
- 9 shipments under RADTRAN 5 case 9
- 13 shipments under RADTRAN 5 case 13
- 15 shipments under RADTRAN 5 case 42
- 50 shipments under RADTRAN 5 case 43

J.5.3 Proposed Action

Radiological transportation under the Proposed Action would include shipments of special nuclear material, tritium, low-level and mixed low-level waste, TRU waste (including the Berkeley drums), and miscellaneous radioactive materials. No cases for tritium or miscellaneous radioactive materials have been quantified because the incident-free impacts are insignificant compared to the quantified shipments.

Therefore, the following RADTRAN 5 runs comprise the Proposed Action analysis (see Table J.3–1:

- 127 shipments under RADTRAN 5 case 1
- 14 shipments under RADTRAN 5 case 2
- 78 shipments under RADTRAN 5 case 3
- 8 shipments under RADTRAN 5 case 4
- 50 shipments under RADTRAN 5 case 6
- 5 shipments under RADTRAN 5 case 7
- 66 shipments under RADTRAN 5 case 8
- 16 shipments under RADTRAN 5 case 9
- 9 shipments under RADTRAN 5 case 13
- 4 shipments under RADTRAN 5 case 14
- 1 shipment under RADTRAN 5 case 15
- 3 shipments under RADTRAN 5 case 16

- 1 shipment under RADTRAN 5 case 33
- 1 shipment under RADTRAN 5 case 34
- 10 shipments under RADTRAN 5 case 40
- 10 shipments under RADTRAN 5 case 41
- 15 shipments under RADTRAN 5 case 42
- 10 shipments under RADTRAN 5 case 43

J.5.4 Reduced Operation Alternative

Radiological transportation under the Reduced Operation Alternative would include shipments of special nuclear material, tritium, low-level and mixed low-level waste, TRU waste, and miscellaneous radioactive materials. No cases for tritium or miscellaneous radioactive materials have been quantified because the incident-free impacts are insignificant compared to the quantified shipments.

Therefore, the following RADTRAN 5 runs comprise the Reduced Operation Alternative analysis (see Table J.3–1):

- 265 shipments under RADTRAN 5 case 1
- 46 shipments under RADTRAN 5 case 8
- 9 shipments under RADTRAN 5 case 9
- 7 shipments under RADTRAN 5 case 13
- 10 shipments under RADTRAN 5 case 42
- 30 shipments under RADTRAN 5 case 44

J.6 SPECIFIC CAMPAIGNS

Although the following shipment campaigns are part of the analysis of alternatives, NNSA has selected these for separate treatment and disclosure of incident-free impacts.

J.6.1 Berkeley Transuranic Waste Drums

Under the Proposed Action, there would be a one-time shipment of fourteen 55-gallon drums of solidified TRU and mixed TRU waste from LBNL to LLNL. The drums would be characterized and placed into the shipment campaign to the WIPP. RADTRAN 5 case 17 constitutes this campaign. The incident-free result would be 4.4×10^{-4} person-rem to the general public, which is equivalent to 3×10^{-7} latent cancer fatalities (LCFs).

J.6.2 *Toxic Substance Control Act*-Listed Low-Level Waste

This shipment campaign under the No Action Alternative would comprise two shipments of liquids and five shipments of solids for treatment at DOE's TSCA incinerator at Oak Ridge National Laboratory. The ash may have to be returned to LLNL. Therefore, NNSA assumed that the liquids would reduce in volume to one 55-gallon drum of ash, but that the solids (diatomaceous earth and gypsum) would not reduce in volume at all. This would mean that six shipments of solids would be returned. Therefore, the following RADTRAN 5 runs comprise this shipment campaign (see Table J.3–1):

- 11 shipments under RADTRAN 5 case 10
- 2 shipments under RADTRAN 5 case 11

The result would be 0.51 person-rem to the general public, which is equivalent to 3×10^{-4} LCFs.

J.6.3 Transuranic Waste Backlog

TRU waste has accumulated at LLNL waiting for the disposal method to become available. NNSA has estimated that under the No Action Alternative, 24 full shipments to the WIPP (case 13) would be needed (see Table J.3–1). This would result in 1.9 person-rem to the general public, which is equivalent to 1×10^{-3} LCFs.

J.6.4 Integrated Technology Project

Details of this Proposed Action shipment campaign are reported in Appendix N. The result would be 0.55 person-rem per year to the general public, which is equivalent to 3×10^{-4} LCFs per year.

J.6.5 National Ignition Facility Target Materials (see Appendix M)

Under the Proposed Action, plutonium and enriched uranium would be shipped from LANL to LLNL. Therefore, the following RADTRAN 5 runs comprise this campaign (see Table J.3–1):

- 10 shipments under RADTRAN 5 case 40
- 10 shipments under RADTRAN 5 case 41
- 15 shipments under RADTRAN 5 case 42
- 10 shipments under RADTRAN 5 case 43

The result would be 0.019 person-rem to the general public, which is equivalent to 1.1×10^{-5} LCFs per year.

J.7 CUMULATIVE IMPACTS ANALYSIS

LLNL and SNL/CA are the largest shippers of radioactive materials in the immediate area. The close proximity of these two government laboratories means that shipments to these laboratories

to or from any location in the county converge on nearby roads, producing a cumulative impact. The most probable route in the immediate area in which these shipments converge is I-580 from the east to Greenville Road to East Avenue. The Greenville Road segment of this route has very low population density. Therefore, for purposes of analysis, NNSA has analyzed a route along I-580 from Greenville Road exit to the Vasco Road exit and then along South Vasco Road to East Avenue.

Using RADTRAN 5, NNSA analyzed all the shipments under the Proposed Action along this 3.5-mile route segment. Except for the route and demographics, all of the analytical parameters for this cumulative impacts analysis were the same as those for the Proposed Action. Shipments to and from SNL/CA were also analyzed for this route segment; NNSA assumed five shipments of low-level waste and other incidental radioactive materials. There were no TRU waste shipments included in the SNL/CA analysis. The collective dose to the general population along this route segment would be 6.1×10^{-2} person-rem per year from LLNL Proposed Action shipments and 1.2×10^{-3} person-rem per year from the SNL/CA shipments, for a cumulative impact of 6.2×10^{-2} person-rem per year. This is equivalent to 3.7×10^{-5} LCFs per year in the exposed population.

J.8 CALCULATION OF LATENT CANCER FATALITIES

In Chapter 5 of this LLNL SW/SPEIS, DOE reports human health effects from transportation of radioactive materials in terms of LCFs. Consistent with recommendations of the Interagency Steering Committee on Radiation Standards (Lawrence 2002), DOE uses a factor to convert collective dose in person-rem to numbers of LCFs. The value would be 6×10^{-4} LCFs per person-rem.

J.9 REFERENCES:

10 CFR Part 71 — Nuclear Regulatory Commission (NRC), "Energy, Packaging and Transportation of Radioactive Material." *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

49 CFR Part 397 — U.S. Department of Transportation, "Transportation, Transportation of Hazardous Materials; Driving and Parking Rules," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised October 1, 2003.

DOE 1996a — U.S. Department of Energy (DOE), *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management, Summary*, Vols. 1-4, DOE/EIS-0236, Washington, DC, September 1996.

DOE 1997e — DOE, *Waste Isolation Pilot Plant Final Supplemental Environmental Impact Statement*, DOE/EIS-026-S-2, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, September 1997.

DOE 1997f — DOE, *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive Waste and Hazardous Waste*, DOE/EIS-0200-F, U.S. Department of Energy, May 1997.

DOE 1999c — DOE, *Surplus Plutonium Disposition Final Environmental Impact Statement*, DOE/EIS-0283, U.S. Department of Energy, Office of Fissile Materials Disposition, Washington, DC, November 1999.

Grove Engineering 1996 — Grove Engineering, *MicroShield-Version 5 User's Manual*, Rockville, MD, October 1996.

Lawrence 2002 — Lawrence, Andy, Memorandum from Andy Lawrence, U.S. Department of Energy, Office of Environmental Policy and Guidance, dated August 9, 2002, regarding the *Radiation Risk Estimation from Total Effective Dose Equivalents (TEDE's)*, Washington, DC, 2002.

NRC 1977a — NRC, *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes*, Vol. 1, NUREG-0170, Nuclear Regulatory Commission, Rockville, MD, December 1977.

ORNL 2000 — Oak Ridge National Laboratory (ORNL), T*ransportation Routing Analysis, Geographic Information System (WebTRAGIS) User's Manual,* ORNL/TM-2000/86, Oakridge National Laboratory, Oak Ridge, TN, April 2000.

SNL 2000 — Sandia National Laboratory (SNL), *RADTRAN5 User Guide*, SNAD2000-1257, Sandia National Laboratories, Albuquerque, NM, May 2000.

APPENDIX K: TABLE OF CONTENTS

APPENDIX K: DISTRIBUTION LIST, INTERGOVERNMENTAL AFFAIRS AND AGENCY CONSULTATIONS

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APPENDIX K: DISTRIBUTION LIST, INTERGOVERNMENTAL AFFAIRS AND AGENCY CONSULTATIONS

Council on Environmental Quality (CEQ) Regulations (40 CFR §1506.6) implementing the *National Environmental Policy Act* (NEPA) compel public participation and involvement in the environmental impact statement (EIS) process. Further, U.S. Department of Energy (DOE) guidelines (10 CFR Part 1021) for implementing NEPA stipulate requirements of public notices during the EIS process. These guidelines also describe the requirements for a formal public hearing and comment period after the release of the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS).

In addition, the EIS process includes intergovernmental affairs activities designed to keep government agencies and officials informed of the issues and the status of the LLNL SW/SPEIS. These activities include opportunities to participate in the scoping process, consultations during data collection, and opportunities to comment on the Draft LLNL SW/SPEIS.

K.1 DISTRIBUTION LIST

The list of those individuals, organizations, and agencies who have received a copy of the Draft LLNL SW/SPEIS follows.

United States Senate

Honorable Barbara Boxer, US Senate
Honorable Dianne Feinstein, US Senate
Honorable Jeff Bingaman, Ranking Minority Member, Committee on Energy and Natural Resources
Honorable Pete Domenici, Chairperson, Subcommittee on Energy and Water Development, Committee on Appropriations; Chairperson, Committee on Energy and Natural Resources
Honorable Carl Levin, Ranking Minority Member, Senate Armed Services Committee
Honorable Harry Reid, Ranking Minority Member, Subcommittee on Energy and Water Development, Committee on Appropriations
Honorable John Warner, Chairperson, Senate Armed Services Committee

United States House of Representatives

Honorable Richard Pombo, US House of Representatives
Honorable Ellen O. Tauscher , US House of Representatives
Honorable John Dingell, Ranking Minority Member, Committee on Energy and Commerce
Honorable David Hobson, Chairperson, Subcommittee on Energy and Water Development, Committee on Appropriations
Honorable Duncan Hunter, Chairperson, House Armed Services Committee
Honorable Ike Skelton, Ranking Minority Member, House Armed Services Committee
Honorable W. J. “Billy” Tauzin, Chairperson, Committee on Energy and Commerce
Honorable Peter Visclosky, Ranking Minority Member, Subcommittee on Energy and Water Development, Committee on Appropriations

Native American Representatives
Andrew Galvan, The Ohlone Indian Tribe
Ramona Garibay, Ohlone/Constanoan Tribe
Jakki Kehl, Ohlone/Constanoan Tribe
Katherine Perez, Ohlone/Costanoan Tribe
Marjorie Ann Reid, Ohlone/Constanoan Tribe
Ella Rodriguez, Ohlone/Constanoan Tribe
Ann Marie Sayer, Chairperson, Indian Canyon Mutsun Band of Costanoan
Thomas P. and Howard S. Soto, Ohlone/Constanoan Tribe
Michelle Zimmer, Amah/Mutsun Tribal Band
Irene Zwierlein, Chairperson, Amah/Mutsun Tribal Band

Federal Agencies
Jan C. Knight Fish & Wildlife Service, U.S. Department of the Interior
Kathy Setian, U.S. Environmental Protection Agency, Region IX
David Tomsovic, U.S. Environmental Protection Agency, Region IX

State Officials and Agencies
Lora Barrett, Department of Toxic Substances Control, Sacramento Regional Office
Edward Bailey, Department of Health Services, Radiological Health Branch
Banky Curtis, Department of Fish & Game, Sacramento Valley-Central Sierra Region 2
Naomi Feger, Regional Water Control Board, San Francisco Bay Region
Rob Floerke, Department of Fish & Game, Central Coast Region 3
Gregoria Garcia, State Clearing, Office of Planning & Research
Guy Houston, California State Assembly
Scott Morgan, State Clearinghouse, Office of Planning and Research
Larry Myers, California Native American Heritage Commission
Mary F. O'Keefe, University of California, Office of the President
Ted Park, Department of Toxic Substances Control, Northern California Coastal Cleanup Operations Branch
Don Perata, California State Senate
Terry Roberts, State Clearinghouse, Office of Planning and Research
Mohinder S. Sandhu, Department of Toxic Substances Control, Sacramento Regional Office
Arnold Schwarzenegger, Governor
Susan Timm, Regional Water Quality Control Board, Central Valley Region
Thomas Torlakson, California State Senate
Cindi Wolff, Federal Documents Librarian, University of California, Berkeley
Jack Zimmerman, University of California, Office of the President

Local Officials and Agencies
Linda Barton, Livermore City Manager
Mark Beeman, Livermore City Council
Dan Bilbrey, Mayor of Tracy
Keith Carson, Alameda County Board of Supervisors
Lorraine Dietrich, Livermore City Council
Susan Frost, Livermore Community Development Department
Scott Haggerty, Alameda County Board of Supervisors

Marshall Kamena, Mayor of Livermore
Alice Lai-Bitker, Alameda County Board of Supervisors
Marj Leider, Livermore City Council
Kevin Roberts, Director, Livermore Community Development Department
Nate Miley, Alameda County Board of Supervisors
Andrea Moss, Berkeley Public Library
William C. Norton, Bay Area Air Quality Management District
Gail Steele, Alameda County Board of Supervisors
Phylis Tait, Pleasanton Public Library
Mee Ling Tung, Alameda County Department of Environmental Health

Individuals and Organizations
Joni Arends, Concerned Citizens for Nuclear Safety
Margaret A. Bauman, Tri-Valley CAREs
Mavis Belisle, Peace Farm
Leslee and Stacy Belmont, Tri-Valley CAREs
Rossidah Berger, Tri-Valley CAREs
Gene Bernard, Tri-Valley CAREs
Vernon J. Brechin, Tri-Valley CAREs
Kevin R. Brown
Faye A. Butler, Tri-Valley CAREs
Jackie Cabasso, Western States Legal Foundation
Sarah Cadman, Tri-Valley CAREs
Linda Caesare, Tri-Valley CAREs
Helen Callbeck, Tri-Valley CAREs
Daven Camara, Tri-Valley CAREs
Marlene Candell, Tri-Valley CAREs
Corrine F. Carey, Tri-Valley CAREs
Frank Chambers LLNL
Tom Clements, Greenpeace
Jay Coghlan, Nuclear Watch of New Mexico
Jennifer Colley, Tri-Valley CAREs
Sharon Delgado, Tri-Valley CAREs
Edward Dierauf, Tri-Valley CAREs
Elena V. Dorabji, Tri-Valley CAREs
Bruce Drew, Tri-Valley CAREs
Erek Dyskant
Miriam Edelweiss, Tri-Valley CAREs
Kathleen M. Eidell, LARPD Planning & Parks Department
Stephanie Erieson, Tri-Valley CAREs
Ed Everts, Tri-Valley CAREs
Harriett Fels, Tri-Valley CAREs
AA Fischer, Tri-Valley CAREs
Sarah Fox, Tri-Valley CAREs
David Fritz, Tri-Valley CAREs
Marily Garrett, Tri-Valley CAREs
Jean Gaylord, Tri-Valley CAREs

Ernest Goitein
K.F. Gordon, Tri-Valley CAREs
Robert Gould, Physicians for Social Responsibility
Harold and Flora Greenblatt, Tri-Valley CAREs
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Janet Greenwald, Citizens for Alternatives to Radioactive Dumping
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Evelyn Hall, Tri-Valley CAREs
Sibylle Hartman, Tri-Valley CAREs
Dorothy Headley, Tri-Valley CAREs
Dave Hedgepeth, Nashville Peace Action
Bert Heffner, Friends of the World
Lorraine Herrera, Tri-Valley CAREs
Chris and Rekha Hiller, Tri-Valley CAREs
Ian Hoffman, Oakland Tribune
Roberta Hopkins
Catherine Houreade, Tri-Valley CAREs
Suzanne Hufft, Tri-Valley CAREs
Ralph Hutchison, Oak Ridge Environmental Peace Alliance
Jerry Joliff, Tri-Valley CAREs
Tyson Kade, University of Washington
Maryann Karim, Tri-Valley CAREs
Fern S. Katz, Tri-Valley CAREs
Marylia Kelley, Tri-Valley CAREs
Candace Kilchenman, Tri-Valley CAREs
Donald F. King, Tri-Valley CAREs
Cecile Lealaide, Tri-Valley CAREs
Vicki Legion, Tri-Valley CAREs
Marvin I. Lewis
Yvonne Logan, Tri-Valley CAREs
Patricia F. Long, Tri-Valley CAREs
Vasia Markides, Tri-Valley CAREs
Diane D. Marks, Tri-Valley CAREs
Tom Marshall, Rocky Mountain Peace and Justice Center
Kevin Martin, Peace Action
Pamela Meidell, The Atomic Mirror
Greg Mello, Los Alamos Study Group
Diana Milligan, Tri-Valley CAREs
Erin Moore, Tri-Valley CAREs
Dale Nesbitt, East Bay Peace Action
Megan Norwood, Tri-Valley CAREs
Jonathan Oldfather, Marin County Peace Conversion Commission
Christopher Paine, Natural Resources Defense Council
Gary Patton, Tri-Valley CAREs
Belinda Peitso, Tri-Valley CAREs
Diana Perry, Tri-Valley CAREs
Erich Pica, Friends of the Earth

Curt Porter, Tri-Valley CAREs
Scott Powell, Tri-Valley CAREs
Martha Priebat
Leo T. Prinster, Tri-Valley CAREs
Stacy Ramos, Tri-Valley CAREs
Heather Rawson, Tri-Valley CAREs
Kevin R. Reilly, Tri-Valley CAREs
Glen A. Risdon, Tri-Valley CAREs
Phill Ritter, Tri-Valley CAREs
Marilyn Robertson, Tri-Valley CAREs
Kathryn Sawyer, Tri-Valley CAREs
Mark Schroeder, Franciscan Friars of St. Barbara Province
Charles and Lindsey Shere, Tri-Valley CAREs
Jay Sordean
Mary Spoerer, Tri-Valley CAREs
Richard and Susan Strong, Tri-Valley CAREs
Elizabeth Switay, Tri-Valley CAREs
Frances Watson Taeger, Tri-Valley CAREs
Timothy D. Taron, Hefner, Stark & Marois, LLP
Steven Taylor
Silvia Theiner, Tri-Valley CAREs
Scott Thornberry, Tri-Valley CAREs
Kalynda Tilges, Shundahai Network
Sue Tritch
Janice Kate Turner
Deborah Tuttelman, Tri-Valley CAREs
Elisabeth Venturini, Tri-Valley CAREs
B. Verhaaren, Argonne National Laboratory
Janet Wabroeg, Tri-Valley CAREs
Carol Wahrer, Tri-Valley CAREs
Geoff Walker, Tri-Valley CAREs
Curtis Waton, Tri-Valley CAREs
Andrea Widener, The Contra Costa Times
Natasha Wist, Tri-Valley CAREs
Stephen Wong
Scott Yundt, Tri-Valley CAREs
Christine Ziebold

Bay Area Nuclear Waste Coalition
Citizen Alert
Citizens Opposed to a Polluted Environment
Energy Research Foundation
Hayward Area Peace and Justice Fellowship
Lane County American Peace Test
Lawyers' Committee on Nuclear Policy
Livermore Conversion Project
Neighbors in Need

Nevada Desert Experience
Nuclear Age Peace Foundation
Plutonium Free Future
Proposition One Committee
San Jose Peace Center
Seattle Women Act for Peace
Sonoma County Center for Peace and Justice
Women for Peace - East Bay
Women's International League for Peace and Freedom - East Bay
Women Concerned/Utahns United

K.2 INTERGOVERNMENTAL AFFAIRS AND AGENCY CONSULTATIONS

Intergovernmental affairs activities are designed to keep relevant government agencies and officials informed of the issues and progress of the LLNL SW/SPEIS. Activities include requests for comments on draft documents and discussions with government agencies and officials throughout the process.

NEPA requires that Federal, state, and local agencies with legal jurisdiction or special expertise regarding any environmental impact be consulted and involved in the LLNL SW/SPEIS process. This involvement ensures that a variety of perspectives are represented. Agencies involved include those with authority to issue applicable permits, licenses, and other regulatory approvals, as well as those responsible for protecting significant resources (e.g., endangered species, critical habitats, or historic resources). This section includes consultation letters between NNSA, the U.S. Department of Interior, U.S. Fish and Wildlife Service, and the California Department of Fish and Game regarding threatened and endangered species, tribal organizations regarding Native American heritage resources, and other state agencies as needed.

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

OCT 2 1 2002

Ms. Jan Knight
Chief, Endangered Species Division
Fish and Wildlife Service
U. S. Department of the Interior
2800 Cottage Way, Room W-2605
Sacramento, CA 95825

Subject: Species Lists for the Lawrence Livermore National Laboratory Site-Wide Environmental Impact Statement (AMNSEIS:020010)

References: (1) Department of Energy, National Nuclear Security Administration, Notice of Intent, Site-Wide Environmental Impact Statement for Lawrence Livermore National Laboratory (Federal Register Doc. 02-15165 Filed 6-14-02; 8:45 am).

(2) United States Department of the Interior, Fish and Wildlife Service; letter from Jan C. Knight to Thomas Grim, (1-1-02-SP-2702, dated July 26, 2002).

Dear Ms. Knight:

The National Nuclear Security Administration's (NNSA), Oakland Operations Office (OAK) is preparing a Site-Wide Environmental Impact Statement (SWEIS) for the continued operation of Lawrence Livermore National Laboratory (LLNL). As a result of our Notice of Intent (Reference 1) to prepare the SWEIS, I received a Threatened and Endangered Species List from your office (Reference 2). While we are appreciative of the advanced list, it covers only the Alameda County portion of our proposed project area. The SWEIS proposed action consists of continued operations of LLNL, both at the Livermore site in Alameda County, and at Site 300, which is located in both Alameda and San Joaquin Counties. The enclosure shows both locations.

The purpose of this letter is to begin the informal consultation process for the proposed action that will be evaluated in the SWEIS and to request a list of threatened, endangered, and candidate species, species that are currently proposed for listing, and identification of designated and proposed critical habitat that may be affected by the proposed action for Alameda and San Joaquin Counties.

The proposed action includes the addition of new projects and upgrades to existing facilities planned through 2014. A No Action Alternative and a Reduced Operations Alternative will also be evaluated in the SWEIS. The No Action Alternative consists of continued Laboratory operations at the current level with no new projects. The Reduced Operations Alternative consists of a reduction or cessation of specific operations to reduce potential environmental impacts.

NNSA/OAK has previously consulted with FWS for project-specific actions at the LLNL Livermore site and at Site 300 and your office has rendered and amended Biological Opinions for these actions. Please continue working with Mr. Thom Kato and his group at LLNL for issues related to these projects.

Should you or your staff have any questions, please feel free to contact me at (925) 422-0704.

Sincerely,

Thomas R. Grim
Document Manager for the LLNL Site-Wide
Environmental Impact Statement
National Nuclear Security Administration
Livermore Site Office

Enclosure:

cc:
D. Buford, Coast Bay Delta Branch Chief, FWS
R. Corey, DAMNS
J. Neville, ESHD
G. Guenterberg, LLNL, L-553
J. Steenhoven, LLNL, L-553
T. Kato, LLNL L-627

AMNSEIS:020010:TGRIM:amf:102102

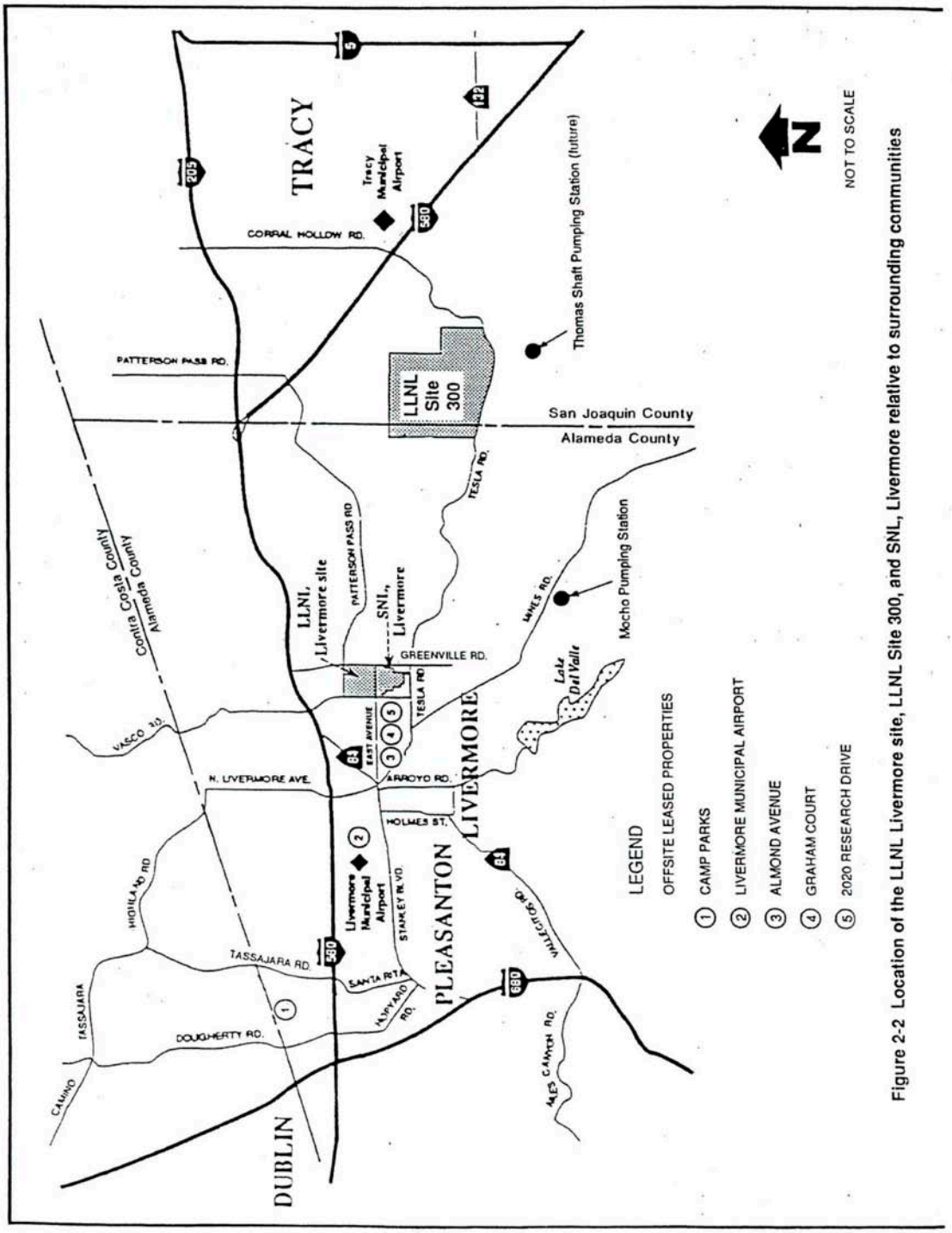


Figure 2-2 Location of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore relative to surrounding communities

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

JAN 0 2 2003

Rob Floerke
Regional Manager
California Department of Fish and Game
Central Coast Region 3
P.O. Box 47
Yountville, CA 94599

Subject: Consultation Concerning Livermore National Laboratory Site-Wide Environmental Impact Statement (Doc. # AMNSEIS:020014)

References: Department of Energy, National Nuclear Security Administration, Notice of Intent, Site-Wide Environmental Impact Statement for Lawrence Livermore National Laboratory (Federal Register Doc. 02-15165 Filed 6-14-02; 8:45 am).

Dear Mr. Floerke:

The National Nuclear Security Administration (NNSA) Livermore Site Office is preparing a Site-Wide Environmental Impact Statement (EIS) for the continued operation of Lawrence Livermore National Laboratory (LLNL). The proposed action consists of continued operations of LLNL, both at the Livermore site in Alameda County, and at Site 300, which is located in both Alameda and San Joaquin Counties. Enclosed is a figure illustrating the location of these sites.

The purpose of this letter is to begin the informal consultation process for the proposed action that will be evaluated in the Site-Wide EIS and to request a list for Alameda County of threatened, endangered, and candidate species, species that are currently proposed for listing, and identification of designated and proposed critical habitat that may be affected by the proposed action.

The proposed action includes the addition of a few new projects and upgrades to existing facilities planned over the next 12 years. A No Action alternative and a Reduced Operations Alternative will also be evaluated in the EIS. The No Action alternative consists of continued Laboratory operations at the current level with no new projects. The Reduced Operations alternative consists of a reduction or cessation of specific operations to reduce potential environmental impacts while continuing to meet NNSA missions.

LLNL has previously consulted with California Department of Fish and Game for project-specific actions at the LLNL Livermore site and at Site 300. Please continue working with Mr. Thom Kato and his group at LLNL for issues related to these projects.

Mr. R. Floerke 2

I look forward to your response to this request. If you have any questions, please do not hesitate to contact me by telephone (925) 422-0704 or by e-mail at tom.grim@oak.doe.gov.

Sincerely,

Thomas R. Grim
Document Manager for the LLNL Site-Wide
Environmental Impact Statement
National Nuclear Security Administration
Livermore Site Office

Enclosure:

cc:
C. Yuan-Soo Hoo, MLSO
M. Hooper, DMLSO
K. King, LEPD
G. Guenterberg, LLNL, L-553
J. Steenhoven, LLNL, L-553
T. Kato, LLNL, L-627

Mr. R. Floerke 3

bcc:
T. Grim, AMNS/EIS
EIS Rdg. File

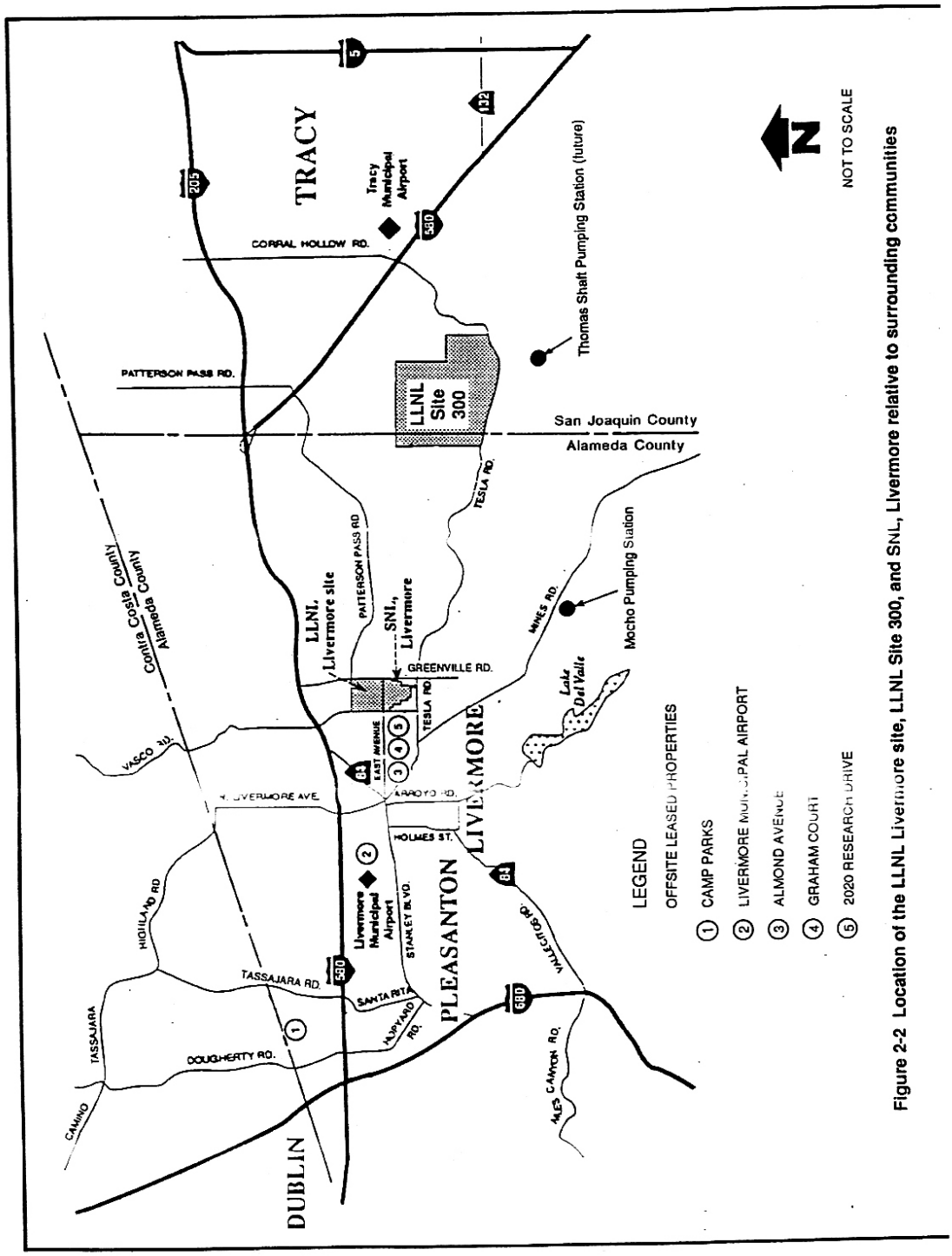


Figure 2-2 Location of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore relative to surrounding communities

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

JAN 0 2 2003

Banky Curtis
Regional Manager
California Department of Fish and Game
Sacramento Valley-Central Sierra Region 2
1701 Nimbus Road,
Rancho Cordova, CA 95670

Subject: Consultation Concerning Livermore National Laboratory Site-Wide Environmental Impact Statement (Doc. # AMNSEIS:020015)

References: Department of Energy, National Nuclear Security Administration, Notice of Intent, Site-Wide Environmental Impact Statement for Lawrence Livermore National Laboratory (Federal Register Doc. 02-15165 Filed 6-14-02; 8:45 am).

Dear Mr. Curtis:

The National Nuclear Security Administration (NNSA) Livermore Site Office is preparing a Site-Wide Environmental Impact Statement (EIS) for the continued operation of Lawrence Livermore National Laboratory (LLNL). The proposed action consists of continued operations of LLNL, both at the Livermore site in Alameda County, and at Site 300, which is located in both Alameda and San Joaquin Counties. Enclosed is a figure illustrating the location of these sites.

The purpose of this letter is to begin the informal consultation process for the proposed action that will be evaluated in the Site-Wide EIS and to request a list for San Joaquin County of threatened, endangered, and candidate species, species that are currently proposed for listing, and identification of designated and proposed critical habitat that may be affected by the proposed action.

The proposed action includes the addition of a few new projects and upgrades to existing facilities planned over the next 12 years. A No Action alternative and a Reduced Operations Alternative will also be evaluated in the EIS. The No Action alternative consists of continued Laboratory operations at the current level with no new projects. The Reduced Operations alternative consists of a reduction or cessation of specific operations to reduce potential environmental impacts while continuing to meet NNSA missions.

LLNL has previously consulted with California Department of Fish and Game for

Mr. B. Curtis 2

project-specific actions at the LLNL Livermore site and at Site 300. Please continue working with Mr. Thom Kato and his group at LLNL for issues related to these projects.

I look forward to your response to this request. If you have any questions, please do not hesitate to contact me by telephone (925) 422-0704 or by e-mail at tom.grim@oak.doe.gov.

Sincerely,

Thomas R. Grim
Document Manager for the LLNL Site-Wide Environmental Impact Statement
National Nuclear Security Administration
Livermore Site Office

Enclosure:

cc:
C. Yuan-Soo Hoo, MLSO
M. Hooper, DMLSO
K. King, LEPD
G. Guenterberg, LLNL, L-553
J. Steenhoven, LLNL, L-553
T. Kato, LLNL, L-627

AMNSEIS:020015:TGRIM:amf:123102

bcc:
T. Grim, AMNS/EIS
EIS Rdg. File

AMNSEIS:020015:TGRIM:amf:123102

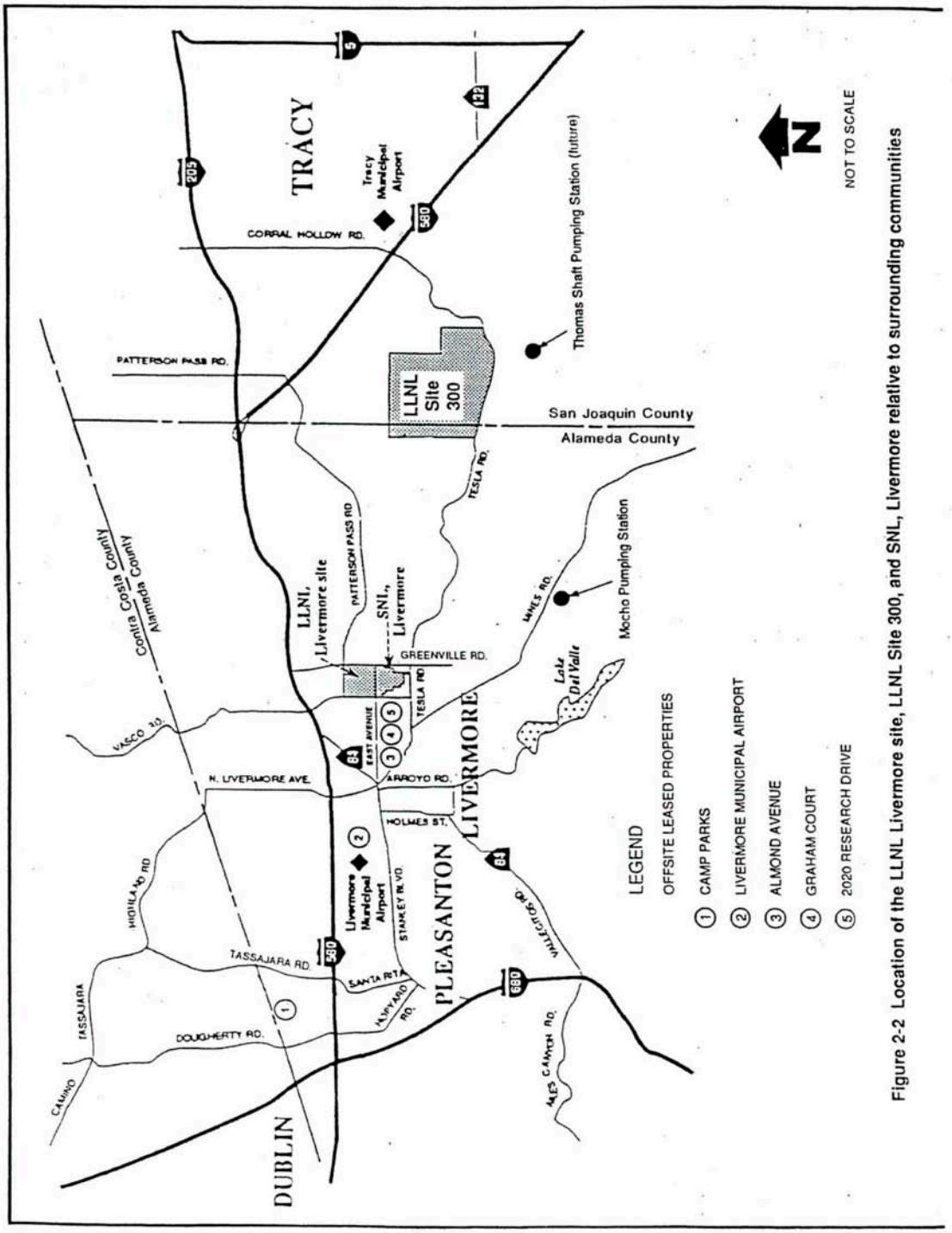


Figure 2-2 Location of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore relative to surrounding communities

STATE OF CALIFORNIA — Gray Davis, Governor

NATIVE AMERICAN HERITAGE COMMISSION
915 CAPITOL MALL, ROOM 364
SACRAMENTO, CA 95814
(916) 653-4082
Fax (916) 657-5390

December 23, 2002

Thomas Grim
Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, CA 94612-5208

RE: Native American Contacts/Lawrence Livermore National Laboratory
#AMNSEIS:020011

Dear Mr. Grim:

I recommend that you contact the Native Americans contacts on the attached list for this project. They may be able to provide input concerning the project site and assist in the mitigation measures. It is with the understanding that the list is to be used only to determine possible areas of cultural sensitivity

The Commission makes no recommendation or preference of a single individual, or group over another. This list should provide a starting place in locating areas of potential adverse impact within the proposed project area. I suggest that all of those indicated be contacted, if they cannot supply information, they may recommend others with specific knowledge. A minimum of two weeks must be allowed for responses after notification.

If you receive notification of change of addresses and phone numbers from any these individuals or groups, please notify me. With your assistance we are able to assure that our lists contain current information. If you have any questions or need additional information, please contact me at (916) 653-4038.

Sincerely,

Debbie Pilas-Treadway
Environmental Specialist III

Post-it® Fax Note 7671	Date	# of pages ▶ 4
To T. GRIM	From D. TREADWAY	
Co./Dept.	Co.	
Phone #	Phone # 916/653-4038	
Fax # 925/422-1776	Fax #	

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December 23, 2002

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Ohlone/Costanoa

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regards to the cultural assessmet for the proposed consultation Lawrence Livermore National Laboratory, Alameda County.

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December 23, 2002

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This list is only applicable for contacting local Native Americans with regards to the cultural assessmet for the proposed consultation Lawrence Livermore National Laboratory, Alameda County.

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This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regards to the cultural assessmet for the proposed consultation Lawrence Livermore National Laboratory, San Joaquin County.

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

JAN 16 2003

Ms. Michelle Zimmer
Amah/Mutsun Tribal Band
4952 McCoy Avenue
San Jose, CA 95130

SIMILAR LETTER SENT TO ALL NATIVE AMERICAN REPRESENTATIVES

Subject: Consultation Concerning Livermore National Laboratory Site-Wide Environmental Impact Statement (Doc. # LSOEIS:0300010)

Reference: Department of Energy, National Nuclear Security Administration, Notice of Intent, Site-Wide Environmental Impact Statement for Lawrence Livermore National Laboratory (Federal Register Doc. 02-15165 Filed 6-14-02; 8:45 am).

Dear Ms. Zimmer:

The California Native American Heritage Commission submitted your name to me as a contact for the Ohlone/Constanoan tribe in response to my inquiry for a listing of heads of tribal governments to consult concerning preparation of the Site-Wide Environmental Impact Statement (SWEIS) for the continued operation of Lawrence Livermore National Laboratory (LLNL). The SWEIS is being prepared by the Department of Energy (DOE), National Nuclear Security Administration's (NNSA), Livermore Site Office.

The SWEIS is being prepared in accordance with the Council on Environmental Quality's National Environmental Policy Act (NEPA). The SWEIS will analyze the potential environmental impacts to the human and natural environment associated with continuing current LLNL operations and foreseeable new and/or modified operations and facilities for approximately the next ten years. The SWEIS will also include analyses of potential effects to Native American heritage resources. The preliminary alternatives to be analyzed in the SWEIS are:

- ***No Action Alternative:*** This alternative includes current facility operations throughout LLNL in support of NNSA missions. NEPA regulations require analysis of the No Action Alternative to provide a benchmark for comparison with environmental effects of other alternatives. This alternative includes the programs and activities that are part of LLNL Missions and those activities for which NEPA review is already underway. Additionally, the No Action Alternative will include any interim actions that proceed independently of the SWEIS.

- ***Proposed Action Alternative:*** This alternative includes increasing LLNL operations to levels reasonably foreseeable over the next ten years, that can be supported by current facilities, or that may require new or modified facilities. This alternative includes the No Action Alternative as described above.

- ***Reduced Operation Alternative:*** This alternative considers and analyzes proposals for the reduction or cessation of specific operations to reduce adverse environmental impacts. This alternative may include reasonable proposals for consolidating operations into fewer facilities (including subsequent analysis of decommissioning or demolition of vacated facilities) that have technical merit.

Federal and state agency coordination and consultation, and public participation are conducted during the project. The SWEIS will analyze LLNL operations at the Livermore site in Alameda County, and at Site 300, which is located in both Alameda and San Joaquin Counties. The enclosure shows both locations.

You can find the Notice of Intent, the reference listed above, and other information concerning the SWEIS at the LLNL Environmental Community Relations web site at http://www-envirinfo.llnl.gov. Please do not hesitate to contact me by telephone at (925) 422-0704 or by e-mail at tom.grim@oak.doe.gov with any questions, comments, or concerns you may have.

Sincerely,

Thomas R. Grim
Document Manager for the LLNL Site-Wide
Environmental Impact Statement National
Nuclear Security Administration
Livermore Site Office

Enclosure:

cc:
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M. Hooper, DMLSO
K. King, LEPD
G. Guenterberg, LLNL, L-553
J. Steenhoven, LLNL, L-553
T. Kato, LLNL, L-627
P. McGuff, LLNL, L-627

bcc:
T. Grim, LSO/EIS
EIS Rdg. File

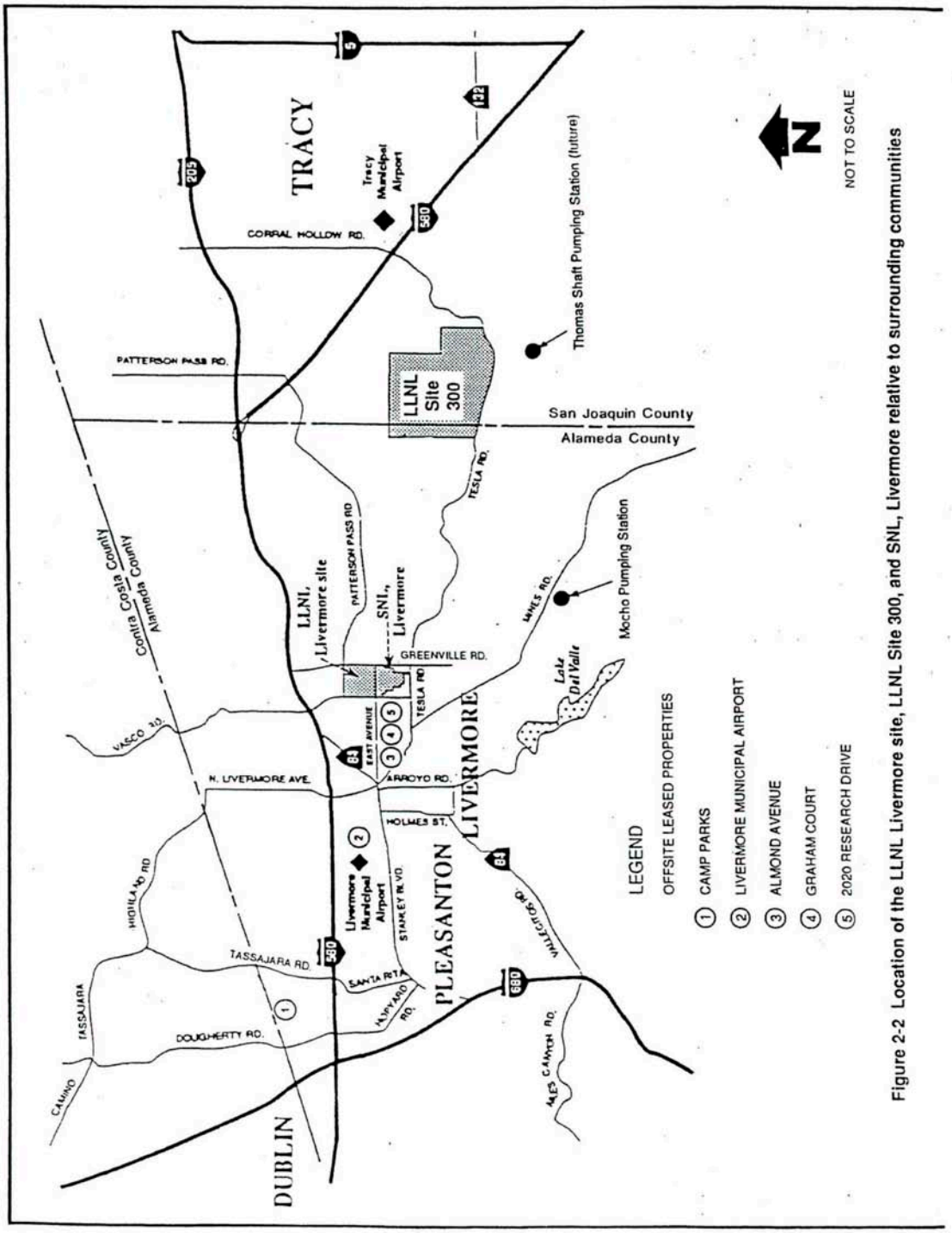


Figure 2-2 Location of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore relative to surrounding communities

Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

JAN 1 6 2003

Ms. Irene Zwierlein
Chairperson, Amah/Mutsun Tribal Band
789 Canada Road
Woodside, CA 94062

Subject: Consultation Concerning Livermore National Laboratory Site-Wide Environmental Impact Statement (Doc. # LSOEIS:030002)

Reference: Department of Energy, National Nuclear Security Administration, Notice of Intent, Site-Wide Environmental Impact Statement for Lawrence Livermore National Laboratory (Federal Register Doc. 02-15165 Filed 6-14-02; 8:45 am).

Dear Ms. Zwierlein:

The California Native American Heritage Commission submitted your name to me as a contact for the Ohlone/Constanoan tribe in response to my inquiry for a listing of heads of tribal governments to consult concerning preparation of the Site-Wide Environmental Impact Statement (SWEIS) for the continued operation of Lawrence Livermore National Laboratory (LLNL). The SWEIS is being prepared by the Department of Energy (DOE), National Nuclear Security Administration's (NNSA), Livermore Site Office.

The SWEIS is being prepared in accordance with the Council on Environmental Quality's National Environmental Policy Act (NEPA). The SWEIS will analyze the potential environmental impacts to the human and natural environment associated with continuing current LLNL operations and foreseeable new and/or modified operations and facilities for approximately the next ten years. The SWEIS will also include analyses of potential effects to Native American heritage resources.

The preliminary alternatives to be analyzed in the SWEIS are:

- ***No Action Alternative:*** This alternative includes current facility operations throughout LLNL in support of NNSA missions. NEPA regulations require analysis of the No Action Alternative to provide a benchmark for comparison with environmental effects of other alternatives. This alternative includes the programs and activities that are part of LLNL Missions and those activities for which NEPA review is already underway. Additionally, the No Action Alternative will include any interim actions that proceed independently of the SWEIS.

- ***Proposed Action Alternative:*** This alternative includes increasing LLNL operations to levels reasonably foreseeable over the next ten years, that can be supported by current facilities, or that may require new or modified facilities. This alternative includes the No Action Alternative as described above.

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Federal and state agency coordination and consultation, and public participation are conducted during the project. The SWEIS will analyze LLNL operations at the Livermore site in Alameda County, and at Site 300, which is located in both Alameda and San Joaquin Counties. The enclosure shows both locations.

You can find the Notice of Intent, the reference listed above, and other information concerning the SWEIS at the LLNL Environmental Community Relations web site at http://www-envirinfo.llnl.gov. Please do not hesitate to contact me by telephone at (925) 422-0704 or by e-mail at tom.grim@oak.doe.gov with any questions, comments, or concerns you may have.

Sincerely,



Thomas R. Grim
Document Manager for the LLNL Site-Wide
Environmental Impact Statement National
Nuclear Security Administration
Livermore Site Office

Enclosure:

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M. Hooper, DMLSO
K. King, LEPD
G. Guenterberg, LLNL, L-553
J. Steenhoven, LLNL, L-553
T. Kato, LLNL, L-627
P. McGuff, LLNL, L-627

LSOEIS:030002:TGrim:amf:011503

Ms. I. Zwierlein 3

bcc:
T. Grim, LSO/EIS
EIS Rdg. File

LSOEIS:030002:TGrim:amf:011503

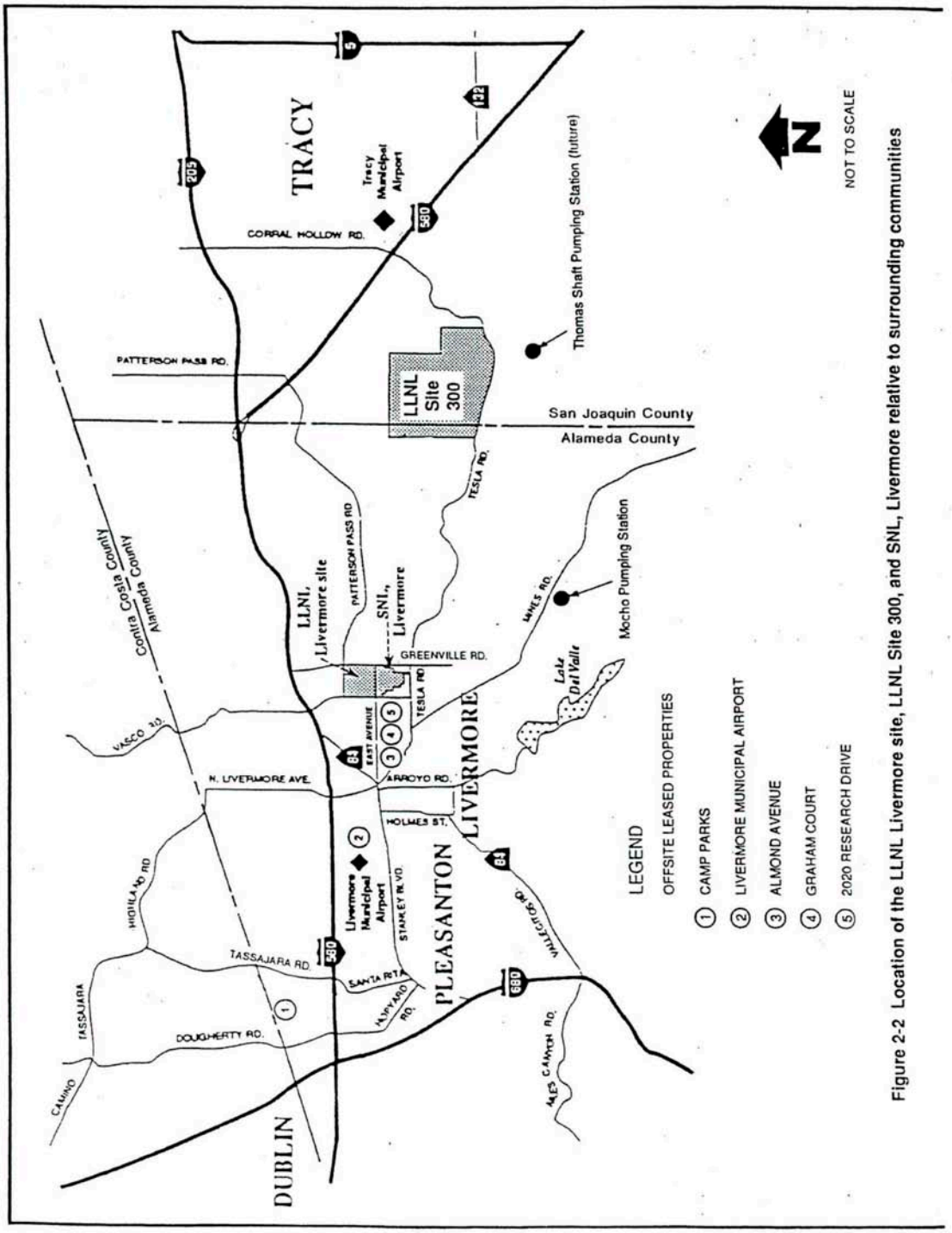


Figure 2-2 Location of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore relative to surrounding communities

K.3 REFERENCES

40 CFR §1506.6 — Council on Environmental Quality (CEQ), "Protection of the Environment, Other Requirements of NEPA, Public Involvement" *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, United States Government Printing Office, Washington, DC, January 1, 2003.

10 CFR Part 1021 — United States Department of Energy (DOE), "Energy, National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, January 1, 2003.

67 FR 41224 — DOE, "Notice of Intent, Site-wide Environmental Pact Statement for the Lawrence Livermore National Laboratory, "*Federal Register*, Vol. 67 Pgs. 41224 – 41227, Office of the Federal Register National Archives and Record Administration, United States Government Printing Office, Washington, DC, June 17, 2002.

LLNL 2002c — Lawrence Livermore National Laboratory (LLNL), *Contributing to a Better Community*, UCRL-AR-146025, Lawrence Livermore National Laboratory, Livermore, CA, 2002.

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APPENDIX L: READING ROOMS

Copies of the *Draft Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS) have been placed in the reading rooms and libraries listed below.

NNSA Service Center*
Energy Information Center
Oakland Federal Building
1301 Clay Street
North Tower, 8th floor
Oakland, CA 94612
Phone: (510) 637-1762
Hours of Operation: Mon. – Fri. 9 am – 5 pm

Environmental Repository at LLNL Visitor Center*
East Entrance, Greenville Road
Livermore, CA 94550
Phone: (925) 424-4026
Hours of Operation: Mon. – Fri. 1 – 4 pm, call for additional availability

Livermore Public Library
1000 So. Livermore Avenue
Livermore, CA 94550
Phone: (925) 373-5500
Hours of Operation: Mon. – Thurs. 10 am – 9 pm; Fri. 10 am – 6pm
Sat. 10 am – 5 pm; Sun. 12 – 6 pm

Tracy Public Library
20 East Eaton Avenue
Tracy, CA 95376
Phone: (209) 831-4250
Hours of Operation: Mon. – Thurs. 10 am – 8 pm; Fri., closed
Sat. 10 am – 5 pm; Sun. 12 – 5 pm
The Draft LLNL SW/SPEIS is also available on the Internet at: http://www-envirinfo.llnl.gov

U.S. Department of Energy*
Public Reading Room
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-3142

* – Reading room locations marked with an asterisk also contain complete sets of reference materials used in preparation of the Draft LLNL SW/SPEIS.

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APPENDIX M: USE OF PROPOSED MATERIAL ON THE NATIONAL IGNITION FACILITY

M.1 INTRODUCTION

The U.S. Department of Energy's (DOE's) National Nuclear Security Administration (NNSA) is building the 192-beam National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL). The primary goals of the NIF are to achieve fusion ignition in the laboratory and to conduct high-energy density experiments in support of national security and civilian applications. The NIF will provide NNSA with the ability to evaluate weapon performance issues to ensure that the Nation's nuclear deterrent remains safe and reliable without underground nuclear testing.

M.1.1 History

The impacts associated with construction and operation of the NIF were evaluated in the Stockpile Stewardship and Management (SSM) Programmatic Environmental Impact Statement (PEIS) (DOE/EIS-0236) (DOE 1996b). A project-specific analysis of the NIF was included in the SSM PEIS as an appendix. The SSM PEIS Record of Decision (61 FR 68014), published in the *Federal Register* (FR) on December 26, 1996, documented the decision to construct and operate the NIF at LLNL. In May 1997, the Natural Resources Defense Council (NRDC) and 39 other organizations brought suit against DOE in *NRDC v. Pena*, Civ. No. 97-936 (SS) (D.D.C.), challenging the adequacy of the SSM PEIS. In January 1998, the plaintiffs amended their complaint and alleged that the potential environmental impacts of experiments using certain hazardous and radioactive materials on the NIF were not adequately analyzed in the SSM PEIS. As a result, DOE filed the *Supplement Analysis for Use of Hazardous Materials in NIF Experiments* (DOE/EIS-SA0236-SA2) (DOE 1998c) with the court, which addressed the use of plutonium and other hazardous materials. The supplement analysis provided the basis for approval of the use of depleted uranium on the NIF and indicated that there was no new information to warrant the preparation of a supplemental SSM PEIS.

On August 19, 1998, the judge in the lawsuit issued a Memorandum Opinion and Order (USDCDC 1998) that dismissed the plaintiff's case. The Memorandum Opinion and Order provided in Paragraph 6 that:

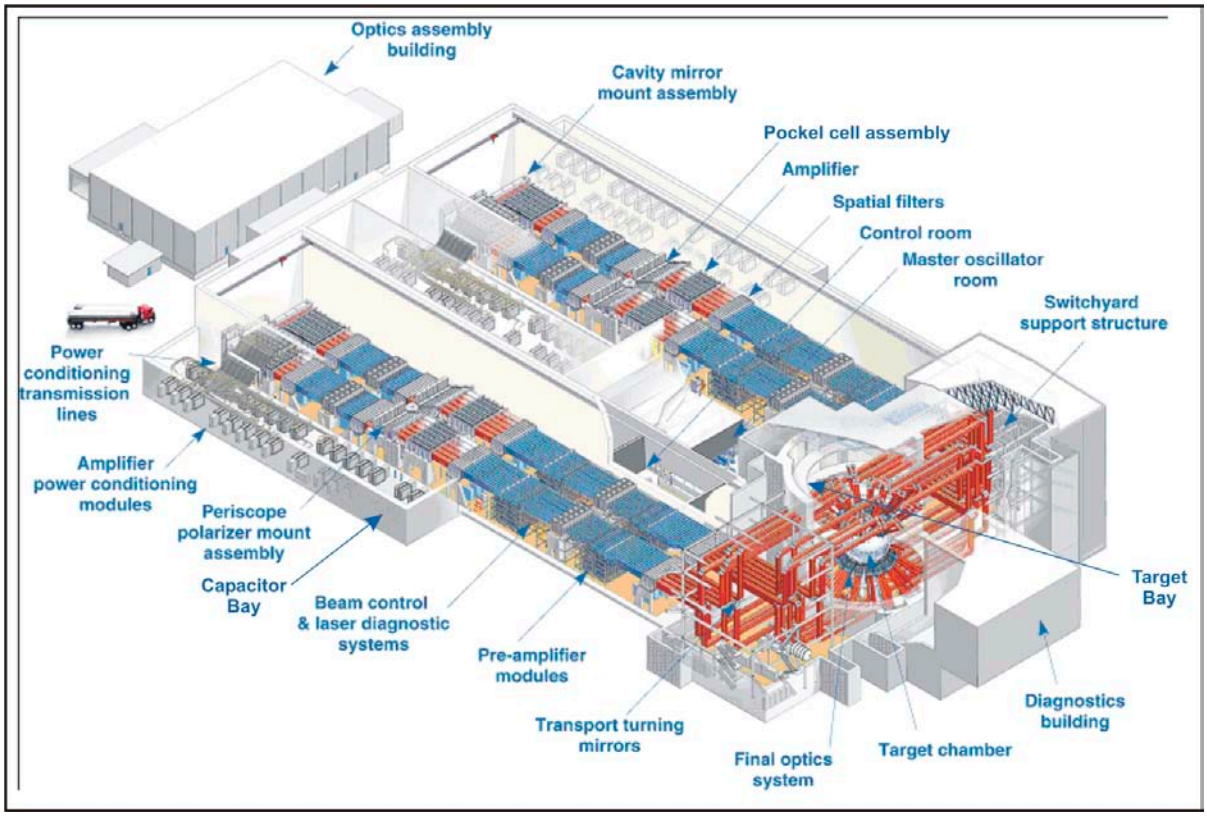
> No later than January 1, 2004, DOE shall (1) determine whether any or all experiments using plutonium, other fissile materials, fissionable materials other than depleted uranium (as discussed in the *Supplement Analysis for the Use of Hazardous Materials in NIF Experiments*, A.R. doc. VII.A-12), lithium hydride, or a Neutron Multiplying Assembly (NEUMA), such as that described in the document entitled *Nuclear Weapons Effects Test Facilitization of the National Ignition Facility* (A.R. doc VII.A-4) shall be conducted in the NIF; or (2) prepare a Supplemental SSM PEIS, in accordance with DOE *National Environmental Policy Act* (NEPA) regulation 10 CFR §1021.314 analyzing the reasonably foreseeable environmental impact of such experiments. If DOE undertakes the action described in subpart (2) of this paragraph, DOE shall complete and issue the Supplemental SSM PEIS and the Record of Decision based thereon within eighteen (18) months after issuing a notice of intent to prepare the Supplemental SSM PEIS.

NNSA has chosen to use the *Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (LLNL SW/SPEIS) as the mechanism for complying with the court's instruction to prepare a supplemental SSM PEIS. The inclusion of this supplemental SSM PEIS in the LLNL SW/SPEIS ensures timely analysis of these proposed experiments within the environmental impacts being evaluated for the continued operation of LLNL. The basis for the analyses in this document was a letter from NNSA (DOE 2001e) to the LLNL Associate Director for NIF Programs requesting that a consolidated technical recommendation be developed by the three NNSA weapons laboratories regarding possible experiments on the NIF using any of the materials indicated in Paragraph 6 of the Memorandum Opinion and Order. The requested tri-weapons laboratory recommendation (LLNL/NIF 2002a) represents the combined input of the Weapons Associate Directors at LLNL, Los Alamos National Laboratory, and Sandia National Laboratories. A classified annex containing the classified details of the proposed experiments was also provided by the Associate Directors (LLNL/NIF 2002b). NNSA evaluated the recommendation and the NNSA Deputy Administrator for Defense Programs determined that NNSA would propose to conduct experiments on the NIF using plutonium, other fissile materials, fissionable materials, and lithium hydride (Crandall 2002). There is no NNSA proposal regarding the use of a Neutron Multiplying Assembly on the NIF.

M.1.2 Project Description

The construction of the NIF conventional facilities is complete and installation of the laser, diagnostic equipment, and target area equipment is in progress. Laser driven experiments will be conducted in the NIF Laser and Target Area Building, the main building of the NIF. The Laser and Target Area Building consists of two laser bays, two optical switchyards, a target chamber in a shielded target bay, target diagnostics areas, four capacitor bays, mechanical equipment areas, control rooms, and operational support areas (see Figure M.1.2–1).

Housed in the Laser and Target Area Building is a 192-beam, neodymium glass laser, which delivers laser light of the required frequency and energy to small targets that are mounted in a 10-meter diameter aluminum alloy vacuum chamber. The target area provides all systems necessary to support the experiments: target chamber, target emplacement, target diagnostic inserters, support structures, environmental protection systems, and support systems. The target chamber confines the radiation and debris generated by each experiment and borated concrete shielding on the chamber surface and in the target bay attenuates neutron and secondary radiation to acceptable levels during fusion ignition experiments that produce measurable neutron yield (yield experiments) and further prevents unacceptable levels of induced radioactivity. At the center of the chamber is a target, precisely located by the target emplacement and positioning/alignment system. An integrated computer control system will control the laser and collect data from laser diagnostic equipment. These systems are supported by electrical power conditioning, diagnostic computer control systems, utilities, and mechanical and auxiliary support systems. Environmental protection systems have been designed to meet key functional requirements, such as limiting tritium inventory and tritium release to the environment. These systems are located adjacent to the target bay and consist of tritium processing systems (which recover tritium onto dryer beds for later disposal or recycling), cleaning and decontamination systems, radiation and tritium monitoring systems, and waste packaging and characterization facilities.

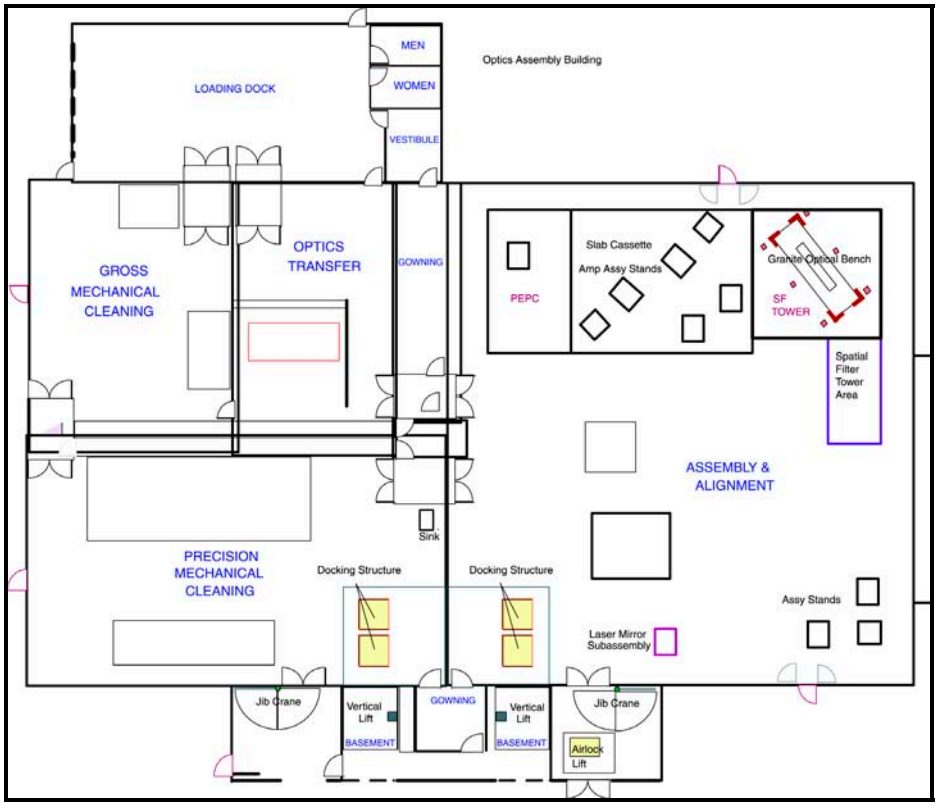


Source: LLNL File Photo 40-00-0996-2100A.

FIGURE M.1.2–1.—*National Ignition Facility Laser and Target Area Building Layout*

The Optics Assembly Building, located adjacent to the Laser and Target Area Building, includes optics processing equipment and general cleaning and precision cleaning equipment. Cleaned specialty optical components are assembled into their frames in the Optics Assembly Building (Figure M.1.2–2). These line-replaceable units are then placed into canisters for transport and insertion into the laser system.

Other required support facilities, such as assembly areas; maintenance areas; optical, electrical, machine, and mechanical shops; and offices are located nearby. In addition, the inertial confinement fusion research and development laboratories and LLNL institutional facilities such as target fabrication, waste management, central plant, development support laboratories, optics processing, and transporters are located nearby.

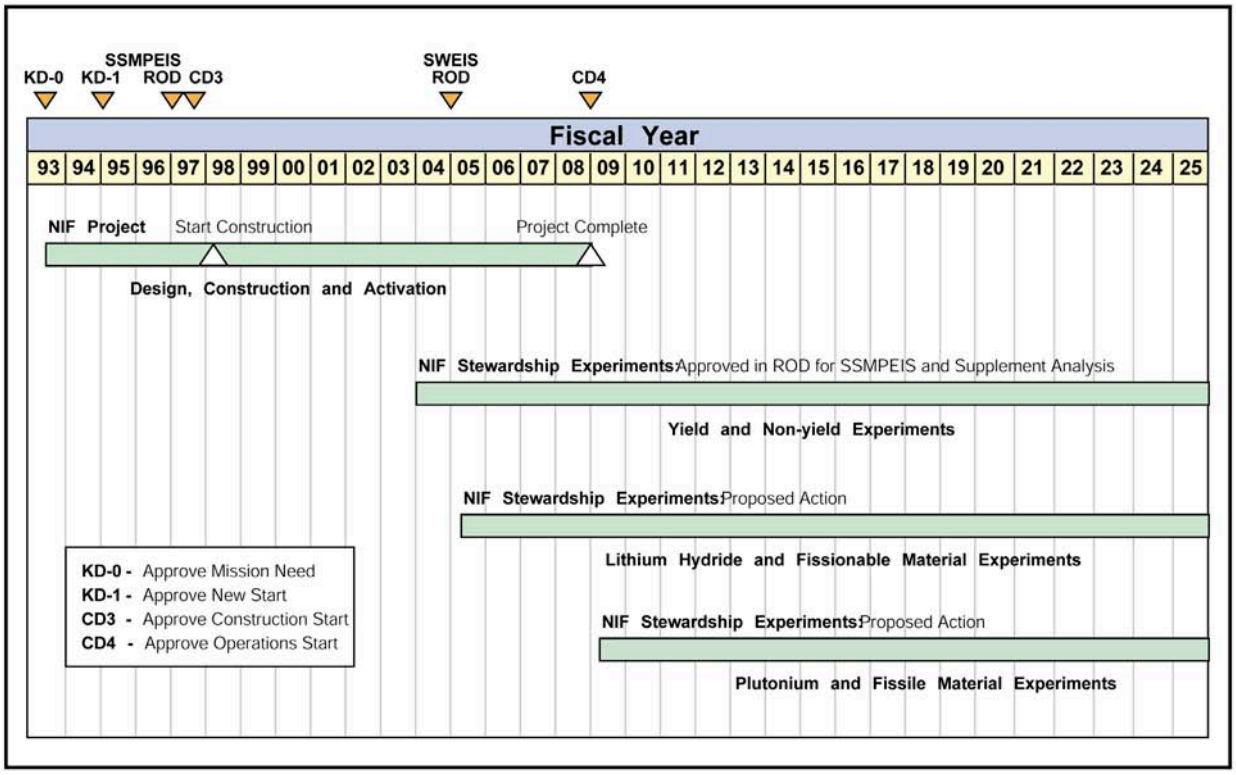


Source: LLNL File Photo LLNL/NIF-1103-07481.

FIGURE M.1.2–2.—*National Ignition Facility Optics Assembly Building Layout*

M.1.3 National Ignition Facility Operations

Experiments on the NIF for stockpile stewardship will begin in parallel with the installation and commissioning of the 192 beam lines. Figure M.1.3–1 provides a timeline for equipment installation and shows the approximate schedule for target physics experiments through 2020. The first phase of testing will include using asymmetric arrangements of the NIF laser beams and will not require the use of tritium or result in neutron yield. As symmetric arrangements of laser beams become available (approximately one half or 96 laser beams), pre-ignition experiments will begin to assess issues of beam pointing stability, power balance, and timing. Limited amounts of tritium will be used and modest neutron yields will be produced in these types of experiments. Once fully operational with 192 beam lines, the NIF will provide the capability to perform the full range of target physics experiments leading up to and including ignition and burn with energy gain. The NIF will also allow researchers to field experiments studying weapons physics, weapons effects, inertial fusion energy, and basic science.



Source: Original.
Note: See page 20 for a discussion of the terms fissile and fissionable

FIGURE M.1.3–1.—*National Ignition Facility Timeline and Relation to Use of Certain Proposed Materials*

M.1.4 Purpose of this Appendix

This appendix updates the environmental impacts of future operation of the NIF discussed in the NIF project specific analysis portion of the SSM PEIS. In addition, this appendix evaluates the proposed use of plutonium, other fissile and fissionable materials, and lithium hydride and the construction and operation of a neutron measurement device called the neutron spectrometer. Analysis of the proposal to use fissile and fissionable material and a neutron spectrometer will be based on conceptual design information, because NNSA does not have detailed designs for these experiments or the diagnostic instruments. However, sufficient information is available to analyze the reasonably foreseeable environmental impacts of these experiments and the neutron spectrometer. The analysis provided in this appendix will bound the operations of the NIF.

This appendix describes the NIF and its purpose and need as well as the purpose and need for the use of proposed materials; considers the No Action Alternative, Proposed Action, and Reduced Operation Alternative; assesses potential environmental impacts; and addresses mitigation measures.

NNSA has chosen to use the LLNL SW/SPEIS as the mechanism for complying with the court instruction to prepare a supplemental SSM PEIS. The inclusion of this appendix in the LLNL SW/SPEIS ensures timely analysis of the proposed experiments within the environmental impacts being evaluated for continued operation of LLNL. In the Record of Decision, NNSA

will address decisions on the use of any or all of these proposed materials for NIF experiments within the context of continuing LLNL operations.

M.2 PURPOSE AND NEED

M.2.1 National Ignition Facility Purpose and Need

In January 1993, the Secretary of Energy approved the justification of mission need for the NIF as a part of approval of Key Decision 0 (DOE 1993a). Figure M.1.3–1 shows the timeline for approval of the key decisions for NIF. The justification stated that the NIF was being proposed to support the inertial confinement fusion program requirement to achieve ignition and propagation of thermonuclear fusion and burn. In October 1994, the Secretary of Energy approved Key Decision 1 that verified the mission need for the NIF (Reis 1994). The mission areas identified in Key Decision 1 were nuclear weapons physics, inertial fusion energy science and technology, and other applications. The nuclear weapons physics discussion stated that "In the absence of underground testing, the NIF would be a critical tool for the Department's Science-Based Stockpile Stewardship Program."

In 1996, DOE changed terminology from "Key Decision" to "Critical Decision."[1] As indicated in the footnote, the terminology went from Key Decision 1 to Critical Decision 3.

In February 1997, the Secretary of Energy approved Critical Decision 3 (Reis 1997), which affirmed the need for the NIF and stated that "The National Ignition Facility is a key element of Defense Programs' science-based Stockpile Stewardship and Management Program." In September 2000, the Secretary of Energy certified to Congress that: "The National Ignition Facility supports the Stockpile Stewardship Program (SSP), and is a vital element of it in three important ways: (1) the experimental study of issues of stockpile aging or refurbishment; (2) weapons science and code development; and (3) attracting and training the exceptional scientific talent required to sustain the program over the long term" (Richardson 2000).

In 2001, former DOE/NNSA Administrator, General John A. Gordon, certified to Congress (Gordon 2001) the importance of the NIF to the SSP based, in part, on NNSA High-Energy-Density Physics (HEDP) Report (DOE 2001h). This report concluded that:

- "A vital HEDP Program is an essential component of the SSP. The baseline HEDP Program, including the 192-beam NIF meets the SSP requirements."
- "Ignition is an important goal for the HEDP Program, the SSP and the national scientific community."
- "A laboratory ignition source is the only known means available to examine thermonuclear burn in the laboratory."
- "The intent is to produce thermonuclear burn that, for a few trillionths of a second, produces some of the conditions found only in the center of stars and in the core of an exploding

[1] The correlations between Key Decisions and Critical Decisions are: Key Decision 0 (approval of mission need) = Critical Decision 0 (approval of mission need); Key Decision 1 (approval to start design) = Critical Decision 1 (approval of preliminary baseline range); Key Decision 2 (approval to start final design) = Critical Decision 2 (approval of performance baseline): Key Decision 3 (approval to start construction) = Critical Decision 3 (approval to start construction); and Key Decision 4 (project completion) = Critical Decision 4 (approval to start operation and project closeout) .

nuclear weapon. Achieving this ignition outside of a nuclear device will be a landmark achievement for the SSP."

As indicated above, the NIF provides a unique capability for DOE/NNSA's science-based stewardship of the nuclear weapons stockpile. Planned experiments on the NIF, at temperatures and pressures approaching those that occur in nuclear weapon detonations, will provide scientific data needed to verify certain aspects of sophisticated computer models. These computer models are needed to simulate weapons performance and to provide insights on the reliability and performance of the Nation's nuclear weapons stockpile. Specially designed experiments on the NIF will address issues of modeling or physics that are of concern because of changes in weapons due to aging or remanufacture. They will also provide a unique source of radiation for studies of nuclear weapon effects; i.e., the effects of radiation on nuclear explosive package, control systems and electronics. The NIF will attract and challenge top scientific and engineering talent to address the elements of physical understanding as those necessary for stewardship of the nuclear stockpile.

It is important to have the NIF provide experimental data well before the end of the decade, as weapons continue to age beyond their original design lifetime. The NIF experiments will address, to various degrees, certain weapons issues connected with fusion ignition and boosting; weapon effects; radiation transport; and secondary implosion, ignition, and output. Most of these processes occur at very high energy density; i.e., at high temperatures and pressures, and are relevant to a weapon's reliability and performance. These experiments and thermonuclear burn are fundamental to the operation of our modern nuclear weapons stockpile.

As a multipurpose facility, the NIF also is important to the Nation's energy and basic science missions. The NIF data could indicate whether inertial confinement fusion can be a viable source of electric power in the future. Achieving ignition, optimizing target performance, and providing initial data on fusion reactor materials could allow sound decisions to be made concerning development of an inertial fusion energy demonstration facility.

NIF experiments will achieve temperatures and pressures that exist in the sun and other stars, providing new laboratory capabilities for exploring basic high-energy-density sciences such as astrophysics and plasma physics (NAS 2003a, NAS 2003b).

M.2.2 Physical Processes of Nuclear Weapons

As indicated in Section M.2.1, planned experiments on the NIF will be conducted at temperatures and pressures approaching those that occur in nuclear weapon detonations and will provide scientific data needed to verify certain aspects of sophisticated computer models. The following unclassified summary of the operation of a nuclear weapon should facilitate understanding of the need for the NIF in relation to the SSP in general.

The relevant physical processes that occur in nuclear weapons or in the immediate environment of an ongoing nuclear explosion can be divided into the following processes:

1. Detonation of high explosive and implosion of fissile materials
2. Conditions for criticality of fissile material
3. Fusion ignition and boosting
4. Radiation transport

5. Secondary implosion
6. Secondary ignition, burn, and output
7. Nuclear weapon effects on other systems

Modern thermonuclear weapons consist of two stages: a primary stage, fission trigger, and a secondary stage, fusion. The primary stage contains a subcritical "pit" of fissile material, generally plutonium, surrounded by a layer of chemical high explosives. The high explosive is detonated, burns rapidly, and compresses the pit. To increase efficiency, modern weapon primaries can employ a process called boosting. In boosted primaries, the pit contains the hydrogen isotopes deuterium and tritium.

The purpose of the primary stage is to produce enough energy in the form of radiation to implode the secondary stage resulting in thermonuclear ignition and burn. The secondary stage produces high yield for modern U.S. strategic weapons. The terms ignition and burn will be used to indicate the process in which fusion fuel is ignited and undergoes self-sustaining fusion and burn.

M.2.3 National Ignition Facility Experimental Capabilities

Specific experiments can be conducted on the NIF with weapon materials to measure relevant equations of state, such as what pressures are created at high temperatures; opacity, i.e., how a material absorbs and emits radiation; and hydrodynamics, i.e., how a material moves in response to forces applied. These experiments apply to several of the processes of interest listed in Section M.2.2. The following discussion focuses on how the NIF will be used to evaluate weapons concerns relevant to the physical processes in that list.

Experiments will be conducted on the NIF to examine the growth and control of hydrodynamic instabilities, which are important both in making inertial confinement fusion targets ignite and burn and in making nuclear weapons perform reliably. Hydrodynamic instabilities ultimately lead to mixing of some quantity of one material with another.

High temperature transport of radiation in complex geometries and materials can be examined to test the ability of computer models to predict this transport. Deposition and re-emission of radiation and the general transport problem within weapons constitute a complex process. This process must be understood to predict the transport of radiation necessary to ignite inertial confinement fusion targets.

Output calculations must be done on the inertial confinement fusion ignition targets so that the performance of the target can be properly measured. Again, however, specific targets can be designed to alter the output radiation. These experiments can be used to test the computer codes used to calculate the output of weapons.

NIF targets, either the basic type for ignition or specially designed ones, would produce x-rays, neutrons, gamma rays, and other radiation. These emissions can be used to assess the consequences of nuclear effects in electronic systems or other hardware intentionally exposed to these radiations. The survivability of military hardware subjected to various nuclear effects is an important factor in ensuring reliability of that hardware.

Experiments conducted on the NIF would address, to some degree, weapons processes that occur in Processes 3 through 7. If the stockpile surveillance program reveals an unanticipated change due to aging or remanufacture, a weapons expert can estimate which of the weapons physics

processes discussed here could be affected. If any of the high-energy-density processes could be affected, then a NIF experiment could be designed to measure the physical properties of the change.

The nuclear weapons expected to remain in the stockpile will age beyond their original design lifetime between the years 2005 and 2010. Should problems arise, it is important to have the NIF in place and producing experimental results successfully during this period so that the facility can be used to help verify new computer models.

M.2.4 Purpose and Need for the Use of Proposed Materials in the National Ignition Facility

M.2.4.1 *High-Energy-Density Physics Program Needs*

The High-Energy-Density Study Report (DOE 2001h) recommended that the possibility of using special nuclear materials, defined as enriched uranium and plutonium, in experiments on the NIF should be examined. This appendix evaluates the safety and environmental effects of the use of these materials in experiments on the NIF.

In the absence of underground nuclear testing, the SSP must continually surveil, maintain, and refurbish weapons in order to certify their safety, performance, and reliability. This is done based on the ability of scientists to evaluate problems using scientific calculations that have been validated with experimental data from the NIF and other SSP facilities and using archival nuclear weapons test data.

The approach to certification by the weapons laboratories involves two major steps. The first is to identify all significant potential failure modes by using scientific and engineering judgment, results from past nuclear tests, aboveground tests and experiments, surveillance, and advanced computational simulations. Second, scientists and engineers attempt to quantify the margin and associated uncertainty, to the extent possible, for each potential failure mode. Certification is achieved by demonstrating that the margin in performance is greater than the uncertainty in the performance prediction of each potential failure mode of the device.

There are many unanswered questions regarding fundamental physical data on special nuclear materials that must still be resolved. This is because past experiments, including nuclear tests, did not examine the behavior of materials, either under the extreme conditions associated with nuclear weapons explosions or with the necessary level of precision to resolve certain fundamental physical properties of nuclear weapons materials. The SSP now demands that validated precision physical data on weapons materials be provided in computer models of nuclear weapons performance, which will allow NNSA to assess the effects of aging, engineering modifications, and safety enhancements on the stockpile. These validated models will allow continued certification of the safety, reliability, and performance of the stockpile without nuclear testing.

The NIF provides a controlled laboratory environment that makes precision and repeatable experiments possible in a way that was not available in underground nuclear testing. Both Los Alamos National Laboratory and LLNL have expressed interest in performing non-ignition and ignition experiments on the NIF using special nuclear materials. Non-ignition experiments are being developed to explore the material properties of various forms of plutonium as it is subjected to dynamic pressure and temperature environments when shocked by high-velocity flyer plates or by x-rays produced by the energetic laser beams on the NIF. Detailed information

on a material's strength and equation of state can be measured on the NIF at much higher pressures than available on current or planned facilities.

When fusion ignition is achieved on the NIF, an ignition capsule would provide a unique source of x-rays and neutrons that is not available on any other current or planned aboveground experimental facility. The fusion output from an ignition capsule can be used to study nuclear, chemical, and thermomechanical behavior of special nuclear materials, including highly enriched uranium, to provide important data for weapons scientists to use in complex three-dimensional computer models of weapons behavior.

There is a need for a variety of experiments using fissionable and fissile material on the NIF as described in the following paragraphs. Additional details on these experiments are provided in the classified annex (LLNL/NIF 2002b).

- There is a need to perform experiments on the NIF with plutonium or enriched uranium without ignition. These experiments are generally designed to study the equation of state of these materials under conditions where phase changes of the material are expected to occur and to study the effects of aging on the physical properties of these materials. There is also a need for experiments to measure fundamental nuclear physics properties using plutonium or highly enriched uranium that require ignition.
- There is a need to perform experiments on the NIF with lithium hydride, which is not a special nuclear material, with and without ignition. These are materials physics and equation of state experiments designed to address fundamental physical behavior of this material and to allow benchmarking of physical models of the material.
- There is a need to perform experiments on the NIF with depleted uranium with ignition. These experiments require high atomic number materials collocated on the ignition target to enhance the conversion of laser light to x-rays for inertial confinement fusion experiments. There is also a need for experiments that use depleted uranium or highly enriched uranium with ignition to study the physics of these materials.
- There is a need to perform experiments on the NIF with fissionable materials (i.e., thorium-232, and fissile materials; e.g., highly enriched uranium,) with ignition. These experiments require the materials to be collocated on the ignition target to provide a measurement of the nuclear processes that occur in an ignition capsule.

There is no NNSA proposal for using a neutron multiplying assembly for experiments on the NIF (Crandall 2002).

The use of special nuclear material on the NIF will allow weapons scientists to accurately evaluate the properties of special nuclear material in the laboratory and to validate weapons test data and refine computer codes to lower the margin of error for these calculations.

M.3 DESCRIPTION OF THE NO ACTION ALTERNATIVE, PROPOSED ACTION, AND REDUCED OPERATION ALTERNATIVE

The construction of the NIF conventional facilities is complete and installation of the laser, diagnostic equipment, and target area equipment is in progress. Experiments on the NIF for stockpile stewardship will begin in parallel with the completion of installation and commissioning of the 192 beam lines. The NIF will transition into full operation following the approval of Critical Decision 4, scheduled to occur in 2008. NEPA compliance for conventional

facility construction and equipment installation of the NIF is described in the NIF project-specific analysis of the SSM PEIS (DOE 1996b) and was amended by the Supplement Analysis for the use of Hazardous Materials in the NIF Experiments (DOE 1998c) and the Supplemental SSM PEIS (DOE 2001f).

This appendix analyzes the No Action Alternative, Proposed Action, and Reduced Operation Alternative for the NIF. Section M.3 is broken into subsections as follows:

- M.3.1 covers the No Action Alternative, which includes the NIF experiments and operations for which decisions have already been made and provides information on the hazardous and radioactive materials approved for use on the NIF.
- M.3.2 covers the Proposed Action for changes in NIF operations; the use of plutonium, other fissile materials, fissionable materials, and lithium hydride in experiments on the NIF; and the construction and operation of a neutron spectrometer.
- M.3.3 evaluates the Reduced Operation Alternative for the NIF.
- M.3.4 provides a summary and comparison of the environmental impacts of the No Action Alternative, Proposed Alternative and Reduced Operation Alternative.

Table M.3–1 summarizes the differences in the operating parameters of the Proposed Action and alternatives.

The data for this appendix were taken mainly from two documents: the SSM PEIS, Volume III, Appendix I (DOE 1996b) and the *NIF Project Input for Assessment of Environmental Impacts of the NIF* (LLNL 2003d).

TABLE M.3–1.—*National Ignition Facility Operating Parameters for Each Alternative*

	No Action Alternative	Proposed Action	Reduced Operation Alternative
Laser energy	1.8 MJ, 192 beams	1.8 MJ, 192 beams	1.8 MJ, 192 beams
Yield, maximum	20 MJ[a]	20 MJ[a]	20 MJ[a]
Total	1,200 MJ/yr	1,200 MJ/yr	800 MJ/yr
Tritium,	1,750 Ci/yr	1,750 Ci/yr	1,500 Ci/yr
Throughput,	500 Ci	500 Ci	500 Ci
Inventory in process,			
Plutonium	No	Yield and nonyield experiments	No
Fissile material use	No	Yield and nonyield experiments	No
Fissionable material use	Only nonyield depleted uranium	Yield and nonyield experiments	Only nonyield depleted uranium
LiH	No	Yield and nonyield experiments	No
Neutron spectrometer	No	Yes	No
Removable inner containment vessel	No	Yes	No
Facility hazards category	Low-hazard, radiological	Low-hazard, radiological	Low-hazard, radiological

Source: LLNL 2003d.
[a]45 MJ maximum credible yield.
Ci = curie; LiH = lithium hydride; MJ = megajoules; yr = year.

M.3.1 No Action Alternative

The No Action Alternative comprises the continued installation of equipment and operation of the NIF. Under the No Action Alternative, the NIF would be operated under the parameters described in the SSM PEIS NIF project specific analysis and summarized in Table M.3–1. The NIF would perform the full ignition program required to meet SSP goals but would not perform experiments with plutonium, other fissile materials, fissionable materials (other than depleted uranium), or lithium hydride. The neutron spectrometer would not be constructed. The NIF would be operated as a low-hazard radiological facility.

This section expands on the basic information provided in Section M.1.2 and provides an overview of the experiments and operation of the NIF. Information is provided on the use of resources and materials under the No Action Alternative. The manner of operation of the NIF laser and target area building and the laser system would be the same for all of the alternatives and will not be repeated in the Proposed Action and the Reduced Operation Alternative sections. The level of operation (number of experiments) and the quantity of materials used would vary among No Action Alternative, Proposed Alternative and Reduced Operation Alternative.

The NIF consists of three main elements housed in the laser and target area building, a single environmentally controlled building. The elements of the NIF are the laser system and optical components, a target chamber placed within a target bay, and an integrated computer system to control the laser and diagnostic equipment. The following sections cover the operation and hazards associated with the NIF laser and target area building (Section M.3.1.1), the laser system (Section M.3.1.2), the target chamber and target area (Section M.3.1.3), and NIF experiments (Section M.3.1.4). Section M.3.1.5 discusses hazardous material use in NIF operations, and Section M.3.1.6 covers facility decontamination and decommissioning (D&D).

The computer control system is an integrated network of computer systems providing the hardware and software needed to support full operational activities. The system includes the computer controls to manage the laser optical system, target system, and data acquisition. Information on the computer control system is not addressed in this appendix. Certain control systems, such as the safety interlock system, are presented where pertinent to the discussion of environmental impacts and accidents.

M.3.1.1 *National Ignition Facility Operations*

The laser and target area building is a reinforced concrete and structural steel building constructed to be vibration isolated, provide radiation confinement and control, and include all necessary system control and diagnostics. It consists of two laser bays, two optical switchyards, a target chamber in a shielded target bay, target diagnostic areas, four capacitor bays, mechanical equipment areas, control rooms, and an operational support area (Figure M.1.2–1).

The laser bays are steel-framed, metal-sided rooms with a metal deck roof and steel-reinforced concrete floor. Each laser bay houses 96 individual laser beam lines. The capacitor bays are four separate rooms that house the power conditioning system used to operate the main laser amplifiers. Capacitor bay equipment includes capacitors, spark-gap electrical switches, and power conditioning equipment. The power for the NIF laser would be supplied by discharging the bank of capacitors. The capacitors would be charged using electricity supplied from LLNL utility system.

The two optical switchyards house optical systems, that is, mirrors and beam tubes, that direct and position the 192 laser beams into the target bay. The switchyards are constructed of steel-reinforced concrete.

The diagnostic building, adjacent to the target bay, houses the environmental protection systems, target receiving area, tritium processing area, and diagnostic support areas. The tritium processing system would operate by oxidizing gaseous tritium and capturing the oxidized tritiated water on molecular sieves. The tritium processing system molecular sieve canisters would be replaced periodically. The preheater reactor and metal bellows pump would be replaced infrequently (on the order of every 10 years).

Facility Utility Usage

Facility operations would require the use of electrical power, water, and natural gas, and would discharge wastewater. The NIF would use electricity to operate the laser and plant equipment necessary to support basic operations. This would include operations of the heating, ventilation, and air conditioning system (HVAC), chilled and heated water systems, lighting, facility heating, etc. The clean-room high-efficiency particulate air (HEPA) filters clean the supply air going into the building.

Water would be used at the NIF for a variety of operations, including boilers, cooling towers, domestic use, landscape irrigation, washing, and fire hydrant testing. Some of the water would be evaporated to the atmosphere, while other water would be discharged to the sanitary sewer or storm drain, as appropriate. More details concerning projected water use and discharge quantities for the NIF are provided in Section M.5.

The NIF has two standby diesel generators; one is 754 horsepower and the other is 250 horsepower. In the event of a power outage, these generators would operate until the utility power is restored.

M.3.1.2 *Laser Operations*

The NIF laser system would generate and deliver high-power optical pulses to a target suspended in the target chamber. Multiple laser beams would be used to uniformly illuminate the target surface area. The NIF laser contains 192 independent laser beams, or beamlets. Each laser bay houses twelve bundles. Each bundle is made up of two quads of four individual beamlets. Each quad has a unique beam path, or beamline, to the target chamber. The 192 beamlets require more than 10,000 discrete optical components. The laser requires all optical components to be enclosed in a controlled beam tube that is under a vacuum or filled with an inert gas (argon) or a clean gas system of an oxygen/nitrogen gas mixture. The clean gas system provides backfill gas for the amplifiers and beam transport system portions of the laser. Argon is provided to the beam transport system in the switchyard and target bay.

The operating parameters established for NIF experiments are indicated below.

- Laser power/energy to the target: 500 terrawatts/1.8 megajoules
- Maximum design yield per experiment: 20 megajoules (maximum credible yield would be 45 megajoules)
- Annual total yield: 1,200 megajoules per year

M.3.1.3 *Target Bay and Target Chamber*

Target Bay

The target bay houses the following major subsystems: target chamber, target emplacement positioner, target diagnostics, support structures, environmental protection, and vacuum and other auxiliary systems. The target bay is a steel reinforced concrete cylindrical structure that houses the target chamber. The steel reinforced concrete would provide initial shielding of radiation produced during yield experiments.

The target bay also would provide radiation confinement in conjunction with the HVAC system for radioactive air emissions, such as activated air created during high-yield experiments or a tritium release. The exhaust would discharge from an elevated release point. The exhaust air would be continually monitored to ensure detection of activated material.

Environmental protection systems, including tritium-handling systems, target storage, and decontamination equipment used to clean the target chamber components, will be located in the decontamination area adjacent to the target bay. X-ray, optical, and neutron measurement instruments would be arranged around the chamber to help evaluate the success of each target experiment. Structural support of the target diagnostics, the target positioner, final optic assemblies, and turning mirrors, would be provided by target area structures. The target area would also provide the following subsystems: the target area auxiliary systems, material handling, the target chamber boom lift, and the diagnostics and control rooms.

The NIF shielding design consists of several components. The basic components include the target chamber borated concrete shielding; target bay walls that are 1.83-meter-thick concrete; target bay roof that is 1.37-meter-thick concrete; switchyard walls that are up to 1.14-meter-thick concrete depending upon the specific location, and switchyard roofs that are 0.46-meter-thick concrete. Due to the large number of penetrations through the target bay walls, additional shielding components have been added. These include mechanical equipment room walls that are 0.31-meter-thick concrete; HVAC collimators, concrete tubes that allow airflow to pass while providing a tortuous path for neutrons and gamma-rays; and switchyard collimators 1.83-meter-long extensions of the target bay walls on the switchyard side of the walls.

Target Chamber

The NIF target chamber is a 10-meter internal-diameter spherical aluminum alloy shell with 10-centimeter thick walls. The exterior of the chamber is encased in 40 centimeters of borated concrete to provide neutron shielding. The target chamber would provide the primary confinement for target experiments. The target chamber is supported vertically by a hollow concrete pedestal and horizontally by radial joints connected to the cantilevered floors. The laser beams would enter the chamber in two conical arrays from the top and two conical arrays from the bottom. At the poles and in the equatorial regions of the chamber, diagnostic equipment would be inserted through the chamber wall. The target chamber would also include the target emplacement and positioning/alignment system.

The laser beams would enter through laser optics, e.g., glass lenses, frequency conversion crystals, and other optics, called the final optics assembly that would be attached to the end of each beam line as it enters the target chamber. The final optics assembly would be protected from damage by a main debris shield and a disposable debris shield. There would be an ongoing waste stream of solid low-level waste (LLW) from replacement of the disposable debris shields.

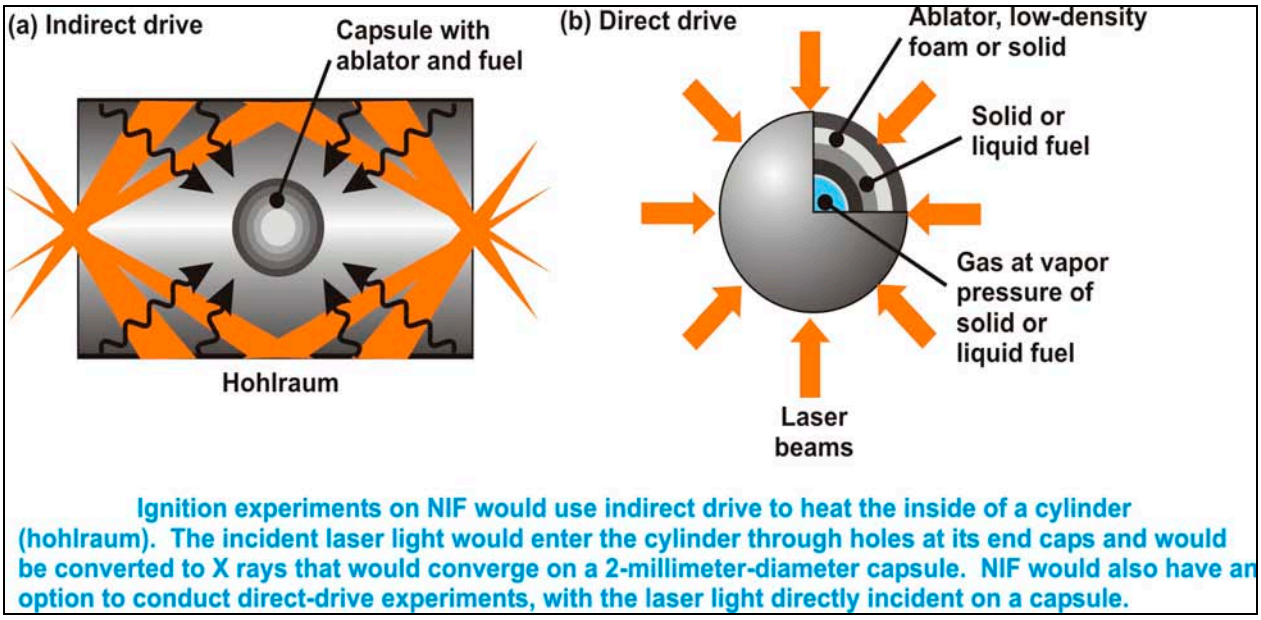
Some of the main debris shields would require periodic cleaning and could require replacement and disposal due to damage.

Laser light would leave the final optics assembly and illuminate the target at the center of the chamber. The diagnostics would capture the required data. Light that is not absorbed by the target would continue towards the opposite wall of the target chamber. Just before hitting the target chamber wall, unconverted laser light that hits the opposite wall would be absorbed by the light-absorbing stainless steel first wall panels located opposite of each beam port. The first wall panels, which would also provide protection of the target chamber from debris and soft x rays, would require periodic replacement due to wear, damage, and/or chemical contamination. It is anticipated that the panels would be replaced once every eight years, resulting in solid radioactive LLW.

The components used in target chamber diagnostics could be damaged during higher yield experiments and become a solid LLW stream. Filters would process the target chamber air exhaust. Charcoal filters would also be used to capture certain isotopes, and these would need periodic, but infrequent replacement. There will be two high-efficiency particulate air filters and two prefilters controlling the emissions from the target chamber. There would be approximately 20 additional HEPA filters with local area control applications. A change out schedule of at least once every 10 years would be required by LLNL. Filter disposal would generate solid LLW.

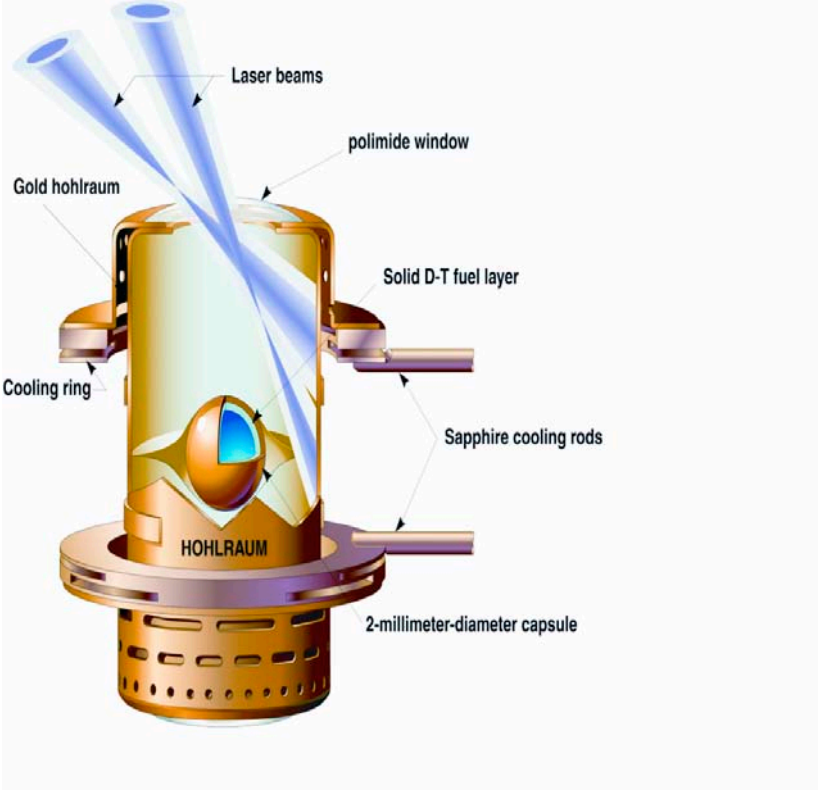
M.3.1.4 *National Ignition Facility Experiments*

Both indirect-drive and direct-drive experiments could be conducted on the NIF, as illustrated in (Figure M.3.1.4–1). Initial operation of the NIF would use indirect-drive experiments where x-rays generated by the interaction of the laser beams with a small metal cylinder or hohlraum would cause the compression of the target (Figure M.3.1.4–2).



Source: LLNL File Photo LLNL/NIF 1103-07482.

FIGURE M.3.1.4–1.—*Indirect- and Direct-Drive Experiment Modes*



Source: LLNL File Photo LLNL-05-00-0798-162.

FIGURE M.3.1.4–2.— ***Schematic View of Hohlraum***

Direct-drive experiments could also be conducted on the NIF. With direct drive, the laser beam, rather than x-rays, would directly compress the target. When the laser fires on an ignition target, all 192 beams would be synchronized and simultaneously illuminate the target. The target would be compressed and heated, creating intense fusion reactions. The direct-drive mode was discussed as part of the SSM PEIS.

Indirect-drive-yield experiments using deuterium and tritium would emit neutrons, energetic particles, debris, and x-rays. The energetic particles, debris, and x-rays would be confined within the aluminum alloy target chamber. Most neutrons and secondary radiation from a yield experiment would travel through the target chamber and its surface shielding layer before being adequately attenuated by target bay structures and concrete walls. Some neutrons would activate target bay structures, including the target chamber, shielding, space frame, optics, beam tubes, catwalks, and reinforced concrete walls.

Tasks that must be performed within the target bay or that involve handling of materials that have been inside the target bay during experiments would result in some level of radiation dose. Dose rates within the target bay would be largely dependent on the yield of the most recent experiment and the amount of time since the experiment took place. The residual radiation intensity within the target bay at any particular location would depend upon local and general activation in the room as well as the history of yield experiments.

Radiation Produced from Fusion Experiments

Neutrons would also penetrate through the roof of the facility and cause skyshine radiation, where the neutrons scatter (reflect) off of the atmosphere above the facility and scatter back down to the ground. Some neutrons would interact with structural material and emit gamma rays as they undergo nuclear reactions, and these gamma rays would also reach the ground.

Tritium

Tritium would arrive at the facility in individual targets, containing up to 5 curies each; 2 curies in the capsule and up to 3 curies in the associated hardware. If direct drive is implemented, each target would contain up to 70 curies. The annual tritium throughput at the NIF would be limited to 1,750 curies per year.

The tritium in-process inventory limit for the NIF would total no more than 500 curies. Tritium could be in process in various locations at the NIF, but would remain below the 500 curies total in-process inventory limit. The total in-process tritium inventory would include any accumulation of tritium in the facility that is releasable and quantifiable, and that is part of the tritium handling cycle in the NIF. This would include inventories in locations such as targets and associated hardware, cryopumps, molecular sieve traps, and decontamination systems. It would not include residual surface contamination and adsorption. Therefore, the tritium adsorbed on the target chamber walls after an experiment would not be part of the in-process inventory.

Particulates

Particulates would be generated in the target chamber from each experiment. During an experiment, the laser energy would vaporize the target. Reflected or unused laser light is absorbed on the protective first wall panels and would induce ablation of this surface, with the loss of mass from the surface of the wall panels by vaporization or as small molten droplets. The emission of x-rays from the experiment could be sufficiently high to induce yet further ablation from nearby equipment surfaces, protective first wall panels, and debris shields. Structures close to the target could undergo melting during high yield experiments. The state of the ablated material after an experiment is expected to be small pieces of debris and fine particulates. For the purpose of this analysis, it was conservatively assumed that all the ablated material would exist as fine particulates about one micron in size; i.e., most easily made airborne and in the respirable range.

As the particulate material is exposed to neutrons from yield experiments, some material would become activated and converted to radioactive material. The particulates would accumulate in the target chamber until the scheduled annual cleanup. The total inventory of activated, mobilizable particulates created in the chamber would be quite small. A list of the prominent nuclides that would be expected as activated particulate in the chamber, room air, and in beam tubes is presented in Section M.5.

M.3.1.5 *Hazardous Materials*

Materials needed to support NIF operations would include inert gases (argon) for laser operations, nitrogen for cryopumps, and other chemicals for cleaning, decontamination, and general use. Some of these materials would be regularly consumed; others could be expended and require replacement during the lifetime of the NIF. There would be no explosives stored or used at the NIF.

The NIF would use volatile organic solvents for lens cleaning and other wipe cleaning operations in the clean room environment. These would include ethanol, acetone and isopropanol. The main agent currently used (Brulin 815 GD) contains no hazardous ingredients, according to its material safety data sheet, and is generally approved for discharge to the sewer. The usage of solvents for wipe cleaning has been greatly reduced by using dilute aqueous solvent solutions, steam cleaning, dry wiping, and other techniques. Other chemicals would be stored in small quantities at the facility. Acetone and ethanol are used only for occasional spot cleaning. Clean room wipes presaturated with 9 percent isopropanol in de-ionized water would be used more frequently, but also in small quantities.

Decontamination processes require a working inventory of cleaning agents. An onsite inventory to replenish working solutions is also needed. This includes phosphoric acid, nitric acid, and sodium hydroxide. These will be utilized in cleaning solutions in the decontamination area.

The power conditioning units used in support of the preamplifier modules would have sets of ignitron switches, which would contain mercury. Each of the 48 preamplifier modules would have a dedicated, closed ethylene glycol/deionized-demineralized water coolant loop for thermal control.

The NIF would handle small quantities of beryllium in the form of targets, up to 1.6 grams, and in diagnostic windows. The NIF would use beryllium in two forms: protected collected solids, primarily in filters, that cannot become particulate, and material in exposed diagnostics and targets that can become particulate. It is not anticipated that there would be significant airborne exposure to workers. This will be confirmed by air monitoring. Surface swiping would be performed to confirm that surface beryllium contamination remains within permissible housekeeping limits for beryllium work areas (10 CFR Part 850).

Targets and hohlraums would be made of components that could include small quantities of hazardous and toxic materials including beryllium, lead, dysprosium, gadolinium, germanium, scandium, silicon, tantalum, and titanium. During an experiment, energy, through either indirect drive with a hohlraum or direct drive, would be deposited on the target resulting in the general vaporization of the target and hohlraum. The debris from the target and hohlraum would be deposited on the target chamber wall and debris shields. Some debris could take the form of particulates (see Section M.3.1.4.3). This appendix assumes that the target chamber would only be decontaminated once per year, to conservatively bound the amount of activated particulates and worker exposure. The actual schedule for decontamination of the target chamber would be managed according to the schedule of experiments, the amount of materials in the target chamber, and the risks to decontamination workers. Decontamination of the target chamber would be performed in accordance with radioactive and hazardous material handling procedures appropriate to the content of the material in the chamber at the time of the decontamination.

M.3.1.6 *Decontamination and Decommissioning of Facilities*

A D&D plan was developed for the NIF during design of the facility (LLNL/NIF 2001). The plan outlines the D&D planning activities and describes general assumptions about the facility including components and their projected status or disposition at the facility end of life. The main purpose of the plan was not to project waste amounts, but to ensure that the decommissioning could be easily accomplished and to examine design features that could facilitate the eventual D&D of the NIF. The NIF is assumed to operate for 30 years. The D&D of

the laser would involve the reuse or salvage of materials, storage of research materials for later experiments in follow-on facilities, and disposition. Most of the waste would be industrial waste.

Cleanup of the NIF target area is expected to generate a total of 263 of cubic meters of LLW waste (including the shipping containers) and 226 cubic meters of hazardous waste (LLNL/NIF 2001). Following D&D of the building, it would be returned back to the institution for further use. Useful building utilities, conventional lighting, water, etc., will remain in place. D&D of the neutron spectrometer would produce another 30 cubic meters of hazardous waste.

M.3.2 Proposed Action

The Proposed Action section discusses the additions to NIF operations that would result from the proposed use of plutonium, other fissile materials, fissionable materials, and lithium hydride in experiments on the NIF. These experiments, as well as the operation of the NIF, have a design lifetime of 30 years. For this discussion the materials considered are: fissile materials; i.e., materials that fission when irradiated by slow or thermal neutrons) such as uranium-235 or plutonium-239, and fissionable materials, i.e., materials that can be induced to fission by fast neutrons such as uranium-238 (depleted uranium) or thorium-232. The specific fissile/fissionable materials (beyond depleted uranium) considered for the Proposed Action would be weapons-grade plutonium[2], highly enriched uranium[3], and thorium-232. Yield experiments and nonyield experiments with highly enriched uranium, thorium-232, and other fissionable materials would most likely be performed in the NIF target chamber without additional containment. Plutonium experiments would be performed using an additional inner containment vessel (see Section M.3.2.1) to protect the target chamber. Experiments with small quantities of specially prepared plutonium could be used without an inner containment vessel provided the environmental impacts do not exceed the bounds defined in this document. It is estimated that there would be a maximum of four yield experiments (with plutonium) per year, at fusion yields up to 45 megajoules, and 10 nonyield plutonium experiments per year with inner containment. If other fissile materials were required for NIF experiments the inventories of these materials would be limited such that their environmental impact, such as offsite accidents, worker exposure, etc., would not exceed the bounds defined in this document. Other materials that would also be used in the Proposed Action at the NIF are beryllium, depleted uranium, and lithium hydride (including lithium deuteride[4]).

In addition, the Proposed Action would include the construction and operation of a neutron spectrometer to more accurately measure neutron yield and diagnose ignition target physics (see Section M.3.2.4).

Section M.3.2.1 discusses the proposed experiments with fissile and fissionable material and changes in the target chamber operations and related information. Section M.3.2.2 covers transportation of materials, and Section M.3.2.3 covers waste generation. Section M.3.2.4 covers the construction and operation of a neutron spectrometer.

The experiments under the Proposed Action involving the use of plutonium, other fissile materials, fissionable materials, and lithium hydride in targets would be in addition to the types

[2] The assumed composition of weapons-grade material is 0.02% plutonium-238, 93.85% plutonium-239, 5.8% plutonium-240, 0.3% plutonium-241, 0.015% americium-241, and 0.02% plutonium-242. Other isotopic mixes could be used if their impacts were within the bounds described here.

[3] Highly enriched uranium contains equal or greater than 20 % uranium-235.

[4] Lithium deuteride consists of lithium and deuterium, which is the nonradioactive isotope of hydrogen.

of experiments that would take place under the No Action Alternative. The basic operation of the facility, the laser, the target area, and eventual D&D of the NIF, would not be affected by these additional types of experiments. They would be the same as described for the No Action Alternative. Therefore, only those aspects of operations that would be changed are discussed here.

M.3.2.1 *National Ignition Facility Experiments*

Section M.2.4 discusses the purpose and need for the use of the proposed materials; i.e., plutonium, other fissile materials, fissionable materials, and lithium hydride in NIF experiments. This section describes the types of experiments that would be conducted and the types of materials that would be used in these experiments. The experiments that are being considered include yield experiments and nonyield experiments using any of the proposed materials. These would be bounded by the yield and nonyield experiments with plutonium.

Experiments with depleted uranium, highly enriched uranium, lithium hydride, fissionable materials, fissile uranium, and experiments with small quantities of specially prepared plutonium would occur in the target chamber in the same manner as all other experiments discussed under the No Action Alternative. There would be both yield and nonyield experiments with these materials. Yield experiments with highly enriched uranium and fissionable materials would generate fission products, but negligible plutonium quantities. These materials would use the same target positioner and similar diagnostics. No new features would have to be added to the NIF or the support facilities to field experiments with these materials. The NIF would be operated as a low-hazard radiological facility under the Proposed Action.

Experiments with Plutonium

For this analysis, a tritium fusion yield experiment with plutonium is covered as the bounding condition. As indicated above, experiments with small quantities of specially prepared plutonium could be conducted without an inner containment vessel. These experiments would be bounded by those covered under the Proposed Action. These experiments would, in general, create additional radiological concerns because fission products would be generated and neutron activation of materials could occur. Because most isotopes of plutonium have a much higher activity than highly enriched uranium, depleted uranium, or thorium-232, a separate inner containment vessel fabricated from stainless steel would be used to prevent the plutonium and fission products from being deposited on the target chamber, first wall, target positioner, or diagnostics. This inner containment vessel would be assembled at a LLNL support facility and transported to a LLNL facility such as the Tritium Facility for loading. Just prior to a plutonium experiment with inner containment, the target would be inserted into the inner containment vessel and the inner containment vessel would be transported in a shipping container to the NIF as a sealed and assembled unit. The inner containment vessel would be placed into the NIF target chamber through the large port on the target chamber equator or through the bottom of the target chamber.

Seismic requirements for support of the inner containment vessel would require new “hard points” being installed in the target chamber to support the inner containment vessel. The side entry system through the large port on the equator would require a custom built manipulator and installation of tracks from the diagnostics building into the target bay. The tracks would have to be removable to close the shield door for yield experiments. Other systems, such as lifting devices, cryogenic systems, and the liquid helium transfer system, could require modification.

Following the installation of the inner containment vessel and the diagnostic package, the target chamber would be evacuated and the laser fired on target. Deposition of laser energy on the target would result in vaporization of the target, emission of x-rays, the release of neutrons and the fission of the plutonium atoms for yield experiments. Radioactive materials generated from these experiments would include plutonium from the vaporized target, activated particulates from neutron activation, and fission products from the fission of the plutonium used in the experiment. All of these materials would be contained by the inner containment vessel. Additionally, x-rays and unconverted laser light would ablate material from surfaces and components, creating particulates in the inner containment vessel.

Once the experiment is completed and after a suitable waiting period, the inner containment vessel would be removed from the NIF target chamber and returned to a LLNL facility, such as the Tritium Facility, for post-experiment examination, processing, and, if needed, decontamination. Personnel at the NIF would not be exposed to the materials inside the inner containment vessel. The inner containment vessel, having been used in a single experiment, would then be placed in a shipping container, either dismantled or whole, and transported to the Nevada Test Site for disposal as LLW. Because the inner containment vessel would only be used for a single plutonium experiment and then removed from the NIF, the bounding inventories for the yield experiment case would include 1 gram of weapons-grade plutonium and the associated fission products and activated particulate. For nonyield experiments, the bounding inventory would be 3 grams of weapons-grade plutonium.

Modifications to LLNL Tritium Facility to accept the inner containment vessel would include adding hoisting and rigging equipment to place the inner containment vessel into a special glovebox. This glovebox would be used to retrieve samples from the inner containment vessel and decontaminate and dismantle, as necessary, prior to shipment to the Nevada Test Site.

Personnel Exposure

For most yield and nonyield experiments with plutonium, placement of the inner containment vessel into the NIF target chamber and its removal after the experiment would result in worker exposure from the target chamber. During this time, personnel are assumed to be in close proximity to a large, open target chamber port. Because they would have a line-of-sight view to the activated target chamber interior, activated as a result of previous experiment, and the inner containment vessel, they would receive some additional amount of exposure. The exposure would be greater during removal of the inner containment vessel after yield experiments because both the inner containment vessel and the NIF target chamber would be further activated from neutrons released during the experiment.

Post-experiment activities would most likely be conducted at the LLNL Tritium Facility and appropriate protective measures, such as protective clothing and gloveboxes, would be used to prevent plutonium exposure would be used. The post-experiment activities that would be conducted in the Tritium Facility include installation of the inner containment vessel into a large glovebox, access to the interior of the inner containment vessel to retrieve samples, if needed, and decontamination and dismantlement of the inner containment vessel prior to shipment as waste. Worker dose would occur mostly due to exposure to the activated inner containment vessel. The inner containment vessel would become activated only for yield experiments.

The increased dose for the Proposed Action would be largely the result of yield experiments, and would occur during removal of the inner containment vessel and post-experiment processing.

Smaller doses are incurred for nonyield experiments (during inner containment vessel placement and removal), and during placement of the inner containment vessel for yield experiments. This additional dose (beyond that of the No Action Alternative) was estimated assuming 4 yield experiments with plutonium at 45 megajoules each and 10 plutonium nonyield experiments per year.

Experiments Without Inner Containment Vessel

Radioactive material generated during these experiments would include neutron-activated radioactive particulates created in the target chamber and any fission products generated during yield experiments with plutonium, highly enriched uranium, depleted uranium, or thorium-232. These radioactive materials would be transferred to the decontamination systems and waste streams as a result of decontamination of the target chamber components. However, because many of the isotopes have short half-lives, the maximum inventories associated with radioactive particulates would be found in the target chamber shortly after the last experiment and well before cleanup. By the time cleaning occurs or components are removed, the radioactive particulate inventory would have decayed to much smaller quantities.

The inventories provided for the analysis in Section M.5 are maximum additional inventories that would be required for the Proposed Action. For nonplutonium experiments, the inventories correspond to a final 45-megajoules-yield experiment, ending one year of experiments with 1,200-megajoules total yield. Experiments of this magnitude (45 megajoules) would not be scheduled as part of the normal experimental plan. However, 45 megajoules is the maximum credible yield that could be obtained. The 45-megajoules inventories are used here to bound all inventories of radioactive particulates and fission products. Table M.3.2.1–1 presents the maximum inventory of beryllium, lithium hydride, depleted uranium, highly enriched uranium, and tracer elements over the maximum inventory associated with the Proposed Action.

TABLE M.3.2.1–1.—*National Ignition Facility Inventories for Proposed Materials*

Material	Maximum Inventory
Beryllium	20 g
Lithium hydride/Lithium deuteride	125 g
Depleted uranium	100 g/yr[a, b]
Plutonium	3 g
Highly enriched uranium[c]	100 g
Thorium-232	450 g
Tracer elements, (iodine is representative)[d]	0.1 g

Source: LLNL 2003d.

[a] The single-experiment inventory limit results from the fission products created during a single high-yield experiment (45 MJ), as well as buildup of the longer-lived fission products during one year of 1,200-MJ operation.

[b] This is the total quantity of depleted uranium that could be in the National Ignition Facility target chamber at any one time. Individual targets for yield experiments would be limited to 2.2 g for depleted uranium.

[c] Assumed composition, by weight, is 93.5 uranium-235, 5.4 % uranium-238, and 1.1 % uranium-234. Individual targets for yield experiments would be limited to 1.2 g for highly enriched uranium.

[d] Other possible tracer elements include: beryllium, lithium, oxygen, neon, chlorine, argon, titanium, chromium nickel, copper, arsenic, bromine, krypton, rubidium, yttrium, zirconium, niobium, molybdenum, rhodium, silver, iodine, xenon, neodymium, samarium, europium, thulium, lutetium hafnium tantalum, tungsten, rhenium, iridium, gold, thallium, bismuth These are bounded by the representative tracer and could be used in similar quantities. The quantity in the table assumes 60 experiments/yr, each at 1.7 mg.

g = gram(s); yr = year.

Releases of activated target bay gases would be unchanged for the Proposed Action; however, some fission products would be created during experiments involving fissile or fissionable materials without an inner containment vessel, and some would be eventually released to the environment as part of normal operations. Many are short-lived and would decay while being

held on the cryopumps. Alternately, they could be discharged to the accumulation tank and held until most have decayed. Some longer-lived gaseous fission products, such as krypton-85 (10.7 years half-life), would not have decayed by much when they would likely be released to the environment. Fission products that are solids (very small amounts) would be retained in the target chamber. Other semivolatile fission products, such as iodine isotopes, would be captured on charcoal filters, thereby minimizing any release of these radionuclides to the environment.

Personnel Exposure

Personnel would be exposed to prompt radiation during the NIF yield operations. Also, during yield operations, tasks that must be performed within the NIF target bay or that involve handling of materials that have been inside the target bay during high-yield experiments would result in some level of radiation dose. This would not change from the No Action Alternative.

In addition, a worker dose would be incurred during routine decontamination activities. This would include handling of contaminated/activated items; disassembling them, if needed; and processing them through the decontamination systems. This dose would be largely related to the cleaning frequency, which is unchanged from the No Action Alternative (once per year). Therefore, this component of the worker dose is not expected to change for the Proposed Action.

Radiation exposure in radiologically controlled areas would be kept as low as reasonably achievable through facility and equipment design and administrative controls.

M.3.2.2 *Transport of Materials*

NIF targets would come from more than one source. Most of the targets would be provided from an onsite source, such as the LLNL Tritium Facility. The other fabrication source would be Los Alamos National Laboratory in New Mexico. Targets for the Proposed Action would include quantities of depleted uranium, highly enriched uranium, thorium-232, or weapons-grade plutonium, in addition to tritium. An additional bounding scenario for the Proposed Action analysis would be the transport of one plutonium target (up to 3 grams) from its source. Post-experiment, the inner containment vessel would be transported onsite from the NIF to the Tritium Facility.

M.3.2.3 *Waste Generated During National Ignition Facility Operations*

Many of the waste streams described under the No Action Alternative would be unchanged for the Proposed Action, as they are not directly related to the proposed changes in materials used for experiments. Because fission products could be produced from some yield experiments, it is expected that there would be a small increase in LLW related to filters. Charcoal filters would be used to capture iodine isotopes, and these would need periodic, though infrequent, replacement. Other waste streams, such as the target chamber hardware or decontamination wastes, would not be expected to change because the cleaning frequency would be the same as under the No Action Alternative.

For plutonium experiments with containment, disposal of the inner containment vessel would substantially increase the low-level radioactive waste stream. The additional waste has been estimated based on 14 plutonium experiments per year: 4 with fusion yield and 10 without yield. Each inner containment vessel would occupy approximately 8.5 cubic meters of space, including void volume. Because it is expected, in most cases that the inner containment vessel would leave LLNL from the Tritium Facility, the waste would appear in the Tritium Facility (Building 331) waste stream. It is expected that only LLW would be generated as a result of using the inner

containment vessel. Section M.5 provides details concerning the estimated waste streams for the Proposed Action.

M.3.2.4 *Neutron Spectrometer*

During the commissioning phase of the NIF, when full laser energy is not available, sub-ignition inertial confinement fusion experiments could be performed using targets that generate low neutron yields. Furthermore, non-inertial confinement fusion experiments are planned for the NIF that would require sensitive neutron diagnostics. A neutron spectrometer capability would more accurately measure neutron yield and diagnose ignition target physics.

The Proposed Action would include the construction and operation of a neutron spectrometer to provide an accurate measure of neutron fluxes in yield experiments. Similar underground construction was done at the University of Rochester Omega laser and at the LLNL Nova laser[5]. The neutron spectrometer construction would not start before fiscal FY2008 and when completed would become part of the NIF operational facility. The eventual design of the neutron spectrometer would depend greatly on the continuing development of detector technologies and the selected imaging technology. Conservative assumptions have been made using past and existing neutron spectrometer measurement systems.

The neutron spectrometer would be contained in a shielded-concrete shaft that would extend underground outward from the NIF target chamber (Figure M.3.2.4–1). The construction of the neutron spectrometer would require excavating and installing a concrete shaft from the target chamber to a point 52 feet below the surface. The shaft would contain approximately 1 cubic meter of solid plastic scintillator (polyvinyl toluene) and would be shielded by approximately 20 tons of lead. The bottom of the shaft would be near the water table. The plastic scintillator, in the form of thin sheets, would be held in a rack at the bottom of the shaft. The shaft would be sealed to prevent contamination of groundwater from any leakage from the shaft or any inflow into the shaft. The design and construction of the shaft would prevent groundwater intrusion.

M.3.3 Reduced Operation Alternative

Under the Reduced Operation Alternative, the neutron spectrometer would not be constructed and there would be no experiments with plutonium; other fissile materials; fissionable materials, other than depleted uranium without yield; or lithium hydride. The operation of the NIF under the Reduced Operation Alternative would be similar to that under the No Action Alternative. The primary difference would be in the schedule of experiments, the annual yield, and tritium throughput. The tritium throughput would be reduced from 1,750 curies per year to 1,500 curies per year.

Annual yield from the NIF ignition experiments would be reduced by 33 percent under the Reduced Operation Alternative, from 1,200 megajoules per year to 800 megajoules per year. The individual experiment yields would remain at up to 20 megajoules (45 megajoules maximum credible yield), but the total number of experiments with high yield would be reduced.

[5] Nova laser was decommissioned in May 1999.

This effectively limits the number of experiments that use ignition to produce the physics data needed to support Stockpile Stewardship Campaign milestones. Some aspects of operations would be affected by the stretching of the experiment schedule. These aspects are discussed individually in this section. The differences in operating parameters among No Action Alternative, Proposed Alternative and Reduced Operation Alternative are presented in Table M.3–1.

The effect of the Reduced Operation Alternative would be to stretch out experimental deliverables by an increasing amount over time in proportion to the reduced yield limits each year. Over a 10-year period, this would correspond to an approximately 3-year addition to the schedule to achieve the same deliverables for Stockpile Stewardship as compared to the No Action Alternative and Proposed Action. In the shorter term, the Reduced Operation Alternative would delay the availability of experimental data needed to optimize the NIF laser and ignition target parameters leading to the achievement of fusion ignition on the NIF. The Reduced Operation Alternative would delay the time when ignition physics data could be made available to benchmark and validate accelerated strategic computing initiative computer codes used for modeling nuclear weapons behavior. The reduced annual yield would also reduce the number of weapons effects tests that would require the intense amount of neutron and x-ray radiation generated by ignition targets and used to test the radiation hardness of military systems and components.

By maintaining the full operations and support facilities staff, the facility would be in complete operational readiness, and the annual yield could be raised to either the No Action Alternative or Proposed Action level of 1,200 megajoules per year and the tritium throughput to 1,750 curies per year.

M.3.3.1 *National Ignition Facility Operations*

The laser and target area building is an environmentally controlled clean room facility housing the laser and target area systems and the integrated computer system. The majority of the building is dedicated to providing the laser power, radiation confinement and control, and all necessary system control and diagnostics. It consists of two laser bays, two optical switchyards, a target chamber in a shielded target area, target diagnostic facilities, capacitor areas, control rooms, and an operations support areas, see Figure M.1.2–1. This equipment and these operations are necessary to operate the NIF for even one experiment. Under the Reduced Operation Alternative, the equipment and operations would be the same as those described for the No Action Alternative in Section M.3.1.1.

The diagnostic building, adjacent to the target bay, houses the environmental protection systems, target receiving area, tritium processing area, and diagnostic support areas. The tritium processing system would operate by oxidizing gaseous tritium and capturing the oxidized tritiated water on molecular sieves. These operations also would be necessary for staging each experiment. These operations would be identical to those described for the No Action Alternative; however, the amount of material captured by the filters and molecular sieves would be related to the number and type of experiments. Thus, the replacement of filters and decontamination of equipment would be reduced, along with the resultant waste streams.

Facility Utility Usage

Facility operations would require the use of electrical power, water, and natural gas and the discharge of wastewater. The NIF would use electricity to operate the laser and plant equipment necessary to support basic operations. The power would be used continuously for 8,760 hours per year, for a total energy consumption of 131,400 megawatt hours per year. This would include operations of the HVAC system, chilled and heated water systems, lighting, and facility heating. The power used to keep the NIF at clean room conditions would be much greater than the power used by the laser in an experiment. Therefore, utility usage would not be reduced under the Reduced Operation Alternative.

The two standby diesel generators would still be maintained in readiness and, under normal conditions, would be operated only for the purpose of maintenance and testing, about 10 hours per year.

M.3.3.2 *Laser Operations*

The operating parameters established for the NIF experiments under the Reduced Operation Alternative are indicated below.

- Laser power/energy to the target: 500 terrawatts/1.8 megajoules
- Maximum design yield per experiment: 20 megajoules (maximum credible yield would be 45 megajoules)
- Annual total yield: 800 megajoules per year

Otherwise the laser operations would be the same as described under the No Action Alternative in Section M.3.1.2.

M.3.3.3 *Target Bay and Target Chamber*

The target bay consists of the following major subsystems: target chamber, target emplacement positioner, target diagnostic control room, support structures, environmental protection, and vacuum and other auxiliary systems. The target bay and target chamber would be operated in the same manner as described under the No Action Alternative in Section M.3.1.3.

Some aspects of the target bay and target chamber operations are scalable to the number and type of experiments conducted and, therefore, would be less under the Reduced Operation Alternative, including the following:

- Generation of radioactive air emissions, such as activated air created during high-yield experiments or a tritium release
- Generation of solid LLW from replacement of the disposable debris shields, periodic cleaning the main debris shields, and the replacement and disposal, as needed, of the main debris shields and first wall panels due to damage or age
- Use of caustic chemicals for cleaning the main debris shields and first wall panels
- Replacement of the charge-coupled discharge cameras used for target chamber diagnostics
- Replacement of filters

M.3.3.4 *National Ignition Facility Experiments*

Both indirect-drive and direct-drive experiments could be conducted on the NIF under the Reduced Operation Alternative in the manner described for the No Action Alternative in Section M.3.1.4. The series of experiments conducted on the NIF to validate system operation and evaluate weapons data would proceed as described for the No Action Alternative. The NIF would be operated as a low-hazard, radiological facility under the Reduced Operation Alternative. Only the schedule for the experiments would be changed.

Radiation Produced from Experiments

The activation of target bay structures and concrete walls by neutrons from the NIF experiments and the skyshine produced by the neutrons would be less than projected for the No Action Alternative. Therefore, worker exposure would be lower under the Reduced Operation Alternative.

Tritium

Tritium would be transported, handled, and used in the same manner as under the No Action Alternative described in Section M.3.1.4. The amount of tritium in individual targets would not be expected to change for the Reduced Operation Alternative, containing up to 5 curies each 2 curies in the capsule and up to 3 curies in the associated hardware. If direct drive were implemented, each target would contain up to 70 curies. The annual tritium throughput at the NIF would be limited to 1,500 curies per year. The frequency of delivering tritium targets would be reduced by approximately 14 percent below the No Action Alternative level. The tritium in-process inventory limit for the NIF would still total no more than 500 curies.

Particulates

The generation of particulates in the target chamber is related to the number and type of experiments. Particulate generation would be less under the Reduced Operation Alternative than that discussed under the No Action Alternative in Section M.3.1.4. As the particulate material is exposed to neutrons from yield experiments, some would become activated and converted to radioactive material. The particulates would accumulate in the target chamber until the scheduled cleanup. At that time, the radioactive particulates created in the target chamber would be transferred to the decontamination systems and waste streams. Under the No Action Alternative, the cleanup was assumed to take place on an annual basis. Under the Reduced Operation Alternative, the cleanup would take place on an 18-month cycle. For the purpose of this analysis, the impacts associated with the cleanup have been annualized and are scalable as two-thirds those of the No Action Alternative.

M.3.3.5 *Hazardous Materials*

The main nonradiological materials at the NIF would include miscellaneous solvents and cleaning chemicals, decontamination process materials, fluids in electrical equipment, and materials that are part of, or placed into, the target chamber. The use of these and other materials needed to support the NIF operations would remain the same under the Reduced Operation Alternative as under the No Action Alternative (Section M.3.1.5).

The use of cleaning agents in the decontamination processes would be less under the Reduced Operation Alternative. A roughly one-third reduction on an annual basis would be seen in the use of these agents, including phosphoric acid, nitric acid, and sodium hydroxide.

The hazardous materials associated with the power conditioning units used in support of the pre-amplified modules would remain the same under the Reduced Operation Alternative.

The NIF would use beryllium in two forms: collected solids, primarily in filters, that cannot become particulate, and material in exposed diagnostics and targets that can become particulate. The NIF would handle small quantities of beryllium in the form of targets and windows for diagnostics. This would not change on a per target basis under the Reduced Operation Alternative. It is not anticipated that there would be significant airborne exposure to the workers. This would be confirmed by air monitoring. Surface swiping would be performed to confirm that surface beryllium contamination would remain within permissible housekeeping limits for beryllium work areas (10 CFR Part 850).

The composition of targets would be the same as for the No Action Alternative. The generation of debris from the target and hohlraum deposited on the target chamber wall and debris shields would be less on an annual basis than projected for the No Action Alternative. Under the No Action Alternative, the target chamber would only be decontaminated once per year. Under the Reduced Operation Alternative, the target chamber would be decontaminated once per 18 months. The inventory of particulates in the target chamber would be reduced by one-third, on an annual basis, from that of the No Action Alternative. There will be no explosive materials stored or used at the NIF.

M.3.4 Comparison of Alternatives and Environmental Impacts

Table M.3.4–1 compares the potential environmental consequences of the Proposed Action, and No Action Alternative, and Reduced Operation Alternative. The details of the environmental consequences, summarized in this table, are provided in Section M.5. The first column of the table provides information from the SSM PEIS environmental impacts. This information is provided to aid the reader in understanding the differences between the SSM PEIS and the No Action Alternative. This information is only provided as a reference. The No Action Alternative is the basis for comparison to the Proposed Action and the Reduced Operation Alternative.

Proposed Action Impacts

As indicated in the table, changes in Proposed Action impacts, as compared to the No Action Alternative impacts, would only occur in three areas. The impacts, while of concern, would not result in significant environmental consequences. The impacts would include an increased use of several hazardous and radiological materials, an increase in low-level solid radioactive waste generation from the use of these materials, and an increase in worker exposure.

Under the Proposed Action there would be an increase in the use of beryllium from 1.6 to 20 grams per year and the use of 125 grams of lithium hydride per year. The neutron spectrometer would also use 4,000 pounds of polyvinyl toluene and 43,000 pounds of lead for the detector. The No Action Alternative limit established for the use of beryllium would be 1.6 grams per year. The use of lithium hydride was not evaluated as part of the No Action Alternative.

Changes in the use of radiological materials under the Proposed Action would include the use of up to 3 grams of weapons-grade plutonium per experiment, 100 grams of highly enriched uranium per year, 100 grams of depleted uranium per year, and 450 grams of thorium per year. The radiological materials limit established under the No Action Alternative would be 5 grams of

depleted uranium per year. The use of fissile and fissionable materials, described above, is not considered under the No Action Alternative. The use of tritium would remain the same as discussed under the No Action Alternative.

The low-level solid radioactive waste would increase from 70 cubic meters per year under the No Action Alternative to 190 cubic meters per year under the Proposed Action. The 190 cubic meters is nearly fifty percent of the estimated sitewide generation of low-level radioactive waste. These levels of waste generation are within the capacity for treatment, transportation, or storage. The other waste categories numbers would remain the same as the No Action Alternative numbers.

The estimated worker exposure for the NIF operations would be 19 person-rem per year for the Proposed Action. The No Action Alternative worker exposure would be 15 person-rem per year. The Proposed Action worker exposure of 19 person-rem per year is 15% of the LLNL estimated total worker population dose. The LCFs projected under the Proposed Action for the NIF would be 1.1×10^{-2}. The LCFs projected under the Proposed Action for LLNL would be 7.5×10^{-2}. No individual will receive more than 500 mrem/year.

Reduced Operation Alternative Impacts

The Reduced Operation Alternative impacts would be less than the No Action Alternative impacts in several areas. These would include a reduction in the use of hazardous and radiological material, a reduction in waste generation, and a decrease in worker exposure. Under the Reduced Operation Alternative, the neutron spectrometer would not be constructed and there would be no experiments with plutonium; other fissile materials; fissionable materials, other than depleted uranium; or lithium hydride.

M.4 DESCRIPTION OF THE AFFECTED ENVIRONMENT

M.4.1 Environmental Setting

Chapter 4 of the LLNL SW/SPEIS describes the environmental setting and existing conditions associated with current operations at LLNL. This information forms a baseline for evaluating the environmental impacts associated with implementing the No Action Alternative, Proposed Action, and Reduced Operation Alternative. Information from Chapter 4 of the LLNL SW/SPEIS was used as a basis for analysis of the impacts presented in Section M.5 of this appendix.

M.5 ENVIRONMENTAL CONSEQUENCES

The No Action Alternative, Proposed Action, and Reduced Operation Alternative are considered in this appendix. Section M.5 is broken into several subsections as follows:

- Section M.5.1 provides a short discussion of methodologies used to assess potential impacts. See the main document for additional information.
- Section M.5.2 discusses the impacts associated with the No Action Alternative and provides information from the SSM PEIS for comparison.
- Section M.5.3 presents the potential impacts that could occur under the Proposed Action involving the changes of the NIF operations associated with the use of plutonium, other fissile materials, fissionable materials, and lithium hydride/deuteride in experiments on the

NIF. In addition the section presents impacts associated with the construction and operation of a neutron spectrometer.

- Section M.5.4 evaluates the changes in impacts that would result from reducing operations on the NIF consistent with the Reduced Operation Alternative.
- Section M.5.5 discusses the mitigation measures.
- Section M.5.6 provides a discussion of the risks and consequences of accidents associated with the operation of the NIF.

M.5.1 Methodology

The evaluation of the No Action Alternative, Proposed Action, and Reduced Operation Alternative in this appendix was performed to provide the information and context with which the decision-maker could reach a decision that would be documented in the Record of Decision. The differences being considered in this appendix are related primarily to the experiments to be conducted on the NIF and their scheduling, not the operation of the NIF as a facility. The facility operations are discussed where the information aids in the understanding of issues being considered.

Some environmental resources are of lesser relevance to the impacts being assessed; the impacts of each environmental resource are evaluated and discussed to the degree that the resource could be affected by the Proposed Action, No Action Alternative, or Reduced Operation Alternative. If there would be little impact to or change in the environmental resource under each of the alternatives, the resource is discussed only briefly. A description of the methodology used to assess the potential impacts associated with each alternative is presented in Chapter 5.1 of LLNL SW/SPEIS. The methodology used for the NIF appendix is the same as that used in the LLNL SW/SPEIS and is not repeated.

M.5.2 No Action Alternative

The No Action Alternative would comprise the continued installation of equipment and operation of the NIF. Under the No Action Alternative, the estimated operating parameters for the NIF would be a maximum credible yield of 45 megajoules. The maximum annual total yield would be 1,200 megajoules per year. The maximum annual tritium throughput would be 1,750 curies per year with a maximum tritium inventory of 500 curies. Under the No Action Alternative, the NIF would perform the full ignition program required to meet the SSP but would not perform experiments with plutonium, other fissile materials, fissionable materials (other than depleted uranium), or lithium hydride. The neutron spectrometer capability would not be constructed. The NIF would continue to be operated as a low-hazard radiological facility.

M.5.2.1 *Land Use and Applicable Plans*

In general, land at and in the vicinity of LLNL is zoned for industrial park use. The industrial land use for the NIF was determined in the SSM PEIS. The NIF land use is compatible with LLNL land use. The No Action Alternative would not result in any change to the land use for the immediate area of the NIF or land use in the overall vicinity. No impacts to land use are expected from the No Action Alternative.

M.5.2.2 *Socioeconomic Characteristics and Environmental Justice*

Socioeconomics

The No Action Alternative would not include the construction of a neutron spectrometer; therefore, there would be no increase in temporary employment due to construction activities.

The employment numbers provided in the SSM PEIS were 330 long-term employees for operating the NIF. Current projections for the No Action Alternative are that 180 employees would be needed for direct operations along with 220 support personnel. Together, 400 long-term workers would be employed at the NIF and its support operations. Most of these workers are already employed at LLNL, either working on making the NIF operational or at other LLNL facilities. It is expected that up to 20 new hires would be needed to reach the 400 long-term employee level. Any new hires would fall within the 5 to 8 percent annual turnover at LLNL. Therefore, no impacts to local housing, schools, or medical services are anticipated.

Environmental Justice

The evaluation of Environmental Justice involves the identification of any disproportionately high and adverse human health or environmental effects of existing or approved projects, programs, policies, and activities on minority populations and low-income populations. There are no block groups within a 5-mile radius that are categorized as minority. There are no block groups within a 10-mile radius of the Livermore Site that have percentages of low-income populations greater than the state average. The impacts associated with the operation of the NIF with potential for disproportionate effects would be radioactive air emissions. Beyond a 5-mile radius these impacts would be negligible (see Section M.5.2.8). Therefore, there would be no disproportionately high and adverse impacts to minority or low-income populations from the No Action Alternative.

M.5.2.3 *Community Services*

The SSM PEIS projected that there would be an increased demand for general services, while there would be no change in fire or police services. The existing LLNL fire protection and emergency services and police protection and security services would not change under the No Action Alternative. The level of services provided currently would not change. Because there would be no substantial change in the workforce, there will be no changes in the socioeconomic impacts and no associated change in school services.

The NIF would not adversely affect the ability of Alameda County to provide adequate solid waste disposal. The SSM PEIS estimated that the NIF would generate 6,000 cubic meters of nonhazardous solid waste per year. This figure was overly conservative as it represented a doubling of LLNL generation of nonhazardous solid waste in 1994. LLNL's current generation of nonhazardous solid waste averages 0.5 cubic meter per person per year or approximately 4,600 cubic meters (LLNL 2002cc).

The NIF is generating and will continue to generate waste office paper, cardboard, plastic, sanitary wastes, and other nonhazardous refuse at a rate similar to the Laboratory as a whole. There is nothing unique about the refuse generation from the NIF, in terms of waste types or amounts; therefore, this type of waste is projected on a per capita basis. As a conservative estimate (current LLNL generation is 0.5 cubic meter per person), it is assumed that each worker would generate 1 cubic meter of nonhazardous solid waste. With a projected total of 400 long-term workers at the NIF and its support operations, the projected amount of nonhazardous solid

waste would be approximately 400 cubic meters per year. Because 380 long-term personnel are already employed at NIF, the associated 380 cubic meters of nonhazardous solid waste is already part of the overall LLNL waste figures. The 20 new hires would generate a maximum of 20 cubic meters of additional nonhazardous solid waste per year. This amount is slightly more than a 0.4 percent increase in the site's generation of nonhazardous waste; therefore, no impacts are expected to the capacity to handle nonhazardous solid waste under the No Action Alternative.

M.5.2.4 *Prehistoric and Historic Cultural Resources*

The SSM PEIS projected that there would be no impacts to cultural resources from the construction and operation of the NIF. No prehistoric archaeological resources have been identified on or near the NIF site. No buildings and facilities at LLNL that could have potential to be eligible to the National Register of Historic Places are located near the NIF. Since much of the NIF site has been developed, the likelihood of finding unrecorded and undisturbed prehistoric sites is low. Under the No Action Alternative, the neutron spectrometer would not be built; therefore no excavation will be required. There would be no impacts expected to prehistoric or historic cultural resources from the No Action Alternative.

M.5.2.5 *Aesthetics and Scenic Resources*

With the exception of temporary dust and vehicle exhaust emissions from construction activities, the SSM PEIS projected no impacts to visual resources from the construction and operation of the NIF. The NIF conventional facility construction is now complete. All conventional facilities are constructed and turned over for equipment installation. No further changes to the visual features would occur in the area of the NIF. There would be no impacts to aesthetic and scenic resources under the No Action Alternative.

M.5.2.6 *Geologic Resources*

The SSM PEIS projected that 25 acres of land would be cleared for the construction of the NIF, with 5 acres being used for a construction laydown area. The SSM PEIS proposed that the laydown area would be restored after construction was complete. The conventional construction of the NIF is now complete. The laydown area is still being used to store and transfer equipment while the NIF is being made operational. Animal fossils have been found beneath the NIF; however, no new excavation is planned under the No Action Alternative. No further impacts to soils or fossils would result from the No Action Alternative.

M.5.2.7 *Ecology*

The SSM PEIS discussed the potential for construction of the NIF to affect the nearby wetland and the potential foraging habitat for the western burrowing owl. The SSM concluded that there would be no adverse impact to these resources from the construction and operation of the NIF.

NIF conventional facility construction is complete. No new construction would occur under the No Action Alternative; therefore, there would be no erosion or changes to existing stormwater flow patterns. No impacts would occur to the nearby wetland area. Few impacts will occur to biological resources during operation of the NIF. The traffic to and from the NIF would have associated losses of road-killed individuals of some species. No adverse impacts to threatened and endangered species or species of special concern would be expected from operation of the NIF.

M.5.2.8 *Air Quality*

During normal operations, some experiments at the NIF would result in atmospheric releases of small quantities of tritium and some radionuclides produced by activation of gases in the target bay air.

Some nonradiological hazardous materials would be present at the NIF. Routine emissions of these types of materials would be expected from operation of electrical equipment, wipe cleaning, and occasional use or maintenance testing of the standby generators. The projected air pollutant emission rates associated with increased fuel combustion in boilers and engines, and the increased vehicular activity associated with increased workforce at LLNL under the LLNL SW/SPEIS No Action Alternative, which includes the NIF, are provided in Chapter 5 of the LLNL SW/SPEIS text. The total emissions are a small fraction of project significance levels and threshold levels for conformity.

Criteria Air Pollutants

The U.S. Environmental Protection Agency has set national ambient air quality standards to protect public health, and the State of California has its own sets of standards, state ambient air quality standards, that are generally more stringent than the Federal standards. Air emissions are discussed below in terms of the Federal and state criteria air pollutants, which are ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter less than 10 microns in diameter (PM_{10}), and lead.

The SSM PEIS stated that air pollutant emissions from operation of the NIF would occur primarily from fuel combustion and solvent cleaning of the debris shields. The criteria air pollutants from fuel combustion for the operation of standby diesel generators for the NIF (Section M.5.2.12) are listed in Table M.5.2.8–1. The current projections for the NIF criteria air pollutant emissions are less than 3 percent of the SSM PEIS projections for PM_{10}, nitrogen dioxide, and sulfur dioxide. The NIF emissions of carbon monoxide would be 22 percent of the SSM PEIS projection. Only the projected emissions of volatile organic compounds (VOCs) would be greater than the rate projected in the SSM PEIS.

Under the No Action Alternative, the NIF would use VOCs for lens cleaning and other wipe cleaning operations in the clean-room environment. These solvents would include ethanol, acetone, and isopropanol. The use of such solvents would be limited to 400 gallons per year by the Bay Area Air Quality Management District's air permit (S-2121). Based on experience to date, it is estimated that the annual solvent usage would not approach 400 gallons per year. However, 400 gallons was used as a bounding quantity in Table M.5.2.8–1. This bounding quantity would represent a 15 percent increase in LLNL volatile organic compounds emission rate. Considering the quantities likely to be used, the potential use of dilute aqueous solvent solutions, and the potential use of other non-solvent cleaning techniques, the increase in VOCs emissions would likely be smaller.

TABLE M.5.2.8–1.—*Annual Emissions from National Ignition Facility Operations at Lawrence Livermore National Laboratory (No Action Alternative)*

Pollutant	SSM PEIS Projected NIF Emissions (t/yr)	2000 LLNL Emissions (t/yr)	Projected NIF Emissions (t/yr)	2000 LLNL Emissions Plus NIF (t/yr)	NIF Percent of 2000 LLNL Emissions
Particulate matter 10 microns or smaller	0.16	2.21	0.0042	2.21	0.19
Volatile organic compounds	0.56	7.87	1.18	9.05	15.0
Carbon monoxide	0.43	5.58	0.094	5.67	1.7
Nitrogen dioxide	1.79	21.6	0.076	21.7	0.35
Sulfur dioxide	0.03	0.241	0.0017	0.242	0.68
Lead	Negligible	Negligible	Negligible	Negligible	Negligible

Source: LLNL 2003d.
LLNL = Lawrence Livermore National Laboratory; NIF = National Ignition Facility; SSM PEIS = Stockpile Stewardship Programmatic Environmental Impact Statement; t/yr = tons per year.

The relatively small amount of solvent usage would probably not be affected by regulatory changes during the life of the project. If emission reductions are required in the future, they could be accomplished by a "capture/control" process employing carbon adsorption. The air district generally applies a "cost-effectiveness" criterion in deciding if the additional controls are warranted, and it is unlikely that such controls would be deemed "cost-effective." It is more likely that solvent usage reductions would be accomplished voluntarily, as a result of pollution prevention/solvent substitution efforts.

The NIF would generate criteria air pollutants during operation of the standby generators. The NIF has two standby diesel generators. Under normal conditions, the generators would be operated only for the purpose of maintenance and testing, for about 10 hours per year. Until recently, emergency standby generators were exempt from air permitting. The regulations were changed to require air permits, and existing generators (such as the two NIF generators) were "grandfathered" into the system of permitted sources. Air permits were received for the two generators in June 2002. The new air permits allow for unlimited operation during a power outage. A power outage is unlikely, because LLNL obtains power from two separate power suppliers. Therefore, air emissions resulting from a power outage are not included in Table M.5.2.8–1.

It has been the Bay Area Air Quality Management District's policy to allow new equipment to be used for a reasonable "useful life" before it must be replaced or retrofitted to reduce emissions. Because the NIF standby generators are relatively new, efficient units, it can be assumed that they would be allowed to be used for at least 10 years without changes. It is possible that they would be allowed to be used without modification for the life of the NIF; therefore, no projections have been made for replacements to the existing combustion equipment.

Hazardous Air Pollutants (HAPs)

The SSM PEIS stated that only minute quantities of hazardous VOCs would be expected to be emitted from the NIF. LLNL evaluates a list of approximately 200 compounds to confirm applicability under the National Emission Standards for Hazardous Air Pollutants (NESHAP). Emissions of hazardous air pollutants for all of LLNL are less than one-half of the thresholds of

7 tons per year for a single hazardous air pollutant or 15 tons per year for a combination of hazardous air pollutants (LLNL 2002ae). The normal operations of the NIF under the No Action Alternative would not result in the emission of hazardous air pollutants, except for the possible beryllium emissions as discussed in the next section.

Toxic Air Emissions

The SSM PEIS did not discuss toxic air emissions. LLNL compiles an inventory of toxic air contaminants under the California Air Toxics "Hot Spots" program. Of the more than 300 "Hot Spot" chemicals, only 3 are emitted at the Livermore Site at levels that exceed the health-risk-based *de minimis* reporting level (benzene, formaldehyde, and trichloroethylene). The NIF inventory would not include these chemicals. Under the No Action Alternative, the NIF would not increase the Livermore Site emission of these chemicals.

The use of beryllium in targets could result in airborne emissions from the NIF operations. Most of the contamination would be contained within the NIF target chamber. The bounding annual amount of particulate beryllium produced from the NIF operations in the target chamber would be 1.6 grams. This would represent the maximum inventory expected to be generated in any given year based on current plans for experiments and their associated targets and diagnostics. The projected air emissions of beryllium would be well below the Bay Area Air Quality Management District's Toxic Air Contaminant threshold for beryllium of 0.015 pounds per year (6.8 grams per year). The toxic air contaminant threshold is used by the Bay Area Air Quality Management District as a guidance tool to determine the health significance of toxic air emissions. The NIF beryllium emissions would be filtered before discharge to the atmosphere and would remain well below the Bay Area Air Quality Management District's toxic air contaminant threshold.

No increase in impacts from LLNL hazardous air pollutants and toxic air emissions would occur under the No Action Alternative. The increase in the emission of VOCs would be bounded at 15 percent. The impacts of the increase would be minor.

Radiological Air Quality

The SSM PEIS concluded that the general public living in areas surrounding LLNL site and LLNL workers could be exposed to small quantities of radionuclides released and radiation emitted from routine NIF operations, but that the expected level of radioactive releases and radiation emissions would be well within regulatory limits.

During normal NIF operations, experiments would result in atmospheric releases of small quantities of tritium and some radionuclides produced from activation of gases in the air. Table M.5.2.8–2 presents the maximum inventory of activated gases from the target bay air and the argon in the beam tubes generated from a single experiment. The total inventory of activated gases would correspond to a 45-megajoule maximum credible yield experiment. Experiments of this magnitude (45 megajoules) are not scheduled as part of the normal experimental plan. However, 45 megajoules is likely to be the maximum credible yield that could be obtained. The 45-megajoule inventory is used here to bound the inventory of activated material.

Because of the short half-lives of the radionuclides and the slow release of target bay air, only a small fraction of the inventory produced would be released to the environment. Negligible quantities of activated gases would be expected to be released from the beam tubes. The total

annual inventories of radioactive gases that would be produced and emitted to the environment for 1,200 megajoules per year are provided in Table M.5.2.8–3.

TABLE M.5.2.8–2.—*Estimated Maximum Activated Gases Inventory per Experiment*

Isotope	Quantity (curies)
Target Bay Air	
Hydrogen-3	1.6×10^{-4}
Nitrogen-13	1.9×10^{1}
Nitrogen-16	3.2×10^{3}
Sulfur-37	4.2×10^{-1}
Chlorine-40	2.4
Argon-41	1.6
Carbon-14	4.9×10^{-5}
Beam Tubes	
Hydrogen-3	3.4×10^{-8}
Sulfur-35	3.4×10^{-6}
Argon-37	8.7×10^{-4}
Argon-39	1.2×10^{-4}
Argon-41	3.5

Source: LLNL 2003d.

These radionuclides would be released through the elevated release point, 35 meters aboveground. The release point is 1.1 meters in diameter and gases would exit at 7.3 meters per second. The maximally exposed individual (MEI) would be expected to be located at the offsite veterinary facility on Greenville Road, 350 meters from the elevated release point. Estimates of annual emissions of activated gases, based on 1,200 megajoules per year of yield, are provided in Table M.5.2.8–3. Up to 30 curies per year of tritium would be released during maintenance activities, when equipment is opened up or brought up to atmospheric pressure.

TABLE M.5.2.8–3.—*Annual Routine Radiological Airborne Emissions from the National Ignition Facility (No Action Alternative)*

Nuclide Produced	Nuclide Half-Life	Production (curies/year)	Emissions (curies/year)
Activated Air			
Hydrogen-3	12.33 yr	4.3×10^{-3}	4.3×10^{-3}
Carbon-14	5730 yr	1.3×10^{-3}	1.3×10^{-3}
Nitrogen-13	9.99 min	5.1×10^{2}	6.8×10^{1}
Nitrogen-16	7.13 sec	8.4×10^{4}	1.5×10^{2}
Sulfur-37	5.06 min	1.1×10^{1}	7.9×10^{-1}
Chlorine-40	1.42 min	6.4×10^{1}	1.3
Argon-41	1.83 hr	4.2×10^{1}	2.6×10^{1}
Tritium (releases during maintenance)			**30**

Source: LLNL 2003d.
hr = hours; min = minutes; sec = seconds; yr = years.

Table M.5.2.8–4 presents the potential impacts of radiological air emissions to the public. The total exposure to the MEI also would include a component from prompt radiation (0.2 millirem per year) as discussed in Section M.5.2.14.1. The prompt dose is important near the site boundary where the MEI would be located. The prompt dose is less important to the general population whose exposure to it would be either transitory or nonexistent. The population dose would be dominated by the radioactive airborne effluent emissions. While some of the radiation exposures from normal operations to workers would result from radiological air emissions, the doses to involved workers would be primarily from direct radiation exposure (see Section M.5.2.14.1). The impacts, as discussed in the SSM PEIS, are presented for comparison.

TABLE M.5.2.8–4.—*Radiological Impacts to the General Public from Airborne Effluent Emissions during Normal Operations (No Action Alternative)*

Receptor	No Action Alternative	
	Dose	**Latent Cancer Fatality Risk**
NIF offsite MEI	0.04 mrem/yr	2.4×10^{-8}/yr of exposure
Population Dose	0.26 person-rem/yr	1.6×10^{-4}

Source: LLNL 2003d.
MEI = maximally exposed individual; mrem = millirems; NIF = National Ignition Facility; yr = year.

The site-wide MEI is a hypothetical individual who spends 24 hours per day, 365 days per year, at the publicly-accessible location where they would receive the greatest dose from LLNL operations. The location of the site-wide MEI would correspond with the NIF MEI location. The baseline dose to the MEI from Livermore Site operations (site-wide MEI) without the NIF operations was 0.017 millirem per year with an associated population dose of 0.16 person-rem per year in 2001 (LLNL 2002cc). Due to planned increases in Building 331 tritium releases, the No Action Alternative dose to the site-wide MEI without the NIF operations would be expected to be 0.039 millirem per year. Conservatively, adding the site-wide MEI No Action Alternative dose to the NIF MEI dose for airborne emissions would result in an estimated dose of 0.079 millirem per year for airborne releases under the No Action Alternative. This dose would be less than 0.8 percent of the NESHAP limit. The component of population dose from routine NIF releases would be 0.26 person-rem per year. Adding this dose to LLNL SW/SPEIS No Action Alternative population dose of 0.89 person-rem per year would result in a dose of 1.15 person-rem per year. This population dose would be many orders of magnitude less than the dose

received from natural background. No adverse impacts on radiological air quality would be expected from the NIF No Action Alternative.

M.5.2.9 *Water*

Under the No Action Alternative, the neutron spectrometer would not be built; therefore, there would be no changes to stormwater flow and no impacts to surface water or groundwater resources from construction activities.

The SSM PEIS projected an annual water usage at the NIF of 152 million liters per year, or approximately 4 percent of LLNL water supply capacity. The LLNL usage of 967 million liters per year in 1995 represented use of approximately 24 percent of LLNL's capacity. The SSM PEIS projected that there would be no impact to water quality or availability from the operation of the NIF.

Water usage at the NIF is currently expected to be 27.6 million liters per year, or approximately a 3.5 percent increase in LLNL usage of 795 million liters per year in 2001. Water used for the NIF operations would be supplied from the Livermore Site water system. The NIF water use would be within LLNL system capacity and no new wells or other sources would be required. Because no expansion of capacity would be required, there would be no impacts associated with expansion of capacity. The impacts of the increase in water use would be negligible in nondrought years. During drought years, the impacts of this increase in water use at LLNL would be of concern.

M.5.2.10 *Noise*

The SSM PEIS discussed the noise from construction of the NIF as the source of the greatest impact to an offsite individual. Noise from operation of the NIF was not discussed. Under the No Action Alternative, there would be no new construction or any demolition.

The main sources of noise from the operation of the NIF would be the vacuum pumps, HVAC systems, and traffic associated with moving equipment and truck deliveries. The noise level would be bounded by that of an industrial facility (approximately 85 decibels). The noise at the NIF would be equal to other local industrial/commercial activities; however, because of the size of LLNL site, the perimeter buffer zone, and intervening roads, the contribution of these activities to offsite noise levels would be small. These activities would not be in conflict with land-use compatibility guidelines. The impulse noise resulting from the NIF experiments would primarily come from the triggering of the capacitors. The noise would be able to be heard outside the NIF building for a short distance only. This noise is momentary and intermittent, occurring only at the time of an experiment, up to 6 times per day. No offsite noise would result from the experiments. The impacts of noise to workers would be normal for industrial facilities. With standard hearing protection, no impacts from noise would be expected. No impacts would be expected from noise to the public.

M.5.2.11 *Traffic and Transportation*

Traffic

The SSM PEIS evaluated the traffic impacts associated with an increase in employees at LLNL from the construction and operation of the NIF. An increase of 470 personnel, with an associated increase of 902 new vehicle trips per day, would result in a projected increase in traffic along local roads. The SSM PEIS projected a 10-percent increase along Patterson Pass Road, a 3- to 6-

percent increase along Vasco Road, a 3- to 4-percent increase along Tesla Road, and a 2- to 3-percent increase along First Avenue and Greenville Road.

The construction of the NIF conventional facilities is completed. As a result, the traffic associated with the construction workers has ceased. The personnel who are working to make the NIF operational and who will operate the NIF are already employed onsite. Therefore, there would be no change in the amount of traffic that currently exists.

Radiological Transportation

The consideration of target fill activities and the exact facilities that would perform these activities have not yet been fully decided. These activities would undergo NEPA and safety reviews prior to initiation of activities. Most of the targets would be provided from an onsite source. Routine onsite transportation of targets would have no impact to the public, as access to LLNL is restricted. The onsite transportation would fall within the scope of operational activities already analyzed for the site and the NIF in particular.

The major offsite source of target material would be Los Alamos National Laboratory. For purposes of analysis, under the No Action Alternative, 5 shipments per year, each with 0.2 grams of depleted uranium, and 15 shipments per year, each with 100 curies of tritium, would occur. The radiological transportation analysis is based on the assumption that these would all be separate shipments.

For incident-free transport; i.e., no accidents, of depleted uranium, the consequence would be the radiation dose potentially received by the truck drivers and members of the public driving on the highways, living near the highways, and present at rest stops. Because of the very small amount of radioactive material being transported and the shielding of the containers and truck, the radiation dose rate near the truck is expected to be immeasurably small. Therefore, there would be no incident-free radiation dose to drivers or members of the public.

Tritium does not produce an external dose rate. Therefore, transport of tritium would also have no incident-free radiological impacts. Section M.5.6 presents the consequences of transportation accidents, including tritium transport accidents.

M.5.2.12 *Utilities and Energy*

The NIF would be operated at clean-room conditions irrespective of the number of experiments. The utility usage at the NIF would be dominated by the operation of the facility at temperature stable clean-room conditions. Changes in the number and type of experiments would not change the overall utility usage.

M.5.2.12.1 *Water Use*

Water availability is discussed in Section M.5.2.9. The SSM PEIS projected that the NIF would have an annual usage of 152 million liters of water. Water usage at the NIF is currently expected to be 27.6 million liters per year, or approximately a 3.5-percent increase in LLNL usage.

Water would be used at the NIF for a variety of operations, including boilers, cooling towers, domestic use, landscape irrigation, washing, and fire hydrant testing. Some of the wastewater would be evaporated to the atmosphere, while other water would be discharged to the sanitary sewer or storm drain, as appropriate. A water balance for LLNL has been developed from several years of experience, which provides the discharge pathways for various water uses. The LLNL

water balance was used to estimate the water/wastewater pathways for the NIF. An estimated breakdown of water use is presented in Table M.5.2.12.1–1.

TABLE M.5.2.12.1–1.—*Projected National Ignition Facility Water Use and Sewer Discharges*

Water Use Type	Water Usage (kgal/day)	To Sewer (kgal/day)
Sanitary	6.2	4.4
Process	4.0	3.9
Washing	1.0	0.90
Landscape irrigation	8.0	0.0
De-ionized water	0.75	0.34
Fire hydrant testing	0.05	0.0
Total (Kgal/day)	20.00	9.54
Total (MLY)	27.6	13.2

Source: LLNL 2003d.
Kgal = thousand gallons; MLY = million liters per year.

The current projected NIF water requirement and sanitary wastewater flow estimate are provided in Table M.5.2.12.1–2. Sanitary wastewater and sewer discharges are discussed in Section M.5.2.12.2. The LLNL water supply capacity would be sufficient to meet the requirements of the NIF; therefore, there would be no impacts associated with the NIF water consumption.

TABLE M.5.2.12.1–2.—*Water and Wastewater Utility Capacity at Lawrence Livermore National Laboratory*

Utility System	Current Usage	NIF Requirement	Projected Usage, Including NIF	Current Capacity
Water supply (MLY)	981	27.6	1009	3,980
Wastewater treatment (MLY)	354	13.2	367	2,340

Source: LLNL 2003d.
MLY = million liters per year; NIF = National Ignition Facility.

M.5.2.12.2 *Sewer*

The SSM PEIS projected the sanitary wastewater treatment requirement for the NIF as 18 million liters per year, or approximately 0.8 percent of LLNL treatment capacity in 1995. The 402 million liters generated at LLNL in 1995 represented approximately 18 percent of LLNL treatment capacity.

The currently projected wastewater treatment requirement for the NIF is 13.2 million liters per year, an increase of 5.2 percent from the 354 million liters per year currently generated at LLNL. The projected sanitary wastewater treatment requirement from the NIF would be within LLNL capacity for treatment. Much of the workforce to operate the NIF is already at work at LLNL and the associated sanitary wastewater generation has already been accommodated by LLNL treatment system. No new treatment facilities or ponds would be required, therefore, there would be no impacts associated with NIF sanitary wastewater and sewer discharges.

M.5.2.12.3 *Electrical Usage*

The SSM PEIS only considered availability of electrical power infrastructure. It did not project the amount of power that would be used. The NIF would use electricity to operate plant

equipment to support basic operations. This would include operation of the HVAC system, chilled water systems, lighting, etc., and operation of the laser equipment; e.g., charging capacitors, operating the control room, and aligning lasers.

The original electric power requirement for the NIF was established by the NIF architecture/engineering firm, Parsons, to be 14 megawatts, or 1.23×10^8 kilowatt-hours per year. In subsequent design, this projection was increased by 7 percent to 15 megawatts, or 1.31×10^8 kilowatt-hours per year. This increase is primarily due to the addition of a new "clean dry air" system. In 2001, electrical power use at the Livermore Site was about 3.12×10^8 kilowatt-hours per year (LLNL 2002dl), with a peak usage of 54 megawatts. The NIF would result in a 42-percent increase in annual power usage over 2001. This would be a substantial increase in electrical usage. The LLNL peak usage would be projected to rise to 77 megawatts (LLNL 2002h). The current system's peak capacity is 125 megawatts.

M.5.2.12.4 *Fuel/Natural Gas*

The SSM PEIS projected that the NIF would use natural gas-fired boilers for HVAC and domestic hot water. The SSM PEIS projected that 2.14×10^7 megajoules (2.03×10^5 therms) of natural gas would be used annually for HVAC and domestic hot water for the NIF. Current projections for natural gas use have not changed. The natural gas usage at the NIF would represent a 2.6-percent increase over LLNL 2001 usage. This would be a minor impact to natural gas usage at LLNL.

The NIF standby generators would be operated by diesel fuel. These generators would be needed only to support key systems in the event of loss of primary power. These generators would be started up and tested/maintained regularly (~10 hour per year); but, because they normally would not be operational, fuel consumption would be low. The SSM PEIS projected an annual consumption of 85 gallons (320 liters) of diesel fuel for the NIF. No impacts are expected from the use of this small amount of diesel fuel.

M.5.2.13 *Materials and Waste Management*

NIF research activities would use a variety of hazardous (radioactive and toxic) materials and nonhazardous materials. No explosive materials would be used at the NIF. All of these would become part of material management for the NIF. Once the materials have been used, they would be classified and managed under the NIF's and LLNL's waste management procedures. Waste management is discussed in Section M.5.2.13.3. During the use and management of these materials, air emissions would occur. Emissions are discussed in Section M.5.2.8.

Particulates would be generated in the target chamber by the melting and vaporization of target material and ablation of the first wall surface, debris shield, and other components within the target chamber. Some of these particulates would be radioactive; some would be hazardous or toxic. Particulates and debris collected during the annual cleanup of the target chamber would be added to the waste streams as discussed in Section M.5.2.13.3. The management of the radioactive particulates and tritium is discussed in Section M.5.2.13.1. Nonradiological materials are discussed in Section M.5.2.13.2.

The primary strategy for the control and management of hazardous materials at the NIF would be to minimize exposures to hazardous substances in accordance with the regulatory requirements, institutional goals, and best management practices by seeking less hazardous substitutes and ensuring safe handling and storage and proper disposal. Practices for material management at the

NIF would include personnel training, inventory control and monitoring, safety assessments, and waste handling. Additionally, standard operating procedures, specific operating procedures, and operating instructions would be prepared for specific activities to establish safe procedures, barriers, and controls and safe work practices with regard to hazardous material operations, including material use and storage.

M.5.2.13.1 *Radionuclide Materials Management*

Under the No Action Alternative, the NIF would use targets that could contain radioactive materials, including depleted uranium and tritium. The amount of material would vary according to each test.

During the NIF yield experiments, all materials in the target bay would be subject to neutron activation. This would include the target chamber walls, vacuum systems, air handling systems, equipment, shielding, filters, facility walls, roof and floors, room air, and support structures including optics and beam lines. Any particulates, adherent material, and target debris left in the target chamber from previous experiments could, in turn, be exposed to neutrons, energetic particles, debris, and x-rays from subsequent experiments. Neutron exposure from yield experiments would result in some of the material and debris from the previous experiment becoming activated. The particulates would accumulate in the target chamber until the scheduled annual cleanup. Exposure to the particulate prior to annual cleanup would be managed to minimize exposure. The radioactive particulates created in the target chamber would be transferred to the decontamination systems and waste streams during cleanup. However, because these are mostly short-lived species, the maximum inventories would be found in the target chamber shortly after the last experiment and well before cleanup. By the time cleaning occurs or components are removed, the radioactive particulate inventory would have decayed to much smaller quantities.

Table M.5.2.13.1–1 lists the prominent radionuclides expected to result from neutron exposure of particulates in the target chamber. The total inventory of activated, mobilizable particulates created in the target chamber would be quite small, but it is included here for completeness. The inventories in Table M.5.2.13.1–1 would be maximum inventories. They would correspond to a final 45-megajoule experiment (maximum credible yield), ending one year of experiments with 1,200 megajoules total yield. The 45-megajoule inventories are used here to bound inventories of activated material.

Depleted Uranium

Depleted uranium would arrive at the facility in individual targets, each with up to 2.2 grams of depleted uranium. The maximum annual depleted uranium throughput at the NIF under the No Action Alternative would be limited to 5 grams. Depleted uranium would be used only in nonyield experiments and would not be considered “activated,” and no fission products would be produced. Depleted uranium is already slightly radioactive; the half-life of uranium-238 (dominant isotope) is 4.5×10^9 years. Depleted uranium is also considered to have toxic properties.

components would be removed during the decontamination process. This would transfer a small amount of tritium to the waste stream. The emissions of tritium are addressed in Section M.5.2.8.4.

M.5.2.13.2 *Nonradiological Materials Management*

The main nonradiological materials at the NIF would include miscellaneous solvents and cleaning chemicals, decontamination process materials, fluids in electrical equipment, and materials that are part of, or placed into, the target chamber. Other materials needed to support the NIF operations would include inert gases (argon) for laser operations, nitrogen for cryopumps, and other chemicals for general use. Some of these materials would be regularly consumed; others could be expended and require replacement during the lifetime of the NIF. These materials would then become part of the waste stream. Waste is discussed in Section M.5.2.13.3.

Nonradiological particulates will be generated in the target chamber from experiments. During the annual cleanup of the target chamber, the particulates and debris will be added to the waste streams discussed in Section M.5.2.13.3. Some of these particulates will be toxic. Based on the expected experimental campaign for the NIF, a total amount of ablated material per experiment was calculated. Table M.5.2.13.2–1 presents the bounding annual amount of particulate material produced from the NIF operations in the target chamber. This represents the maximum inventory that would be generated in any given year based on current plans for experiments and their associated targets and diagnostics.

A summary of nonradiological materials that would be used at the NIF is provided in Table M.5.2.13.2–2 along with applicable exposure criteria and maximum facility inventories. The NIF would use volatile organic solvents for lens cleaning and other wipe cleaning operations in the clean-room environment (see Section M.5.2.8.1). The handling, storage, and use of these materials would be managed to minimize exposures.

Throughout the Laser and Target Area Building, small quantities of various cleaners, oils, and miscellaneous other materials would be needed. These are not specifically listed in Table M.5.2.13.3–2, as the quantities and hazard level are bounded by other materials listed.

Each of the power conditioning units used to support the preamplifier modules would have a set of ignitron switches, which would contain 0.018 liter of mercury. A total of 3.5 liters of mercury would be contained in the 192 switches used at the facility.

The Optics Assembly Building would have a small inventory of chemicals, primarily used for cleaning. The main agent currently used (Brulin 815 GD) contains no hazardous ingredients, according to its Material Safety Data Sheet, and is generally approved for discharge to the sewer. The other chemicals listed would be stored in small quantities at the facility. Acetone and ethanol would be used only for occasional spot cleaning. Clean-room wipes, presaturated with 9-percent isopropanol in de-ionized water, would be used more frequently, but also in small quantities. The power for the NIF laser would be supplied by discharging a bank of capacitors. These capacitors would contain castor oil, which is nontoxic.

TABLE M.5.2.13.2–1.—*Bounding Annual Nonradiological Particulate Inventories in the Target Chamber (No Action Alternative)*

Material	Maximum Inventory (grams)
Aluminum	2.1×10^3
Gold	4.0×10^1
Beryllium	1.6
Copper	1.7×10^2
Dysprosium	2.1
Iron	2.6×10^2
Gadolinium	2.0×10^1
Germanium	2.0×10^1
Lead	3.0×10^1
Scandium	7.0
Silicon	5.0×10^2
Tantalum	2.9×10^1
Titanium	1.0×10^1
B4C	1.1×10^3

Source: LLNL 2003d.

M.5.2.13.3 *Waste Management*

At the NIF, waste management activities would consist of managing, storing, and preparing wastes for transfer to LLNL waste management facilities in accordance with applicable Federal and state regulations, permits obtained under applicable regulations, and DOE orders. The waste categories routinely generated by activities associated with the NIF under the No Action Alternative would include radioactive waste; i.e., LLW and mixed LLW (MLLW])[6]; hazardous waste, which would include *Resource Conservation and Recovery Act* hazardous waste, state-regulated waste, and *Toxic Substances and Control Act* waste; and nonhazardous solid waste and process wastewater. The wastes in this section are discussed in terms of the activities that generate them. Each description breaks out the amounts of LLW, MLLW, hazardous, and nonhazardous wastes.

The approach used in this section was to use the SSM PEIS estimates as a point of reference, and to make changes as appropriate, based on new quantitative information. Where there is uncertainty about potential reductions from the SSM PEIS estimates, the SSM PEIS estimates were retained, thereby providing a "contingency" to address the uncertainties in the estimates. Table M.5.2.13.3–1 summarizes the estimated waste streams under the No Action Alternative. The waste associated with the cleanup of the target chamber, i.e., particulates, discussed in Section M.5.2.13.1, is included under chemical treatment/decontamination.

[6] MLLW is low-level radioactive waste containing a *Resource Conservation and Recovery Act* hazardous chemical.

TABLE M.5.2.13.3–1.—*National Ignition Facility Waste Estimates for Low-Level, Mixed, and Hazardous Wastes (Annual) under the No Action Alternative*

Source of Waste	Low-Level Radioactive		Mixed		Hazardous	
	Solid (m^3)	Liquid (m^3)	Solid (m^3)	Liquid (m^3)	Solid (m^3)	Liquid (m^3)
SSM PEIS Total/yr	6.65[a]	1.6	0.9	5.0	8.0	4.6
Tritium processing	3.2	–	0.003	–	–	–
Wipe cleaning	3.3	0.3	1.0		1.0	–
HEPA filters/pre-filters	0.23	–	–	–	–	–
Waste hardware	63	–	0.5	–	–	–
Chemical treatment/decontamination	–	1.3	0.3	4.9		1.5
Waste oils/equipment	0.06	–	–	0.2	7.5	0.2
General chemicals	–	–	–	–	–	4.6
Total/year	70	1.6	1.8	5.1	8.5	6.3

Source: LLNL 2003d.
[a] Does not include debris shields.
HEPA = high-efficiency particulate air; m^3 = cubic meters; SSM PEIS = Stockpile Stewardship Management Programmatic Environmental Impact Statement.

M.5.2.13.3.1 *Radioactive and Mixed Waste*

Wastes from the Tritium Processing System

The tritium processing system would operate by oxidizing gaseous tritium in a reactor and capturing the oxidized tritium on molecular sieves. Wastes from this source would consist of 9 to 10 waste molecular sieve canisters per year from the tritium processing system module, replacement of the preheater reactor every 10 years, replacement of gloves on glove boxes every 6 months, and replacement of metal bellows pumps every 10 years. The SSM PEIS estimated this waste stream as 0.98 cubic meters per year of solid LLW. An additional waste stream of palladium catalysts, 0.003 cubic meters per year, which is assumed to be a mixed solid waste, has also been identified. Current estimates would be to replace 32 molecular sieve canisters per year, increasing this waste stream to 3.2 cubic meters per year of solid waste.

Waste from Wipe Cleaning, Chemical Treatment, and Decontamination

The wipe-cleaning waste would result from worker-protection personal protective equipment and the waste wipes and solvents associated with manual wipe cleaning of the NIF materials. The optics assembly building and the laser and target area building would conduct solvent wipe cleaning as part of the general clean-room operations. Usually, the solvent used would be isopropyl alcohol, although ethyl alcohol and acetone could be used at times. Most of the solvent wipe cleaning would be done with an aqueous solution of isopropyl alcohol, with 9-percent alcohol concentration. Used wipes with a concentration less than 24-percent alcohol are not a hazardous waste. In some cases, the wipes could be laundered and recycled. Used, wet wipes from aqueous solutions above 24 percent would be managed as hazardous waste, or mixed waste, as appropriate. Components entering the target chamber would also receive some surface tritium contamination. The decontamination process would transfer small amounts of tritium to the chemical treatment and decontamination waste streams.

The wipe cleaning waste estimates include 3.3 cubic meters per year of solid LLW, 0.3 cubic meters per year of liquid LLW, 1.0 cubic meter per year of solid MLLW, and 1.0 cubic meters per year of hazardous solid waste.

Chemical treatment and decontamination wastes would be created during the cleaning of the first wall panels in the target chamber and the main debris shields and associated hardware. Alternative cleaning methods considered include carbon dioxide snow cleaning, laser cleaning, ultrasonic cleaning, and chemical treatment. The current recommended method is chemical treatment, using an acidic bath for the first wall panels and a caustic bath for the main debris shields. Both of these processes would require rinsing after the chemical treatment. If acid foam is used, it would be followed with an aqueous rinse. In both cases, the chemical treatment and rinsing would generate a liquid LLW or a mixed waste. It is assumed that waste liquid from the chemical baths would be mixed waste, and waste rinsate would be LLW. The cleaning baths would be recirculated and filtered, and the solid filters would be disposed of as mixed solid waste. Waste estimates are 1.3 cubic meters of liquid LLW, 0.3 cubic meter of solid MLLW, 4.9 cubic meters of liquid MLLW, and 1.5 cubic meters of liquid hazardous waste. Most of the acid could be recovered, concentrated, and recycled, thereby reducing the waste stream estimates.

Waste Hardware

The first wall panels, which would provide protection of the target chamber, would require periodic replacement due to wear, damage, and/or chemical contamination. The panels would be replaced every 8 years, resulting in an average estimated waste stream of 1 cubic meter per year of solid LLW waste.

Current design involves a disposable debris-fused silica or glass shield optic concept, which would remotely insert debris shields with a mechanical device somewhat like a compact disc changer. The SSM PEIS did not evaluate this design change. As a result, there would be an increase in the solid LLW as compared to the SSM PEIS. The disposable debris shield optics, which would protect the main debris shields and would be approximately 1-millimeter thick and would be mounted in a plastic frame and held in a cassette holding about 15 debris-shield optics. There would be an ongoing waste stream of solid LLW from the disposable debris shields, estimated at about 59.5 cubic meters per year. Some of the main debris shields would also be disposed of due to damage or other factors, estimated at about 1.9 cubic meters per year.

Other waste hardware associated with the target chamber could be disposed of as solid MLLW because of damage or induced radiation in the material. This waste hardware is estimated to be 0.5 cubic meters per year.

The charge-coupled device cameras used for target chamber diagnostics could be damaged during higher yield experiments and could become a solid LLW stream. There would be as many as 96 cameras used at one time, but they would be small, about 10 cubic centimeters each, and would not increase waste totals significantly.

The total LLW created from these sources would be 63 cubic meters per year, with 0.5 cubic meter per year of MLLW.

High-Efficiency Particulate Air Filters/Pre-filters

There would be two HEPA filters and two pre-filters that would filter radioactive emissions from the target chamber. Approximately 20 additional HEPA filters would filter the air from different areas of the NIF. A change-out schedule of at least once every 10 years would be required by LLNL, unless the HEPA system contains in-line sprinklers (the NIF would not). The LLW waste stream for HEPA filter replacement would be 0.23 cubic meter per year, based on the replacement of the HEPA filters and pre-filters every 10 years. There would be many more HEPA filters in the buildings that would provide clean-room air. These HEPA filters would be contaminated with ambient air contaminants only and would not be a hazardous waste or LLW. The clean-room HEPA filters would not be subject to the change-out schedule discussed above, because their function would not be the protection of persons or the environment.

Waste Oils and Associated Equipment

Vacuum pumps are used to draw a vacuum on the target chamber. An estimate of 0.2 cubic meters per year of mixed liquid oil waste was used in the SSM PEIS for vacuum pump operations. By the time of the 1998 NIF Pollution Prevention Plan (LLNL 1998h), it was believed that oil-free pumps could be used, and that this waste stream could be eliminated. At this time, it is anticipated that vacuum pumps would be used that have oil isolated in the pump transmission casing, so there would be no oil back streaming. The oil must be changed periodically as part of normal maintenance. The oil from the vacuum pumps that are not close to the target chamber could be regulated as hazardous waste. There is still some uncertainty about the volume of waste oil; estimates range from 0.002 to 0.4 cubic meters per year; therefore, the 0.2-cubic-meter value from the SSM PEIS was retained as a reasonable estimate. Waste bearings from the pumps and other spent materials are estimated at 0.06 cubic meters per year of LLW.

M.5.2.13.3.2 *Hazardous Waste*

Waste Oils and Associated Equipment

Oil-filled capacitors would be filled with castor oil. As part of disposal, the castor oil would be drained from the metal frame of the spent capacitor. This waste stream, including the stabilized oil, is estimated to be 7.5 cubic meters per year of hazardous solid. The waste castor oil is usually not a hazardous waste and, under current regulations, could be recycled at an offsite facility. Also, the remaining metal parts of the capacitors could be recycled at an offsite facility to recover the metal content. Therefore, it is possible that this waste stream could be eliminated by recycling. There is some uncertainty, however, whether the oil chemistry could change over time, future regulations could change and affect the management of this waste stream, or the availability of suitable recycling facilities could change. Therefore, a conservative approach was taken for this analysis, and recycling was not assumed.

General Chemicals

Activities in the optics assembly building and laser and target area building would generate some hazardous waste, although there would be pollution prevention techniques in place to eliminate hazardous wastes. The optics assembly building would have two state-of-the-art precision cleaners that would use a nonhazardous aqueous solution for cleaning. The wastewater from these precision cleaners would be sewerable; therefore, this wastewater is included in the sewage wastewater total in Section M.5.2.12. The optics assembly building also would use steam cleaning for general cleaning of surfaces, which also would result in a sewerable discharge.

There would be some metal treating processes, such as passivation of steel, which could result in hazardous acidic or alkaline wastewater.

The mechanical equipment in the optics assembly building and laser and target area building, such as cranes, hoists, and transporters, would require periodic maintenance. The maintenance would generate some petroleum-contaminated wastes, which could be managed as hazardous waste. Maintenance work with paints, coatings, sealants, and adhesives could also contribute to hazardous wastes. This waste stream is estimated at 4.6 cubic meters per year for the optics assembly building and laser and target area building.

M.5.2.14 *Occupational Protection and Human Health*

M.5.2.14.1 *Radiological Exposure*

Personnel would be exposed to two sources of prompt radiation during the NIF yield operations: direct radiation and skyshine radiation. First, personnel located within or very close to the facility would be exposed to some quantity of direct radiation. Direct radiation would consist of both neutrons and gamma rays that would be produced as the neutrons scatter and penetrate through the concrete shield wall and other materials. Second, the neutrons penetrating the facility walls will scatter off of the atmosphere. Personnel throughout the Livermore Site would be exposed to some level of this skyshine radiation. The NIF shielding is designed to reduce the levels of direct and skyshine radiation exposure.

The skyshine dose at an air-ground interface as a function of distance from the center of the cylindrical target bay was calculated using 3-D Monte Carlo analysis. The 1.37-meter-thick concrete target bay roof would limit the skyshine dose at the nearest site boundary, 350 meters due east of the target bay, to less than 0.2 millirem per year for all possible target illumination configurations (Table M.5.2.14.1–1). This was added to the airborne MEI exposure of 0.04 millirems per year to give a total MEI exposure of 0.24 millirems per year.

Personnel within the NIF would also receive a direct dose. Operations personnel, located in the main control room, would receive a direct dose of approximately 5 millirems per year. Those in the diagnostics building would receive about 3 millirems per year, and those in the optics assembly building would receive approximately 1 millirem per year. These direct doses are based upon a 40-hour workweek.

Finally, non-involved workers moving past the target chamber end of the NIF would receive a direct dose of approximately 1 millirem per year, assuming an occupancy of 30 minutes for walkways and roads, as recommended by the National Council on Radiation Protection (NCRP 1993).

The NIF target bay includes about 50 doorways to allow for adequate access of personnel and equipment. To maintain prompt doses at required levels, the entry points would be fitted with steel-enclosed, concrete-shield doors. The doors would range from 0.31 meter to 1.83 meters thick, depending upon their elevation relative to the target chamber and the room to which they lead. Prompt doses immediately outside shield doors in potentially occupied areas would be less than 30 millirems per year.

TABLE M.5.2.14.1–1.—*Radiological Impacts to Public and Workers from Normal Operations (No Action Alternative)*

Receptor	No Action Alternative		SSM PEIS	
	Dose	Latent Cancer Fatality Risk	Dose	Latent Cancer Fatality Risk
Public (site-wide MEI)	0.24 mrem/yr	1.4×10^{-7}	0.1 mrem/yr	6.0×10^{-8}
Population	0.26 person-rem/yr	1.6×10^{-4}	0.2 person-rem/yr	1.2×10^{-4}
Involved workers	<15 person-rem/yr	0 cancers in population (calculated value = 9×10^{-3})	<10 person-rem/yr	0 cancers in population (calculated value = 6×10^{-5})
Noninvolved worker [a]	1 mrem/yr	6×10^{-7}/yr of exposure	0.2 person-rem/yr	1.2×10^{-4}/yr of exposure

Source: LLNL 2003d.

[a] The SSM PEIS presented the dose for the NIF workers and non-NIF workers as a group instead of individuals as analyzed in this appendix. While the number of the NIF workers used in the analysis was not apparent, the SSM PEIS used 330 persons as the employment for the NIF operations. It is unknown how many workers were considered Non-NIF" workers.

MEI = maximally exposed individual; mrem/yr = millirems per year; SSM PEIS = Stockpile Stewardship and Management Programmatic Environmental Impact Statement.

During high-yield operations, tasks that must be performed within the NIF target bay or that involve handling of materials that have been inside the target bay during high-yield experiments would result in some level of radiation dose. Dose rates within the target bay would be dominated by the yield of the most recent experiment. The residual radiation intensity within the NIF target bay at any particular location would depend upon local and general activation in the room as well as the history of yield experiments. The highest intensity would be inside the 10-centimeter-thick, 5-meter-radius, aluminum-alloy target chamber. At early times following a yield experiment, magnesium-27 (half-life = 9.5 minutes) and manganese-56 (2.6 hours) would dominate the residual dose rate. At times of 6 hours to 10 days after yield experiments, sodium-24 (15 hours) would dominate. After decay times of more than 10 days, manganese-54 (312 days), cobalt-60 (5.3 years), and zinc-65 (244 days) would dominate. Occupational doses would be monitored, and maintenance activities and procedures would be organized to minimize occupational doses. Cost-benefit analyses would be performed and auxiliary shielding would be used to ensure that worker doses are kept as low as reasonably achievable.

In addition, a worker dose would be incurred during routine decontamination activities. This would include handling of contaminated/activated items, disassembling them (if needed), and processing them through the decontamination systems.

NIF annual worker exposure goals would include:

- Less than 500 millirems per year individual worker dose
- Less than 15 person-rems per year cumulative worker dose

Physical features, such as confinement, ventilation, tritium processing system, shielding, and an elevated release point would be used as supplemental methods to control radiation exposure. A *Measurement and Retrofit Plan* has been written to identify key locations in which prompt and residual doses would be measured and facility additions and/or modifications that could be made if measurements suggest that radiation protection calculations underestimated those doses (LLNL/NIF 1997b). An *Auxiliary Shielding Plan* has been written to identify potential uses for

temporary neutron and gamma-ray shielding (LLNL/NIF 1997a). Such shielding could prove beneficial in reducing worker doses to as low as reasonably achievable (ALARA) levels.

The dose at the site boundary would be dominated by neutron skyshine; direct dose would be small by comparison. Such doses are not covered by NESHAP, but are limited by DOE O 5400.5, "Radiation Protection of the Public and the Environment." This order limits doses caused by all pathways of release of radiation or radioactive material to 100 millirems per year effective dose equivalent for prolonged exposure and 500 millirems per year effective dose equivalent for occasional exposure (DOE 1993a).

The NIF MEI dose from airborne effluent releases would be 0.04 millirem per year (Section M.5.2.8.4). When added to the 0.2-millirem-per-year dose from the skyshine, the total MEI dose from the NIF operations under the No Action Alternative would be 0.24 millirem per year. This dose is less than 0.3 percent of the DOE standard and would result in an increase in annual latent cancer fatality risk of 1.2×10^{-7}. The skyshine would not result in any increase in the overall population dose because the exposure to the skyshine would be limited to close proximity to LLNL boundary next to the NIF.

M.5.2.14.2 *Nonradiological Exposure*

Potential nonradiological impacts to human health and safety posed by the NIF operations under the No Action Alternative would include chemical exposure pathways and risks of occupational injuries, illnesses, and fatalities resulting from normal (accident-free) operations, and potential laser exposure. Involved and uninvolved workers could be affected.

Operations at the NIF would involve a range of activities that would pose the potential for exposures of hazardous materials or conditions to the NIF workers and other LLNL workers. These hazards would include chemical and industrial hazards. Evaluation of occupational protection issues considers existing LLNL programs that specifically address worker and general population protection measures implemented to control, reduce, or eliminate operational hazards. Appendix C of LLNL SW/SPEIS presents a detailed description of LLNL Environment, Safety, and Health (ES&H) programs implemented to monitor and ensure that all sectors of the local environment are protected.

It is the policy of NNSA and LLNL to operate the Laboratory in a manner that protects the health and safety of employees and the public, preserves the quality of the environment, and prevents property damage. ES&H is to be a priority consideration in the planning and execution of all work activities at LLNL. It is also the policy of LLNL to comply with applicable ES&H laws, regulations, and requirements; and with directives promulgated by DOE regarding occupational safety and health, as adopted in LLNL Work Smart Standards set. ES&H functional organizations provide assistance and direction in implementing worker, environmental, and public safety programs to assure that all regulatory requirements are met.

Some nonradiological hazardous materials would be present at the NIF. Occasional nonroutine air emissions of these types of materials would be expected from operation of electrical equipment, wipe cleaning, and occasional use or maintenance/testing of the standby generators.

The potential exists for personnel exposures to beryllium resulting from the NIF operations. Beryllium containing targets would contribute to airborne and surface contamination. This contamination would be contained within the NIF target chamber. Personnel exposures to these contaminants would be controlled through the implementation of ES&H requirements,

specifically Document 14.4, *Implementation of the Chronic Beryllium Disease Prevention Program Requirements* (LLNL 2001ad). Personnel monitoring and area decontamination practices would be employed to reduce the contamination source term and to minimize hazards to facility workers.

The use of the chemicals under the No Action Alternative (see Section M.5.2.13.2) would not necessarily result in additional worker exposures. Continued application of site ES&H and Integrated Safety Management System principles would result in minimal impacts to worker and the public. Thus no adverse impacts from this action would be expected.

M.5.2.14.3 *Physical Hazards*

The NIF would use a powerful laser. Powerful lasers are hazardous to the eyes and skin, whether exposure is to the direct beam of the laser or reflections. At the NIF, laser safety would be particularly important. Laser safety officers would ensure that lasers are operated according to LLNL safety procedures, which are based on integrated safety management techniques. These management techniques would include controlling access to the laser operational area and requiring use of safety interlocks, warning systems and signs, remote operation, and eye protection.

Physical hazards, such as noise, electrical shock, and workplace injuries/illnesses, would exist under the No Action Alternative, but workplace injury/illness statistics show a decreasing trend over the past 10 years.

M.5.3 Proposed Action

The Proposed Action would involve the proposed use of plutonium; other fissile materials, materials that fission when irradiated by slow or thermal neutrons such as small quantities of special nuclear material, uranium-235; fissionable materials, materials that can be induced to fission by fast neutrons such as uranium-238 (depleted uranium) or thorium-232; and lithium hydride/deuteride in experiments on the NIF. The specific fissile/fissionable materials, beyond depleted uranium, considered for the Proposed Action would be weapons-grade plutonium, highly enriched uranium, and thorium-232. Yield experiments and non-yield experiments with highly enriched uranium, thorium-232, small quantities of specially prepared plutonium, and other fissionable materials would be performed at the NIF target chamber without additional containment. Most special nuclear material experiments would be performed using an additional sealed inner containment vessel to protect the target chamber.

It is estimated that there would be a maximum of four yield experiments with an inner containment vessel per year, at maximum fusion yields up to 45 megajoules, and 10 nonyield experiments with an inner containment vessel with plutonium per year. Other highly radioactive actinides, whose use is not currently envisioned, would also require the use of the inner containment vessel. If used, the inventories of these materials would be limited such that their environmental impact (offsite accidents, worker exposure, etc.) would not exceed the bounds defined in this document. Other materials that would also be used under the Proposed Action at the NIF would be increased quantities of depleted uranium, beryllium, and lithium hydride/deuteride.

In addition, the Proposed Action would include the construction and operation of a neutron spectrometer. Construction and operation of a neutron spectrometer is proposed to more accurately measure neutron yield and diagnose ignition target physics.

M.5.3.1 *Land Use and Applicable Plans*

The generalized land use at LLNL and vicinity is zoned for industrial park use. The industrial land use for the NIF would be the same as outlined under the No Action Alternative. The NIF land use would be compatible with LLNL land use. The construction of the neutron spectrometer would be consistent with the NIF land use. The Proposed Action would not result in any change to the land use for the immediate area of the NIF or land use in the overall vicinity. No impacts to land use would be expected under the Proposed Action.

M.5.3.2 *Socioeconomic Characteristics and Environmental Justice*

M.5.3.2.1 *Socioeconomics*

The Proposed Action would include the potential addition of a neutron spectrometer. The construction of the neutron spectrometer would result in the temporary employment of 20 workers.

Under the Proposed Action, the NIF would be operated as evaluated in the No Action Alternative plus the operations associated with experiments containing additional materials. Current projections for the Proposed Action are that 186 employees would be needed for direct operations along with 240 support personnel. Together, 426 long-term workers would be employed at the NIF and its support operations. This is an increase of 26 new hires over the employment level under the No Action Alternative. Most of these workers are already employed at LLNL, either working on making the NIF operational or at other LLNL facilities. Any new hires would fall within the 5- to 8-percent annual turnover at LLNL. Therefore, no impacts to local housing, schools, or medical services would be anticipated.

M.5.3.2.2 *Environmental Justice*

The impacts associated with the operation of the NIF with potential for disproportionate effects would be radioactive air emissions. These impacts would be negligible beyond a 5-mile radius (see Section M.5.3.8). Therefore, there would be no disproportionately high and adverse impacts to minority or low-income populations under the Proposed Action.

M.5.3.3 *Community Services*

The existing LLNL fire protection and emergency services, police protection, and security services would not change under the Proposed Action. The level of services provided currently and during the construction of the NIF would not change. Because there would be no substantial change in the workforce, there would be no changes in the socioeconomic impacts and no associated change in school services.

The NIF is generating and would continue to generate waste office paper, cardboard, plastic, sanitary wastes, and other nonhazardous refuse at a rate similar to LLNL as a whole. There would be nothing unique about the refuse generation from the NIF, in terms of waste types or amounts; therefore, this type of waste is projected on a per capita basis. As a conservative estimate, it is assumed that each worker would generate one cubic meter of nonhazardous solid waste. With a projected total of 426 long-term workers at the NIF and its support operations, the projected amount of nonhazardous solid waste would be 426 cubic meters per year. This would be an increase of 26 cubic meters, or 6.5 percent, over the amount of nonhazardous solid waste generated under the No Action Alternative. Because 380 long-term personnel are already

employed at NIF, it would take 46 new personnel to meet the projected employment level under the Proposed Action. These new hires would represent an associated increase of 46 cubic meters of nonhazardous solid waste over the amount of waste that is already part of the overall LLNL waste figures. This amount represents a 1 percent increase in the site's current generation of nonhazardous waste; therefore, no impacts would be expected to the capacity to handle nonhazardous solid waste under the Proposed Action.

M.5.3.4 *Prehistoric and Historic Cultural Resources*

No prehistoric archaeological resources have been identified on or near the NIF site. No buildings and facilities at LLNL that may have potential to be eligible to the National Register of Historic Places are located near the NIF. Because much of the NIF site has been developed, the likelihood of finding unrecorded and undisturbed prehistoric sites is low. There is the possibility that undisturbed sites lay buried under the modern landscape. Under the Proposed Action, the potential construction of the neutron spectrometer would involve excavation. A small potential exists for sites to be encountered during excavation and other site activities. Should any buried materials be encountered, LLNL would evaluate the materials and proceed with recovery in accordance with cultural requirements and agreements. Operation of the NIF, as described in the Proposed Action, would not impact any prehistoric or historic cultural resources.

M.5.3.5 *Aesthetics and Scenic Resources*

The NIF conventional facility construction is now complete. All conventional facilities are constructed and turned over for equipment installation. No further changes to the visual features would occur in the area of the NIF. The only potential new construction, the neutron spectrometer, would be entirely underground with an outside stairwell for access. There would be no impacts to aesthetic and scenic resources under the Proposed Action.

M.5.3.6 *Geologic Resources*

The Proposed Action includes the potential addition of a neutron spectrometer. The construction of the neutron spectrometer would result in excavation within a 3,400-square-foot area to a maximum depth of 52 feet (up to 176,000 cubic feet in volume). The area to be excavated would be adjacent to the southwest side of the NIF. Because this area has been disturbed during the construction of the NIF, no further impacts to soils would result under the Proposed Action. Aggregate and other geologic resources, such as sand, would be required to support the construction of the neutron spectrometer, but these resources are abundant in Alameda County.

The potential exists for fossils, contaminated soils, and other media to be encountered during excavation. During construction of the NIF, mammoth bones, including a jawbone, partial skull, tusks, and some vertebrae, were found. The area was surveyed at the time and no sign of additional fossils was noted. LLNL would sample the area to be excavated before any digging. Should any buried materials be encountered, LLNL would evaluate the materials and proceed with recovery in accordance with appropriate requirements and agreements.

M.5.3.7 *Ecology*

The Proposed Action includes the potential addition of a neutron spectrometer. The construction of the neutron spectrometer would result in the disturbance of an area of 3,400 square feet. The area to be excavated would be adjacent to the southwest side of the NIF. Because this area has been disturbed during the construction of the NIF and excavation would occur within the existing stormwater control area, no further impacts to biological resources would result from the

construction associated with the Proposed Action. No impacts would occur to the nearby wetland area. Few impacts would occur to biological resources during operation of the NIF. The traffic to and from the NIF would have associated animal road kill occurrences. No adverse impacts to threatened and endangered species or species of special concern would be expected from operation of the NIF.

M.5.3.8 *Air Quality*

During normal operations, some experiments at the NIF would result in atmospheric releases of small quantities of tritium, some radionuclides produced by activation of gases in the target bay air, and, in the case of the Proposed Action, small quantities of fission product gases.

Some nonradiological hazardous materials would be present at the NIF. Routine emissions of these types of materials would be expected from operation of electrical equipment, wipe cleaning, and occasional use or maintenance testing of the standby generators. The projected air pollutant emission rates associated with increased fuel combustion in boilers and engines, and the increased vehicular activity associated with increased workforce at LLNL under the LLNL SW/SPEIS No Action Alternative, which would include the NIF, are provided in Table 5.2.8.1–3 of the main LLNL SW/SPEIS text. The total emissions would be a small fraction of project significance levels and threshold levels for conformity.

M.5.3.8.1 *Criteria Air Pollutants*

The emission of criteria air pollutants that would result from normal operations of the NIF under the Proposed Action are equivalent to those that would be expected from normal operations under the No Action Alternative. The criteria air pollutants emissions would occur primarily from solvent cleaning and fuel combustion. These activities would be the same under the Proposed Action as under the No Action Alternative.

M.5.3.8.2 *Hazardous Air Pollutants*

LLNL evaluates a list of approximately 200 compounds to confirm applicability under the NESHAP. Emissions of hazardous air pollutants for all of LLNL would be less than one-half of the threshold of 7 tons per year for a single hazardous air pollutant or 15 tons per year for a combination of hazardous air pollutants (LLNL 2002ae). The normal operations of the NIF under the Proposed Action would not result in the emission of hazardous air pollutants, except for possible beryllium emissions at very low levels.

M.5.3.8.3 *Toxic Air Emissions*

Under the Proposed Action, the toxic air emissions at the NIF would not increase substantially above that associated with the No Action Alternative. An additional 18.4 grams of beryllium would be used; however, extremely small emissions would be expected well below the toxic air contaminant threshold.

No increase in impacts from LLNL hazardous air pollutants would occur under the Proposed Action. There would be an increase in the very small emissions of beryllium. This small increase would have negligible impacts. The increase in the emission of VOCs would be bounded at 15 percent. The impacts of the increase would be minor.

M.5.3.8.4 *Radiological Air Quality*

Under the Proposed Action, releases of activated target bay gas would be the same as presented for the No Action Alternative in Section M.5.3.8.4. The air in the target bay and the yield of the experiments would be the same as under the No Action Alternative.

Under the Proposed Action, fission products would be created during nonplutonium experiments with yield involving fissile or fissionable materials, and some would be routinely released to the environment as part of normal operations. For yield experiments with plutonium, fission products would be contained within the inner containment vessel. Some longer-lived gases would remain when the vessel is opened to retrieve debris for analysis. These, along with remaining semivolatile fission products, once scrubbed through the radioactive confinement system, would be released to the environment from the Tritium Facility. There would be a maximum of four yield experiments with plutonium per year, at fusion yields up to 45 megajoules.[7]

The fission product inventories created in the target chamber from plutonium experiment neutron activation would be bounded by the highly enriched uranium fission products routinely released and listed in Table M.5.3.8.4–1. Many of these fission products are short-lived, and would decay while being held on the cryopumps or in the accumulation tank. Some long-lived gaseous fission products, such as krypton-85 (10.7-year half-life), would likely be released to the environment. Other semivolatile fission products; e.g., iodine isotopes, would be captured on charcoal filters, which would be at least 99 percent efficient, thus minimizing any release of these radionuclides to the environment. For the purpose of this analysis, a conservative efficiency of 95 percent has been assumed for the filters. Therefore, 5 percent of the mobilizable iodine isotopes could be released.

Table M.5.3.8.4–1 lists the maximum annual quantities of fission products expected to be produced and released under the Proposed Action. These emissions would be in addition to the releases of activated target bay gases listed under the No Action Alternative. The quantities represent the inventories that would result from a 1,200-megajoule annual yield and that would be uniformly released to the environment over one year. Possible sources of these additional fission product emissions are provided: highly enriched uranium, depleted uranium, and thorium-232, with highly enriched uranium as the limiting case for comparable masses.

Table M.5.3.8.4–2 presents the potential impacts of radiation exposures from normal operations to the public. The doses to involved workers would be due, primarily, to radiation exposure from activated structures and components (see Section M.5.3.14.1). The impacts under the No Action Alternative are presented for comparison.

[7] There would also be up to 10 nonyield experiments per year, but these would not contribute to any additional routine radioactive airborne emissions.

TABLE M.5.3.8.4–1.—*Annual Routine Radioactive Airborne Emissions under the Proposed Action (Fission Products)*

Nuclide	Annual Amount Available for Release (Ci/1,200 MJ)[b]	Annual Air Effluents Via Charcoal Filter[a] (Ci/1,200 MJ)
Krypton-83m	1.1×10^{-13}	1.1×10^{-13}
Krypton-85	3.5×10^{-4}	3.5×10^{-4}
Krypton-85m	2.9×10^{-7}	2.9×10^{-7}
Krypton-87	0	0
Krypton-88	2.3×10^{-11}	2.3×10^{-11}
Krypton-89	0	0
Iodine-131	1.9	9.3×10^{-1}
Iodine-132	3.9	1.9×10^{-1}
Iodine-132m	0	0
Iodine-133	1.1	5.6×10^{-2}
Iodine-133m	0	0
Iodine-134	0	0
Iodine-134m	0	0
Iodine-135	6.1×10^{-4}	2.8×10^{-5}
Iodine-136	0	0
Xenon-131	6.1×10^{-3}	6.1×10^{-3}
Xenon-133	5.9	5.9
Xenon-133m	2.1×10^{-1}	2.1×10^{-1}
Xenon-134m	0	0
Xenon-135	4.5×10^{-2}	4.5×10^{-2}
Xenon-135m	9.0×10^{-5}	9.0×10^{-5}
Xenon-137	0	0
Total	1.3×10^{1}	6.5

Source: LLNL 2003d.
[a] The effluents from the cryopumps during regeneration and from the target chamber when bringing to air would be passed through 2-inch-thick charcoal filters to remove iodines, with 99 percent being collected by charcoal bed. Here, only 95 percent is assumed removed for conservatism.
[b] 1.2 gram uranium-235/target: 2×10^{16} Fissions per 1,200-MJ experiment, 60 experiments per year.
Ci = curies; MJ=megajoules.

TABLE M.5.3.8.4–2.—*Radiological Impacts to the General Public from Airborne Effluent Emissions during Normal Operations (Proposed Action)*

Receptor	Proposed Action		No Action Alternative	
	Dose	Latent Cancer Fatality Risk	Dose	Latent Cancer Fatality Risk
NIF Offsite MEI	0.07 mrem/yr	4.2×10^{-8} /yr of exposure	0.04 mrem/yr	2.4×10^{-8} /yr of exposure
Population Dose	0.29 person-rem/yr	1.7×10^{-4}	0.26 person-rem/yr	1.6×10^{-4}

Source: LLNL 2003d.
MEI = maximally exposed individual; mrem = millirems; yr = year; NIF = National Ignition Facility.

The baseline dose to the MEI from Livermore Site operations (site-wide MEI) without the NIF operations would be 0.017 millirem per year with an associated population dose of 0.16 person-rem per year (SNL 2000). Due to proposed increases in Building 331 tritium releases, the LLNL SW/SPEIS Proposed Action dose to the site-wide MEI without the NIF operations would be 0.058 millirem per year. The location of the site-wide MEI would correspond with the NIF MEI location. Conservatively adding the site-wide MEI Proposed Action dose (0.058 millirem per year) to the NIF MEI dose for airborne effluent emissions (0.068 millirem per year) results in an estimated dose of 0.126 millirem per year for airborne effluent emissions under the NIF Proposed Action. This dose would be less than 2 percent of the NESHAP limit. The component of population dose from routine of the NIF releases would be 0.29 person-rem per year. Adding this dose to LLNL SW/SPEIS Proposed Action population dose of 1.55 person-rem per year would result in a dose of 1.84 person-rem per year. This population dose would be many orders of magnitude less than the dose received from natural background. No adverse impacts on radiological air quality are expected from the Proposed Action.

M.5.3.9 *Water*

The NIF conventional facility construction is now complete. The Proposed Action includes the potential addition of a neutron spectrometer. The construction of the neutron spectrometer would result in excavation to a depth of 52 feet. This depth is close to the level the water table reaches in rainy seasons. Best management practices would be implemented to control stormwater and sediment runoff during construction. Potential impacts to water resources would be similar to those described in Section 5.3.9 of this LLNL SW/SPEIS.

The neutron spectrometer is a detection device that does not impart any radioactivity of its own to the soils or groundwater. The neutron spectrometer could use 1 cubic meter of a plastic scintillator material in a concrete shaft, with a geomembrane underneath to prevent any contamination of the groundwater during operation.

Under the Proposed Action, water usage at the NIF would be the same as under the No Action Alternative, currently expected to be 27.6 million liters per year or approximately a 3.5 percent increase in LLNL usage of 795 million liters per year in 2001. Because no expansion of capacity would be required, there would be no impacts associated with expansion of capacity. The impacts of the increase in water use would be negligible in nondrought years. During drought years, the impacts of this increase in water use at LLNL would be of concern.

M.5.3.10 *Noise*

There would be minor temporary construction noise associated with the construction of the neutron spectrometer.

The noise level under the Proposed Action would be the same as for the No Action Alternative, similar to an industrial facility (approximately 85 decibels). The noise at the NIF would be equal to other local industrial/commercial activities. The contribution of these activities to offsite noise levels offsite is small. The impulse noise resulting from the NIF experiments would primarily come from the triggering of the capacitors. The noise would be heard outside the NIF building for a short distance only. This noise is would be momentary and intermittent, occurring only at the time of an experiment, up to 6 times per day. No offsite noise would result from the experiments. The impacts of noise to workers would be normal for industrial facilities. With

standard hearing protection, no impacts from noise would be expected. No impacts would be expected from noise to the public.

M.5.3.11 *Traffic and Transportation*

Traffic

The construction of the NIF conventional facilities is completed. As a result, the traffic associated with the construction workers has ceased. The pre-operational and operational workforces are already employed onsite. The construction of the neutron spectrometer would result in the temporary employment of 20 workers and some temporary material transportation. Any new employees for operation of the NIF under the Proposed Action would fall within the 5- to 8-percent annual turnover at LLNL. Therefore, there would be no substantial change in the amount of traffic that currently exists.

Radiological Transportation

Routine onsite transportation of targets would have no impact to the public, as access to LLNL is restricted. The onsite transportation would fall within the scope of operational activities already analyzed for the site and the NIF in particular.

Under the Proposed Action, radioactive materials would be transported to LLNL from Los Alamos National Laboratory for NIF targets. These materials would include 10 shipments per year, each with 6 grams of plutonium; 10 shipments per year, each with 3 grams of highly enriched uranium; 10 shipments per year, each with 5 grams of depleted uranium; and 15 shipments per year, each with 100 curies of tritium.

For incident-free, i.e., no accidents, transport; of plutonium, highly enriched uranium, and depleted uranium, the consequences would be the radiation dose potentially received by the truck drivers and members of the public driving on the highways, living near the highways, and present at rest stops. Because of the very small amounts of radioactive material being transported and the shielding of the containers and vehicle, the radiation dose rate near the truck would be immeasurably small. Therefore, there would be no incident-free radiation dose to drivers or members of the public.

Tritium does not produce an external dose rate. Therefore, transport of tritium would also have no incident-free radiological impacts. Section M.5.6 presents the consequences of transportation accidents, which includes tritium transport accidents.

Transportation of Plutonium Targets and Inner Containment Chamber

An inner containment vessel for experiments with plutonium would be loaded and brought from the Superblock and transported to the NIF as a sealed and assembled unit. The vessel would be transported in a shipping container. Once the test is complete, the inner chamber would be removed, placed in a shipping container and returned to the Superblock for post-test examination and processing. The inner chamber, having been used in a single test, would then be dismantled, if appropriate; placed in a shipping container; and transported to the Nevada Test Site for disposal as LLW.

M.5.3.12 *Utilities and Energy*

The utility usage at the NIF would be dominated by the operations of the facility at clean-room conditions. Changes in the number and type of experiments would not change the overall utility usage. Under the Proposed Action, the utility usage would be the same as that discussed under the No Action Alternative.

M.5.3.13 *Materials and Waste Management*

NIF research activities would use a variety of hazardous (radioactive and toxic) and nonhazardous materials. No explosive materials would be used at the NIF. All of these would become part of material management for the NIF. The primary strategy for the control and management of hazardous materials at the NIF would be to minimize exposures to hazardous substances in accordance with regulatory requirements, institutional goals, and best management practices. Once the materials have been used, they would be classified and managed under the NIF's and LLNL's waste management procedures. Waste management is discussed in Section M.5.3.13.3. During the use and management of these materials, air emissions would occur. Emissions were discussed in Section M.5.3.8.

Particulates would be generated in the target chamber from each experiment. The management of the radioactive particulates and tritium is discussed in Section M.5.3.13.1. Nonradiological materials are discussed in Section M.5.3.13.2.

M.5.3.13.1 *Radionuclide Materials Management*

The materials contained in targets and the activation of materials in the target bay described under the No Action Alternative would be the same under the Proposed Action. Yield experiments would emit neutrons, energetic particles, debris, and x-rays. Some neutrons would activate the target chamber and target bay air. Under the Proposed Action, there would be the additional use of plutonium, other fissile materials, fissionable materials, and lithium hydride/deuteride in experiments. Most of the unburned tritium would be exhausted to the tritium processing system, while a small amount would be adsorbed onto the target chamber wall and other items contained in the target chamber.

The particulates would be generated in the same manner as described under the No Action Alternative. The particulates created in the target chamber under the Proposed Action, in addition to the No Action Alternative quantities, would include increased amounts of beryllium and depleted uranium as well as lithium hydride/deuteride, plutonium, highly enriched uranium, thorium-232, and other materials used as tracers. Table M.5.3.13.1–1 lists the upper bounds on the amount of materials that would be expected in the target chamber under the Proposed Action. The in-chamber inventories provided in Table M.5.3.13.1–1 are conservative estimates of the amount of material that would be present as particulates at the end of one year.

Particulates created in the target chamber would see neutrons from yield experiments and be subject to neutron activation. Fissile and fissionable isotopes would also be subject to fission. Table M.5.3.13.1–2 lists the prominent nuclides expected to result from neutron exposure of target materials in the target chamber. This includes the gas that could be contained in targets or created during nonplutonium fissile material experiments with yield, such as krypton, xenon, deuterium, and tritium. The gas would be removed through the high-vacuum cryopumps.

As noted earlier, for experiments, radioactive particulates created in the target chamber would be transferred to the decontamination systems and waste streams. However, because many are

short-lived species, the maximum inventories associated with particulates would be found in the target chamber shortly after the last experiment and well before cleanup. By the time cleaning occurs or components are removed, the radioactive particulate inventory would have decayed to much smaller quantities. The inventories in Table M.5.3.13.1–2 would be maximum radionuclide inventories under the Proposed Action. This would include the production of activated species and fission products from yield experiments. Experiments correspond to a final 45-megajoule-yield experiment, ending one year of experiments with 1,200- megajoules total yield.

For most plutonium experiments, an inner containment vessel would be used. The inventory from each yield experiment with plutonium would remain inside its inner containment vessel. Consequently, the inventory for the yield experiment case would not contribute to the inventory that builds up in the target chamber. Each inner containment vessel would only be used for a single experiment. These inventories would include 3 grams of weapons-grade plutonium for the nonyield experiments. For yield experiments, the inventory would include 1 gram of plutonium, associated fission products, and activated particulates resulting from a single 45-megajoule experiment. After retrieving any debris for analysis from inside the inner containment vessel (performed in the Tritium Facility), the inner containment vessel and remaining contents would enter the waste stream.

The inventories presented in Table M.5.3.13.1–2 represent the maximum inventories for each type of experiment: depleted uranium plus fission products, highly enriched uranium plus fission products, thorium-232 plus fission products, weapons-grade plutonium (3 grams), weapons-grade plutonium (1 gram) plus fission products, or tracer activation products, calculated as if each type was present during a last 45-megajoule experiment just before the annual cleanup. While each experiment could not be the last experiment, the inventories from the other experiments would have more time to decay. However, because there is no way to predict which type of experiment would be the last, the maximum inventory of each type is used to set the radiological bound.

TABLE M.5.3.13.1–2.—*Estimated Maximum Mobilizable Radionuclide Inventories (Proposed Action) (continued)*

Isotope	Quantity (Ci)

Source: LLNL 2003d.

[a] Depleted uranium is already slightly radioactive; the half-life of uranium-238 (dominant isotope) is 4.5×10^9 yrs. The assumed composition would be 99.64% uranium-238, 0.36% uranium-235, and 0.0028% uranium-234. The quantities listed correspond to the maximum quantity that would be used under the Proposed Action of 100 g. Fission products would result from a single target (maximum of 2.2 g) subject to 45-MJ fusion yield (4.6×10^{16} fissions) and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories provided would be peak post-experiment inventories.

[b] HEU is already slightly radioactive; the half-life of uranium-235 (dominant isotope) is 7.0×10^8 yrs). The assumed composition would be 93.5 wt% uranium-235, 5.4 % uranium-238, and 1.1 % uranium-234. The quantity listed corresponds to the maximum quantity that would be used under the Proposed Action of 100 g. Fission products would result from a single target (maximum of 1.2 g) subject to a 45MJ fusion yield (4.6×10^{16} fissions) and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories provided would be peak post-experiment inventories.

[c] Thorium-232 is already slightly radioactive, with a half-life of 1.4×10^{10} yrs). The quantity listed corresponds to the maximum quantity that would be used under the Proposed Action of 450 g. Fission products would result from a single target (maximum of 7.9 g) subject to a 45-MJ fusion yield (5.3×10^{16} fissions) and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories provided would be peak post-experiment inventories.

[d] The assumed composition of weapons-grade material would be 0.02% plutonium-238, 93.85% plutonium-239, 5.8% plutonium-240, 0.3% plutonium-241, 0.015% americium-241, and 0.02% plutonium-242. Other isotopic mixes could be used as long as their impacts are within the bounds described here. The fission products would result from a single target (maximum of 1 g) subject to a 45-MJ fusion yield (3.2×10^{16} fissions). Because only a single experiment would occur within an inner containment vessel, only the fission products resulting from this single experiment would be included. The fission product inventories would be peak post-experiment inventories.

[e] Bounds the use of small quantities of specially prepared plutonium.

Ci = curies; g = grams; MJ = megajoules; wt% = percent by weight.

Plutonium Experiment Containment Vessel

For most tests with plutonium[8], an inner containment vessel, presently assumed to be fabricated from stainless steel, would be used to prevent the weapons-grade plutonium[9] and associated fission products from being deposited on the main NIF target chamber, first wall, target positioner, or diagnostics. This inner containment vessel would be brought from the Tritium Facility as a sealed and assembled unit. The vessel would be placed into the target chamber through the large port at the waist of the target chamber or through the bottom of the NIF target chamber. The inner containment vessel would be positioned so that the target would be placed at the target chamber center and the experiment performed using all or a subset of the laser beams. Once the experiment is complete, the inner containment vessel would be returned to the Tritium Facility for post-experiment examination and processing.

Depleted Uranium

Depleted uranium would arrive at the facility in individual targets, each with up to 2.2 grams of depleted uranium. The maximum annual depleted uranium throughput at the NIF under the Proposed Action would be limited to 100 grams. Depleted uranium is slightly radioactive; the half-life of uranium-238 [(dominant isotope]) is 4.5×10^9 years). Depleted uranium is also considered to have toxic properties.

[8] If other fissile materials were required for NIF experiments, the inventories of these materials would be limited such that their environmental impact (offsite accidents, worker exposure, etc.) would not exceed the bounds defined in this document.

[9] The assumed composition of weapons-grade material would be 0.02% plutonium-238, 93.85% plutonium-239, 5.8% plutonium-240, 0.3% plutonium-241, 0.015% americium-241, and 0.02% plutonium-242. Other isotopic mixes could be used as long as their impacts are within the bounds described here.

Tritium

Under the Proposed Action, tritium would be handled and used in the same manner as under the No Action Alternative.

Fission Products

Fission products would be created during yield experiments involving fissile or fissionable materials. The fission product inventories would be bounded by the highly enriched uranium fission products that would be routinely released, which are listed in Table M.5.3.8.4–1. For yield experiments with plutonium, fission products would be contained within the inner containment vessel. Some longer-lived gases would remain when the vessel is opened to retrieve debris for analysis. Once scrubbed through the radioactive confinement system, these gases, along with remaining semi volatile fission products, would be released from the Tritium Facility to the environment.

M.5.3.13.2 *Nonradiological Materials Management*

The management of nonradiological materials would be essentially the same as for the No Action Alternative. Waste is discussed in Section M.5.3.13.3.

Nonradiological Particulates

The nonradiological particulates that would be generated under the Proposed Action, in addition to those generated under the No Action Alternative (Table M.5.3.13.2–1), would include increased amounts of beryllium, depleted uranium, and lithium hydride. Table M.5.3.13.2–1 provides a summary of the nonradiological particulate inventories estimated under the Proposed Action.

TABLE M.5.3.13.2–1.—*Bounding Annual Nonradiological Particulate Inventories in the Target Chamber (Proposed Action)*

Material	Maximum Inventory (grams)
Beryllium	20
Lithium hydride/deuteride	125
Uranium	100

Source: LLNL 2003d.

The in-chamber inventories provided in Table M.5.3.13.2–1 are conservative estimates; i.e., over-estimates, of the amount of material that would be present as particulates at the end of one year. Target chamber cleaning more than once a year would reduce the inventory.

The use of volatile organic solvents, cleaning agents, mercury in power conditioning units and preamplifier modules, cleaners, oils, and miscellaneous other materials would be the same as under the No Action Alternative.

Chemical Use in Neutron Spectrometer

The main material used in the neutron spectrometer would be 43,000 pounds of lead used as the fixed shielding in the underground chamber. Sheets of polyvinyl toluene would be used as scintillation sources. A total volume of 1 cubic meter of polyvinyl toluene would be used.

Table M.5.3.13.2–2 provides a summary of the nonradiological materials that would be used in the neutron spectrometer.

TABLE M.5.3.13.2–2.—*Estimated Important Chemical Inventories for the Neutron Spectrometer*

Chemical	Source	Quantity	Exposure Criteria[a]
Lead	Shielding for neutron spectrometer	43,000 lbs	150 mg/m^3
Polyvinyl toluene	Scintillation material	1 m^3, 4,000 lbs	Not determined

Source: LLNL 2003d.
lbs = pounds; m^3 = cubic meters; mg/m^3 = milligrams per cubic meter.

M.5.3.13.3 *Waste Management*

The wastes from the NIF operations under the Proposed Action (Table M.5.3.13.3–1) would be substantially the same as those described under the No Action Alternative. Many of the waste streams, such as wastes from tritium processing and mixed waste, would be unchanged for the Proposed Action, as they would not be directly related to the proposed changes in materials used for experiments. The use of the inner containment vessel would involve the generation of additional LLW, primarily from the spent vessels.

TABLE M.5.3.13.3–1.—*National Ignition Facility Waste Estimates for Low-Level, Mixed, and Hazardous Wastes (Annual) under the Proposed Action*

Source of Waste	Low-Level Radioactive		Mixed		Hazardous	
	Solid (m^3)	Liquid (m^3)	Solid (m^3)	Liquid (m^3)	Solid (m^3)	Liquid (m^3)
Tritium processing	3.2	–	0.003	–	–	–
Wipe cleaning	3.3	0.3	1.0		1.0	–
HEPA filters/pre-filters	0.27	–	–	–	–	–
Waste hardware	63	–	0.5	–	–	–
Chemical treatment/decontamination	–	1.3	0.3	4.9		1.5
Waste oils/equipment	0.06	–	–	0.2	7.5	0.2
General chemicals	–	–	–	–	–	4.6
Inner containment vessel	120					
Total/year	190	1.6	1.8	5.1	8.5	6.3
No Action Alternative Total/year	70	1.6	1.8	5.1	8.5	6.3

Source: LLNL 2003d.
HEPA = high efficiency particulate air; m^3 = cubic meters.

M.5.3.13.3.1 *Radioactive and Mixed Waste*

High-Efficiency Particulate Air Filters/Pre-filters

Because fission products could be produced from some yield experiments, it is expected that there would be a small increase (0.04 cubic meters) in LLW related to filters processing the target chamber exhaust. Charcoal filters would be used to capture iodine isotopes, and these would need periodic, although infrequent, replacement. Other waste streams, such as target chamber hardware or decontamination wastes, would not be expected to change since the same cleaning frequency as the No Action Alternative would seem appropriate.

Plutonium Experiment Containment Vessel

For plutonium experiments, disposal of the inner containment vessel would increase the low-level radioactive waste stream. Because the inner containment vessel, in most or all cases, would leave LLNL site after post-experiment processing in the Tritium Facility, this source of waste would appear in the Tritium Facility waste stream. Each inner containment vessel would occupy approximately 8.5 cubic meters of space, including void volume. The solid LLW stream quantity for 10 nonyield and 4 yield experiments would be 120 cubic meters per year. Because the inner containment vessel would be used only once, it would not require treatment and/or decontamination after each experiment. After sample retrieval, the inner containment vessel would be packaged and shipped to the Nevada Test Site for disposal as LLW.

M.5.3.13.3.2 *Hazardous Waste*

The hazardous waste streams from the NIF operations would be the same for the Proposed Action as for the No Action Alternative. The experiments with additional materials would not generate additional hazardous wastes.

M.5.3.14 ***Occupational Protection and Human Health***

M.5.3.14.1 *Radiological Exposure*

Personnel would be exposed to two sources of prompt radiation during the NIF yield operations: direct radiation and skyshine radiation. Also, after yield operations, tasks that must be performed within the NIF target bay or that involve handling of materials that have been inside the target bay during yield experiments would result in some level of radiation dose. This would not change from the No Action Alternative.

For most plutonium nonyield and yield experiments, an additional exposure would occur during placement of the inner containment vessel into the NIF target chamber and then again during its removal after the experiment. During this time, personnel would be close to a large, open target chamber port. Because they would have a line-of-sight view to the activated target chamber interior, activated as a result of previous experiments, they would receive some amount of exposure. Appropriate protective measures for plutonium exposure would be used during post-experiment activities.

The inner containment vessel would not be activated during nonyield experiments. Thus, no additional routine exposure would be expected if the post-experiment inner containment vessel needs to be accessed to retrieve debris for analysis or during packaging of the inner containment vessel as waste. For 10 nonyield plutonium experiments per year, the additional exposure incurred during inner containment vessel placement and removal from the target chamber would be no more than 1 person-rem per year.

For yield experiments with plutonium, an additional exposure would occur during handling of the post-experiment inner containment vessel; i.e., placement and removal, accessing it to retrieve debris for analysis, and packaging it as waste. This dose would occur mostly as a result of exposure to the activated inner containment vessel. This additional dose was estimated assuming 4 plutonium yield experiments per year, at 45 megajoules each. An additional 3 person-rem per year of worker exposure could result from these plutonium yield experiments.

In addition, a worker dose would be incurred during routine decontamination activities. This would include handling of contaminated/activated items; disassembling them, if needed; and

processing them through the decontamination systems. This dose would be largely related to the cleaning frequency, which is expected to be once per year. Thus, this component of the worker dose would not change under the Proposed Action. Table M.5.3.14.1–1 presents the calculated radiation doses to the public, the NIF workers, and noninvolved workers during normal operations.

TABLE M.5.3.14.1–1.—*Radiological Impacts to the Public and Workers from Normal Operations (Proposed Action)*

Receptor	Proposed Action		No Action Alternative	
	Dose	**Latent Cancer Fatality Risk**	**Dose**	**Latent Cancer Fatality Risk**
Public (site-wide MEI)	0.27 mrem/yr	1.6×10^{-7}	0.24 mrem/yr	1.4×10^{-7}
Population	0.29 person-rem/yr	1.7×10^{-4}	0.26 person-rem/yr	1.6×10^{-4}
Involved workers	<19 person rem/yr	0 cancers in population (calculated value = 1.1×10^{-2})	<15 person-rem/yr	0 cancers in population (calculated value = 9×10^{-3})
Noninvolved worker	1 mrem/yr	6×10^{-7}/yr of exposure	1 mrem/yr	6×10^{-7}/yr of exposure

Source: LLNL 2003d.
MEI = maximally exposed individual; mrem = millirems; yr = year.

The dose at the site boundary would be dominated by neutron skyshine; direct dose would be small by comparison. The NIF MEI dose from airborne releases would be 0.068 millirem per year (Section M.5.3.8.4). When added to the 0.2 millirem per year dose from the skyshine, the total MEI dose from the NIF operations under the Proposed Action would be 0.27 millirem per year. This dose would be less than 0.3 percent of DOE standard and would result in an increase in annual latent cancer fatality risk of 1.6×10^{-7}. The skyshine would not result in any increase in the overall population dose because the exposure to the skyshine would be limited to close proximity to LLNL boundary next to the NIF.

M.5.3.14.2 *Nonradiological Exposure*

Potential nonradiological impacts to human health and safety posed by the NIF operations under the Proposed Action would include chemical exposure and risks of occupational injuries, illnesses, and fatalities resulting from normal, accident-free, operations and potential laser exposure. Involved and uninvolved workers could be affected.

The potential exists for personnel exposures due to an increased amount of beryllium as well as alkali metals resulting from the NIF operations under the Proposed Action. Beryllium- and lithium- containing targets would contribute to airborne and surface contamination. This contamination would be contained within the NIF target chamber. Personnel exposures to these contaminants would be controlled through the implementation of ES&H requirements, specifically Document 14.4, *Implementation of the Chronic Beryllium Disease Prevention Program Requirements,* and Document 14.7, *Safe Handling of Alkali Metals and Their Reactive Compounds.* Personnel monitoring and area decontamination practices would be employed to reduce the contamination source term and to minimize hazards to facility workers.

The use of chemicals under the Proposed Action would be the same as discussed in Section M.5.2.13.2, and would not necessarily result in additional worker exposures. Thus, no adverse impacts from this action would be expected.

M.5.3.14.3 *Physical Hazards*

The NIF would use powerful lasers. Powerful lasers are hazardous to the eyes and skin, whether exposure is to the direct beam of the laser or reflections. At NIF, laser safety would be particularly important. Laser safety officers would ensure that lasers are operated according to LLNL safety procedures, which is based on integrated safety management techniques. These management techniques would include controlling access to the laser operational area and requiring use of safety interlocks, warning systems and signs, remote operation, and eye protection.

Physical hazards, such as noise, electrical shock, and workplace injuries/illnesses, could increase under the Proposed Action, but workplace injury/illness statistics show a decreasing trend over the past 10 years (see Section M.5.2.14).

M.5.4 Reduced Operation Alternative

Under the Reduced Operation Alternative, the neutron spectrometer would not be constructed and there would be no experiments with plutonium, other fissile materials, fissionable materials (other than depleted uranium without yield), or lithium hydride. The operation of the NIF under the Reduced Operation Alternative would be similar to that under the No Action Alternative. The primary difference would be in the schedule of experiments, the annual yield, and tritium throughput. The Reduced Operation Alternative would stretch the 12-month No Action Alternative experiment schedule into an 18-month experiment schedule. The annual level of operations on the NIF would be reduced from 1,200 megajoules per year to 800 megajoules per year. Section M.3.3 provides additional information on the programmatic impacts of adopting the Reduced Operation Alternative.

M.5.4.1 *Land Use and Applicable Plans*

The generalized land use at LLNL and vicinity is zoned for industrial park use. The industrial land use for the NIF would be the same as outlined under the No Action Alternative. The Reduced Operation Alternative would not result in any change to the land use for the immediate area of the NIF or land use in the overall vicinity. No impacts to land use would be expected from the Reduced Operation Alternative.

M.5.4.2 *Socioeconomic Characteristics and Environmental Justice*

M.5.4.2.1 *Socioeconomics*

The Reduced Operation Alternative would not include the construction of a neutron spectrometer; therefore, there would be no increase in temporary employment due to construction activities.

The projected level of long-term workers that would be needed for this level of operations is 367, with 172 employees for direct operations along with 195 support personnel. There are 380 long-term employees currently associated with the NIF. The current level of workers exceeds the number that would be needed under the Reduced Operation Alternative. The reduction in force of 13 workers would be made through attrition consistent with the 5- to 8-percent annual turnover rate at LLNL, or through internal transfers to other projects. Therefore, no impacts to local housing, schools, or medical services are anticipated.

M.5.4.2.2 *Environmental Justice*

The impacts associated with the operation of the NIF with potential for disproportionate effects would be radioactive air emissions. Beyond a 5-mile radius, these impacts would be negligible (see Section M.5.3.8). Therefore, there would be no disproportionately high and adverse impacts to minority or low-income populations under the Reduced Operation Alternative.

M.5.4.3 *Community Services*

The existing LLNL fire protection and emergency services, police protection, and security services would not change under the Reduced Operation Alternative. The level of services provided currently would not change. Because there would be no substantial change in the workforce, there would be no changes in the socioeconomic impacts and no associated change in school services.

The NIF is generating and would continue to generate waste office paper, cardboard, plastic, sanitary wastes, and other nonhazardous refuse at a rate similar to LLNL as a whole. There would be nothing unique about the refuse generation from the NIF, in terms of waste types or amounts; therefore, this type of waste is projected on a per capita basis. With a projected total of 367 long-term workers at the NIF and its support operations, the projected amount of nonhazardous solid waste would be approximately 367 cubic meters per year. As a conservative estimate, it is assumed that each worker would generate 1 cubic meter of nonhazardous solid waste. This would be a decrease of 33 cubic meters or 8.3 percent of the amount of nonhazardous solid waste generated under the No Action Alternative. Because 380 long-term personnel are already employed at NIF, the decrease of 13 personnel projected under the Reduced Operation Alternative would represent an associated decrease of 13 cubic meters of nonhazardous solid waste from the amount of waste that is already part of the overall LLNL waste figures. This amount represents an approximate 0.3 percent decrease in the site's current generation of nonhazardous waste; therefore, no impacts are expected to the capacity to handle nonhazardous solid waste under the Reduced Operation Alternative.

M.5.4.4 *Prehistoric and Historic Cultural Resources*

No prehistoric archaeological resources have been identified on or near the NIF site. No buildings and facilities at LLNL that may have potential to be eligible to the NRHP are located near the NIF. Because much of the NIF site has been developed, the likelihood of finding unrecorded and undisturbed prehistoric sites is low. Under the Reduced Operation Alternative, the neutron spectrometer would not be built. There would be no impacts expected to prehistoric or historic cultural resources from the Reduced Operation Alternative.

M.5.4.5 *Aesthetics and Scenic Resources*

The NIF conventional facility construction is now complete. All conventional facilities are constructed and turned over for equipment installation. No further changes to the visual features would occur in the area of the NIF. There would be no impacts to aesthetic and scenic resources under the Reduced Operation Alternative.

M.5.4.6 *Geologic Resources*

The NIF conventional facility construction is now complete. No further excavation is planned, therefore, no impacts to soils would result from the Reduced Operation Alternative. Animal fossils have been found beneath the NIF; however, no new excavation is planned under the

Reduced Operation Alternative. No further impacts to soils or fossils would result from the Reduced Operation Alternative.

M.5.4.7 *Ecology*

The NIF conventional facility construction is complete. No new construction would occur under the Reduced Operation Alternative; therefore, there would be no erosion or changes to existing stormwater flow patterns. No impacts would occur to the nearby wetland area. Few impacts would occur to biological resources during operation of the NIF. The traffic to and from the NIF would have associated losses of road-killed individuals of some species. No adverse impacts to threatened and endangered species or species of special concern are expected from operation of the NIF.

M.5.4.8 *Air Quality*

During normal operations, some experiments at the NIF would result in atmospheric releases of small quantities of tritium and some radionuclides produced by activation of gases in the target bay air.

Some nonradiological hazardous materials would be present at the NIF. Routine emissions of these types of materials would be expected from operation of electrical equipment, wipe cleaning, and occasional use or maintenance testing of the standby generators. The total emissions would be a small fraction of project significance levels and threshold levels for conformity.

M.5.4.8.1 *Criteria Air Pollutants*

The emission of criteria air pollutants would be dominated by the operation of the facility rather than the experiments. Therefore, the emissions that would result from normal operations of the NIF under the Reduced Operation Alternative are equivalent to those that would be expected from normal operations under the No Action Alternative. The criteria air pollutant emissions would occur primarily from solvent cleaning and fuel combustion. These activities would be the same under the Reduced Operation Alternative as under the No Action Alternative.

M.5.4.8.2 *Hazardous Air Pollutants*

LLNL evaluates a list of approximately 200 compounds to confirm applicability under NESHAP. Emissions of hazardous air pollutants for all of LLNL would be less than one-half of the threshold of 7 tons per year for a single hazardous air pollutant or 15 tons per year for a combination of hazardous air pollutants (LLNL 2002ae). The normal operations of the NIF under the Reduced Operation Alternative would not result in the emission of hazardous air pollutants, except for possible beryllium emissions, well below the toxic air contaminant threshold.

M.5.4.8.3 *Toxic Air Emissions*

Under the Reduced Operation Alternative, the toxic air emissions at the NIF would decrease because of the reduced number of experiments per year. In general, the emissions would be one-third less than those associated with the No Action Alternative.

No increase in impacts from LLNL hazardous air pollutants and toxic air emissions would occur under the Reduced Operation Alternative. The increase in the emission of VOCs would be bounded at 15 percent. The impacts of the increase would be minor.

M.5.4.8.4 *Radiological Air Quality*

During normal NIF operations under the Reduced Operation Alternative, experiments would result in normal atmospheric releases of small quantities of tritium and some radionuclides produced from activation of gases in the target bay air. The total annual inventories of radioactive gases produced relates directly to annual yield. Therefore, the annual inventory produced under the Reduced Operation Alternative would be less than that of the No Action Alternative. Annual emissions of activated gases, based on 800 megajoules per year of yield, are provided in Table M.5.4.8.4–1. Up to 30 curies per year of tritium would be released during maintenance activities, when equipment would be opened up or brought up to air.

TABLE M.5.4.8.4–1.—*Routine Radiological Air Emissions from the National Ignition Facility (Reduced Operation Alternative)*

Nuclide Produced	Nuclide half-life	Production (Ci/year)	Emissions (Ci/year)
Activated Air:			
Hydrogen-3	12.33 yr	2.88×10^{-3}	2.88×10^{-3}
Carbon-14	5730 yr	8.67×10^{-4}	8.67×10^{-4}
Nitrogen-13	9.99 min	3.41×10^{2}	4.52×10^{1}
Nitrogen-16	7.13 sec	5.61×10^{4}	1.02×10^{2}
Sulfur-37	5.06 min	7.40	5.29×10^{-1}
Chlorine-40	1.42 min	4.27×10^{1}	8.60×10^{-1}
Argon-41	1.83 hr	2.79×10^{1}	1.75×10^{1}
Tritium (releases during maintenance)			**30**

Source: LLNL 2003d.
Ci = curies; hr = hours; min = minutes; sec = seconds; yr = year(s).

Table M.5.4.8.4–2 presents the potential impacts of radiological air emissions to the public. While some of the radiation exposures from normal operations to workers would result from radiological air emissions, doses to involved workers would be primarily from direct radiation exposure (see Section M.5.4.14.1). The impacts under the No Action Alternative are here presented for comparison.

TABLE M.5.4.8.4–2.—*Radiological Impacts to the General Public from Airborne Effluent Emissions during Normal Operations (Reduced Operation Alternative)*

Receptor	Reduced Operation Alternative		No Action Alternative	
	Dose	Latent Cancer Fatality Risk	Dose	Latent Cancer Fatality Risk
NIF offsite MEI	0.03 mrem/yr	1.8×10^{-8} /yr of exposure	0.04 mrem/yr	2.4×10^{-8} /yr of exposure
Population Dose	0.24 person-rem/yr	1.4×10^{-4}	0.26 person-rem/yr	1.6×10^{-4}

Source: LLLNL 2003d.
MEI = maximally exposed individual; mrem = millirems; yr = year; NIF = National Ignition Facility.

The baseline dose to the MEI from Livermore Site operations (site-wide MEI) without the NIF operation would be 0.017 millirem per year with an associated population dose of 0.16 person-rem per year (SNL 2000). Due to planned increases in Building 331 tritium releases, the LLNL SW/SPEIS Reduced Operation Alternative dose to the site-wide MEI without the NIF operations would be 0.039 millirem per year. The location of the site-wide MEI would correspond with the NIF MEI location. Conservatively, adding the site-wide MEI Reduced Operation Alternative dose to the NIF MEI dose for airborne effluent emissions would result in an estimated dose of 0.068 millirem per year for airborne releases under the NIF Reduced Operation Alternative. This

dose would be less than 0.7 percent of the NESHAP limit. The component of population dose from routine NIF releases would be 0.24 person-rem per year. Adding 0.24 person-rem per year to LLNL SW/SPEIS Reduced Operation Alternative population dose of 0.89 person-rem per year would result in a dose of 1.1 person-rem per year. This population dose would be many orders of magnitude less than the dose received from natural background. No adverse impacts on radiological air quality would be expected from the Reduced Operation Alternative.

M.5.4.9 *Water*

Under the Reduced Operation Alternative, the neutron spectrometer would not be built; therefore, there would be no changes to stormwater flow and no impacts to surface water or groundwater resources from construction activities.

Water usage at the NIF is currently expected to be 27.6 million liters per day or approximately a 3.5 percent increase in LLNL usage; i.e., 795 million liters per year in 2001. Under the Reduced Operation Alternative, there would be some reduction in water usage, but the difference would be minor. The reduction, though minor, could be of beneficial impact in drought years.

M.5.4.10 *Noise*

While the level of operations of the NIF would be reduced under the Reduced Operation Alternative, the manner of operation of the NIF facility would be similar. The main sources of noise from the operation of the NIF would be the HVAC systems and traffic associated with an industrial facility, moving equipment, and truck deliveries; i.e., approximately 85 decibels. The noise at the NIF would be equal to other local industrial/commercial activities. The contribution of these activities to noise levels offsite would be small. Noise resulting from the NIF experiments would be heard outside the NIF building for a short distance only. This noise would be momentary and intermittent, occurring only at the time of a, experiment, up to 6 times per day. The impacts of noise to workers would be normal for industrial facilities. With standard hearing protection, no impacts from noise would be expected. No impacts would be expected from noise to the public.

M.5.4.11 *Traffic and Transportation*

Traffic

The construction of the NIF conventional facilities is completed. As a result, the traffic associated with the construction workers has ceased. The personnel who are working to make the NIF operational and will operate the NIF are already employed onsite. Therefore, there would be no change in the amount of traffic that currently exists. Slightly fewer employees would operate the NIF under the Reduced Operation Alternative, resulting in a slight reduction in traffic from current levels.

Radiological Transportation

The consideration of target fill activities and the exact facilities that would perform these activities has not yet been fully decided. These activities would undergo NEPA and safety review prior to initiation. Most of the targets would be provided from an onsite source. Routine onsite transportation of targets would have no impact to the public as access to LLNL is restricted. The onsite transportation would fall within the scope of operational activities already analyzed for the site and the NIF in particular.

The major offsite source of target material would be Los Alamos National Laboratory. Under the Reduced Operation Alternative, 3 shipments per year, each with 0.2 gram of depleted uranium; and 10 shipments per year, each with 100 curies of tritium, would occur. The radiological transportation analysis is based on the assumption that these would all be separate shipments.

For incident-free transport; i.e., no accidents, of the depleted uranium, the consequence would be the radiation dose potentially received by the truck drivers and members of the public driving on the highways, living near the highways, and present at rest stops. Because of the very small amount of radioactive material being transported and the shielding of the containers and truck, the radiation dose rate near the truck is expected to be immeasurably small. Therefore, there would be no incident-free radiation dose to drivers or members of the public.

Tritium does not produce an external dose rate. Therefore, transport of tritium would also have no incident-free radiological impacts. Section M.5.6 presents the consequences of transportation accidents, which include tritium transport accidents.

M.5.4.12 *Utilities and Energy*

Under the Reduced Operation Alternative, fewer NIF experiments would be implemented per year. However, the facility would be operated at clean-room conditions irrespective of the number of experiments. The utility usage would be dominated by the operation of the facility as a clean room. The reduction in utility usage would be minor, as the overall operation of the NIF would not be greatly reduced. The utility usage would be only slightly less than that discussed under the No Action Alternative.

M.5.4.13 *Materials and Waste Management*

NIF research activities would use a variety of hazardous; i.e., radioactive and toxic, materials and nonhazardous materials. All of these would become part of material management for the NIF. The primary strategy for the control and management of hazardous materials at the NIF would be to minimize exposures to hazardous substances in accordance with regulatory requirements, institutional goals, and best management practices. Once the materials have been used, they would be classified and managed under the NIF's and LLNL's waste management procedures. Waste management is discussed in Section M.5.4.13.3. During the use and management of these materials, air emissions would occur. Emissions are discussed in Section M.5.4.8.

Particulates would be generated in the target chamber from each experiment. When the cleanup of the target chamber occurs, the particulates and debris would be added to the waste streams discussed in Section M.5.4.13.3. The management of the radioactive particulates and tritium is discussed in Section M.5.4.13.1. The remaining particulates and hazardous materials are discussed in Section M.5.4.13.2.

M.5.4.13.1 *Radionuclide Materials Management*

The materials contained in targets and the activation of materials in the target area described under the No Action Alternative would be the same for the Reduced Operation Alternative. Under the Reduced Operation Alternative, the inventories of activated material in the target chamber and the gases from the target bay air would be the same as under the No Action Alternative, because this would be largely determined by the individual experiment yield.

Particulates would be generated in the same manner as described under the No Action Alternative. Because these are mostly short-lived species, the maximum inventories would be

found in the target chamber shortly after the last experiment and well before cleanup. By the time cleaning occurs or components are removed, the radioactive particulate inventory would have decayed to much smaller quantities. Under the Reduced Operation Alternative, there would be longer periods between experiments and potentially more time for the inventory to decay before cleanup.

Depleted Uranium

Under the Reduced Operation Alternative, depleted uranium would be handled and used in the same manner as under the No Action Alternative.

Tritium

Under the Reduced Operation Alternative, tritium would be handled and used in the same manner as under the No Action Alternative.

M.5.4.13.2 *Nonradiological Materials Management*

The management of nonradiological materials would be the same as described under the No Action Alternative. Waste is discussed in Section M.5.4.13.3.

The amount of nonradiological particulates that would be generated under the Reduced Operation Alternative would be similar to, but less than, that generated under the No Action Alternative (Table M.5.2.13.2–1). The exact amount would depend on the type and schedule of the experiments.

The nonradiological materials expected to be used on the NIF under the Reduced Operation Alternative would be the same as those used under the No Action Alternative (see Table M.5.2.13.2–2).

M.5.4.13.3 *Waste Management*

Under the Reduced Operation Alternative, many of the waste streams from the NIF would be unchanged from those of the No Action Alternative, as the difference in operations would not be directly related to annual yield. For the waste streams that are related to yield or the number of experiments, such as target chamber hardware or decontamination wastes, changes would be in proportion to the differences in annual yield. Under the Reduced Operation Alternative, the cleaning schedule would be performed over 18 months compared to the 12-month cleaning schedule under the No Action Alternative. The Reduced Operation Alternative would generate proportionately less waste than the No Action Alternative on an annual basis. A summary of the waste stream estimates for the Reduced Operation Alternative is provided in Table M.5.4.13.3–1.

M.5.4.13.3.1 *Radioactive Waste and Mixed Waste*

Wastes from Wipe Cleaning, Chemical Treatment, and Decontamination

Wipe cleaning is primarily related to maintaining clean-room conditions. These conditions would be maintained even under a reduced schedule. Therefore, the waste from wipe cleaning would be the same as under the No Action Alternative. While the type of experiments expected under the Reduced Operation Alternative would be the same as under the No Action Alternative, the schedule would be extended with more time between each experiment. Under the Reduced Operation Alternative, it would take 18 months to perform the same number of experiments that would be performed in 12 months under the No Action Alternative. This lengthening of the experiment schedule would result in the expansion of the schedule for chemical treatment and

decontamination of the target chamber. Under the Reduced Operation Alternative, the target chamber would be decontaminated once per 18 months instead of annually. Therefore, the impacts associated with the decontamination activities would be proportionately less on an annual basis.

TABLE M.5.4.13.3–1.—*National Ignition Facility Annual Waste Estimates for Low-Level, Mixed, and Hazardous Wastes for the Reduced Operation Alternative*

Source of Waste	Low-Level		Mixed		Hazardous	
	Solid (m^3)	Liquid (m^3)	Solid (m^3)	Liquid (m^3)	Solid (m^3)	Liquid (m^3)
Tritium processing	3.2	–	0.003	–	–	–
Wipe cleaning	3.3	0.30	1.00	–	1.0	–
HEPA filters/pre-filters	0.23	–	–	–	–	–
Waste hardware	42	–	0.33	–	–	–
Chemical treatment/decontamination	–	0.65	0.20	3.3	–	1.5
Waste oils/equipment	0.06	–	–	0.2	7.5	0.2
General chemicals	–	–	–	–	–	4.6
Total/year	**49**	**0.95**	**1.6**	**3.5**	**8.5**	**6.3**
No Action Alternative Total/year	70	1.6	1.8	5.1	8.5	6.3

Source: LLNL 2003d.
HEPA = high-efficiency particulate air; m^3 = cubic meters.

Waste Hardware

The amount of waste hardware would be reduced by one-third under the Reduced Operation Alternative. The target chamber components, such as debris shields and first wall panels, would last 50 percent longer.

M.5.4.13.3.2 *Hazardous Waste*

The waste oils and associated equipment would be the same as discussed under the No Action Alternative. The general chemicals waste would also be the same as under the No Action Alternative.

M.5.4.14 *Occupational Protection and Human Health*

M.5.4.14.1 *Radiological Exposure*

Personnel would be exposed to two sources of prompt radiation during the NIF yield operations: direct radiation and skyshine. These exposure pathways would be reduced by one-third for the 800-megajoule per year Reduced Operation Alternative, compared to the 1,200-megajoule per year level under the Proposed Action and No Action Alternative. For the Reduced Operation Alternative, the skyshine dose at the nearest site boundary (350 meters due east of the target bay) would be less than 0.13 millirem per year for all possible target illumination configurations. The dose at the site boundary would be dominated by neutron skyshine; the direct dose would be small by comparison.

Personnel within the NIF would also receive a direct dose. Operations personnel, located in the main control room, would receive a direct dose of about 3 millirems per year. Those in the diagnostics building would receive about 2 millirems per year, and those in the optics assembly

building would receive approximately 0.7 millirem per year. These direct doses are based upon a 40-hour workweek.

Finally, noninvolved workers moving past the target chamber end of the NIF would receive a direct dose of approximately 0.7 millirem per year, assuming an occupancy of 30 minutes each day for walkways and roads, as recommended by the National Council on Radiation Protection (NRC 1977a). Table M.5.4.14.1–1 presents the calculated radiation doses to the public and the NIF workers and noninvolved workers during normal operations.

TABLE M.5.4.14.1–1.—*Radiological Impacts to the Public and Workers from Normal Operations (Reduced Operation Alternative)*

Receptor	Reduced Operation Alternative		No Action Alternative	
	Dose	Latent Cancer Fatality Risk	Dose	Latent Cancer Fatality Risk
Public (site-wide MEI)	0.16 mrem/yr	9.6×10^{-8}	0.24 mrem/yr	1.4×10^{-7}
Population	0.24 person-rem/yr	1.4×10^{-4}	0.26 person-rem/yr	1.6×10^{-4}
Involved worker	<10 person rem/yr	0 cancers in population (calculated value = 6×10^{-3})	<15 person-rem	0 cancers in population (calculated value = 9×10^{-3})
Noninvolved worker	1 mrem/yr	6×10^{-7}/yr of exposure	1 mrem/yr	6×10^{-7}/yr of exposure

Source: LLNL 2003d.
MEI = maximally exposed individual; mrem = millirems; yr = year.

The NIF MEI dose from airborne releases would be 0.029 millirem per year (Section M.5.4.8.4). When added to the 0.13-millirem per year dose from the skyshine, the total NIF MEI dose from the NIF operations under the Reduced Operation Alternative would be 0.16 millirem per year. This dose would be less than 0.2 percent of DOE standard and would result in an increase in annual LCF risk of 9.6×10^{-8}. The skyshine would not result in any increase in the overall population dose because the exposure to the skyshine would be limited to close proximity to LLNL boundary next to the NIF.

M.5.4.14.2 *Nonradiological Exposure*

The use of chemicals under the Reduced Operation Alternative would be the same as discussed in Section M.5.2.13.2 and would not necessarily result in additional worker exposures. Continued application of site ES&H and Integrated Safety Management System principles would result in minimal impacts to workers and the public. Thus, no adverse impacts from this action would be expected.

M.5.4.14.3 *Physical Hazards*

The NIF would use powerful lasers. Powerful lasers are hazardous to the eyes and skin, whether exposure is to the direct beam of the laser or reflections. Laser safety would be particularly important at the NIF. Laser safety officers would ensure that lasers would be operated according to LLNL safety procedures, which are based on integrated safety management techniques. These management techniques would include controlling access to the laser operational area and requiring use of safety interlocks, warning systems and signs, remote operation, and eye protection.

Physical hazards, such as noise, electrical shock, and workplace injuries/illnesses, under the Reduced Operation Alternative would remain the same as under the No Action Alternative or decrease slightly, but workplace injury/illness statistics show a decreasing trend over the past 10 years (see Section M.5.2.14).

M.5.5 Mitigation Measures

The regulations promulgated by the CEQ to implement the procedural provisions of NEPA (42 U.S.C. §4321) require that an EIS include a discussion of appropriate mitigation measures (40 CFR §§1502.14[f] and 16[h]). Mitigation measures are discussed in Chapter 5.6 of this LLNL SW/SPEIS. The resource areas for mitigation are waste management and occupational protection (worker dose). The NIF mitigation action plan (DOE 1997a), developed as part of the SSM PEIS, discusses mitigation of waste generation and will remain in effect until completion of the NIF project. As indicated in Chapter 5.6, occupational exposure will be kept as low as reasonably achievable.

M.5.6 Accident Analysis

NEPA requires that an agency evaluate reasonably foreseeable significant adverse effects on the human environment in an EIS. This section informs the decision-maker and the public about the chances that reasonably foreseeable accidents associated with the NIF, including the No Action Alternative, Proposed Action, and Reduced Operation Alternative, could occur, and about their potential adverse consequences. An accident is considered bounding if no reasonably foreseeable accident can be found with greater consequences. An accident is reasonably foreseeable if the analysis of occurrence is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason (40 CFR §1502.22[b][4], DOE 1993b, DOE 2002t).

This section presents the potential impacts on workers (both involved and noninvolved) and the public due to potential accidents associated with operation of the NIF. 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. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as a 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. Initiating events fall into three categories:

- *Internal initiators* normally originate in and around the facility, but are always a result of facility operations. Examples include equipment or structural failures and human errors.
- *External initiators* are independent of facility operations and normally originate from outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, and nearby explosions.
- *Natural phenomena initiators* are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, and lightning. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

If an accident were to occur involving the release of radioactive or chemical materials, 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 location. The offsite public would also be at risk of exposure to the extent that meteorological conditions exist for the environmental dispersion of released hazardous materials. Using approved computer models, the atmospheric dispersion of released hazardous materials and their effects were predicted. However, prediction of latent potential health effects becomes increasingly difficult to quantify for facility workers as the distance between the accident location and the worker decreases. This is because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The worker also may be injured or killed by physical effects of the accident itself.

This section presents the potential impacts on workers (both involved and noninvolved) and the public from accidents associated with operation of the NIF. Additional details supporting the information presented here are provided in Appendix D.

M.5.6.1 *Radiological Accident Scenarios*

M.5.6.1.1 *No Action Alternative*

A review was conducted of accidents potentially resulting in a radiological release from the NIF under the No Action Alternative (LLNL 2003d.). These scenarios included:

- Operational upsets resulting in tritium release
- Loss of target chamber vacuum
- Waste drum fire
- Release during decontamination operations
- Worker contamination/exposure scenarios
- Earthquakes and other natural phenomena
- External events; e.g., aircraft crash

These scenarios would have varying probabilities and consequences. They also would have differing release fractions and could occur at different times after the experiment. To encompass all potential radiological consequences from NIF operations, a bounding scenario resulting in the release of radionuclides to the environment was identified. The initiating event would be a severe earthquake; i.e., beyond design basis. The scenario considers an earthquake of frequency 10^{-4} per year (~ 1*g* horizontal ground acceleration) occurring at the time of a maximum credible yield experiment. Assuming 100 high-yield experiments per year, the estimated frequency of the accident would be 2×10^{-8} per year, assuming a 1-minute time window for the earthquake. The target bay has been shown to withstand a severe earthquake (LLNL 2003d), but other areas and components have not been analyzed beyond their design basis. The beam tubes leading from the switchyard into the target chamber were assumed to fail in the proposed earthquake. The switchyards could withstand the earthquake, but were conservatively assumed to collapse.

Inventories vulnerable to release in the target bay would include activated gases in the air and beam tubes and activated material in the target chamber. For inventories in the target bay, a pathway out to the environment would be created through the beam tube penetrations in the

target bay walls. Dispersion in the environment would take place as the material is transported downwind.

Tritium sources located outside the target bay in the laser and target area building would also be vulnerable to release. These primarily would include tritium in elemental form as stored targets or on the cryopumps, or tritium as oxide on the molecular sieve of the tritium processing system. Further, natural gas piping would be located in areas of the laser and target area building outside the target bay. Thus, localized fires outside the target bay could be expected under these extreme conditions (LLNL 2003d).

Aircraft Crash

The probability of a light aircraft crash impacting the NIF laser and target area building would be a credible event; the frequency of occurrence would be approximately 1.6×10^{-4} per year. Specific areas of concern from a release of material standpoint would be the tritium-handling and processing/decontamination areas and the laser bays. If the aircraft crashed into other areas of the laser and target area building, there would be facility damage, but the accident would not result in the release of radioactive material.

The NIF target bay is constructed of thick, reinforced concrete. The primary purpose of this construction is radiological shielding; however, as an additional benefit, the construction also makes the facility essentially impervious to impact by light aircraft. Should an aircraft crash into the target bay, the chief hazard would be to the occupants of the aircraft and any onsite personnel in the way of falling plane wreckage and burning aviation fuel. The thickness of the reinforced concrete walls and roof are such that they would withstand the impact of a direct hit from a light aircraft. The switchyard is also constructed of reinforced concrete, a minimum of 0.61 meters thick. This area is also impervious to a light aircraft. See Section M.5.6.2.1 for discussion of potential chemical releases from an aircraft crash.

Source Terms

Radioactive inventories vulnerable to release include activated gases, activated particulates in the target chamber, and tritium.

Activated Gases

If the earthquake were to occur immediately after a high-yield experiment, air activation products in the target bay atmosphere and beam tubes would be available for release. Inventories of activated gases created in the target bay atmosphere as a result of a maximum yield experiment are provided in Table M.5.2.8.4–1 in Section M.5.2.8.4.

A direct pathway to the environment could be created by the seismic event, resulting in the release of activated air from the target bay. The activated air would be forced out as the wind blows from one collapsed switchyard, through the beam tube penetrations on one side of the target bay, through the target bay, and then out through the beam tube penetrations and collapsed switchyard on the opposite side. No mitigation is assumed.

Activated Particulate

A small quantity of activated debris would be created in the target chamber. Conservatively, for the purpose of this analysis, it is assumed that all of this solid debris would exist as fine particulates.

The particulates would accumulate in the target chamber until a scheduled cleanup. It is conservatively assumed here that the material would accumulate in the target chamber for one year. The bounding annual radionuclide particulate dispersible target chamber inventories; i.e., the inventory in the form of particulates, subsequent to the last yield experiment of the year, assumed to be at the maximum credible yield of 45 megajoules, are provided in Table M.5.2.13.1–1 in Section M.5.2.13.1.

Collapse of the beam tubes and failure of debris shields, diagnostic windows, etc., would open many penetrations to the target chamber. This would allow rapid air ingress to the target chamber. The inflow of air would disturb any settled particulates, causing them to become airborne within the target chamber. A conservative airborne release fraction of 10^{-3} for solid particulate is assumed. With rapid air ingress that is assumed to occur in the event, some of the particulates on the surface could become airborne due to resuspension mechanisms. Resuspension occurs as a result of mechanical disturbances as well as by wind. In what follows, a simple method would be used to estimate the airborne release fraction (ARF), based on the resuspension data. The ARF is used to estimate the release of material in particulate form to the environment.

The resuspension factor is defined as:

$$RF = \text{airborne concentration} / \text{surface concentration}$$

Applying the definition of RF to the target chamber, leads to the following:

$$RF = (\text{airborne particulate} / 4\pi/3 \times R^3) / (\text{particulate on surface}/4\pi \times R^2)$$

$$= (3/R) \times (\text{airborne particulate}/ \text{particulate on surface})$$

$$= (3/R) \times ARF$$

Where,

R is the radius of the target chamber.

Thus,

$$ARF = (R/3) \times RF$$

The value for the resuspension factor, RF, would range from 10^{-9} to 10^{-4} for wind resuspension and from 10^{-7} to 10^{-3} for mechanical disturbance (LLNL 2003d). Using the target chamber radius of 5 meters, the ARF would range from 10^{-9} to 10^{-3}. In this evaluation, the conservative value of 10^{-3} is used for the ARF. According to DOE-STD-1027, an average ARF of 10^{-3} is used generally for solids, powders, and liquids for various accidents in facility categorization.

Some deposition of the particulates would occur within the target chamber and target bay. Including in-facility deposition would reduce the quantity of radioactive material reaching the environment. This has not been considered at this time. Thus, a conservative source term has been estimated.

Tritium

Tritium would arrive at the facility in targets containing up to 35 curies; an additional 35 curies could be in the associated support structure, for a total maximum target assembly inventory of 70 curies. No more than 100 curies of tritium would be in the facility in the form of targets and associated support structure. Individual targets would be placed in the target chamber for experiments. Unburned tritium would be exhausted and retained in the tritium processing system. The inventory in the collection system could be controlled and maintained such that the maximum facility in-process inventory would not exceed 500 curies. This would be accomplished by active inventory control and periodic removal of the molecular sieve and transfer to shipping containers for disposal or recovery offsite.

The seismic event could lead to the release of any tritium contained in targets. Release could occur as a result of direct crushing of the targets or failure of the cryogenic support system leading to pressurization and failure of the capsule. This tritium would be released from the targets in the elemental form. There could be small quantities of flammables, such as solvents, in the area; therefore, there exists the small possibility of a fire. It is presumed that the fire mitigation system would be unavailable during this event. For the purpose of this severe accident analysis, the probability of the fire occurring and continuing for some time is taken to be 1.0. Thus, any tritium released from targets is conservatively assumed to become oxidized and to be released as tritiated water. Because the targets would be stored in an area that could be severely damaged by this earthquake, the tritium released from the targets would directly enter the environment.

During the hypothesized seismic event, it is possible that there would be damage to components of the tritium processing system. These are designed to survive the design-basis earthquake. Their behavior in more severe earthquakes is not known, and thus, these components are assumed to fail; i.e., the molecular sieve would be directly exposed to the atmosphere. Under the extreme conditions of this accident, a fire could occur near the tritium processing system. This would provide an energy source for the release of the tritium from the molecular sieve directly into the atmosphere. It is also possible that water piping in the area would fail, leading to flooding. Water sources could include domestic water, low conductivity water, and fire protection water. It is much more likely that the domestic and low conductivity water supplies would fail when compared to the fire sprinkler system. The sprinkler system has been designed to National Fire Protection Association standards and would survive the design-basis earthquake. Because the behavior of the sprinkler system under more severe seismic loads is not known, failure is postulated. If this were the case, any fire in the area would be unmitigated. If the area is flooded, an alternate release pathway is provided. Flooding would provide the opportunity for exchange with the material absorbed on the molecular sieve and would result in tritium contamination of the water pool. Subsequent evaporation from the pool would release the tritium to the environment via the airborne pathway, although at a much slower rate than the fire release mechanism. In either case, the tritium would directly enter the environment, as the tritium processing area is located outside of the target bay in a location that would likely be severely damaged by the earthquake.

The total tritium source term would be 500 curies. The most conservative source term would result from a fire in the area, because the release would occur more quickly and all of the tritium would be released in the more hazardous oxide form. The entire tritium inventory could be

released over a short period; 3 minutes would be a conservative estimate to release all of the tritium from the molecular sieve.

For this very severe scenario, 100 percent of the tritium inventory would be released from the decontamination area. The activation product particulate inventories and activated gases mentioned previously also would be released, with a release fraction of 10^{-3} for particulates and 1.0 for gases. The inventories that could be released under severe accident conditions are summarized in Table M.5.6.1.1–1.

TABLE M.5.6.1.1–1.—*National Ignition Facility Laser and Target Area Building Estimated Maximum Radionuclide Inventories Released Under Severe Accident Conditions for the No Action Alternative*

Radionuclide	Quantity (Ci)
Total tritium	500
Activated particulates[a]	
Sodium-24	4.0×10^{-4}
Manganese-56	1.3×10^{-3}
Cobalt-60	7.4×10^{-5}
Manganese-54	1.4×10^{-4}
Scandium-48	3.6×10^{-5}
Iron-55	7.1×10^{-4}
Scandium-46	4.6×10^{-5}
Calcium-45	1.0×10^{-4}
Scandium-44	2.0×10^{-4}
Tantalum-182	2.5×10^{-5}
Scandium-44m	6.4×10^{-5}
Gadolinium-153	2.5×10^{-5}
Nickel-65	2.0×10^{-4}
Copper-64	1.5×10^{-3}
Cobalt-62m	1.6×10^{-4}
Lead-203	1.6×10^{-5}
Scandium-47	2.4×10^{-5}
Potassium-42	1.8×10^{-5}
Gallium-72	2.8×10^{-6}
Hafnium-181	2.8×10^{-6}
Gadolinium-159	8.6×10^{-5}
Chromium-51	4.7×10^{-5}
Dysprosium-159	4.2×10^{-6}
Europium-156	7.9×10^{-7}
Nickel-63	8.8×10^{-6}
Depleted uranium[b]	
Uranium-234	8.6×10^{-10}
Uranium-235	4.0×10^{-11}
Uranium-238	1.6×10^{-9}

TABLE M.5.6.1.1–1.—*National Ignition Facility Laser and Target Area Building Estimated Maximum Radionuclide Inventories Released Under Severe Accident Conditions for the No Action Alternative (continued)*

Radionuclide	Quantity (Ci)
Activated gases[c]	
Target bay air	
Hydrogen-3	1.6×10^{-4}
Nitrogen-13	1.9×10^{1}
Nitrogen-16	3.2×10^{3}
Sulfur-37	4.2×10^{-1}
Chlorine-40	2.4
Argon-41	1.6
Carbon-14	4.9×10^{-5}
Beam tubes	
Hydrogen-3	4.7×10^{-6}
Sulfur-35	2.3×10^{-5}
Argon-37	4.1×10^{-4}
Argon-39	1.7×10^{-3}
Argon-41	3.5

Source: LLNL 2003d.

[a] After one year of operation without cleanup; corresponds to a final 45-MJ experiment, ending a year with a 1,200-MJ total yield.

[b] Depleted uranium would be used only in non-yield experiments and would, therefore, not be considered "activated," and no fission products would be produced. Depleted uranium is already slightly radioactive; the half-life of uranium-238 (dominant isotope) is 4.5×10^{9} yrs. The assumed composition is 99.64% uranium-238, 0.36% uranium-235, and 0.0028% uranium-234. The quantities listed correspond to the maximum use over a year of 5 g.

[c] After a single 45-MJ experiment.

Ci = curies; g = grams; MJ = megajoules.

It is also possible that water piping in the area would fail, leading to flooding. If the area were flooded, an alternate release pathway would be provided. Flooding would provide the opportunity for exchange with the material absorbed on the molecular sieve and would result in tritium contamination of the water pool. Subsequent evaporation from the pool would release the tritium to the environment via the airborne pathway, although at a much slower rate than the fire release mechanism. In either case, the tritium would directly enter the environment, as the tritium processing area is located outside of the target bay in a location that would likely be severely damaged by the earthquake.

Worker Exposure

The following summarizes worker exposure during accident situations. The bounding airborne radiological accident would be a release of all stored tritium within the NIF. This would results in 0.2 rem of exposure to the NIF worker. This assumes the trained worker will respond properly upon hearing alarms or discovering the situation, secure the work area, and leave the room within ten minutes. This exposure estimate is still well below the 5-rem routine occupational exposure limit.

The bounding radiological exposure accident would result from a worker remaining in the NIF target bay during a yield experiment. Workers could be exposed to lethal doses of neutron and prompt gamma radiation if accidentally present during a yield experiment.

Premature entry into the target bay after a high-yield experiment could also result in 15 rems of worker exposure. This assumes that the individual would remain in the area for one hour. The interlock system and other controls are critical to preventing such exposure. This exposure would be the same under the No Action Alternative, the Proposed Action, and the Reduced Operation Alternative.

M.5.6.1.2 *Proposed Action*

The Proposed Action would not introduce any new types of accident scenarios. Thus, the scenarios considered under the No Action Alternative have been examined with a revised source term for the Proposed Action. Because of facility inventory limits, some materials would not be simultaneously allowed into the facility. Strict inventory controls would be in place and adhered to. Several possible source terms are provided. Consequences have been assessed for the one that would result in the bounding offsite consequences.

Source Terms

Radioactive inventories vulnerable to release include activated gases, activated particulates in the target chamber, and tritium. There would be no change in the activated gas or tritium source terms under the Proposed Action. The activated particulate inventory in the target chamber would change based on the new materials proposed. Gaseous and semivolatile fission products would be present immediately after the experiment and would be vulnerable to release. Alternately, inventories from tracers that would be part of the Proposed Action could also be present. Plutonium experiments would use weapons-grade material for yield experiments, and associated fission products and activated particulates would be formed in the inner containment vessel. These source terms would not all be simultaneously present. The target chamber inventories that would be released during an earthquake under the No Action Alternative are listed in Table M.5.6.1.1–1. The possible additional bounding target chamber inventories that would result for the Proposed Action are listed in Table M.5.6.1.2–1. The source terms under both of these alternatives are summarized in Table M.5.6.1.2–2.

The accident with the highest consequence to the offsite population (Table M.5.6.1.2–3) would be an earthquake during a plutonium experiment without yield. The radiological consequences onsite and at the site boundary are calculated to be higher for this accident than those for any other radiological accident scenario. The radiation dose at the site boundary nearest to the release under median meteorological conditions would be 1.65×10^{-3} rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, as shown in Table M.5.6.1.2–3, the MEI dose would have a probability of $9.89 \times 10^{-7,}$ or one chance in 1,011,000, of developing a fatal cancer.

The collective radiation dose to the approximately 6,900,000 people living within 50 miles of LLNL under median meteorological conditions was calculated to be 0.546 person-rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, as shown in Table M.5.6.1.2–3, the collective population dose would result in an estimated 3.28×10^{-4} LCFs to this population.

For onsite personnel, the radiation dose under median meteorological conditions would be 4.99×10^{-3} rem at a distance of 100 meters. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, as shown in Table M.5.6.1.2–1, the 100-meter dose would have a probability of 3.00×10^{-6}, or one chance in 334,000, of developing a fatal cancer. The collective radiation dose to the population of noninvolved workers under median meteorological conditions would be 7.41×10^{-1} person-rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, this collective dose would result in an estimated 4.45×10^{-4} LCFs in this worker population.

The radiation dose at the site boundary nearest to the release under unfavorable meteorological conditions would be 2.16×10^{-2} rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, as shown in Table M.5.6.1.2–4, the MEI dose would have a probability of 1.30×10^{-5}, or one chance in 77,000, of developing a fatal cancer.

The collective radiation dose to the approximately 6,900,000 people living within 50 miles of LLNL under unfavorable meteorological conditions was calculated to be 8.33 person-rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, as shown in Table M.5.6.1.2–4, the collective population dose would result in an estimated additional 5.0×10^{-3} LCFs to this population. The calculated risks under this extremely unlikely bounding scenario, even assuming unfavorable meteorology, would be very low and would result in no adverse health impacts to LLNL workers or the offsite population.

For onsite personnel, the radiation dose under unfavorable meteorological conditions would be 4.69×10^{-2} rem at a distance of 100 meters. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, as shown in Table M.5.6.1.2–4, the 100-meter dose would have a probability of 2.82×10^{-5}, or one chance in 35,500, of developing a fatal cancer. The collective radiation dose to the population of noninvolved workers under unfavorable meteorological conditions would be 8.23 person-rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, this collective dose would result in an estimated 4.94×10^{-3} LCFs in this worker population.

Tables M.5.6.1.2-5 and M.5.6.1.2-6 show the frequency and risk of the postulated set of NIF accidents for a noninvolved worker, assumed to be a worker located 100 meters from the release point; the population of noninvolved workers; and the public, maximally exposed offsite individual and the general population living within 50 miles of LLNL, for both median and unfavorable meteorological conditions. The term “risk” means the consequence of the accident; i.e., radiation dose or LCFs, multiplied by the frequency per year for that accident.

M.5.6.2 *Chemical Accident Scenarios*

M.5.6.2.1 *No Action Alternative*

The two types of materials that would be involved in NIF operations and that would contribute to the nonradiological hazard are hazardous chemicals, which would be used at the NIF for a variety of purposes, including cleaning, decontaminating processes, and supporting electrical equipment operation; and material in particulate form. A review was conducted of accidents potentially resulting in a release of nonradiological material from the NIF under the Proposed Action (LLNL 2003d). These scenarios included:

- Spills, such as solvents or decontamination solutions
- Failure of electrical equipment
- Waste drum fire
- Loss of target chamber vacuum/particulate release
- Earthquake or other natural phenomenon
- External event; e.g., aircraft crash

These scenarios would have varying probabilities and consequences. They also would have differing release fractions. To encompass all potential consequences from NIF operations, bounding scenarios have been selected and are discussed below. Table M.5.6.2.1–1 lists the source terms for these chemical accident scenarios.

TABLE M.5.6.2.1–1.—*Potential Chemical Accident Scenarios – No Action*

Accident	Source Term or Hazard
Materials spill	400 L nitric acid solution (70%) 210 L acetone
Mercury release from ignitrons	9.8 g mercury
Aircraft crash	0.072 L mercury (980 g)
Earthquake	0.016 g beryllium 0.005 g uranium

Source: LLNL 2003d.
g = gram; L = liter.

Materials Spill

Solvents would be used for miscellaneous cleaning activities throughout the laser and target area and the optics assembly building; acidic and caustic solutions would also be used for various decontamination operations in the decontamination area of the Diagnostics Building. An anticipated scenario would be a spill of solvent or decontamination solution onto the ground outside the facility, possibly caused by a forklift during handling or movement.

The chemicals evaluated were selected on the basis of amount of material at risk, exposure criteria, and volatility. That is, chemicals without inventory thresholds that would be present in relatively small quantities, with low volatility, and those with relatively high exposure criteria were not considered further. Many of the solvents and decontamination chemicals potentially used at the NIF could be eliminated from further analysis on this basis (LLNL 2003d). In the end, one solvent (acetone) and one decontamination material (nitric acid) were selected to determine potential consequences.

Source Terms

The material from the spill was assumed to form a puddle on the ground that was subsequently allowed to evaporate. No mitigation was assumed. A minimum puddle depth of 1 centimeter was assumed, and the ambient temperature was assumed to be 95 degrees Fahrenheit ($^{\circ}$F). The evaporated material would be dispersed to the environment. Based on the quantity of material available to spill, material properties, and hazard level, the most severe spill could be determined. This spill would bound the other spill scenarios.

Mercury Release from Ignitrons

Electrical equipment in the NIF could contain castor oil in the capacitors, mercury in the preamplifier module (PAM) power conditioning units (PCUs), or ethylene glycol, a PAM coolant. Mercury is significantly more hazardous than the other materials. Therefore, a scenario involving mercury has been selected.

PCUs would support the PAMs located in the laser bays. There would be 48 PCUs. Each PCU would have four ignitron switches, and each ignitron switch would contain 0.018 liter (245 grams) of mercury. A scenario involving a single PCU (four switches) has been postulated to bound the mercury release from the facility. The initiator for this scenario would be an explosive failure of an ignitron switch.

Source Terms

The explosive release would be expected to create a spray of liquid droplets and a small quantity of vapor under this bounding scenario. Though the PCUs would be enclosed in a 6-millimeter-thick steel box, the explosion would produce enough energy to cause the failure of this enclosure. The liquid droplets would deposit in the immediate vicinity of the failed switch and form a puddle, while the vapor would remain airborne. No mitigation was assumed. To evaluate the impact of this event, two source terms were estimated:

- The airborne mercury was estimated using a release fraction of 0.01, based on DOE-STD-1027; this corresponds to a total of 9.8 grams of airborne mercury.
- The puddle from the four failed PCU switches in one PCU would consist of approximately 0.072 liter (0.98 kilograms) of mercury. Evaporation of the mercury was determined for a puddle depth of 5 millimeters, at an ambient temperature of 68°F. The vapor would then be released to the environment through the laser bay HVAC discharge point.

Aircraft Crash

The probability of a light aircraft crash impacting the NIF laser and target area building would be a credible event; the frequency of occurrence would be approximately 1.6×10^{-4} per year. Specific areas of concern from a release of material standpoint would be the tritium-handling and processing/decontamination areas and the laser bays. If the aircraft crashed into other areas of the laser and target area building, there would be facility damage, but the accident would not result in the release of hazardous material.

The NIF target bay is constructed of thick, reinforced concrete. The primary purpose of this construction is radiological shielding; however, as an additional benefit, the construction also makes the facility essentially impervious to impact by light aircraft. Should an aircraft crash into the target bay, the chief hazard would be to the occupants of the aircraft and any onsite personnel

in the way of falling plane wreckage and burning aviation fuel. The thickness of the reinforced concrete walls and roof are such that they would withstand the impact of a direct hit from a small aircraft. The switchyard is also constructed of reinforced concrete, a minimum of 0.61 meters thick. This area is also impervious to a light aircraft.

The roof of the laser bays and mechanical equipment area is steel deck with concrete fill, approximately 10 centimeters thick, and the exterior walls are metal siding. These areas would be vulnerable to damage from a small aircraft impact. There is a small possibility that an aircraft could impact PAM PCUs, different than the main PCUs located in the capacitor bays, and result in the release of mercury from the ignition switches. The PCUs would support the PAMs, which would be part of the preamplifier system that would provide laser energy gain to the low-level input pulse. The PCUs would be steel-framed boxes with 0.25-inch steel plate siding. The two laser bays would each house 24 PCUs, and each PCU would have four mercury-containing ignitron switches, for about 0.072 liters (0.98 kilograms) mercury total per PCU.

Only a small part of each laser bay's walls are actually exterior walls. Most of the laser bay walls are interior walls, adjoining the capacitor bays. Capacitor bays 1 and 4 would act as buffers between most of the laser bays and the exterior. A small aircraft crashing into an outer capacitor bay would not be expected to reach a laser bay. For an aircraft to reach a PAM PCU, a crash would have to occur either through the section of exposed laser bay wall (~150 feet for each laser bay) or through the laser bay roof. Penetration through the sidewalls of the laser bays and impacting a PAM would be extremely unlikely for a combination of reasons. First, the direction of the penetrating aircraft would have to be perpendicular to the normal flight path taken by aircraft in this area on approach to the Livermore Airport. Second, in addition to the direct protection the external capacitor bays would provide for the laser bay walls; they protrude and also would "shadow" or hide the exposed portion of the laser bay walls, considering the normal direction of travel of the aircraft, further reducing the available aircraft impact angle. Last, the 1.6×10^{-4} per year accident frequency pertains to the entire Laser and Target Area Building area. When the susceptible area (surface area of all 48 PCUs) is ratioed to the Laser and Target Area Building area, the accident probability is substantially reduced.

The roof of the laser bay would not provide much protection against a crashing airplane, but many obstacles would still stand between the plane and a PCU. Just below the roof is a layer of steel frames in the vertical, horizontal, and transverse directions. This layer would shear off the main body of the light aircraft and the fuel-filled wings. Because most of the mass of the light airplane is associated with the engine, it is this component of the plane that would cause the most damage. The engine would then have to pass through a series of barriers, including the beam transport system and a laser structural support system, comprising steel piping, steel reinforced concrete members, structural steel members, and concrete-steel composite members, before reaching a PCU. The aircraft engine must then penetrate the 0.25-inch steel panels of the PCU before damaging the set of ignitron switches. Consequently, a PCU located within a laser bay would not be affected by an aircraft crash, as these barriers would provide substantial protection.

Source Term

In the event such a remote incident would occur, only one PCU containing four switches, (0.072 liter or 0.98 kilograms of mercury, would be damaged. As there would be separation between the fuel in the wings and the aircraft engine upon impact with the roof, the spilled mercury would not be involved in a fire. The temperature of the mercury pool would be

approximately 90 degrees centigrade (^{o}C), to account for possible heat transfer from warm engine parts. This scenario would then result in the evaporation of spilled mercury.

Particulate Release (Earthquake)

Several accident scenarios could result in the release of material in particulate form. They would be a waste drumfire, a target chamber vacuum window failure, and a beyond-design-basis earthquake.

The beyond-design-basis earthquake would be identical to the one described in the radiological release, Section M.5.5.1. The airborne release fraction for this scenario would be 1×10^{-3} and the respirable fraction would be 1. The airborne release fraction is defined as the ratio of the airborne material to the material at risk, and the respirable fraction is defined as the fraction of airborne material that is in the respirable range, meaning the aerodynamic equivalent diameter is less than 10 microns. This scenario would be used as a bounding case to estimate the amount of material in particulate form that would be released to the environment. A waste drum fire and a target vacuum window failure would be bounded by the earthquake scenario because the source terms and associated release fractions would be bounded by the earthquake.

An airborne release fraction of 10^{-3} can be applied to the material in particulate form. This gives the quantity of material that would become airborne, as summarized in Table M.5.6.2.1–1. No mitigation was assumed.

M.5.6.2.2 *Proposed Action*

No new accident scenarios would be created as a result of the Proposed Action. However, the source term for the particulate release scenario would change. Several accident scenarios could result in the release of material in the particulate form. They would be a waste drum fire, a target chamber vacuum window failure, and a beyond-design-basis earthquake. Table M.5.6.2.2–1 lists the source terms for the chemical accident scenarios.

TABLE M.5.6.2.2–1.—*Potential Chemical Accident Scenarios – Proposed Action*

Accident	Source Term or Hazard
Materials spill	400 L nitric acid solution (70%) 210 L acetone
Mercury release from ignitrons	9.8 g mercury
Aircraft crash	0.072 L mercury (980 g)
Earthquake	0.02 g beryllium 0.1 g uranium

Source: LLNL 2003d.
g = gram; L = liter.

The beyond-design -basis earthquake would be identical to the one described in the radiological release section. This scenario would be used as a bounding case to estimate the amount of material in particulate form released to the environment. The waste drum scenario and vacuum window failure scenario would be bounded by the earthquake scenario because the associated release fractions would be equal to or less than the associated release fractions for the earthquake. The particulate materials that would be released in this accident scenario would be lithium hydride, beryllium, uranium, and thorium. Because of the low radiological effects of uranium and thorium, they were also examined from a toxicological standpoint. The accident consequences for these materials are listed in Table M.5.6.2.2–2, for median meteorological conditions, and Table M.5.6.2.2–3, for unfavorable meteorological conditions.

TABLE M.5.6.2.2–2.—*National Ignition Facility Chemical Accident Consequences (Median Meteorology)*

		Noninvolved Worker		Site Boundary		
ERPG-2[a] Concentration (ppm)	ERPG-3[a] Concentration (ppm)	Average Predicted Concentration (ppm)	Fraction of ERPG-2	Average Predicted Concentration (ppm)	Fraction of ERPG-2	ERPG-2 Distance (meters)
Release of nitric acid solution						
6	78	199	33.2	17.6	2.93	604
Release of Acetone						
8,500	8,500	279	0.033	279	0.033	11
Mercury release from ignitrons						
0.25	0.5	0.0153	0.0612	0.0098	0.0392	23
Aircraft crash release of mercury						
0.25	0.5	0	0	0	0	< 10
Earthquake release of lithium hydride[b]						
0.31	1.56	0	0	0	0	< 10
Earthquake release of beryllium[b]						
0.068	0.27	0	0	0	0	< 10
Earthquake release of thorium[b]						
5.27	26.37	0	0	0	0	< 10
Earthquake release of uranium[b]						
0.103	1.03	0	0	0	0	< 10

Source: LLNL 2003d.
[a] ERPG=Emergency Response Planning Guideline.
[b] Smaller amounts used for No Action and Reduced Action Alternatives.
ppm = parts per million.

TABLE M.5.6.2.2–3.—*National Ignition Facility Chemical Accident Consequences (Unfavorable Meteorology)*

		Noninvolved Worker		Site Boundary		
ERPG-2[a] Concentration (ppm)	ERPG-3[a] Concentration (ppm)	Average Predicted Concentration (ppm)	Fraction of ERPG-2	Average Predicted Concentration (ppm)	Fraction of ERPG-2	ERPG-2 Distance (meters)
Release of nitric acid solution						
6	78	394	65.7	31.8	5.3	1,100
Release of acetone						
8,500	8,500	552	0.065	552	0.065	30
Mercury release from ignitrons						
0.25	0.5	0.25	1.0	0.164	0.66	100
Aircraft crash release of mercury						
0.25	0.5	0	0	0	0	11
Earthquake release of lithium hydride[b]						
0.31	1.56	0.1076	0.35	0	0	58
Earthquake release of beryllium[b]						
0.068	0.27	0	0	0	0	44
5.27	26.37	0.00128	2.43×10^{-4}	0	0	< 10
Earthquake release of uranium[b]						
0.103	1.03	0.00262	0.025	0	0	16

Source: LLNL 2003d.
[a] ERPG=Emergency Response Planning Guideline.
[b] Smaller amounts used for No Action and Reduced Action Alternatives.
ppm = parts per million.

M.5.6.3 *Transportation Accident Scenarios*

Under the No Action Alternative, Proposed Action, and Reduced Operation Alternative, radioactive materials would be shipped to LLNL from Los Alamos National Laboratory, as depicted in Table M.5.6.3-1. For a transportation shipment to undergo an accident in which radioactive materials would be released and expose members of the public, a high-impact accident with fire (a Category 8 accident as described by NRC (1977a), would have to occur. Of the four materials being transported, an accident involving plutonium would result in the greatest consequences, 11 person-rem with 6×10^{-3} LCFs. Under the Proposed Action, the probability of such an accident would be 3.5×10^{-11} per year, which would not be credible. Lesser accidents could injure drivers and members of the public, but would not result in release of radioactivity.

Under the No Action and Reduced Operation Alternatives, a tritium accident would result in the greatest impact. The result of a tritium accident would be 0.4 person-rem and 2×10^{-4} LCFs. The probabilities of such an accident would be 5.2×10^{-11} per year under the No Action Alternative and 3.5×10^{-11} per year under the Reduced Operation Alternative.

TABLE M.5.6.3–1.—*Annual Radiological Shipments under the No Action Alternative, Proposed Action, and Reduced Operation Alternative*

	No Action	Proposed Action	Reduced Operation
Plutonium	No shipments	10 shipments of 6 grams each	No shipments
Highly enriched uranium	No shipments	10 shipments of 3 grams each	No shipments
Depleted uranium	5 shipments of 0.2 grams each	10 shipments of 5 grams each	3 shipments of 0.2 grams each
Tritium	15 shipments of 100 curies each	15 shipments of 100 curies each	10 shipments of 100 curies each

Source: LLNL 2003d.

M.5.6.4 *Laser Exposure Accident*

The NIF laser could present a variety of hazards to both personnel operating the laser and others through exposure to direct or reflected beams. Under all alternatives, the risk of a laser accident would be similar. This would be most likely to occur during maintenance and could result in permanent disabling injuries to the eyes or severe burns if a worker were exposed. The likelihood of such an accident is considered to be a low frequency potential due to the numerous preventive features including enclosed beams, physical barriers, shutters, interlocks on the laser system, run/safety switches, visible and audible alarms, protective eye equipment, access control, pre-shot sequence, physical sweep of the laser area, personnel accountability, operations procedures, and training.

M.6 REFERENCES

10 CFR Part 850 — DOE, "Energy, Chronic Beryllium Disease Prevention Program." *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

10 CFR §1021.314 — U.S. Department of Energy (DOE), "Energy, National Environmental Policy Act Implementing Procedures, Supplemental Environmental Impact Statements," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

40 CFR §1502.14[f] — Council on Environmental Quality (CEQ), "Protection of the Environment, Environmental Impact Statement, Alternatives Including the Proposed Action, Subpart f" *Code of Federal Regulations*, Office of the Federal Register, national Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

40 CFR §1502.16[h] — CEQ, "Protection of the Environment, Environmental Consequences, Subpart h, "*Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

40 CFR §1502.22[b][4] — CEQ, "Protection of the Environment, Environmental Impact Statement, Incomplete or Unavailable Information, Subpart b, 4" *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

42 U.S.C. §4321 et seq. — "National Environmental Policy Act, " *United States Code*, Title 42, Chapter 55, Sec. 4321 through 4347, Revised January 22, 2002.

61 FR 68014 — DOE, "Record of Decision Programmatic Environmental Impact Statement for Stockpile Stewardship and Management," *Federal Register*, Vol. 61 Pgs. 68014-68026, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, December 26, 1996.

Crandall 2002 — Crandall, David H., Letter from David Crandall, National Nuclear Security Administration, Deputy Administrator for the Defense Programs Proposal to Everet H. Beckner, Deputy Administrator for Defense Programs, dated November 21, 2002, regarding the proposal to use certain materials in the NIF; plutonium, other fissile materials, fissionable materials, and lithium hydride, Washington, DC, 2002.

DOE 1993a — DOE, *Justification of Mission Need, National Ignition Facility, Key Decision Zero Documentation*, U.S. Department of Energy, 1993.

DOE 1996b — DOE, *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, Summary, Vols. 1-4, DOE/EIS-0236, Washington, DC, September 1996.

DOE 1997a — DOE, *Mitigation Action Plan for the National Ignition Facility*, U.S. Department of Energy, February 1997.

DOE 1998c — DOE, *Supplement Analysis for Use of Hazardous Materials in NIF Experiments*, CA, DOE/EIS-0236-SA2, U.S. Department of Energy, Oakland Operations Office, Oakland, March 13, 1998.

DOE 2001e — DOE, Letter from DOE/NNSA to the LLNL Associate Director of NIF, dated 2001, requesting that a consolidated technical recommendation be developed by the three NNSA weapons laboratories, 2001.

DOE 2001f — DOE, *NIF Final Supplemental Environmental Impact Statement to the Stockpile Stewardship and Management Programmatic Environmental Impact Statement*, Vol. 1, DOE/EIS-2036-S1F, U.S. Department of Energy, Oakland Operations Office, CA, January 2001.

DOE 2001h — DOE, High Energy Density Physics Study Report, A Comprehensive Study of the Role of High-Energy Density Physics in the Stockpile Stewardship Program, U.S. Department of Energy, National Nuclear Security Administration, Washington, DC, April 6, 2001.

DOE O 5400.5 — DOE, *Radiation Protection of the Public and Environment, Change 2*, Washington DC, 1993.

Gordon 2001 — General Gordon, John A, Letter from General Gordon, DOE/NNSA, to Dennis J. Hastert, Speaker of the House of Representatives, dated April 6, 2001, regarding the Certification to Congress on the Importance of NIF in the Stockpile Stewardship Program, 2001.

LLNL 1998h — LLNL, *National Ignition Facility Pollution Prevention and Waste Minimization Plan*, UCRL-AR-131194; NIF-0010575, Lawrence Livermore National Laboratory, Livermore, CA, September 1, 1998.

LLNL 2001ad — LLNL, *Environmental Safety and Health Manual, Implementation of the Chronic Beryllium Disease Prevention Program Requirements*, Vol. 2, Document 14.4, Lawrence Livermore National Laboratory, Livermore, CA, August 1, 2001.

LLNL 2002ae — LLNL, *Environment, Safety & Health (ES&H) Manual, Environment, Controls and Hazards, Discharge to Air*, Vol 3, Part 31, UCRL-MA-133867, Lawrence Livermore National Laboratory, Livermore, CA, September 16, 2002.

LLNL 2002h — LLNL, C*omprehensive Site Plan*, LLNL-0062, Lawrence Livermore National Laboratory, Livermore, CA, September 17, 2002.

LLNL 2002cc — LLNL, *2001 Site Annual Environmental Report (SAER) for LLNL*, UCRL-50027-01, Lawrence Livermore National Laboratory, Livermore, CA, September 1, 2002.

LLNL 2002dl — LLNL, Plant Engineering, *Electricity Recharge Composite Rates/Annual Energy Consumption, FY 90 - FY 02 and Electrical Energy Consumption Estimates, FY 01-FY 09*, Lawrence Livermore National Laboratory, Livermore, CA, September 10, 2002.

LLNL 2003d — LLNL, *NIF Project Input for Assessment of Environmental Impacts of NIF for the Site-wide Environmental Impact Statement*, UCRL-TR-155675, Lawrence Livermore National Laboratory, Livermore, CA, October, 2003.

LLNL/NIF 1997a — Lawrence Livermore National Laboratory/National Ignition Facility (LLNL/NIF), Letter from Jeff Latkowski, dated September 8, 1997, regarding the *NIF Auxiliary Shielding Plan*, NIF REF. 0013424, Lawrence Livermore National Laboratory, Livermore, CA, 1997.

LLNL/NIF 1997b — LLNL/NIF, Letter from Jeff Latkowski and Mike Singh, dated September 8, 1997, regarding the *Measurement and Retrofit Plan for NIF Shielding*, NIF REF. 0003376, Lawrence Livermore National Laboratory, Livermore, CA, 1997.

LLNL/NIF 2001 — LLNL/NIF, *Decontamination and Decommissioning Plan, Fiscal Year 2001 Update*, NIF-0071441, Lawrence Livermore National Laboratory, Livermore, CA, 2001.

LLNL/NIF 2002a — LLNL/NIF, Letter from George Miller, Director NIF-LLNL to Dr. David H. Crandall, Assistant Deputy Administrator for Research, Development, and Stimulation Defense Programs, NNSA, dated September 30, 2002, regarding the *Tri-weapons Laboratory Recommendation*, Lawrence Livermore National Laboratory, Livermore, CA, 2002.

LLNL/NIF 2002b — LLNL/NIF, Letter from George Miller, Director NIF-LLNL to Dr. David H. Crandall, Assistant Deputy Administrator for Research, Development, and Stimulation Defense Programs, NNSA, dated September 30, 2002, regarding the Classified Annex to the *Tri-weapons Laboratory Recommendations*, Lawrence Livermore National Laboratory, Livermore, CA, 2002.

NAS 2003a — National Academy of Sciences (NAS), *Frontiers in High Energy Density Physics*, National Academy of Sciences, National Research Council, Washington, DC, 2003.

NAS 2003b — NAS, *Connecting Quarks with the Cosmos*, National Academy of Sciences, National Research Council, Washington, DC, 2003.

NCRP 1993 — National Council on Radiation Protection (NCRP), *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, National Council on Radiation Protection and Measurements, Bethesda, MD, 1993.

NRC 1977a — Nuclear Regulatory Commission (NRC), *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes*, Vol. 1, NUREG-0170, Nuclear Regulatory Commission, Rockville, MD, December 1977.

Reis 1994 — Reis, Victor H., Memorandum from Victor H. Reis to the Secretary of Energy, dated October 1994, regarding the *Key Decision One Approval for the National Ignition Facility*, 1994.

Reis 1997 — Reis, Victor H. Memorandum from Victor H. Reis, to the Energy Systems Acquisition Advisory Board, dated 1997, regarding the *Critical Decision 3*, 1997.

Richardson 2000 — Richardson, Bill, Congressional Certification Letter from Bill Richardson, Secretary of the U.S. Department of Energy, to Senator Pete V. Domenici, dated September 14, 2000, regarding the NIF Project, Washington, DC, 2000.

SNL 2000 — Sandia National Laboratory (SNL), *RADTRAN5 User Guide*, SNAD2000-1257, Sandia National Laboratories, Albuquerque, NM, May 2000.

USDCDC 1998 U.S. District Court for District of Columbia (USDCDC), *Memorandum Opinion and Order, NRDC v. Pena v. Civil No. 97-936 (SS) (D.D.C),* Washington DC, August 19, 1998.

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APPENDIX N: INTEGRATED TECHNOLOGY PROJECT

N.1 PURPOSE AND NEED FOR AGENCY ACTION

The U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA) is the Federal Agency responsible for providing the U.S. with nuclear weapons and ensuring that those weapons remain safe and reliable. The Stockpile Stewardship Program comprises the activities associated with research, design, development, and testing of nuclear weapons, as well as the assessment and certification of their safety and reliability.

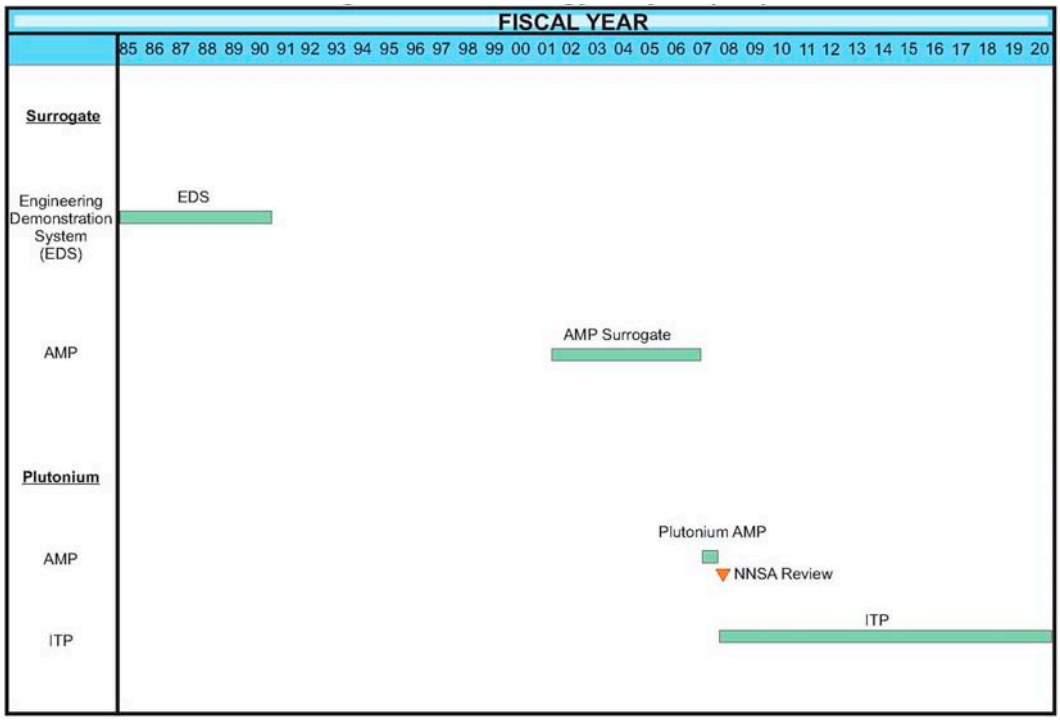
NNSA expects existing weapons to remain in the stockpile for decades. Accordingly, the effect of the aging process on weapon reliability is a critical area of research. In the past, weapons certification and reliability were demonstrated through underground nuclear tests of nuclear weapons. With this option no longer available, alternatives to underground weapons testing have been developed to verify the safety and reliability of the aging weapons. The Science-Based Stockpile Stewardship and Management Program (SBSSMP) includes both analytical and experimental components. The goal of the Accelerated Strategic Computing Initiative (ASCI), for example, is to model weapons and weapons physics analytically. The experimental effort consists of a wide range of tests, including small-scale constitutive experiments, subcritical experiments, and dynamic experiments. The goal of these experiments is to better understand both the physics of nuclear weapons as well as their ability to meet specified military requirements.

SBSSMP experiments are needed to increase the understanding of the complex physics and behavior of materials during a nuclear explosion and ultimately to certify the efficacy of the Nation's aging stockpile. Accurate, theoretical, scientific, and experimental data are required to validate the computer models of the weapon performance. SBSSMP experiments involve the use of both surrogate and actual materials that would be used in the weapon system.

In 2000, the Office of Defense Programs (DP) determined that there was a need for augmentation of the current inventory of special nuclear materials (e.g., plutonium, enriched uranium) to support the Stockpile Stewardship certification activities. DP directed that the Atomic Vapor Laser Isotope Separation[1] (AVLIS) capabilities be made available for use and the AVLIS facilities be maintained in a state of readiness. Lawrence Livermore National Laboratory (LLNL) responded with a proposal for the development of a low-level AVLIS effort to foster the technology and ensure that critical skills were not lost (LLNL 2000v). This effort, known as the Advanced Material Program (AMP), was designed to develop and retain the necessary AVLIS equipment and skill set through a series of enrichment demonstrations of the technology.

[1] A laser isotope separation technique based on small atomic spectroscopic differences to selectively ionize one isotope over another.

The purpose of the Integrated Technology Project (ITP) is to apply AMP-demonstrated technology to support augmentation of special nuclear materials for SBSSMP experiments. The mission need is discussed in an NNSA classified reference to this appendix (NNSA 2003c). NNSA would minimize development of new infrastructure by using existing facilities, inventories of plutonium, and existing technologies of sufficient flexibility to accommodate different plutonium feed stocks. The proposed timeline for the AMP and ITP is shown in Figure N.1–1.



Source: Original.
Note: EDS, the Engineering Demonstration System, is discussed in Section N.2.2.

FIGURE N.1–1.—*Proposed Advanced Material Program Integrated Technology Project Timeline*

N.2 PROJECT OVERVIEW

This chapter discusses the basic science, AVLIS technology background and process of laser isotope separation. This discussion is intended to provide the reader and decisionmaker with enough information and perspective to evaluate the alternatives presented in Chapter 3 of the LLNL SW/SPEIS.

N.2.1 Isotopes and Isotope Separation

Separated isotopes of different elements are needed for many purposes, including nuclear reactors, weapons, power supplies for space probes, medicine, and research. While different isotopes of an element have different weights and different nuclear properties, they have nearly identical chemical properties. They react to chemicals in the same manner, and melt and boil at essentially the same temperature. Therefore, except for the lightest elements, it is difficult to separate the isotopes from one another using normal industrial means. Instead, isotope separation techniques have been developed that isolate the different isotopes based on their slight mass-dependent differences.

The AVLIS technology is based on the small atomic spectroscopic differences to selectively ionize, or remove electrons, from one isotope over another. The electron energy states of any atom are very precisely defined and depend slightly on its atomic weight. Therefore, the electron energy states of one isotope will differ slightly from that of another isotope of the same element. These different electron energy states of each isotope correspond to unique laser light absorption characteristics. When the correct frequency (or frequencies) of precisely tuned laser light hits an atom of the desired isotope, the atom absorbs the energy and loses an electron. The loss of the negatively charged electron leaves the atom, now an ion, with a positive charge. The isotopically selected positive ions can be separated from the rest of the uncharged or neutral isotopes by the application of an electrical field. In summary, the AVLIS technology involves the separation of isotopes by selectively ionizing the isotopes of choice, then separating the ions with an electromagnetic field.

N.2.2 AVLIS Technology Background

During World War II, the U.S. developed large-scale isotope separation capabilities to produce enriched uranium. The legacies of this effort are the gaseous diffusion plants at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. In the 1970s, the U.S. initiated a program to develop the advanced gaseous centrifuge technology as the next step in uranium isotope enrichment. The U.S. also supported the development of other approaches to uranium isotope separation. After intensive review and competition between these programs in the 1980s, the AVLIS technology developed at LLNL was chosen as the only advanced uranium enrichment technology program in the U.S.

Research on the AVLIS technology began at LLNL in the early 1970s and has been ongoing ever since. The practical development of the AVLIS technology at LLNL has required a major engineering effort over two decades. The original goal of the work on the AVLIS technology at LLNL was to develop a safe, environmentally acceptable, and cost-effective means of separating isotopes of uranium.

As the scientific and technical feasibility of using the AVLIS technology to separate uranium isotopes became clear in the 1970s, scientists at LLNL successfully demonstrated the scientific approach to separating isotopes of plutonium. In a peer review competition in 1983, the AVLIS technique was selected as the Nation's technology for plutonium isotope enrichment to convert DOE's fuel-grade plutonium to weapon-grade. A scientific and engineering development program for the AVLIS technology, the Special Isotope Separation (SIS) Program, was carried out at LLNL during the 1980s. This program was directed toward the proposed construction and operation of an AVLIS plutonium separation plant at one of the DOE nuclear materials sites.

As part of the LLNL program, the Engineering Demonstration System (EDS) was designed and built in the Building 332 Plutonium Facility within the Superblock to perform demonstration experiments using the AVLIS technology for providing design process data for the future plant process lines for SIS. Control equipment, optical equipment, equipment frameworks, gloveboxes, utilities, and beamtubes were installed in Building 332 as part of the EDS (Figure N.2.2–1). Successful experiments were conducted in EDS using selected lanthanides as surrogate materials in a series of demonstration experiments.

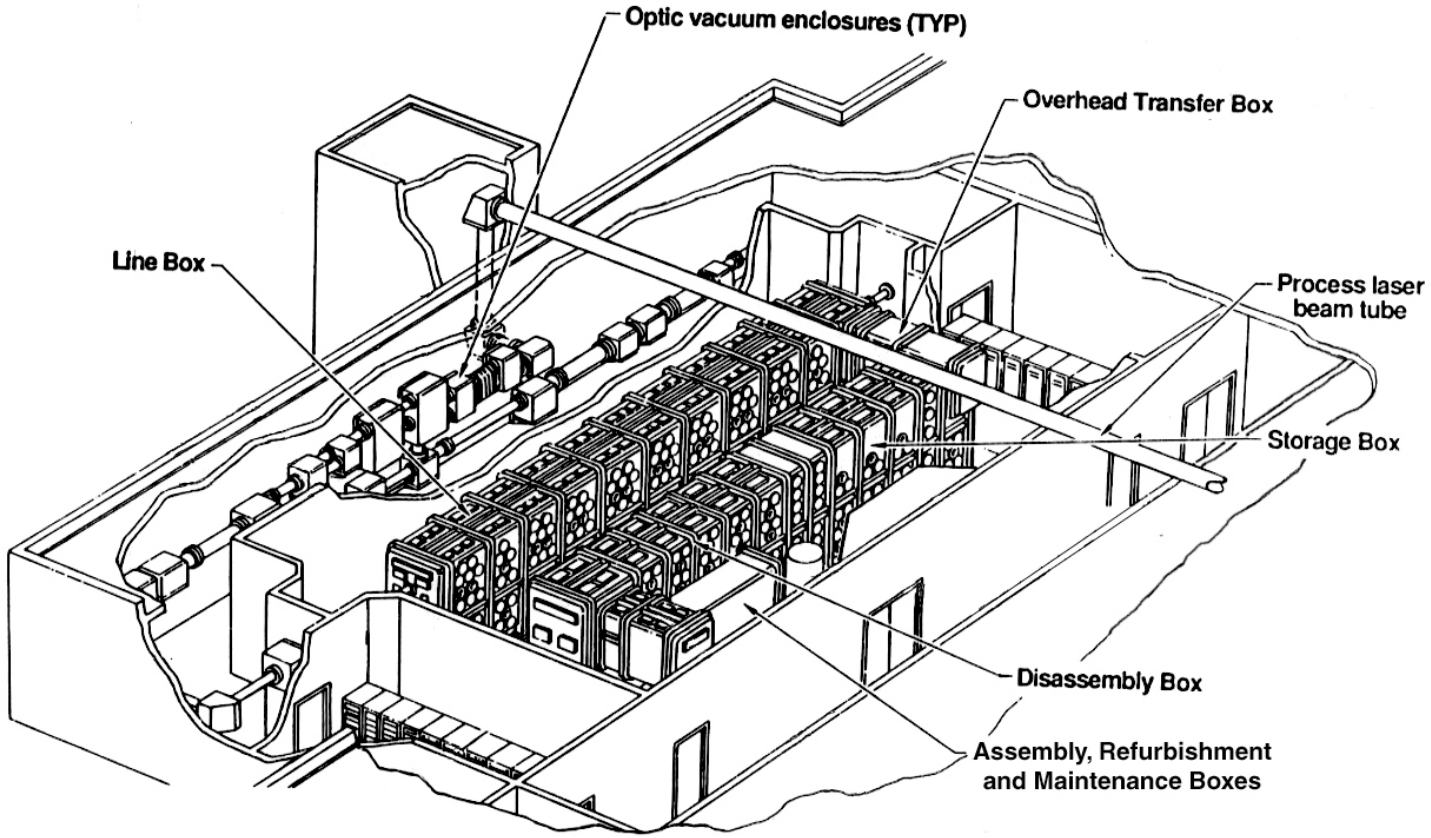
An Environmental Assessment (EA) was issued in 1990 (DOE/EA-0421) (DOE 1990d) on the Proposed Action to assess resuming the use of the AVLIS technique with nonradioactive, nonhazardous surrogate metals in anticipation of any additional demonstration activities that might have been needed to verify the SIS facility design.

In 1990, the Secretary of Energy announced a decision to indefinitely postpone construction of the SIS plutonium production plant being proposed for construction. The SIS Program at LLNL was closed out and the equipment was placed in standby, with the glovebox de-inventoried and the EDS cleaned of surrogate materials.

The basic equipment associated EDS (e.g., glovebox racks, ventilation equipment, power leads) are still mostly intact. A large fraction of the skilled personnel who worked on the EDS project are still employed at LLNL, although many have retired or would soon be eligible for retirement.

The Finding of No Significant Impact (FONSI) for the EDS EA (DOE 1990b) stated that the resumption of EDS tests using surrogate materials simulating plutonium characteristics would allow minimizing the scope of, and defining the manner in which EDS tests for SIS using plutonium would proceed, if DOE were to pursue such operations in the future. In the FONSI, DOE committed that any proposed plutonium operations associated with the EDS would require preparation of an Environmental Impact Statement (EIS) and issuance of a Record of Decision. Experiments were run using nonradioactive surrogate materials only.

In 2002, NNSA determined that the AMP is included within the bounds of the scope and impacts of the *Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories* (LLNL 1992a) and the *Supplemental Analysis for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories* (DOE 1999a). AMP would use the LLNL AVLIS technology to conduct a series of limited laser isotope separation experiments on plutonium (and nonradioactive surrogates of plutonium), utilizing the newly built solid state laser systems (DOE 2002o).



Source: Adapted from LLNL 1988a.

FIGURE N.2.2–1.—*Engineering Demonstration System Equipment Layout*

N.2.3 Process Description

The AVLIS process uses precisely tuned laser light to ionize a specific isotope or isotopes within a vapor of mixed isotopes. Once ionized, the desired isotope is separated from the other isotopes by attracting it to an electrically charged plate. The process can also be operated so that the unwanted isotopes are ionized and extracted, leaving the desired isotope. The choice between the two methods depends on the desired isotope and the mixture of the isotopes in the feedstock, but usually the minor species are ionized.

The mass balance aspects of separating isotopes using the AVLIS technology involve several steps. These steps include preparation of the feed material, separation of the isotopes, and processing of the separated isotopes.

N.2.3.1 *Preparation of Feed Material*

The isotope separation process discussed in this document requires feed material in the form of metal spheres that each weigh about 300 grams. The preparation of the feed material is dependent upon the chemical form of the feedstock. If the feedstock has other elements present or is not in the metallic form, it must undergo chemical purification and/or conversion to metal. Once produced, the metal feed material is fashioned into the spheres required for use in the separator unit.

N.2.3.2 *AVLIS Technology*

The separation of isotopes using lasers relies on the differences in the light absorption characteristics of the individual isotopes. The isotope separation process consists of two basic systems: the laser system and the separator system (Figure N.2.3.2–1).

N.2.3.2.1 *Laser System*

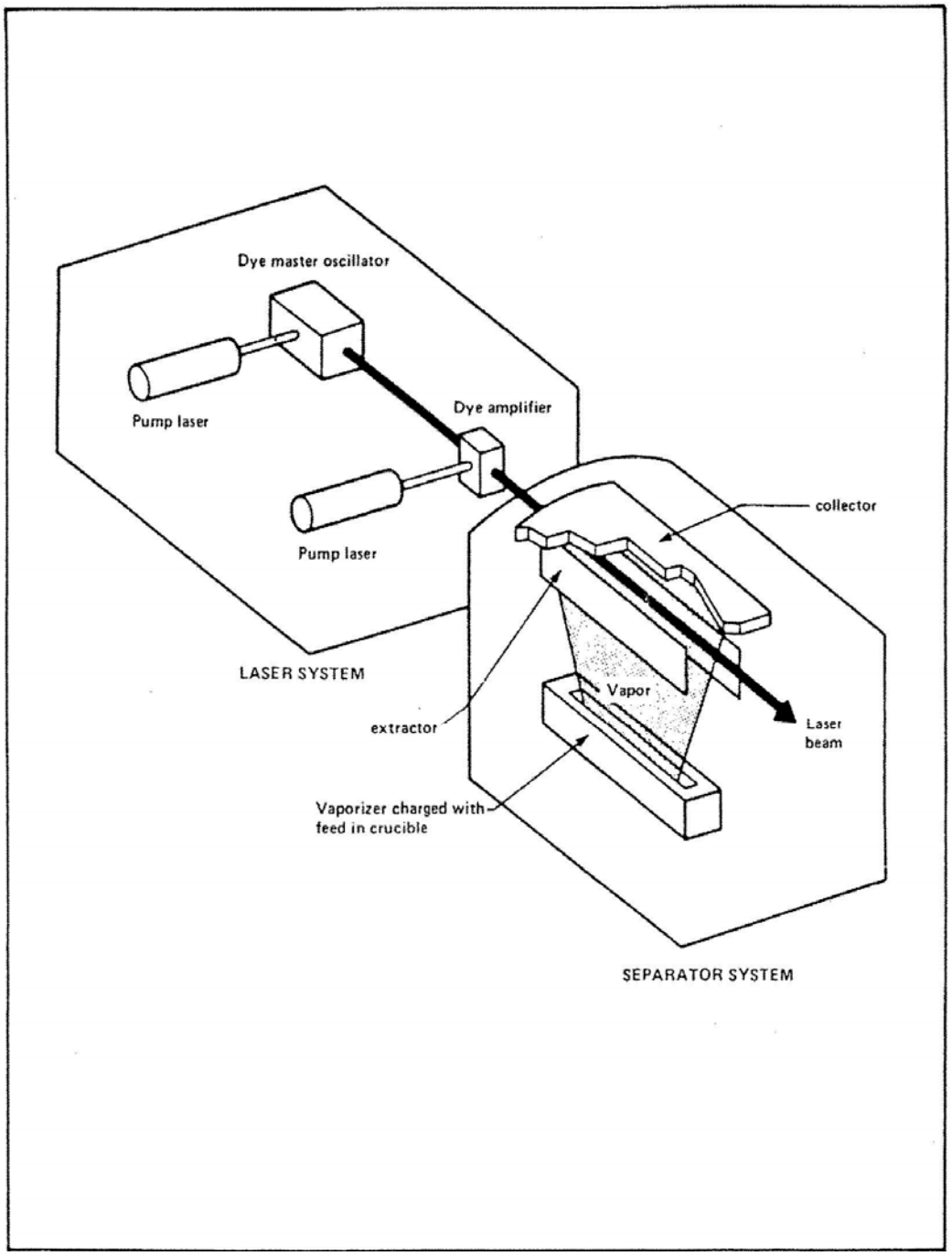
The laser system uses pumped dye lasers to produce the precisely tuned light at the frequencies required to ionize the desired isotopes in the separator vapor stream. The construction of the laser system is described in Section N.3.1.1.

Laser Instrumentation and Control Subsystem

The laser instrumentation and control subsystem measures all parameters and directly controls all laser functions. Local control is usually provided at the workstation level, while integrated remote control systems allow for supervisory control during operations.

N.2.3.2.2 *Separator System*

In the separator unit, the metal feed is vaporized from a crucible by an electron beam heat source. The stream of atomic vapor moves upward from the crucible where it is illuminated by the precisely tuned laser beams. The lasers supply light at the exact frequencies to ionize the desired isotope(s) in the vapor stream. The ionized isotope(s) is attracted to the electrically charged plates (extractor plates) at the sides of the separator (Figure N.2.3.2–1). The remaining neutral isotopes in the vapor stream continue upward between the charged plates and condense on an uncharged plate (collector plate) at the top of the separator unit.



Source: Adapted from LLNL 1988a.

FIGURE N.2.3.2–l.—*Schematic of AVLIS System*

Usually, the minor isotope(s) is ionized and collected at the charged plates. The non-ionized vapor stream, depleted of the minor ionized isotope, deposits on the uncharged plate overhead. The minor isotope is often the desired isotope and is called the product, whereas the neutral vapor collected on the overhead plate is called the byproduct.

In other cases, the minor isotope is an impurity. In these cases the extracted material is the byproduct and the collected material is the product. The same laser system could be tuned to ionize either. The process parameters and the logistics of the particular separation run are tailored to the specific feed material and mission requirements.

Separator Equipment

A separator unit, in which the laser light and vapor interact to provide the separation of isotopes, consists of a feeder mechanism, vaporizer assembly, charged extractor plates, and an uncharged collector plate. The separator unit is placed within a vacuum chamber. Associated utilities include cooling systems, power supplies, vacuum pumps, and Instrumentation and Control equipment.

N.2.3.3 *Processing of Separated Isotopes*

After the material has undergone isotope separation, the collector and extractor plates undergo chemical processing to remove the separated isotopes that are in the metallic form. As discussed above, the desired isotope (product) may be on either the extractor plates or the collector plate with the other plate(s) containing the remaining isotopes (byproduct).

N.3 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

Since the closeout of the SIS, laser technology in general has continued to advance. The AMP at LLNL is a research and development project that began in 2001 to conduct a series of laser isotope separation demonstrations on surrogate materials and, on a limited basis, plutonium utilizing modern laser hardware. Under the No Action Alternative, the AMP would continue through completion. As part of the AMP, new lasers would be built and deployed and a separator unit would be installed in the Superblock. At the conclusion of the AMP, the equipment would be placed in cold standby.

Under the Proposed Action, the AMP would continue through completion. However, instead of placing the equipment in cold standby the equipment developed under the No Action Alternative would be used to process sufficient amounts of material as required by the broader SBSSMP objectives. This proposed project is called the ITP.

Under the Reduced Operation Alternative, the AMP would be discontinued and would not be completed.

The ITP alternatives evaluated in this document make the following bounding assumptions:

- An annual feedstock throughput of 100 kilograms of plutonium over the life of the system (20 years) for the Proposed Action, with a representative isotopic assay, was chosen to both define and bound the human health and environmental impacts for this analysis. Alternate feedstocks and throughput would be bounded by these quantities.
- The AMP and ITP separation operations would be located in the room within Building 332, where the EDS operations took place, using some of the existing legacy equipment and

installed utilities. Alternative rooms and equipment could also be used; however, the analysis here is based on the present EDS location and bounds the environmental impacts of the separation operations. Alternative rooms and equipment arrangements would be designed to remain within the bounds of the environmental impact of the present EDS location.

N.3.1 No Action Alternative

Under the No Action Alternative, the AMP would be completed with the following three phases: (1) construction and installation of modern laser technology capable of separating isotopes, (2) the separation of isotopes of surrogate materials, and (3) separation of limited plutonium quantities with the newly built hardware. The AMP would utilize existing laboratories, facilities, and capabilities primarily in Buildings 161, 332, and 335.

N.3.1.1 *Construction of Laser System*

The pump lasers used for the SIS Program employed copper vapor. Since the closeout of SIS, laser technology has continued to advance. Today's pump lasers are much more efficient and involve lesser use of hazardous chemicals. The first phase of the AMP involves the construction of modern solid state (Class 4) laser systems that pump the precisely tuned dye lasers used to separate isotopes.

The construction and testing of the new solid state lasers would take place in Building 161. The expected efficiency of the new solid-state pump lasers would be greater than the copper vapor laser technology. Therefore, less electrical power, equipment, space, and material usage would be required. The solid state lasers would not use hazardous chemicals.

Once built and tested, the pump lasers would be used to excite the tunable recirculating organic dye lasers. The dye solutions for the dye lasers would be prepared from a variety of dyes dissolved in alcohol in specific concentrations. The dyes are chemically distinct but have similar physical properties.

The dyes are stored in powder form in glass or plastic containers until needed. The dyes would vary, but all are likely carcinogenic or mutagenic. Rhodamine 6G (R6G), is a commercially available dye within this family chemically similar dyes and has a material safety data sheet specifying its hazards. The dyes would be mixed with an alcohol, such as ethyl, isopropyl, and methyl alcohols. A dye laser would use, at most, 15 liters of organic dye solution. The mixed dye would be stored in glass or plastic containers labeled as to the contents, concentrations, and appropriate warnings. The powders and mixed laser dyes would be stored in designated chemical storage cabinets. Total estimated use for the AMP is 60 liters of dye mixture. Disposal of the spent dyes would be in accordance with LLNL hazardous waste disposal requirements.

N.3.1.2 *Separation of Isotopes of Surrogate Materials*

In the second phase of the AMP, the complete laser system would be used to demonstrate the separation of isotopes of surrogate materials. The surrogate materials are nonradioactive rare-earth elements in the lanthanide series. This phase would allow for the certification of fieldable hardware and for validation of the process physics models. The separation experiments and the chemical processing of the surrogate feed material and processed isotopes would take place in Building 161 and would not involve radioactive materials.

Initially, several runs of 10 to 20 hours would be conducted to calibrate and test the separator hardware and laser systems. Subsequently, up to six experimental runs separating isotopes of the surrogate materials would be performed. Each run would last up to 200 hours. After the experimental runs, the separated material would be processed for recovery. The surrogate materials would be chemically recovered in nonnuclear facilities at LLNL through dissolution in a hydrochloric acid bath.

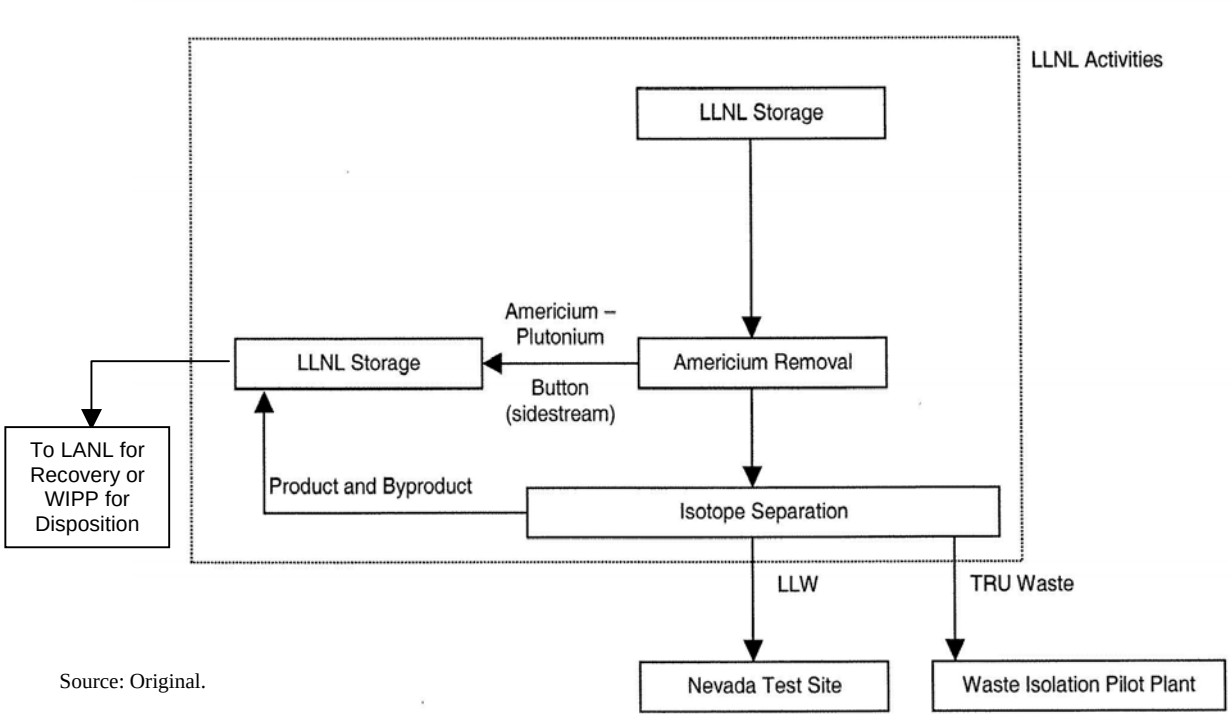
N.3.1.3 *Separation of Plutonium Isotopes*

After the experiments using surrogate materials are complete, the third phase of the AMP would begin. In the third phase, the equipment and work would be relocated to Building 332 and Building 335. The process lasers would be relocated from Building 161 to Building 335, which has existing space, utilities, and laser system support structures still in place from the SIS Program. Building 335 is separate from Building 332 where plutonium is handled and stored. The process light beams would be combined for transport through an evacuated beam tube to Building 332, where the separators would be installed.

The experiments in Building 332 would initially use surrogate material, in the same manner as the experiments performed in Building 161, to recalibrate the equipment and establish baseline operating parameters. Subsequently, several small runs of 10 to 20 hours with plutonium feed material would be conducted to calibrate and test the separator hardware and laser systems for the parameters to separate isotopes of plutonium. Once the equipment has been recalibrated, two to four plutonium isotope separation demonstration runs would be performed processing up to 4 kilograms. Each run would last up to 200 hours. The chemical processing of the feed material, handling of the isotope separation process, and the chemical processing of the separated isotopes would be different for experiments using plutonium than those for surrogate materials. Certain existing techniques, procedures, and equipment in Building 332 would be used for plutonium. The preparation of the plutonium feed material, separation of the isotopes, and processing of the product and byproduct that are associated with the AMP are discussed below.

N.3.1.3.1 *Preparation of Feed Material*

Plutonium already stored at LLNL would be used as the feed material for the third phase of the AMP. There would be no offsite transportation of plutonium associated with the AMP (Figure N.3.1.3.1–1). The plutonium feedstock would be chemically purified and cast into the proper feed form in the Materials Processing Laboratory of Building 332. The chemical processing of the plutonium would use the existing gloveboxes, equipment, and personnel in the Materials Processing Laboratory. Similar work with plutonium is currently performed in this room for other projects. For the separation of plutonium isotopes, the feedstock is often in powdered oxide form and contains varying amounts of americium as a result of radioactive decay. Therefore, the feedstock must be converted to plutonium metal, the americium removed, and the purified plutonium cast into the appropriate feed form.



Source: Original.

FIGURE N.3.1.3.1–1.—*Material Flowchart for the Advanced Materials Program*

Metal Conversion (Direct Oxide Reduction)

First the plutonium oxide feedstock (containing a small amount of americium oxide) is converted to metal. In metal conversion, the oxide powder is heated, or calcined, to remove any residual absorbed water and other volatile materials. Then the oxide is reduced to metal through direct oxide reduction. This is a one-step conversion process in which the oxide reacts with calcium metal to produce metal. A molten-salt mixture dissolves the reaction byproduct, calcium oxide, allowing the plutonium (and americium) metal to coalesce. The reaction takes place in a glovebox furnace designed for pyrochemical operations. The salt is then physically separated from the plutonium metal. If required, the metal is transferred to the next process step of americium removal. The salt resulting from the direct oxide reduction step contains a small amount of plutonium. The residue salt containing this plutonium is regenerated by bubbling hydrogen chloride or chlorine through the dissolved salt. The dissolved calcium oxide is converted to calcium chloride with oxygen released to the glovebox exhaust. The residual plutonium is converted to plutonium chloride or Cs_2PuCl_6 that is reduced back to metal during the next direct oxide reduction.

Americium Removal (Molten-Salt Extraction)

A molten-salt extraction process is used to remove the americium from the feedstock. In the molten-salt extraction process, plutonium metal is put in contact with a molten salt mixture containing a small amount of plutonium chloride or Cs_2PuCl_6, which is supplied from a sidestream. The plutonium chloride or Cs_2PuCl_6 selectively converts the americium to americium chloride, and after cooling, the americium chloride containing salt is separated from the plutonium metal. The plutonium metal is then sent to feed casting.

Residual americium chloride and plutonium chloride in the residue salt are reduced to a metal alloy during a salt scrub process. In the salt scrub process, the residue salt is heated to a molten state and then similar to direct oxide reduction, calcium metal is used to reduce the actinide chlorides to americium and plutonium alloyed metals and producing a calcium chloride salt (reaction byproduct). Because of the differences in density, the alloy and salt are easily separated once cooled. The calcium chloride salt can be discarded as transuranic waste or recycled after being regenerated. The americium/plutonium metal button (americium/plutonium button) would be stored for future transport to a facility for further plutonium recovery and disposition of the americium, or sent to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

Feed Material Casting

After the americium has been removed from the plutonium metal, the plutonium metal is melted and cast into the spheres needed for the separators. These so-called feedballs would be loaded into a carousel that would be placed into the separator unit.

Some plutonium metal would be left over in the casting melt crucible called a skull. The plutonium skull from casting would be recycled by hydriding the plutonium, chlorinating the plutonium hydride, and using the resulting plutonium chloride as the sidestream input to the molten-salt extraction process described under americium removal.

N.3.1.3.2 *Separator System*

Installation of Equipment

The separators and support equipment would be installed in Building 332 in the room where the EDS is located. The legacy EDS mechanical structures, glovebox frames, utilities, and beam tubes are still in place. The EDS was comprised of the Line Box, a large glovebox with eight separator stations in line with the laser beam with the storage capacity for an additional eight separators. The upper part of the Line Box also contained the various vacuum, cooling system, power conditioning, and instrument support equipment. The lower portion of the Line Box housed a transport system used to move the separator units between stations and the other gloveboxes. A separator refurbishment station; a separator disassembly station; and two assembly, re-supply, and maintenance boxes (Box A and B) comprised the remainder of the EDS (Figure N.2.2–1).

The AMP may convert the assembly, resupply, and maintenance boxes at the east end of the legacy EDS equipment, to a separator station and one separator refurbishment station (Figure N.2.2–1). The central part of maintenance Box A contains a test chamber in the upper half of the box that is nearly identical to the vacuum chambers in the EDS Line Box. The test chamber would be replaced with a separator chamber. Laser beam ports and vapor control ports would be added. Assembly, resupply, and maintenance Boxes A and B would be radiologically isolated

from the rest of the EDS line. Assembly, resupply, and maintenance Box B would undergo minor changes to serve as the refurbishment glovebox, where the separated isotopes would be removed from the separator and new feed material added. One separator unit left over from the EDS would be used in these experiments. The remainder of the EDS equipment would remain inactive.

Separation of Isotopes

The carousel loaded with plutonium metal feedballs from the Materials Processing Laboratory would be attached to the separator unit. In the separator unit, the plutonium metal feedballs would be fed, as needed, from the carousel into a heated side arm where they melt and the molten plutonium pours into a crucible. In the crucible, the molten plutonium would be further heated by an electron beam causing it vaporize and move rapidly upward through the laser beam(s). The laser light selectively ionizes different plutonium isotopes. The ionized plutonium isotopes are separated from the remaining isotopes by their attraction to electrically charged plates.

N.3.1.3.3 *Processing of Separated Isotopes*

After the plutonium has undergone isotope separation, the collector and extractor plates would be processed in the Materials Processing Laboratory to remove the separated isotopes. The separator plates and other components would be processed for plutonium recovery, hydriding the plutonium and collecting the resultant powder. The process depends on the composition and size of the plates. The plutonium hydride from the product and byproduct would be either converted back to plutonium metal or oxide powder for storage.

The separator plates and other components containing the product and byproduct metal would be processed in existing gloveboxes and equipment in Building 332. The chemical processing of the amounts of feed material and separated isotopes to be used in AMP fall within the current levels of chemical processing capacity of Building 332 at LLNL. No major changes in existing gloveboxes would be required to provide this support.

N.3.1.3.4 *Transportation*

There would be no offsite transportation of plutonium feed material, byproduct, or product associated with the AMP.

N.3.2 Proposed Action

The Proposed Action for ITP is to utilize the separation system (composed of the separator and laser subsystems) described under the No Action Alternative in Section N.3.1, to process different feedstocks of plutonium for use in Stockpile Stewardship Program experiments (see Chapter 1 of the LLNL SW/SPEIS). Any decision to proceed with the Proposed Action is subject to the successful performance of the AMP demonstration and a determination of Program need. Under the Proposed Action, the amount of material that would be processed, up to 100 kilograms of plutonium per year, would be considerably greater than the 4 kilograms per year processed under the AMP (No Action Alternative). The changes to the AMP equipment and the Materials Processing Laboratory operations are described below. Some changes to existing Material Processing Laboratory operations, some reactivation of old equipment, and a greater amount of material use, storage, and transportation must be implemented.

N.3.2.1 *Development of Laser Systems*

The lasers installed in Building 335 as part of the AMP would not be put in cold standby as under the No Action Alternative. Instead they would be used to provide laser energy for the separation of plutonium isotopes under the Proposed Action. No additional changes to the laser system are anticipated.

N.3.2.2 *Separation of Plutonium Isotopes*

The separation of plutonium isotopes would proceed as described for the AMP under the No Action Alternative. Under the Proposed Action, there would be more extensive operations, both in terms of equipment use and material throughput. On an annual basis, processing of up to 100 kilograms of plutonium would be conducted.

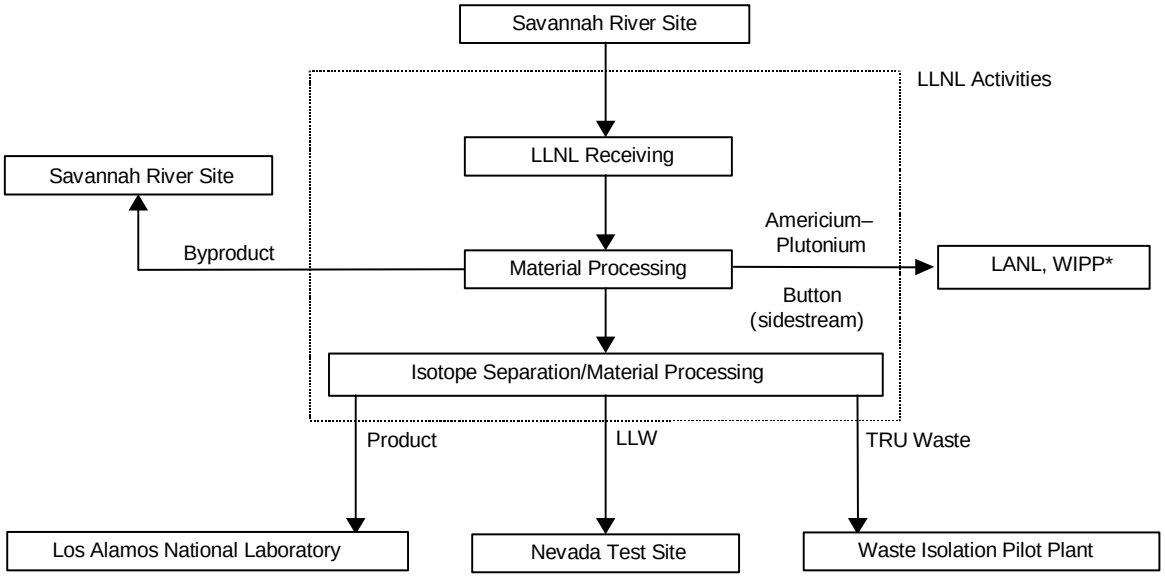
This change in throughput would require some changes in equipment and procedures from those described for the AMP. These changes would mostly involve the automation of some process steps to reduce doses to personnel.

In addition, the feed materials would vary under the Proposed Action and would include the shipment of products and byproducts to Los Alamos National Laboratory (LANL). The impacts of the isotope separation would differ somewhat according to the amount and type of feed material and the desired product, but are bounded by the choice of feed material assumed in the analysis.

To assess the impacts and wastes associated with the overall operations, those missions that could be foreseen as needing particular plutonium isotopes were used to develop realistic and bounding feed materials and other conditions for potential separation work. These conditions were used to evaluate the potential impacts to human health and the environment.

Various feedstock materials were identified for potential use. An Evaluation Feedstock (Section N.3.2.2.1) shipped from the Savannah River Site (SRS) was postulated for purposes of analysis that would bound the impacts of the potential feedstocks for most environmental resource areas and potential accidents. However, feedstock from Hanford was also evaluated in regard to transportation to assess the impacts from different routes. Figures N.3.2.2–1 and N.3.2.2–2 show the general material flow for the Evaluation Feedstock and the Hanford feedstock, respectively.

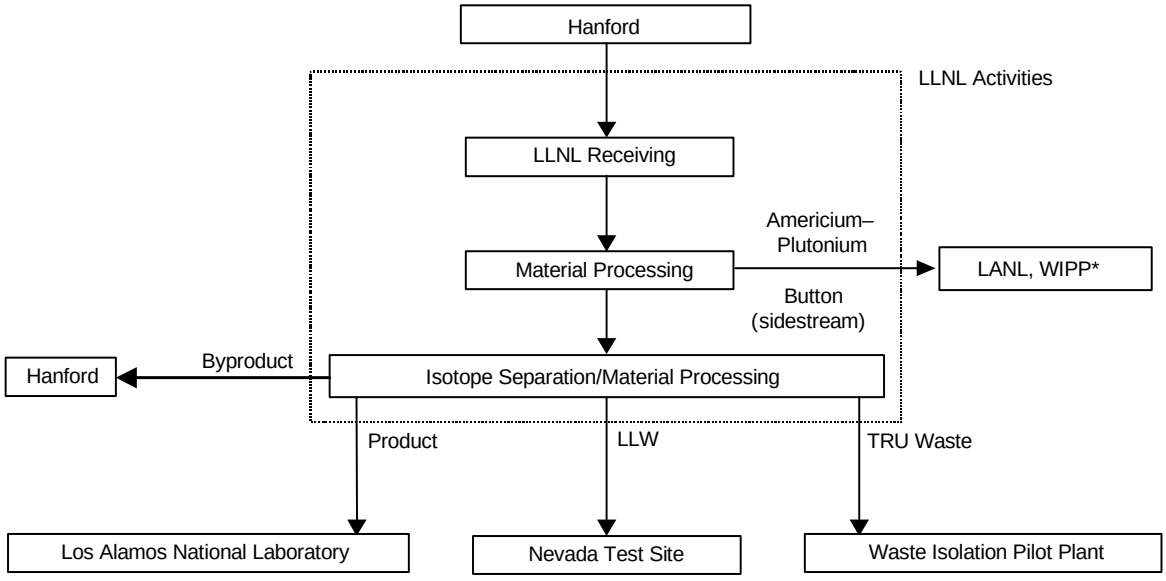
An annual process throughput of plutonium oxide, equivalent to 100 kilograms of plutonium metal with the Evaluation Feedstock isotopic composition, was used to bound the analyses of process rates, material amounts, radiation exposure, emissions, wastes, accidents, and transportation, unless otherwise stated.



Source: Original.

***** The byproduct of the MSE step, an americium/plutonium button would be either sent to WIPP or sent to LANL to recover and recycle the plutonium.

FIGURE N.3.2.2–1.—*Material Flowchart for the Evaluation Feedstock*



Source: Original.

***** The byproduct of the MSE step, an americium/plutonium button would be either sent to WIPP or sent to LANL to recover and recycle the plutonium.

FIGURE N.3.2.2–2.—*Material Flowchart for the Hanford Feedstock*

N.3.2.2.1 *Preparation of Feed Material*

The Evaluation Feedstock is an average of the isotopic characteristics of potential feedstock materials. The americium would be completely removed from the plutonium feed material prior to receipt at LLNL. However, it was assumed that 2 years of interim storage of the feedstock would occur before it would be used. During this time, there would be substantial ingrowth of americium-241 in the Evaluation Feedstock. Table N.3.2.2.1–1 presents the parameters of the Evaluation Feedstock at the time it is postulated that processing would begin. The feedstock would arrive at LLNL in the powdered oxide form.

TABLE N.3.2.2.1–1.—*Evaluation Feedstock Parameters*

Element	Weight Percentage
Plutonium (all isotopes)	99.22
Americium	0.64
Uranium	0.14

Source: NNSA 2003c.

The Evaluation Feedstock would be processed through direct oxide reduction, molten-salt extraction, and feed material casting prior to isotope separation. The processes are described in Section N.3.1.2.

A substantial amount of americium would be extracted from the feed material in the molten-salt extraction step. The americium/plutonium chloride salt would be reduced to an americium/plutonium metal button. Instead of storage at LLNL as under the No Action Alternative, the americium/plutonium metal button would be sent to WIPP for disposal or LANL for plutonium recovery. The annual bounding throughput of 100 kilograms of Evaluation Feedstock metal would result in approximately 10 kilograms of americium/plutonium metal annually.

N.3.2.2.2 *Separator System*

Installation of Equipment

In addition to the equipment used for the AMP, a second separator unit may be installed alongside the first.

Separation of Isotopes

The separation of the plutonium isotopes would proceed as described for the AMP in Section N.3.1.3. However, under the Proposed Action, the separator(s) would run a large part of the year to produce plutonium with the required isotopic composition. The bounding scenario assumes an annual process throughput of 100 kilograms of plutonium metal with the Evaluation Feedstock isotopic composition.

N.3.2.2.3 *Processing of Separated Isotopes*

After the plutonium has undergone isotope separation, the collector and extractor plates would be processed to obtain the product and byproduct as described for the No Action Alternative in Section N.3.1.3. The plutonium byproduct would be converted to oxide powder for packaging and shipment back to the site where the feed material originated. The product would be dehydrided to the metal or converted to oxide for packaging and shipment to LANL.

N.3.2.2.4 *Material at Risk Increase*

To accommodate the full throughput of 100 kilograms per year of plutonium processed and to permit plutonium processing for other NNSA programs, the material-at-risk (MAR) would be increased from 20 kilograms of fuel-grade plutonium equivalent to 60 kilograms of fuel-grade plutonium equivalent. Without this increase in MAR, the Proposed Action throughput levels could not be achieved. All environmental evaluations (e.g., accidents, worker population dose) have been performed with 60 kilograms MAR for the Proposed Action.

N.3.2.2.5 *Transportation*

In order to evaluate transportation, several cases were considered. In all cases, the product would be either dehydrided to metal or converted to the oxide for packaging and shipping to LANL. It is assumed to be a single shipment per year, though most likely the shipment would be combined with other material shipments to LANL.

One scenario involves the transportation of feed material from SRS and the return of the byproduct to SRS. In this case, the americium/plutonium button from the molten-salt extraction process would be shipped to WIPP, or sent to LANL for recovery and recycle of plutonium.

Another case involves the transportation of the feed material from Hanford to LLNL and the return of the byproduct to Hanford. The americium/plutonium button from the molten-salt extraction process would be shipped to WIPP, or sent to LANL for recovery and recycle of plutonium.

N.3.3 Reduced Operation Alternative

Under the Reduced Operation Alternative, the AMP activities would be discontinued. The No Action Alternative or the Proposed Action would not be implemented. No laser separation of isotopes of surrogate material or plutonium would take place. The Building 332 EDS equipment would remain in its current status of cold standby.

N.3.4 Comparison of Alternatives and Environmental Consequences

Impacts

Table N.3.4–1 compares the potential environmental consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative. Section N.5 provides detailed assessments of the alternatives and environmental consequences. The evaluations of the consequences summarized in Table N.3.4–1 are based on mitigation measures that would be implemented.

As indicated in the Table N.3.4–1, changes in the Proposed Action impacts as compared to the No Action and Reduced Operation Alternatives occur in several areas. The primary impacts include increase in transuranic and low-level waste. These range from 10.42 cubic meters per year of transuranic waste in the Proposed Action to 0.42 cubic meters per year in the No Action Alternative and none in the Reduced Operation Alternative. Low-level waste generation would range from 10.42 cubic meters per year during the Proposed Action to 0.63 cubic meters during the No Action Alternative, and none for the Reduced Operation Alternative.

TABLE N.3.4–1.—*Comparison of Potential Impacts of No Action Alternative, Proposed Action, and Reduced Operation Alternative*

	No Action		Proposed Action		Reduced Operation
Socioeconomics					
Long-Term Employees	10		27		0
New Hires	0		14		0
Local Housing	No Impacts		No Impacts		No Impacts
Environmental Justice	No Disproportionately High and Adverse Impacts		No Disproportionately High and Adverse Impacts		No Impacts
Community Services					
Fire/Police	No Impacts		No Impacts		No Impacts
School	No Impacts		No Impacts		No Impacts
Nonhazardous waste	Minimal Impacts		Minimal Impacts		No Impacts
Air Quality					
Hazardous toxic air pollution	No Impacts		No Impacts		No Impacts
Radiological Air Pollutants	Pu 3.0×10^{-4} µCi/yr Am 3.4×10^{-7} µCi/yr U 3.8×10^{-10} µCi/yr		Pu 7.4×10^{-3} µCi/yr Am 8.6×10^{-6} µCi/yr U 9.4×10^{-9} µCi/yr		No Impacts
	Annual Dose	LCF/yr	Annual Dose	LCF/yr	
MEI	2.5×10^{-9} mrem	1.5×10^{-15}	6.2×10^{-8} mrem	3.7×10^{-14}	No Impacts
Offsite Population	1.3×10^{-7} person-rem	7.7×10^{-11}	3.3×10^{-6} person-rem	2.0×10^{-9}	
Noise					
	No Impacts		No Impacts		No Impacts

TABLE N.3.4–1.—*Comparison of Potential Consequences of No Action Alternative, Proposed Action, and Reduced Operation Alternative (continued)*

	No Action				Proposed Action					Reduced Operation
Traffic and Transportation										
Traffic	No Impacts				No Impacts					No Impacts
Transportation	No Impacts				Up to 0.55 person-rem (3.3×10^{-4} LCFs) for incident free transportation.					No Impacts
Utilities and Energy										
Electricity	100 MWh per year				2.8 GWh per year (less than 1% of LLNL usage)					No Impacts
Materials and Waste Management										
Materials Management	Would involve use of radioactive and hazardous materials, plutonium, americium, laser dyes, and cleaning fluids				Would involve use of radioactive and hazardous materials, plutonium, americium, laser dyes, and cleaning fluids. Plutonium use would be 25 times that of No Action.					No Impacts
Waste Management (quantities in m^3 per year)	Hazardous Solid 0.42	LLW Solid 0.63	TRU solid 0.42		Hazardous Solid 0.21	Hazardous Liquid 0.21	LLW Solid 10.42	TRU Solid 10.42	Mixed Solid 0.42	No Impacts
Occupational Protection										
	Annual Dose				Annual Dose					No Impacts
	MEI		Population		MEI		Population			
Radiological Dose	Dose mrem	LCF	Dose Person-rem	LCF	Dose mrem	LCF	Dose person-rem	LCF		
Public	2.5×10^{-9}	1.5×10^{-15}	1.3×10^{-7}	7.7×10^{-11}	6.2×10^{-8}	3.7×10^{-14}	3.3×10^{-6}	2.0×10^{-9}		
Workers	6.8×10^{-2}	4.1×10^{-5}	1.4	8.6×10^{-4}	1.2	7.0×10^{-4}	32.2	1.9×10^{-2}		

TABLE N.3.4–1.—*Comparison of Potential Consequences of No Action Alternative, Proposed Action and Reduced Operation Alternative (continued)*

Bounding Radiological Accidents		
No Action	**Proposed Action**	**Reduced Action**
Aircraft Crash	**Room Fire Unfiltered**	
For the bounding radiological accident: Median Meteorology - 0.2 LCFs to the noninvolved worker population - 0.06 LCFs in the offsite population Unfavorable Meteorology - 1.5 LCFs to the noninvolved worker population - 0.72 LCFs in the offsite population	For the bounding radiological accident: Median Meteorology - 0.56 LCFs to the noninvolved worker population - 0.17 LCFs in the offsite population Unfavorable Meteorology - 4.7 LCFs to the noninvolved worker population - 2.0 LCFs to the offsite population	No Impact

Source: Original.

Am = americium; LCF = latent cancer fatality; LLW = low-level waste; MEI = maximally exposed individual; MWH = megawatt hour; m^3 = meters cubed; µCi/yr = microcuries per year; TRU = transuranic; Pu = plutonium; U = uranium.

The worker population dose is estimated to be 32.2 person-rem per year for the Proposed Action, 1.43 person-rem per year for the No Action Alternative, and none for the Reduced Operation Alternative.

Facility accidents for the Proposed Action are predicted to result in less than one latent cancer fatality (LCF) to the public based on the median meteorology. Using unfavorable meteorological conditions, two LCFs to the public and five additional LCFs for the noninvolved worker population are expected. The bounding radiological accident for the noninvolved worker population for No Action is the aircraft crash into Building 332. This is based on a MAR of 20 kilograms plutonium and results in a person-rem dose of 3.2×10^2 and less than one (0.2) LCF.

For the Proposed Action, the bounding radiological accident for the noninvolved worker population would be the unfiltered room fire in Building 332. This is based on a MAR of 60 kilograms plutonium and results in a person rem dose of 9.3×10^2 and less than one (0.6) LCF. The bounding transportation accident involves shipment of ITP transuranic waste to WIPP. Although the probability of its occurrence is only 8.4×10^{-10} per year, the accident yields 4.6×10^4 person-rem and 28 LCFs. This is the bounding transportation accident for the entire LLNL.

N.3.5 Alternatives Eliminated from Detailed Review

Separation in Calutrons at Oak Ridge

A calutron uses the electromagnetic deflection of ionized atoms to separate isotopes. The calutrons at Oak Ridge were used to separate isotopes of uranium for the development of the first atomic bomb. During the Cold War they were replaced as the main process for the separation of uranium isotopes by other technologies such as gaseous diffusion. Since then, the calutrons have been used to produce a number of nonradioactive isotopes. The calutrons are currently being decommissioned. Therefore, the calutrons are unavailable for processing the materials for the SBSSMP testing program.

Chemical Separation at Savannah River Site

Plutonium production and recovery activities were carried out in the past at the SRS. This chemical separation activity involved the processing of materials that had been irradiated in the production reactors to produce new plutonium for the weapons program. These facilities have been placed in cold standby. While the chemical processing of the feed materials for the SBSSMP does not qualify as processing for production purposes, the facilities at SRS are considered plutonium production facilities and are being shut down per NNSA and U.S. policies and programmatic decisions. Therefore, the SRS facilities are not considered available for supplying the materials needed for the SBSSMP testing program. Also the SRS facilities are large-scale facilities unsuited for production of small amounts of this research material.

N.4 DESCRIPTION OF THE AFFECTED ENVIRONMENT

Chapter 4 of the LLNL SW/SPEIS describes the environmental setting and existing conditions associated with the current operations at LLNL pertinent to the issues evaluated in this appendix.

N.5 ENVIRONMENTAL CONSEQUENCES

The environmental consequences resulting from the No Action Alternative, Proposed Action, and Reduced Operation Alternative as well as bounding accident scenarios are presented in the following sections.

N.5.1 No Action Alternative

The No Action Alternative is a brief, one-time demonstration project. It would take place in existing rooms in existing buildings. No excavation would be needed. Therefore, there would be no impacts to Land Use and Applicable Plans, Prehistoric and Historic Cultural Resources, Aesthetics and Scenic Resources, Geologic Resources (geologic hazards are considered as part of the accident screening), Ecology, and Water Resources (water use and wastewater treatment).

While the AMP would only fully operate with plutonium for about a month in Building 332, the impacts are given in annual terms to allow comparison with the Proposed Action. In addition, the AMP would not use the same feedstock material as the Proposed Action. Material already at LLNL would be used. However, to bound the material that might be used and provide easy comparison to the Proposed Action, 4 kilograms of Evaluation Feedstock is assumed to be processed in the AMP.

The quantities of materials to be used in AMP fall within the current working limits of Building 332 and LLNL. The chemical processing of the feed material and separated isotopes would be minor and within the current levels of chemical processing capacity of the Materials Processing Laboratory in Building 332 at LLNL. The chemical processing associated with the 1984 laser separation of plutonium isotopes was performed in Building 332.

N.5.1.1 *Socioeconomic Characteristics and Environmental Justice*

Implementation of AMP, would not employ any new personnel. The personnel that would perform the work are already employed at LLNL. There would be no impacts to employment, population, housing, or economic factors. There would be no disproportionately high and adverse impacts to minority or low-income populations.

N.5.1.2 *Community Services*

The No Action Alternative would not be a special generator of nonhazardous solid waste. The generation of nonhazardous waste is proportional to the number of employees. Since existing LLNL employees would perform the work associated with AMP, there would be no increase in the generation of nonhazardous waste.

N.5.1.3 *Air Quality*

The laser, separator and chemical processing activities would generate air emissions. Some gaseous effluents would be generated in the glovebox operations. These effluents would be exhausted through the Building 332 stack. Radioactive atmospheric releases during normal operations are shown in Table N.5.1.3–1. The release pathway is through the glovebox filter and two stages of facility high-efficiency particulate air (HEPA) filtration prior to discharge to the building stack. A HEPA filter efficiency of 99.97 percent was assumed.

TABLE N.5.1.3–1.—*Estimated Annual Radioactive Release for Normal Operations (No Action Alternative)*

Element	Feed Composition Weight Percentage	Release (µCi/year)
Plutonium	99.22	3.0×10^{-4}
Americium	0.64	3.4×10^{-7}
Uranium	0.14	3.8×10^{-10}
Total Atmospheric Release		**3.0×10^{-4}**

Source: NNSA 2003c.
µCi/yr = microcuries per year.

N.5.1.4 *Noise*

The activities in the Materials Processing Laboratory under the No Action Alternative would be the same as current activities. The noise level would be the same as current levels. The lasers, separators, and chemical processing systems are not a large source of noise. The No Action Alternative would not increase noise in Building 332.

N.5.1.5 *Traffic and Transportation*

The No Action Alternative would not involve new hires that would affect traffic counts in the LLNL area and therefore would not require the rerouting of any traffic. There would be no offsite transportation of feed material, byproduct, or product associated with AMP.

N.5.1.6 *Utilities and Energy*

The estimated electrical usage for the No Action Alternative including lasers is 100 megawatt hours per year. This usage is within the capacity of the LLNL electricity supply.

The main cooling of the laser system is supplied by a dual channel closed loop cooling system containing a water-cooled condenser section. The LLNL Low Pressure Cooling Water system would be used to supply cooling water. The cooling water would be recirculated back into the LLNL system. Any primary loop cooling water that was accidentally fouled by the laser chemicals would be disposed of per LLNL hazardous waste disposal guidelines. The separators would use cooling water from the Building 332 cooling water system. The supply of this cooling water is within the normal operations of Building 332.

The AMP would need clean, dry compressed air at 75 to 100 pounds per square inch on a routine basis, and on occasion, limited amounts of argon. The supply of these gases is within the normal operations of Building 332.

N.5.1.7 *Materials and Waste Management*

The laser system would be solid-state lasers optically pumping recirculating organic dye lasers. The organic dyes (R6G is bounding) are stored in either powder or liquid form. The dyes would be mixed with ethyl, isopropyl, or methyl alcohol, depending on the dye requirements. About 50 liters of the mix would be used per year. Total alcohol use and storage is bounded by one 55-gallon drum.

The organic dyes are mutagenic and carcinogenic chemicals. Handling and storage of these chemicals is routine for the laser program. Proper environment and safety procedures for handling and storage would be implemented.

It is estimated that the AMP experiments and recovery operations would generate a one-time inventory of two 55-gallon drums of hazardous waste, three drums of low-level waste (discarded gloves, booties, wipes, etc.), and two drums of transuranic waste.

N.5.1.8 *Decontamination and Decommissioning*

Decontamination and decommissioning (D&D) for the AMP demonstration involve the separator related equipment including gloveboxes and the process lasers. The Material Processing Laboratory systems provide general support to multiple Plutonium Facility programs and would not be decontaminated and decommissioned at the end of the AMP activities.

The D&D of the separator and laser equipment would take approximately 18 months and would result in a one-time generation of 4 cubic meters of transuranic waste, 12 cubic meters of low level waste, and 0.5 cubic meters of hazardous waste.

N.5.1.9 *Occupational Protection*

Impacts from Normal Operations

Public Health Impacts

NNSA expects minimal public health impacts from the radiological consequences of AMP operations. Public radiation doses would likely occur from airborne releases only. Table N.5.1.9–1 lists the projected normal radionuclide emission rates for the AMP process, the incremental radiation doses estimated for the public (offsite maximally exposed individual [MEI] and collective population dose), and the corresponding incremental LCFs, which represent the impacts of the airborne radioactive releases.

TABLE N.5.1.9–1.—*Annual Radiological Impacts on the Public from Advanced Materials Program Operations*

		Offsite MEI	Offsite Population[a]		
Radionuclide	**Emission Rate (Ci/yr)**	**Dose (mrem/yr)**	**LCF Probabilities[b, c]**	**Dose (person-rem)**	**LCFs[c]**
Plutonium	3.0×10^{-10}	2.4×10^{-9}	1.4×10^{-15}	1.3×10^{-7}	7.6×10^{-11}
Americium	3.4×10^{-13}	1.3×10^{-10}	7.6×10^{-17}	3.2×10^{-9}	1.9×10^{-12}
Uranium	3.8×10^{-16}	3.4×10^{-14}	2.0×10^{-20}	8.4×10^{-13}	5.1×10^{-16}
Total:		**2.5×10^{-9}**	**1.5×10^{-15}**	**1.3×10^{-7}**	**7.7×10^{-11}**

Source: NNSA 2003c.

[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.

[b] Indicates the increased probability of a LCF to this individual receptor.

[c] Based on a cancer risk estimator of 0.0006 LCFs per person-rem.

Ci/yr = curies per year; LCF = latent cancer fatality; MEI = maximally exposed individual; mrem/yr = millirem per year.

As shown in the table, the expected annual radiation dose to the offsite MEI would be much smaller than the limit of 10 millirem per year set by both the U.S. Environmental Protection Agency (EPA) (40 CFR Part 61) and DOE (DOE O 5400.5) for airborne releases of radioactivity. The risk of a LCF to this individual from operations would be approximately 1.50×10^{-15} per year (i.e., about 1 chance in 667 trillion per year of a LCF). The projected number of fatal cancers to the population within 50 miles would be 7.7×10^{-11} per year (i.e., about 1 LCF in 129 billion years).

Impacts to Advanced Materials Program Workers

Estimates of annual radiological doses to workers involved with AMP facility operations are a function of (1) the number of radiological workers, as determined in the development of the AMP staffing estimate for each process; (2) the average working dose rate at the process location (e.g., glovebox surface) for each unit operation or workstation; and (3) the amount of time spent by workers in the area.

This last factor was determined from a time-motion study previously performed for the SIS project of direct "hands-in-gloves" labor required to perform each individual operation. Dose rate reduction and efficiency scaling factors were applied for operations that were assumed to be automated.

As indicated above, the collective annual doses (millirem per year) received by an individual is calculated based on the number of workers required for the various processes, the time spent in each process area, and the associated dose rates for each operation. The average individual dose is calculated as the collective exposure divided by the estimated number of radiological workers. The estimates of annual radiological doses and health effects to workers are provided in Table N.5.1.9–2 based on the flow process of Figure N.3.1.3.1–1. As shown in the table, the annual doses to individual workers for all levels of production would be below DOE limit of 5 rem (10 CFR Part §835.202), and would not exceed DOE recommended control level of 1 rem (10 CFR Part §835.1002). The projected number of fatal cancers in the workforce from annual operations would be 0.00086 (or 1 chance in 1,162 that the worker population would experience a fatal cancer per year of operations).

TABLE N.5.1.9–2.—*Annual Radiological Impacts on Advanced Materials Program Workers*

Number of Radiological Workers (FTEs)	21
Individual Workers[a]	
Average individual whole body dose (rem/year)	6.8×10^{-2}
Average worker LCF probability[b]	4.1×10^{-5}
Worker Population	
Collective dose (person-rem/year)	1.4
LCFs[b]	8.6×10^{-4}

Source: Original.

[a] The regulatory dose limit for an individual worker is 5,000 millirem per year (10 CFR Part §835). However, 10 CFR Part 835.1002 establishes a Control Level of 1,000 millirem per year. To reduce doses to levels that are as low as is reasonably achievable, an effective dose reduction plan would be enforced.

[b] Based on a cancer risk estimator of 6.0×10^{-4} LCFs per person-rem.

FTEs = Full Time Equivalent workers; LCF = latent cancer fatality.

N.5.2 Proposed Action

The Proposed Action would take place in existing rooms in existing buildings. Therefore, there would be no impacts to land use and applicable plans, prehistoric and historic cultural resources, aesthetics and scenic resources, geologic resources (geologic hazards are considered as part of the accident screening), ecology, water resources (water use and wastewater treatment are discussed in utilities and energy), and noise.

N.5.2.1 *Socioeconomic Characteristics and Environmental Justice*

The Proposed Action would employ 27 people with an annual payroll of $2.1 million to $2.3 million. Some of these personnel are already employed at LLNL. However, it is assumed that up to 14 people may be new hires. The annual cost of equipment and supplies is approximately $3 million. The addition of new workers would be within the 5 to 8 percent turnover/new hire

rate at LLNL, or through internal transfers to other projects. There would be no impacts to employment, population, housing, economic factors, or environmental justice.

N.5.2.2 *Community Services*

The Proposed Action would not be a special generator of nonhazardous solid waste. The amount of waste would be proportional to the number of employees. Since approximately 14 employees could be new hires, a 0.1 percent increase in the workforce, the increase in nonhazardous solid waste would be a 0.1 percent increase, or 6.1 cubic meters per year.

N.5.2.3 *Air Quality*

The laser, separator and chemical processing activities would generate air emissions. Gaseous effluents would be generated in the glovebox operations. These effluents would be exhausted through the Building 332 stack. Radioactive atmospheric releases during normal operations are shown in Table N.5.2.3–1. The release pathway is through the glovebox filter and two stages of facility HEPA filtration prior to discharge to the building stack. A HEPA filter efficiency of 99.97 percent was assumed.

TABLE N.5.2.3–1.—*Estimated Annual Radioactive Release for Normal Operations (Proposed Action)*

Element	Feed Composition Weight Percentage	Release (µCi/year)
Plutonium	99.22	7.4×10^{-3}
Americium	0.64	8.6×10^{-6}
Uranium	0.14	9.4×10^{-9}
Total Atmospheric Release		**7.4×10^{-3}**

Source: Original.
µCi/yr = microcuries per year.

N.5.2.4 *Noise*

The activities in the Materials Processing Laboratory under the Proposed Action would be the same as current activities. The noise level would be the same as current levels. The laser and separators are not a large source of noise. The Proposed Action would not increase noise in Building 332.

N.5.2.5 *Traffic and Transportation*

The ITP would not employ enough new hires to affect traffic counts in the LLNL area. The ITP would not require the rerouting of any traffic.

Under the Proposed Action, the radioactive feed materials would be transported to LLNL for processing into materials useful for SBSSMP. The resulting product, byproducts, and transuranic waste would be shipped to locations offsite. The feed, product, and byproduct from the Isotope Separation step (see Figure 3.2.2–1 and 3.2.2–2) would be shipped in Safe Secure Transport (SST) vehicles in model 9975 containers. If the plutonium from the molten-salt extraction step was to be recovered and recycled, this byproduct from the molten-salt extraction step americium/plutonium button (see Figures 3.2.2–1 and 3.2.2–2) would be shipped to LANL in SST's in 9975 containers. If the plutonium in the molten-salt extraction process was not recycled, the byproduct would be shipped to WIPP as transuranic waste in Transuranic Package

Transporter-II (TRUPACT-II) containers on trucks. All other transuranic waste would also be shipped to WIPP in TRUPACT-II containers on trucks.

Using limitations on mass, heat, and fissile gram equivalents specified by the container certifications, the number of containers per shipment campaign was calculated. Based on the number of containers that can be transported on the specified trucks, the number of shipments was calculated. For purposes of analysis, it was assumed that Safe Secure transporters carry 25 Model 9975 containers. Trucks for transuranic waste carry up to three TRUPACT-II. Table N.5.2.5–1 describes the shipment campaigns under the ITP Proposed Action. The shipment campaign list contains two options for shipment of the americium/plutonium button. Only one option would be selected.

The methodology for calculating radiological consequences from this transportation is described in Section 5.1.11 and Appendix J of this LLNL SW/SPEIS. For incident-free transport (no accidents), the consequence would be the radiation dose received by the truck drivers and members of the public driving on the highways, living near the highways, and present at rest stops. Because of the small amount of radioactive material being transported and the shielding of the containers and truck, the actual radiation dose rate near the truck is expected to be immeasurably small. For analysis purposes, a small dose rate of one millirem per hour was assumed near the trucks. Table N.5.2.5–2 presents the collective dose and number of LCFs from transportation under the ITP Proposed Action.

TABLE N.5.2.5–1.— ***Integrated Technology Project Shipment Campaigns Under the Proposed Action***

Material	Origin	Destination	Packaging	Number of Containers	Number of Shipments/Year
SRS-Origin Material					
Feed	SRS	LLNL	9975	79	4
Product	LLNL	LANL	9975	1	1
Byproduct	LLNL	SRS	9975	66	3
Am/Pu Button (LANL case)	LLNL	LANL	9975	14	1
Am/Pu Button (WIPP case)	LLNL	WIPP	TRUPACT-II	19	7
TRU Waste	LLNL	WIPP	TRUPACT-II	2	1
Hanford-Origin Material					
Feed	Hanford	LLNL	9975	49	2
Product	LLNL	LANL	9975	1	1
Byproduct	LLNL	Hanford	9975	24	1
Am/Pu Button (LANL case)	LLNL	LANL	9975	23	1
Am/Pu Button (WIPP case)	LLNL	WIPP	TRUPACT-II	32	11
TRU Waste	LLNL	WIPP	TRUPACT-II	3	1

Source: Original.
Am/Pu = americium/plutonium; LANL = Los Alamos National Laboratory; SRS = Savannah River Site; TRU = transuranic; TRUPAC-II = transuranic package transporter-II; WIPP = Waste Isolation Pilot Plant.

TABLE N.5.2.5–2.—*Annual Impacts from Incident Free Radiological Transportation*

	Occupation (drivers)		Public	
Material	**Collective Dose (person-rem)**	**Number of LCFs**	**Collective Dose (person-rem)**	**Number of LCFs**
SRS-Origin Material				
Feed	9.4×10^{-2}	5.6×10^{-5}	1.9×10^{-1}	1.1×10^{-4}
Product	1.1×10^{-2}	6.4×10^{-6}	1.7×10^{-3}	1.0×10^{-6}
Byproduct	7.1×10^{-2}	4.2×10^{-5}	1.4×10^{-1}	8.4×10^{-5}
Am/Pu Button (LANL case)	9.3×10^{-3}	5.6×10^{-6}	6.9×10^{-3}	4.1×10^{-6}
Am/Pu Button (WIPP case)	6.1×10^{-2}	3.6×10^{-5}	1.3×10^{-1}	7.7×10^{-5}
TRU Waste	8.7×10^{-3}	5.2×10^{-6}	1.8×10^{-2}	1.1×10^{-5}
Hanford-Origin Material				
Feed	1.6×10^{-2}	9.7×10^{-6}	4.4×10^{-2}	2.7×10^{-5}
Product	1.1×10^{-2}	6.4×10^{-6}	1.7×10^{-3}	1.0×10^{-6}
Byproduct	8.1×10^{-3}	4.8×10^{-6}	2.1×10^{-2}	1.3×10^{-5}
Am/Pu Button (LANL case)	9.3×10^{-3}	5.6×10^{-6}	2.0×10^{-2}	1.2×10^{-5}
Am/Pu Button (WIPP case)	9.5×10^{-2}	5.7×10^{-5}	2.0×10^{-1}	1.2×10^{-4}
TRU Waste	8.7×10^{-3}	5.2×10^{-6}	1.8×10^{-2}	1.1×10^{-5}

Source: Original.
Am/Pu = americium/plutonium; LANL = Los Alamos National Laboratory; LCF = latent cancer fatality; TRU = transuranic; WIPP = Waste Isolation Pilot Plant.

Should a shipment undergo a high-impact accident with fire, radioactive materials could be released and expose members of the public. Table N.5.2.5–3 presents the highest consequences of an accident for each shipment campaign and the estimated probability of that accident occurring. Although lesser impact accidents with higher probability could occur, they would release a lesser amount or no radioactivity. Also the same high-impact accident could occur in a lesser-populated area with lesser impacts but somewhat greater probability.

To determine consequences of complete scenarios that can be implemented, the shipment campaigns must be combined into a scenario involving five parts: feed, product, byproduct, americium/plutonium button, and transuranic waste. Table N.5.2.5–4 presents the complete scenario consequences for both the SRS- and Hanford-origin feed. For incident-free consequences, the reported values are sums from Table N.5.2.5–2 based on the assumption that the americium/plutonium button is shipped to WIPP as transuranic waste. Because accident consequences do not sum, the accidents with the highest consequences from Table N.5.2.5–3 are provided.

The total probability (sum of probabilities for all accidents with releases) of any accident occurring that releases radioactive material is 4.0×10^{-6} per year for SRS-origin material, with consequences ranging from 6.5×10^{-3} to 3.5×10^{4} person-rem (3.9×10^{-6} to 21 LCFs). For Hanford-origin material, the total probability of any accident that releases radioactive material is also 4.0×10^{-6} per year with consequences ranging from 6.5×10^{-3} to 4.6×10^{4} person-rem (3.9×10^{-6} to 28 LCFs).

TABLE N.5.2.5–3.—*Annual Accident Consequences and Probabilities from Radiological Transportation*

Material	Collective Dose (person-rem)	Number of LCFs	Probability
SRS-Origin Material			
Feed	2.6×10^{4}	16	2.8×10^{-11}
Product	7.9×10^{3}	4.8	3.5×10^{-12}
Byproduct	2.7×10^{4}	16	2.1×10^{-11}
Am/Pu Button (LANL case)	7.2×10^{3}	4.3	3.5×10^{-12}
Am/Pu Button (WIPP case)	3.5×10^{4}	21	5.9×10^{-9}
TRU Waste	1.3×10^{4}	7.9	8.4×10^{-10}
Hanford-Origin Material			
Feed	2.4×10^{4}	14	8.0×10^{-12}
Product	2.0×10^{3}	1.2	3.5×10^{-12}
Byproduct	2.4×10^{4}	14	4.0×10^{-12}
Am/Pu Button (LANL case)	2.8×10^{3}	1.7	3.5×10^{-12}
Am/Pu Button (WIPP case)	3.2×10^{4}	19	9.2×10^{-9}
TRU Waste	4.6×10^{4}	28	8.4×10^{-10}

Source: Original.
Am/Pu = americium/plutonium; LCF = latent cancer fatality; LANL = Los Alamos National Laboratory; TRU = transuranic; WIPP = Waste Isolation Pilot Plant.

Table N.5.2.5–4.—*Complete Scenario Impacts*

	Incident Free Impacts		Highest Consequence Accident Impacts		
	Collective Dose (person-rem)	Number of LCFs	Collective Dose (person-rem)	Number of LCFs	Probability per Year
SRS-origin Material	5.5×10^{-1}	3.3×10^{-4}	3.5×10^{4}	21	5.9×10^{-9}
Hanford-origin Material	1.6×10^{-1}	9.5×10^{-5}	4.6×10^{4}	28	8.4×10^{-10}

Source: Original.
LCF = latent cancer fatality; SRS=Savannah River Site.

N.5.2.6 *Utilities and Energy*

The estimated electrical usage for the ITP including powering the lasers is 2.8 gigawatt hours per year. This usage is less than 1 percent of the LLNL usage in the year 2001 and well within the capacity of the LLNL electricity supply.

The main cooling of the laser system is supplied by a dual channel closed loop cooling system containing a water-cooled condenser section. The LLNL Low Pressure Cooling Water system would be used to supply cooling water. The cooling water would be recirculated back into the LLNL system. Any primary loop cooling water that was accidentally fouled by the laser chemicals would be disposed of per LLNL hazardous waste disposal guidelines. The separators would use cooling water from the Building 332 cooling water system.

The ITP would need clean dry compressed air at 75 to 100 pounds per square inch on a routine basis, and on occasion, limited amounts of argon. The supply of these gases is within the normal operations of Building 332.

N.5.2.7 *Materials and Waste Management*

Materials Management

The laser system would be solid state lasers optically pumping recirculating organic dye lasers. The organic dyes (e.g., R6G) are stored in either powder or liquid form. The dyes would be mixed with ethyl, isopropyl, or methyl alcohol depending on the dye requirements. About 50 liters of the mixed would be used initially and about 15 liters per year replenishment would be required. Total alcohol use and storage is bounded by one 55-gallon drum.

The organic dyes are mutagenic and carcinogenic chemicals. Handling and storage of these chemicals is routine for the laser program. Proper environment and safety procedures as described in the LLNL Health and Safety Manual for handling and storage would be implemented.

Waste Management

It is estimated that the ITP operations would generate hazardous, radioactive, and mixed waste. Table N.5.2.7–1 presents the amounts for each type of waste generated annually from the ITP. This generation is slightly above the average waste generation for the Materials Processing Laboratory, but within the rate generated during historical surges in operations. Under the Proposed Action, transuranic waste generated at Superblock would be shipped directly to WIPP following a certification process (LLNL 2003x).

TABLE N.5.2.7–1.—*Annual Waste Generation from the Proposed Action*

Waste Type	Form	Annual Amount (55 gallon drums)
Hazardous	Solid	1
	Liquid	1
LLW	Solid	50
TRU Waste[a]	Solid	50
Mixed Waste	Solid	2

Source: LLNL 2003bj.
[a] Includes Am/Pu button shipments to WIPP.
LLW = low-level waste; TRU = transuranic.

N.5.2.8 *Decontamination and Decommissioning*

D&D for the ITP involves the separator related equipment including gloveboxes and process cases. The Material Processing Laboratory systems provide general support to multiple Plutonium Facility programs and would not be D&D at the end of the ITP activities.

The D&D of the separator and laser equipment would take approximately 20 months and would result in the one-time generation of 4 cubic meters of transuranic waste, 12 cubic meters of low level waste, and 0.5 cubic meters of hazardous waste.

N.5.2.9 *Occupational Protection*

Impacts from Normal Operations

Public Health Impacts

NNSA expects minimal public health impacts from the radiological consequences of ITP operations. Public radiation doses would likely occur from airborne releases only. Table N.5.2.9–1 lists the projected normal radionuclide emission rates for the ITP process, the incremental radiation doses estimated for the public (offsite MEI and collective population dose), and the corresponding incremental LCFs which represent the impacts of the airborne radioactive releases.

TABLE N.5.2.9–1.—*Annual Radiological Impacts on the Public from Proposed Action*

		Offsite MEI		Offsite Population[a]	
Radionuclide	**Emission Rate (Ci/yr)**	**Dose (mrem/yr)**	**LCFs[b,c]**	**Dose (person-rem)**	**LCFs[c]**
Plutonium	7.4×10^{-9}	5.9×10^{-8}	3.6×10^{-14}	3.3×10^{-6}	2.0×10^{-9}
Americium	8.6×10^{-12}	3.2×10^{-9}	1.9×10^{-15}	7.9×10^{-8}	4.7×10^{-11}
Uranium	9.4×10^{-15}	8.5×10^{-13}	5.1×10^{-19}	2.1×10^{-11}	1.3×10^{-14}
Total		$\mathbf{6.2 \times 10^{-8}}$	$\mathbf{3.7 \times 10^{-14}}$	$\mathbf{3.3 \times 10^{-6}}$	$\mathbf{2.0 \times 10^{-9}}$

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Indicates the increased probability of a LCF to this individual receptor.
[c] Based on a cancer risk estimator of 0.0006 LCFs per person-rem.
Ci/yr = curies per year; LCF = latent cancer fatality; MEI = maximally exposed individual.

As shown in the table, the expected annual radiation dose to the offsite MEI would be much smaller than the limit of 10 millirem per year set by both the EPA (40 CFR Part 61) and DOE (DOE O 5400.5) for airborne releases of radioactivity. The risk of a LCF to this individual from operations would be approximately 3.7×10^{-l4} per year (i.e., about 1 chance in 27 trillion per year of a LCF). The projected number of fatal cancers to the population within 50 miles would be 2.0×10^{-9} per year (i.e., about 1 LCF in 500 million years).

Impacts to ITP Workers

Estimates of annual radiological doses to workers involved with ITP facility operations are a function of (1) the number of radiological workers, as determined in the development of the ITP staffing estimate for each process; (2) the average working dose rate at the process location (e.g., glovebox surface) for each unit operation or workstation; and (3) the amount of time spent by workers in the area. This last factor was determined from a time-motion study previously performed for the SIS project of direct "hands-in-gloves" labor required to perform each individual operation. Dose rate reduction and efficiency scaling factors were applied for operations that were assumed to be automated. Automation, local shielding, and administrative measures have been utilized to achieve minimum worker doses.

The average individual dose is calculated as the collective exposure divided by the estimated number of radiological workers. Exposure to individual workers would be monitored to ensure that no individual worker would exceed the LLNL limit for worker dose. Some work may be rotated among workers to ensure individual worker dose remains within the LLNL limit.

The estimates of annual radiological doses and health effects to workers are provided in Table N.5.2.9–2. As shown in the table, the annual doses to individual workers for all levels of production would be below DOE limit of 5 rem (10 CFR Part §835.202), but could exceed DOE recommended Control Level of 1 rem (10 CFR Part §835.1002). There are no projected fatal cancers in the workforce from annual operations. The collective dose to all workers of 32.2 person-rem per year would result in no LCFs (calculated value of 1.9×10^{-2} or 1 chance in 50 that the worker population would experience a fatal cancer per year of operations).

TABLE N.5.2.9–2.—*Annual Radiological Impacts for Proposed Action*

Materials and Storage Retrieval (MSR) Workers	
Number of Workers	10
Average individual whole body dose (rem/year)	1.0
Average worker LCF probability[b]	6.0×10^{-4}
Collective dose (person-rem/year)	10
LCFs[b]	6.0×10^{-2}
Radiological Workers other than MSR (FTEs)	
Number of Workers	19
Average individual whole body dose (rem/year)[a]	1.17
Average worker LCF probability[b]	7.0×10^{-4}
Worker Population	
Collective dose (person-rem/year)	22.2
LCFs[b]	1.3×10^{-2}
All Workers	
Collective dose (person-rem/year)	32.2
LCFs[b]	1.9×10^{-2}

Source: Original.

[a] The regulatory dose limit for an individual worker is 5,000 millirem per year (10 CFR Part 835). However, 10 CFR Part §835.1002 establishes a Control Level of 1,000 millirem per year. To reduce doses to levels that are as low as is reasonably achievable, an effective dose reduction plan would be enforced.

[b] Based on a cancer risk estimator of 6.0×10^{-3} LCFs per person-rem.

FTEs = Full Time Equivalent workers; LCF = latent cancer fatality.

N.5.3 Reduced Operation Alternative

Under the Reduced Operation Alternative, neither the No Action Alternative, AMP, nor the Proposed Action, ITP, would be implemented. There would be no impacts to any of the environmental resource aspects discussed in Chapter 4 of this LLNL SW/SPEIS. The purpose and need discussed in Section N.1 would not be fulfilled. The ongoing loss of experienced personnel would continue without replacement. This technology would not be developed further and knowledgeable personnel would eventually be lost to other employment or retirement.

N.5.4 Bounding Accident Scenarios

Impacts from Facility Accidents

This section presents the potential impacts on workers (both involved and noninvolved) and the public due to potential accidents associated with operation of the AMP and ITP. 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. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as a 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. Initiating events fall into three categories:

- *Internal initiators* normally originate in and around the facility, but are always a result of facility operations. Examples include equipment or structural failures and human errors.
- *External initiators* are independent of facility operations and normally originate from outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.
- *Natural phenomena initiators* are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, and lightning. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

If an accident were to occur involving the release of radioactive or chemical materials, 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 location. The offsite public and noninvolved workers would also be at risk of exposure to the extent that meteorological conditions exist for the atmospheric dispersion of released hazardous materials. Using approved computer models, the atmospheric dispersion of released hazardous materials and their effects were predicted. However, prediction of latent potential health effects becomes increasingly difficult to quantify for facility workers as the distance between the accident location and the worker decreases. This is because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The worker also may be injured or killed by physical effects of the accident itself.

Radiological Accidents

The radiological impacts to three receptors were estimated: (1) the MEI at the LLNL boundary, (2) the offsite population within 50 miles of the Livermore Site, (3) a noninvolved worker 100 meters from the release point, and (4) the population of noninvolved workers. Each of the analyzed scenarios could result in the fatality or serious injury of one or more involved workers depending on the number present.

Tables N.5.4–1 and N.5.4–2 show the frequencies and consequences of the postulated set of accidents for the No Action Alternative for the public (offsite MEI and the general population living within 50 miles of the facility), a hypothetical noninvolved worker, and the population of noninvolved workers for both median and unfavorable meteorological conditions. No accidents were postulated for the Reduced Operation Alternative as AMP activities would be discontinued and the Proposed Action would not be implemented. Tables 5.4–3 and 5.4–4 show this same information for the Proposed Action. The accidents listed in these tables were selected from the accident scenarios associated with current plutonium operations in Building 332 as described in the Building 332 Safety Analysis Report (LLNL 2003t) and accident scenarios associated with separator operations described in previous analyses prepared to support the EDS (LLNL 1989).

The selection process and screening criteria, used in Appendix D, ensure that the accidents chosen for evaluation in this LLNL SW/SPEIS bound the impacts of all reasonably foreseeable accidents that could occur at the ITP and AMP.

The bounding accident for the Proposed Action is a room fire (unfiltered) because of the potential for fatalities and offsite exposure. This scenario would also apply to ITP operations. This accident scenario has a frequency of 3.9×10^{-7}. The material at risk is assumed to be the entire maximum potential inventory of 60 kilograms (fuel-grade equivalent plutonium) for all programs. Applying release fractions that are consistent with those in the Building 332 Safety Analysis Report, this event leads to a release into the environment of 0.75 grams of fuel-grade equivalent plutonium.

Another accident associated with current plutonium operations in Building 332 is a radioactive material spill (unfiltered). This scenario would also apply to ITP operations. This accident scenario has a frequency of 1.0×10^{-6} per year, and leads to a release into the environment of 0.11 grams of fuel-grade equivalent plutonium.

An inadvertent plutonium criticality for a powder in a workstation is also a credible accident scenario for current plutonium operations in Building 332. This scenario would also apply to ITP operations. This scenario has a frequency of 3.2×10^{-5} per year and is assumed to involve $l \times l0^{-5}$ fissions and an associated release of radioactive noble gases (i.e., isotopes of krypton and xenon) and volatile substances (i.e., isotopes of iodine). The release rates are shown in Appendix D of this LLNL SW/SPEIS.

Potential accident scenarios associated with the separation process include the Design-Basis Fire and a radioactive materials spill. The Design-Basis Fire has a frequency of 2.0×10^{-4} per year (LLNL 1989) and would result in a release to the environment of 0.003 grams of fuel-grade equivalent plutonium.

The radioactive materials spill scenario associated with the separation process has a frequency of 10^{-6} to 10^{-4} per year (LLNL 1989) and would result in a release to the environment of 0.0037 grams of fuel-grade equivalent plutonium.

Consequences of accidental radiological releases were determined using the MELCOR Accident Consequence Code System, Version 2 (MACCS2) computer code (Chanin and Young 1997). MACCS2 is a DOE/Nuclear Regulatory Commission-sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power industry and in support of safety and the *National Environmental Policy Act* documentation for facilities throughout DOE complex. The MACCS2 code is further described in Appendix D.

The accident with the highest consequence to the offsite population (Table N.5.4–3) is the room fire (unfiltered). The increased number of LCFs in the offsite population would be 0.17 per year (i.e., about 1 chance in 6 of a LCF). The risk of a LCF to the offsite MEI would be 2.6×10^{-4} (i.e., about 1 chance in 3,790 of a LCF). The risk of a LCF to a noninvolved worker located at a distance of 100 meters from the accident would be 3.1×10^{-3} (i.e., about 1 chance in 320 per year of a LCF). The increased number of LCFs in the population of noninvolved workers would be 0.56 (or 1 chance in 1.8 of a LCF).

Table N.5.4–1.—*Accident Frequency and Consequences for the No Action Alternative (Median Meteorology)*

		MEI		Offsite Population[a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose (rem)**	**LCFs[b]**	**Dose (person-rem)**	**LCFs[c]**	**Dose (rem)**	**LCFs[b]**	**Dose (person-rem)**	**LCFs[c]**
Room Fire, Unfiltered	3.9×10^{-7}	1.5×10^{-1}	8.8×10^{-5}	9.3×10^{1}	5.6×10^{-2}	1.7	9.9×10^{-4}	3.1×10^{2}	1.9×10^{-1}
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	7.4×10^{-2}	4.4×10^{-5}	4.1×10^{1}	2.4×10^{-2}	8.5×10^{-1}	5.1×10^{-4}	1.4×10^{2}	8.5×10^{-2}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	1.4×10^{-2}	8.7×10^{-6}	3.3×10^{-1}	2.0×10^{-4}	6.6×10^{-2}	4.0×10^{-5}	1.6×10^{1}	9.4×10^{-3}
Design Basis Fire (Separation Process)	2.0×10^{-4}	1.8×10^{-3}	1.1×10^{-6}	1.1	6.7×10^{-4}	2.0×10^{-2}	1.2×10^{-5}	3.7	2.2×10^{-3}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	2.5×10^{-3}	1.5×10^{-6}	1.4	8.2×10^{-4}	8.0×10^{-4}	4.8×10^{-7}	4.8	2.9×10^{-3}
Aircraft Accident	1.5×10^{-6}	1.5×10^{-1}	8.9×10^{-5}	9.7×10^{1}	5.8×10^{-2}	1.8	1.1×10^{-3}	3.2×10^{2}	2.0×10^{-1}

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Increased likelihood of latent cancer fatalities.
[c] Increased number of latent cancer fatalities.
LCF = latent cancer fatality; MEI = maximally exposed individual.

N.5.4–2.—*Accident Frequency and Consequences for the No Action Alternative (Unfavorable Meteorological Conditions)*

		Offsite MEI		Offsite Population[a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose (rem)**	**LCFs[b]**	**Dose (person-rem)**	**LCFs[c]**	**Dose (rem)**	**LCFs[b]**	**Dose (person-rem)**	**LCFs[c]**
Room Fire, Unfiltered	3.9×10^{-7}	2.8	1.7×10^{-3}	1.1×10^{3}	6.5×10^{-1}	1.5×10^{1}	8.9×10^{-3}	2.6×10^{3}	1.6
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	1.4	8.4×10^{-4}	7.2×10^{2}	4.3×10^{-1}	9.6	5.8×10^{-3}	1.1×10^{3}	6.3×10^{-1}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	2.7×10^{-2}	1.6×10^{-5}	1.1×10^{1}	6.4×10^{-3}	3.8×10^{-1}	2.3×10^{-4}	2.2×10^{1}	1.4×10^{-2}
Design Basis Fire (Separation Process)	2.0×10^{-4}	3.4×10^{-2}	2.0×10^{-5}	1.3×10^{1}	7.8×10^{-3}	1.8×10^{-1}	1.1×10^{-4}	3.1×10^{1}	1.9×10^{-2}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	4.7×10^{-2}	2.8×10^{-5}	2.4×10^{1}	1.4×10^{-2}	3.2×10^{-1}	1.9×10^{-4}	3.6×10^{1}	2.2×10^{-2}
Aircraft Accident	1.5×10^{-6}	2.89	1.7×10^{-3}	1.2×10^{3}	7.2×10^{-1}	2.4×10^{1}	1.4×10^{-2}	2.5×10^{3}	1.5

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Increased likelihood of latent cancer fatalities.
[c] Increased number of latent cancer fatalities.
LCF = latent cancer fatality.

TABLE N.5.4–3.—*Integrated Technology Project Accident Frequency and Consequences for the Proposed Action (Median Meteorology)*

		MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose (rem)**	**LCFs[b]**	**Dose (person-rem)**	**LCFs[c]**	**Dose (rem)**	**LCFs[b]**	**Dose (person-rem)**	**LCFs[c]**
Room Fire, Unfiltered	3.9×10^{-7}	4.4×10^{-1}	2.6×10^{-4}	2.8×10^{2}	1.7×10^{-1}	4.94	3.1×10^{-3}	9.3×10^{2}	5.6×10^{-1}
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	7.4×10^{-2}	4.4×10^{-05}	4.1×10^{1}	2.4×10^{-2}	8.4×10^{-1}	5.1×10^{-4}	1.4×10^{2}	8.5×10^{-2}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	1.5×10^{-2}	8.7×10^{-6}	3.3×10^{-1}	2.0×10^{-4}	6.6×10^{-2}	4.0×10^{-5}	1.6×10^{1}	9.5×10^{-3}
Design Basis Fire (Separation Process)	2.0×10^{-4}	1.8×10^{-3}	1.1×10^{-6}	1.1	6.7×10^{-4}	2.0×10^{-2}	1.2×10^{-5}	3.7	2.2×10^{-3}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	2.5×10^{-3}	1.5×10^{-6}	1.4	8.2×10^{-4}	8.0×10^{-4}	4.8×10^{-7}	4.8	2.9×10^{-3}
Aircraft Accident	1.5×10^{-6}	1.5×10^{-1}	8.9×10^{-5}	9.7×10^{1}	5.8×10^{-2}	1.8×10^{1}	1.1×10^{-3}	3.2×10^{2}	2.0×10^{-1}

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Increased likelihood of a LCF.
[c] Increased number of LCFs.
LCF = latent cancer fatality; MEI = maximally exposed individual.

TABLE N.5.4–4.—*Integrated Technology Project Accident Frequency and Consequences for the Proposed Action (Unfavorable Meteorological Conditions)*

		Offsite MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose (rem)**	**LCFs [b]**	**Dose (person-rem)**	**LCFs[c]**	**Dose (rem)**	**LCFs [b]**	**Dose (person-rem)**	**LCFs [c]**
Room Fire, Unfiltered	3.9×10^{-7}	8.4	5.0×10^{-3}	3.3×10^{3}	2.0	4.5×10^{1}	2.7×10^{-2}	7.8×10^{3}	4.7
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	1.4	8.4×10^{-4}	7.2×10^{2}	4.3×10^{-1}	9.9	5.8×10^{-3}	1.1×10^{3}	6.3×10^{-1}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	2.7×10^{-2}	1.6×10^{-5}	1.1×10^{1}	6.4×10^{-3}	3.8×10^{-1}	2.3×10^{-4}	2.2×10^{1}	1.4×10^{-1}
Design Basis Fire (Separation Process)	2.0×10^{-4}	3.4×10^{-2}	2.0×10^{-5}	1.3×10^{1}	7.8×10^{-3}	1.8×10^{-1}	1.1×10^{-4}	3.1×10^{1}	1.9×10^{-2}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	4.7×10^{-2}	2.8×10^{-5}	2.4×10^{1}	1.4×10^{-2}	3.2×10^{-1}	1.9×10^{-4}	3.6×10^{1}	2.1×10^{-2}
Aircraft Accident	1.5×10^{-6}	2.9	1.7×10^{-3}	1.2×10^{3}	7.1×10^{-1}	2.4×10^{1}	1.4×10^{-2}	2.5×10^{3}	1.5

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Increased likelihood of a LCF.
[c] Increased number of LCFs.
LCF = latent cancer fatality.

Using data representing unfavorable meteorological conditions, the increased number of LCFs in the offsite population would be 2.0 per year. The risk of a LCF to the offsite MEI would be 5.0×10^{-3} (i.e., about 1 chance in 198 of a LCF). The risk of a LCF to a noninvolved worker located at a distance of 100 meters from the accident would be 2.7×10^{-2} (i.e., about 1 chance in 37 of a LCF). The increased number of LCFs in the population of noninvolved workers would be 4.7.

Tables N.5.4–5 and N.5.4–6 show the frequency and risk of the postulated set of accidents for the No Action Alternative for a noninvolved worker (assumed to be a worker located 100 meters from the release point), the population of noninvolved workers, and the public (offsite MEI and the general population living within 50 miles of LLNL) for both median and unfavorable meteorological conditions. The term "risk" means the consequence of the accident (radiation dose or LCFs) multiplied by the frequency for that accident (per year). Tables N.5.4–7 and N.5.4–8 show this same information for the Proposed Action.

Nonradiological Accidents

Accidents were evaluated for previous applications of the AVLIS technology where the amount of dye used was 10 to 100 times the amount to be used in the ITP (LLNL 1992b). For the previous system, spills, fires, and explosions were assessed involving hundreds of gallons of ethanol or dye solution. Table N.5.4–9 presents the maximum exposures associated with these accidents.

TABLE N.5.4–9.—*Hazardous Chemical Exposures Due to Accidents Associated with Large-scale AVLIS Activities*

Compound	Receptor	Distance	Exposure	Effect
Ethanol Vapor	Onsite	100 m	23 mg/m^3	Negligible
	Offsite	320 m	2.3 mg/m^3	Negligible
Dye Release	Onsite	100 m	1.3 mg/m^3	Negligible
	Offsite	320 m	0.075 mg/m^3	Negligible

Source: Original.
m = meters; mg/m^3 = milligrams per cubic meter.

Given that the amounts dye and alcohol involved in the analyzed accidents is orders of magnitude above the entire inventory for the ITP, the impacts of accidents associated with the laser system would be limited to the physical affects of any fire and bounded by other nonradiological accidents.

TABLE N.5.4–5.—*Accident Frequency and Risk for the No Action Alternative (Median Meteorology)*

		MEI		Offsite Population		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose Risk (rem)**	**LCFs Risk**	**Dose Risk (person-rem)**	**LCFs Risk**	**Dose Risk (rem)**	**LCFs Risk**	**Dose Risk (person-rem)**	**LCFs Risk**
Room Fire, Unfiltered	3.9×10^{-7}	5.7×10^{-8}	3.4×10^{-11}	3.6×10^{-5}	2.2×10^{-8}	6.4×10^{-7}	3.8×10^{-10}	1.2×10^{-4}	7.2×10^{-8}
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	7.4×10^{-8}	4.4×10^{-11}	4.1×10^{-5}	2.4×10^{-8}	8.5×10^{-7}	5.1×10^{-10}	1.4×10^{-4}	8.5×10^{-8}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	4.6×10^{-7}	2.8×10^{-10}	1.0×10^{-5}	6.3×10^{-9}	2.1×10^{-6}	1.3×10^{-9}	5.0×10^{-4}	3.3×10^{-7}
Design Basis Fire (Separation Process)	2.0×10^{-4}	3.5×10^{-7}	2.1×10^{-10}	2.2×10^{-4}	1.3×10^{-7}	4.0×10^{-6}	2.4×10^{-9}	7.4×10^{-4}	4.5×10^{-7}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	2.5×10^{-7}	1.5×10^{-10}	1.4×10^{-4}	8.2×10^{-8}	8.0×10^{-8}	4.8×10^{-11}	4.8×10^{-4}	2.9×10^{-7}
Aircraft Accident	1.5×10^{-6}	2.2×10^{-7}	1.3×10^{-10}	1.4×10^{-4}	8.8×10^{-8}	2.8×10^{-6}	1.7×10^{-9}	4.8×10^{-4}	2.9×10^{-7}

Source: Original.
LCF = latent cancer fatality; MEI = maximally exposed individual.

TABLE N.5.4–6.—*Accident Frequency and Risk for the No Action Alternative (Unfavorable Meteorological Conditions)*

		MEI		Offsite Population		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose Risk (rem)**	**LCFs Risk**	**Dose Risk (person-rem)**	**LCFs Risk**	**Dose Risk (rem)**	**LCFs Risk**	**Dose Risk (person-rem)**	**LCFs Risk**
Room Fire, Unfiltered	3.9×10^{-7}	1.1×10^{-6}	6.6×10^{-10}	4.2×10^{-4}	2.5×10^{-7}	5.8×10^{-6}	3.5×10^{-9}	1.0×10^{-3}	6.1×10^{-7}
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	1.4×10^{-6}	8.4×10^{-10}	7.2×10^{-4}	4.3×10^{-7}	9.6×10^{-6}	5.8×10^{-9}	1.1×10^{-3}	6.3×10^{-7}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	8.8×10^{-7}	5.3×10^{-10}	3.4×10^{-4}	2.0×10^{-7}	1.2×10^{-5}	7.3×10^{-9}	7.2×10^{-4}	4.3×10^{-7}
Design Basis Fire (Separation Process)	2.0×10^{-4}	6.7×10^{-6}	4.0×10^{-9}	2.6×10^{-3}	1.6×10^{-6}	3.6×10^{-5}	2.1×10^{-8}	6.2×10^{-3}	3.7×10^{-6}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	4.7×10^{-6}	2.8×10^{-9}	2.4×10^{-3}	1.4×10^{-6}	3.2×10^{-5}	1.9×10^{-8}	3.6×10^{-3}	2.1×10^{-6}
Aircraft Accident	1.5×10^{-6}	4.4×10^{-6}	2.6×10^{-9}	1.8×10^{-3}	1.1×10^{-6}	3.6×10^{-5}	2.1×10^{-8}	3.8×10^{-3}	2.3×10^{-6}

Source: Original.
LCF = latent cancer fatality; MEI = maximally exposed individual.

TABLE N.5.4.–7.—*Integrated Technology Project Accident Frequency and Risk for the Proposed Action (Median Meteorology)*

		MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	Frequency (per year)	Dose Risk (rem)	LCFs Risk [b]	Dose Risk (person-rem)	LCFs Risk [c]	Dose Risk (rem)	LCFs Risk [b]	Dose Risk (person-rem)	LCFs Risk [c]
Room Fire, Unfiltered	3.9×10^{-7}	1.7×10^{-7}	1.0×10^{-10}	1.1×10^{-4}	6.6×10^{-8}	1.9×10^{-6}	1.2×10^{-9}	3.6×10^{-4}	2.2×10^{-7}
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	7.4×10^{-8}	4.4×10^{-11}	4.1×10^{-5}	2.4×10^{-8}	8.5×10^{-7}	5.1×10^{-10}	1.4×10^{-4}	8.6×10^{-8}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	4.6×10^{-7}	2.8×10^{-10}	1.0×10^{-5}	6.3×10^{-9}	2.1×10^{-6}	1.3×10^{-9}	5.0×10^{-4}	3.0×10^{-7}
Design Basis Fire (Separation Process)	2.0×10^{-4}	3.5×10^{-7}	2.1×10^{-10}	2.2×10^{-4}	1.3×10^{-7}	4.0×10^{-6}	2.4×10^{-9}	7.4×10^{-4}	4.5×10^{-7}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	2.5×10^{-7}	1.5×10^{-10}	1.4×10^{-4}	8.2×10^{-8}	8.0×10^{-8}	4.8×10^{-11}	4.8×10^{-4}	2.9×10^{-7}
Aircraft Accident	1.5×10^{-6}	2.2×10^{-7}	1.3×10^{-10}	1.5×10^{-4}	8.7×10^{-8}	2.7×10^{-6}	1.7×10^{-9}	4.8×10^{-4}	3.0×10^{-7}

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Increased likelihood of a LCF.
[c] Increased number of LCFs.
LCF = latent cancer fatality; MEI = maximally exposed individual.

TABLE N.5.4–8.—*Integrated Technology Project Accident Frequency and Risk for the Proposed Action (Unfavorable Meteorological Conditions)*

		MEI		Offsite Population[a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	Frequency (per year)	Dose Risk (rem)	LCFs Risk[b]	Dose Risk (person-rem)	LCFs Risk[c]	Dose Risk (rem)	LCFs Risk[b]	Dose Risk (person-rem)	LCFs Risk[c]
Room Fire, Unfiltered	3.9×10^{-7}	3.3×10^{-6}	2.0×10^{-9}	1.3×10^{-3}	7.6×10^{-7}	1.7×10^{-5}	1.0×10^{-8}	3.0×10^{-3}	1.8×10^{-6}
Radioactive Material Spill, Unfiltered	1.0×10^{-6}	1.4×10^{-6}	8.4×10^{-10}	7.2×10^{-4}	4.3×10^{-7}	9.6×10^{-6}	5.8×10^{-9}	1.1×10^{-3}	6.3×10^{-7}
Inadvertant Plutonium Criticality for a Powder	3.2×10^{-5}	8.8×10^{-7}	5.3×10^{-10}	3.4×10^{-4}	2.0×10^{-7}	1.2×10^{-5}	7.3×10^{-9}	7.2×10^{-4}	4.3×10^{-7}
Design Basis Fire (Separation Process)	2.0×10^{-4}	6.7×10^{-6}	4.0×10^{-9}	2.6×10^{-3}	1.6×10^{-6}	3.6×10^{-5}	2.1×10^{-8}	6.2×10^{-3}	3.7×10^{-6}
Radioactive Material Spill (Separation Process)	10^{-6} to 10^{-4}	4.7×10^{-6}	2.8×10^{-9}	2.4×10^{-3}	1.4×10^{-6}	3.2×10^{-5}	1.9×10^{-8}	3.6×10^{-3}	2.1×10^{-6}
Aircraft Accident	1.5×10^{-6}	4.4×10^{-6}	2.6×10^{-9}	1.8×10^{-9}	1.1×10^{-6}	3.6×10^{-5}	2.1×10^{-8}	3.8×10^{-3}	2.3×10^{-6}

Source: Original.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.
[b] Increased likelihood of a LCF.
[c] Increased number of LCFs.
LCF = latent cancer fatality; MEI = maximally exposed individual.

N.6 MITIGATION MEASURES

The regulations promulgated by the Council on Environmental Quality to implement the procedural provisions of the *National Environmental policy Act* (42 USC §4321) require that an EIS include a discussion of appropriate mitigation measures (40 CFR Parts §1502.14[f] and 16[h]). Mitigation measures are discussed in Section 5.6 of this LLNL SW/SPEIS. The applicable mitigation areas for the Proposed Action are (1) waste management, where an active program of waste minimization and pollution prevention exists, (2) occupational protection (worker dose), where automation, local shielding, and administrative modules ensure that worker doses are as low as reasonably achievable, and (3) accidents where a formal program of HEPA filter maintenance and inspection is in place to ensure that no degraded HEPA operation contributes to the impact of a ITP radiological accident.

N.7 REFERENCES

10 CFR Part 835 — DOE, "Energy, Occupational Radiation Protection," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

10 CFR §835.202 — U.S. Department of Energy (DOE), "Energy, Occupational Radiation Protection, Occupational Dose Limits for General Employees" *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

10 CFR §835.1002 — DOE, "Energy, Occupational Radiation Protection, Facility Design and Modifications," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

40 CFR Part 61 — U.S. Environmental Protection Agency (EPA), "Protection of the Environment, National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, July 21, 2003.

40 CFR §1502.14[f] — Council on Environmental Quality (CEQ), "Protection of the Environment, Environmental Impact Statement, Alternatives Including the Proposed Action, Subpart f," *Code of Federal Regulations*, Office of the Federal Register, national Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

40 CFR §1502.16[h] — CEQ, "Protection of the Environment, Environmental Consequences, Subpart h," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.

42 U.S.C. §4321 et seq. — "*National Environmental Policy Act*," *United States Code*, Title 42, Chapter 55, Sec. 4321 through 4347, Revised January 22, 2002.

Chanin and Young 1997 — Chanin, David and Mary L. Young, *Code Manual for MACCS2: Volume 1, User's Guide*, SAND97-0594.UC-610, Sandia National Laboratories, Accident Analysis/Consequence Assessment Department, Albuquerque, NM, March 1998.

DOE Order 5400.5 — DOE, Radiation Protection of the Public and Environment, Change 2, Washington DC, 1993.

DOE 1990b — DOE, *Finding of No Significant Impact, Resumption of Surrogate Testing in the Engineering Demonstration System at the Lawrence Livermore National Laboratory*, U.S. Department of Energy, June 11, 1990.

DOE 1990d — DOE, *Resumption of Surrogate Testing in the Engineering Demonstration System at the Lawrence Livermore National Laboratory*, DOE/EA-0421, U.S. Department of Energy, April 1990.

DOE 1999a — DOE, *Supplemental Analysis for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories*, Vol. 1, DOE/EIS-0157-SA-01, U.S. Department of Energy, Oakland Operations Office, Oakland, CA, March 1999.

DOE 2002o — DOE, *National Environmental Policy Act Review of the Advanced Materials Program (AMP), Buildings 161, 332, and 335*, U.S. Department of Energy, Oakland Operations Office, Oakland, CA, June 20, 2002.

LLNL 1988a — LLNL, Safety Analysis Report, Addendum 1, Building 332, Plutonium Facility, Engineering Demonstration System, Atomic Vapor Laser Isotope Separation, UCAR-1021; SAR- 332, Addendum 1, Lawrence Livermore National Laboratory, Livermore, CA, July 1988.

LLNL 1989 — LLNL, Engineering Demonstration System (EDS) for Special Isotope Separation; NEPA Determination (UCNI), Lawrence Livermore National Laboratory, Livermore, CA, March 1, 1989.

LLNL 1992a — LLNL, *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence National Laboratory and Sandia National Laboratories*, Vols. 1-5, DOE/EIS-0157, Lawrence Livermore National Laboratory, Livermore, CA, August 1992.

LLNL 1992b — LLNL, *Laser Demonstration Facility Safety Analysis Document*, Lawrence Livermore National Laboratory, Livermore, CA, 1992.

LLNL 2000v — LLNL, Letter from M. R. Anastasio, Associate Director, Defense and Nuclear Technologies, to Gen. T. F. Gioconda, Defense Programs, DOE, Livermore, CA, dated May 5, 2000.

LLNL 2003t — LLNL, *Safety Analysis Report and Technical Safety Requirements Regarding B332 DSA*, Lawrence Livermore National Laboratory, Livermore, CA, October 10, 2003.

LLNL 2003x — LLNL, Letter from Ellen Raber, LLNL EPD, to Daniel Nakahara, U.S. Department of Energy, dated June 6, 2003, regarding the *Proposed Actions in the Site-Wide Environmental Impact Statement concerning TRU shipments from Superblock to WIPP*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bj — LLNL, Email from Karen Dodson, LLNL, to Ralph Barr, Tetra Tech, Inc. dated June 18, 2003, regarding Annual Waste Generation from Integrated Technology Program Operations at Lawrence Livermore National Laboratory, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

NNSA 2003c — NNSA, *Project Specific Analysis for the Integrated Technology Program (U)*, Classified, U.S. Department of Energy, National Nuclear Security Administration, August 1, 2003.

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APPENDIX O: POLLUTION PREVENTION

O.1 INTRODUCTION

Pollution prevention includes practices that reduce the use of hazardous materials, energy, water, and other resources along with practices that protect natural resources through conservation, more efficient use, and recycling. Pollution prevention encompasses source reduction, waste minimization, and energy, water, and natural resource conservation programs and activities. Lawrence Livermore National Laboratory (LLNL) programs address this broad scope of pollution prevention.

This appendix discusses pollution prevention programs and activities of LLNL. Section O.2 presents the regulatory setting for these programs. Section O.3 discusses the history of pollution prevention, energy efficiency, and water conservation at LLNL and introduces the site organizations that lead and facilitate the programs. Section O.4 includes descriptions of various pollution prevention, water conservation, and energy efficiency activities and projects recently completed and ongoing. Section O.5 discusses LLNL research and development projects that have implications and applications for pollution prevention and energy conservation for government, businesses, and individuals.

O.2 REGULATORY SETTING

LLNL operations regarding pollution prevention, water conservation, and energy efficiency are conducted pursuant to Executive Orders, U.S. Department of Energy (DOE) Orders, and applicable Federal and state laws and regulations. Major requirements and goals are summarized in Table O.2–1.

TABLE O.2–1.— ***Summary of Major Requirements and Goals Associated With Pollution Prevention, Water Conservation, and Energy Efficiency***

Requirements and Goals	Description
Pollution Prevention Act of 1990 (42 U.S.C. §13101 et seq.)	This Act sets the national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal. In response, DOE committed to voluntary participation in EPA's 33/50 Pollution Prevention Program, as set forth in Section 313 of SARA.
RCRA Section 6002 (42 U.S.C. § 6962)	This section of the Act directs Federal agencies to establish Affirmative Procurement Programs for acquiring recycled content products designated by EPA. RCRA Section 6002(c)(1) requires agencies to procure designated items composed of the highest percentage of recovered materials practicable. Procuring agencies may decide not to procure such items if they are not reasonably available in a reasonable period of time; fail to meet reasonable performance standards; or are only available at an unreasonable price.
Comprehensive Guideline for Procurement of Products Containing Recovered Materials (40 CFR Part 247)	This EPA guideline designates recycled content products pursuant to RCRA Section 6002.
Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition (EO 13101)	This EO confirmed the requirement for Federal agencies to have affirmative procurement programs for EPA-designated guideline items. The EO further required that Federal agencies require that 100 % of their purchases of products meet or exceed EPA guidelines unless written justification is provided. The EO addressed solid waste prevention and recycling by requiring Federal agencies to establish goals for prevention and recycling or diversion to be met by 2000, 2005, and 2010.
Greening the Government Through Efficient Energy Management (EO 13123)	This EO directs Federal agencies to develop and implement energy management programs in order to reduce cost and emissions that contribute to air pollution and global climate change. The EO established goals for greenhouse gases reduction, energy efficiency, renewable energy use, and water conservation. DOE directs implementation of the EO through DOE O 430.2A.
Greening the Government Through Leadership in Environmental Management (EO 13148)	This EO directs all Federal agencies to develop and implement environmental management systems to support environmental compliance; right-to-know disclosures requirements; pollution prevention; reducing toxic chemical releases; reducing use of toxic chemicals, hazardous substances, and other pollutants; reducing ozone depleting substances; and promoting environmentally and economically beneficial landscaping.
Greening the Government Through Federal Fleet and Transportation Efficiency (EO 13149)	This EO requires Federal agencies that operate 20 or more motor vehicles to reduce its entire vehicle fleet's annual petroleum consumption by at least 20 % by the end of FY2005, compared with FY1999 petroleum consumption levels. Agencies have numerous options for developing a strategy to meet the petroleum reduction levels. Measures include the use of alternative fuels in light, medium, and heavy-duty vehicles; the acquisition of vehicles with higher fuel economy, including hybrid vehicles; the substitution of cars for light trucks; an increase in vehicle load factors; a decrease in vehicle miles traveled; and a decrease in fleet size.

TABLE O.2–1.— ***Summary of Major Requirements and Goals Associated With Pollution Prevention, Water Conservation, and Energy Efficiency (continued)***

Requirements and Goals	Description
Federal Workforce Transportation (EO 13150)	This EO addresses Federal employees' contribution to traffic congestion and air pollution. Federal agencies were required to implement a transportation fringe benefit program that offers qualified Federal employees the option to exclude employee commuting costs incurred through the use of mass transportation and vanpools from taxable wages and compensation.
Hazardous Waste Reduction Act (California Health and Safety Code §25244.12-25)	This Act expands the State of California hazardous waste source reduction activities to accelerate reduction in hazardous waste generation.
DOE Secretary Memorandum on Pollution Prevention and Energy Efficiency Leadership Goals for FY2000 and Beyond, November 12, 1999 (Richardson 1999a)	The memorandum established the following 14 goals for DOE facilities: 1. Reduce waste from routine operations by 2005, using a 1993 baseline, for these waste types: a. Hazardous waste by 90 percent. b. TRU waste by 80 %. c. LLW by 80 %. d. MLLW by 80 %. 2. Reduce releases of toxic chemicals subject to toxic chemical release inventory reporting by 90 % by 2005, using a 1993 baseline. 3. Increase the purchase of electricity from clean energy sources. a. Increase purchase of electricity from renewable energy sources by including provisions for such purchase as a component of requests for bids in 100 % of all future DOE competitive solicitations for electricity. b. Increase the purchase of electricity from less greenhouse gas-intensive sources including, but not limited to, new advanced technology fossil energy systems, hydroelectric, and other highly efficient generating technologies. 4. Retrofit or replace 100 % of chillers of greater than 150 tons of cooling capacity and manufactured before 1984 that use Class I refrigerants by 2005. 5. Eliminate use of Class I ozone-depleting substances by 2010, to the extent economically practicable, and to the extent that safe alternative chemicals are available for DOE Class I applications. 6. Reduce greenhouse gas emissions attributed to facility energy use through life-cycle cost effective measures by 25 % by 2005 and 30 % by 2010, using 1990 as a baseline. 7. Reduce entire fleet's annual petroleum consumption by at least 20 % by 2005 in comparison to 1999, including improving the fuel economy of new light-duty vehicle acquisitions and by other means. 8. Acquire each year at least 75 % of light-duty vehicles as alternative-fuel vehicles, in accordance with the requirements of the *Energy Policy Act* of 1992. 9. Increase usage rate of alternative fuel in departmental alternative fuel vehicles to 75 % by 2005 and 90 % by 2010 in areas where alternative fuel infrastructure is available.
DOE O 430.2A, "In-House Energy Management"	This Order contains the following energy usage and ozone-depleting substance reduction goals applicable to DOE or the operating contractor: • Reduce energy consumption per gross square foot (or other unit as applicable) for laboratory and industrial facilities through life-cycle cost-effective measures by 20 % by 2005 and 25 % by 2010, using 1990 as a baseline.

TABLE O.2–1.— ***Summary of Major Requirements and Goals Associated With Pollution Prevention, Water Conservation, and Energy Efficiency (continued)***

Requirements and Goals	Description
	• Increase the purchase of electricity from nonhydroelectric renewable energy sources by including provisions for such purchases as a component in all future DOE competitive solicitations for electricity. DOE will purchase 3 % of its total electricity needs from nonhydroelectric renewable energy sources by 2005 and 7.5 % of its total from nonhydroelectric renewable energy sources by 2010. Nonhydroelectric renewable energy is energy generated from solar, geothermal, biomass, or wind technologies. • Increase the purchase of electricity from less greenhouse gas-intensive sources, including but not limited to, new advanced technology fossil energy systems and other highly efficient generating technologies. • Increase use of off-grid generation systems, including solar hot water and solar electricity supporting the Million Solar Roofs initiative, solar outdoor lighting, small wind turbines, fuel cells, and other technologies, when such systems are life-cycle cost effective and offer other benefits. • Retrofit or replace all chillers of greater than 150 tons of cooling capacity and manufactured before 1984 that use Class I refrigerant by 2005. • Reduce greenhouse gas emissions attributed to facility energy use through life-cycle cost-effective measures by 30 % by 2010, using 1990 as a baseline. Greenhouse gas emissions are carbon dioxide emissions calculated by DOE's Federal Energy Management Program from energy consumption reported by the contractor. • Apply energy efficiency criteria and sustainable design principles to new building designs and submit Energy Efficiency/Sustainable Design Reports to DOE's Federal Energy Management Program on individual projects after completion of Title II design.
DOE O 450.1, "Environmental Protection Program"	This Order requires DOE sites to implement Environmental Management Systems, a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. These systems must be part of the Integrated Safety Management Systems established pursuant to DOE P 450.4, Safety Management System Policy.

EO = Executive Order; EPA = U.S. Environmental Protection Agency; RCRA = *Resource Conservation and Recovery Act;* SARA = *Superfunds Amendments and Reauthorization Act.*

O.3 POLLUTION PREVENTION PROGRAMS

O.3.1 History

Since the early 1990s, LLNL has had a formal pollution prevention program. However, activities that had beneficial pollution prevention implications for LLNL began before the 1990s. Process improvements implemented in 1988 at the energetic materials and components testing facilities at Site 300 led to reductions in low-level and mixed radioactive waste (LLNL 1997a). In the early 1990s, DOE initiated a return on investment program to fund pollution prevention projects that pay for themselves within 3 years by reducing hazardous material usage and waste generation. LLNL has implemented more than 30 such projects, some of which are described in the following sections. Since 1991, LLNL has operated a site-wide paper recycling program (LLNL 2002ag). LLNL met the DOE recycling goal for sanitary solid waste of 45 percent long before the target date of 2005, necessitating the establishment of a higher goal, 66.7 percent, by 2005 (LLNL 2002cc).

More than 15 years ago, LLNL engineers conducted comprehensive energy audits with the purpose of identifying conservation opportunities. Implementation of energy conservation projects led to a reduction of energy consumption of 23 percent from 1990 levels (LLNL2002bi). Water usage has also been scrutinized and conservation efforts implemented, including revising irrigation practices to optimize and reduce water consumption. LLNL also replaced toilets with ultra low-flow models and retrofitted urinals to reduce water usage. Recently, a pilot program was implemented to evaluate waterless urinals.

LLNL has also established an affirmative procurement program to use its buying power in order to promote recycled-content products. In 2000, LLNL spent $1.1 million on recycled-content products targeted by the U.S. Environmental Protection Agency (EPA) (LLNL 2001q).

O.3.2 Program Organizations

The pollution prevention program strives to use a cross-disciplinary and inter-organizational approach to identify and address pollution prevention issues. Recent pollution prevention project teams included individuals from LLNL's Environmental Protection Department, the Chemistry and Materials Science Directorate, the Plant Engineering Department, Public Affairs Office, and DOE. These teams worked well enough together to win two "Champions of Green Government" awards from EPA (LLNL 2003bv). LLNL organizations leading the pollution prevention effort are the Pollution Prevention Team and the Energy Management Program. The Procurement and Material Department, Fleet Management, and Plant Engineering's Facility and Maintenance Management Division are other LLNL organizations that are responsible for certain aspects of pollution prevention.

The LLNL Pollution Prevention Team is within the Environmental Protection Department. The team works in conjunction with the directorates to devise and implement measures to eliminate or reduce wastes and pollutants. The team conducts pollution prevention opportunity assessments to help waste generators evaluate processes that generate pollution and identify prevention opportunities (e.g., using less hazardous raw materials, implementing closed-loop systems to eliminate discharges, and adding controls for greater process efficiency). The Pollution

Prevention Team also assists the Energy Management Program in their integration of sustainable design into project planning, design, construction, and building life cycle management including equipment specifications and material design. The LLNL Environmental Protection Department also operates the Chemical Exchange Warehouse to promote chemical exchange rather than disposal (LLNL/EPD 2003).

The Pollution Prevention Team works with procurement and contracting officials, including Central Supply, the Print Plant, and the Procurement and Material Department, to implement the Affirmative Procurement Program. The Affirmative Procurement Program purchase recycled-content products. Purchasing recycled-content products is considered part of pollution prevention for its role in ensuring that a market for products manufactured from waste items is collected for recycling.

The Environmental Protection Department provides pollution prevention training and awareness and award programs for LLNL, including a site-wide Earth Expo coinciding with Earth Day that focuses on pollution prevention and natural resource conservation. Pollution prevention principles are promoted through new employee training and orientation, posters, articles in LLNL publications, administrative briefings, and memorandums. Pollution prevention requirements and responsibilities are documented for technical employees in Document 30.1, "Waste Minimization and Pollution Prevention," of the Environment, Safety and Health (ES&H) Manual (LLNL 2002cc).

Other aspects of pollution prevention including reducing energy consumption by LLNL facilities; water conservation; and off-grid energy generation systems. Incorporation of sustainable design practices in new facilities is promoted by Energy Management Program within the Laboratory Services Directorate (Figure O.3.2–1). It is Plant Engineering's Design and Construction and Project Management Divisions that are responsible for project planning, design, and construction. The Energy Management Program also reports electricity, natural gas, and fuel oil consumption to DOE's Federal Energy Management Program for the purposes of calculating greenhouse gas emissions.

Even though the Energy Management Program and the Pollution Prevention Team are not linked organizationally, the two teams often interact informally to promote pollution prevention. The Pollution Prevention Team also assists the Energy Management Program in promoting the integration of sustainable design into project planning, construction, de-construction, equipment specifications, and material selection.

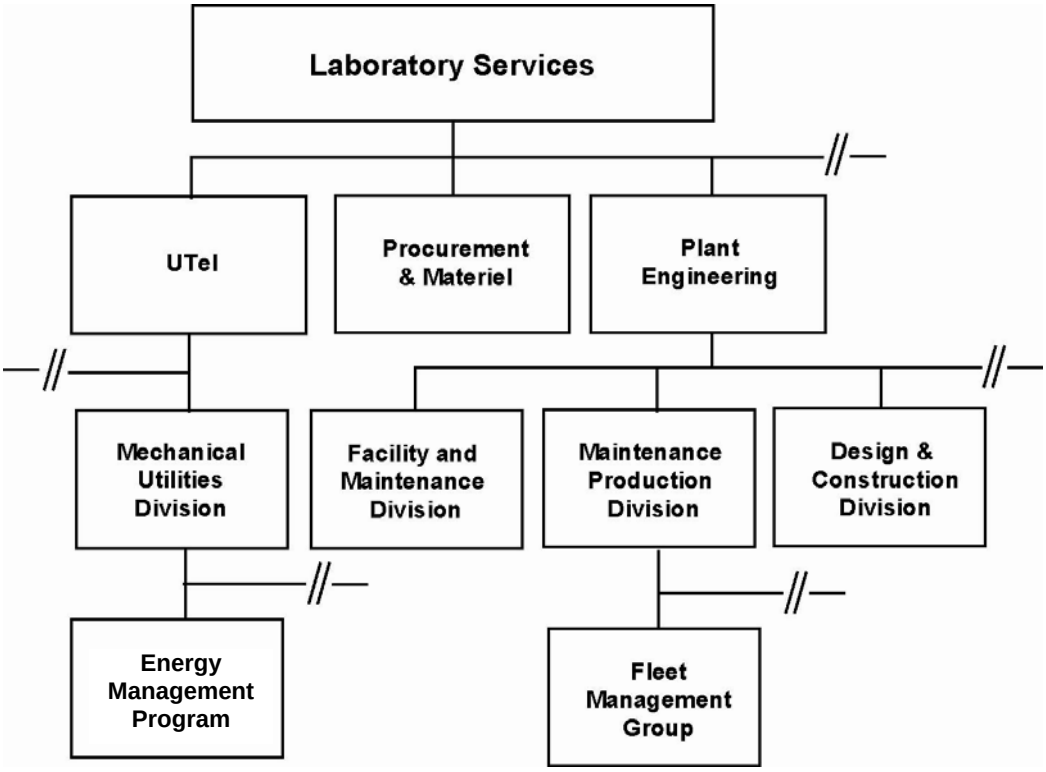


FIGURE O.3.2–1.—*Laboratory Services Organization Showing Pollution Prevention Organizations*

Fleet Management, a part of the Plant Engineering Department's Maintenance Production Division leads LLNL efforts to reduce petroleum consumption, thus conserving fossil fuels and reducing air pollution from the burning of fossil fuels. Fleet Management oversees LLNL's fleet of cars and trucks, heavy equipment, and the bicycle program. Fleet Management also promotes car and vanpools through the Transportation Systems Management Program.

Plant Engineering's Facility and Maintenance Management Division is responsible for retrofitting and replacing equipment that relies on ozone-depleting substances such as Freon. The Division is working toward phasing out ozone-depleting substances (ODSs) on a schedule based on DOE pollution prevention goals.

O.3.3 Sustainable Design

Executive Order (EO) 13123, "Greening the Government through Efficient Energy Management," and DOE O 430.2A, "In-House Energy Management," (DOE O 430.2A) require DOE to improve energy efficiency, conserve water, use renewable energy, and practice sustainable design.

Pollution prevention, energy efficiency, and water conservation are key elements in sustainable design. The sustainable design approach recognizes the fact that every design choice may have an impact on the natural and cultural resources of the local, regional, and global environments. This new design method incorporates life-cycle costs and associated impacts of a building's construction; use, including installation and operation of equipment and human occupancy, and

deconstruction into the earliest stages of design; thus front loading the design process with criteria that would traditionally be considered after much of the design has been set. Breakthroughs in building science, technology and operations available to designers, builders, and owners are promoting sustainable design principles. The pollution prevention benefits of sustainable design include reduced indoor and outdoor air pollution, water discharges, and waste generation and conservation of natural resources through more efficient use of energy and materials.

LLNL has begun integrating this design approach into its design, contracting, and procurement elements. Traditionally, designing a building for LLNL took a linear approach. LLNL designers would plan the structure and then the building systems such as the electrical and heating, ventilation, and air conditioning would be added one at a time. Finally, the group that would occupy the building, and other support organizations such as the Environmental Protection Department, would review the completed drawings and plans. With this linear approach, pollution prevention and energy efficiency opportunities are more difficult to incorporate into the design.

LLNL has applied sustainable design principles to the International Security Research Facility, Building 140, and several other new facilities. Pollution prevention and energy efficiency were considered during the conceptual design phase, the earliest design phase. This approach applied during the early design phase leads to a more resource-efficient design.

Also, sustainable design principles were applied to the National Ignition Facility (NIF) project to identify opportunities for pollution prevention and energy efficiency. Recommendations were made for more energy efficient building insulation, chillers, cooling towers, and heating and cooling systems. The project also incorporates existing buildings, facilities, and resources saving materials and expenses. The project has developed pollution prevention plans for the construction, operation, and decommissioning phases.

To further integrate the sustainable design approach, LLNL and DOE began training managers and engineers using LEED™, the "Leadership in Energy & Environmental Design" principles developed by the U.S. Green Building Council. LLNL may require new construction and major renovation projects to be LEED™ Certified or rated.

The training has lead to LLNL incorporating selected sustainable design requirements into contract specifications. Several office buildings are planned for construction over the next few years. The contract specification for one of the first office buildings requires the designer to apply the following sustainable design principles (LLNL 2003bs):

- **Optimize Potential of Selected Site.** Site planning activities shall include evaluation of solar and wind orientation, local microclimate, drainage patterns, existing utilities, and site features to develop an optimal building site design and low-maintenance landscaping.

- **Minimize Energy Consumption.** Consider building orientation and massing, natural ventilation, daylighting, and other passive energy strategies that may lower a facility's energy demand and utilization. Meet or exceed Federal and/or State of California energy

performance standards for energy efficiency and additional details and considerations required by DOE O 430.2A.

- **Protect and Conserve Water.** Water conservation is enhanced by low-flow plumbing fixtures, appropriate landscaping, and the reuse of site runoff when feasible.

- **Use Environmentally Preferable Products.** Environmentally preferable building materials minimize life-cycle environmental impacts and minimize impact on occupant health. To the extent feasible, consider materials containing recycled content and salvage/recycle waste during construction.

- **Enhance Indoor Environmental Quality.** Appropriate ventilation/moisture control and the avoidance of materials and products with high volatile organic compound emissions will enhance occupant health and comfort.

O.3.4 Construction Practices

To address pollution prevention during construction, LLNL includes standard measures for controlling pollution as part of every construction subcontract. Construction is defined to include building, renovating, modifying, painting, decorating, repairing, or demolishing of facilities and structures. For example, general construction practices at LLNL include contract specifications that require that fugitive emissions be reduced by water spraying of roads and the wheels and lower portions of construction vehicles (LLNL 2001r). To maximize recycling of building materials and minimize cost, demolition contractors with salvage operations are used whenever possible. The value of the recovered building material is sometimes partial compensation for the job.

To aid in the identification of mitigation measures, LLNL requires that subcontractors complete a project-specific task identification process list for all construction projects. This list, a questionnaire listing typical concerns and hazards, helps subcontractors identify potential topics to be addressed in project-specific compliance plans. This list (LLNL 2001r) contains specific line items that assist in the identification of requirements related to air resource protection during facility construction.

- Will all gasoline or diesel-powered portable electric generators be rated below 50 horsepower?

- Will construction equipment and vehicles be inspected daily for leaks of fuel, engine coolant, and hydraulic fluid?

- Will work involve chemicals, solvents, painting, welding, torch cutting, brazing, or grit blasting?

    - Are all paints in compliance with Bay Area Air Quality Management District limits on volatile organic compound content?

    - Will adequate measure be taken to prevent discharge of hazardous and regulated materials to the environment?

- Will the project involve concrete demolition or disturbance?
    - Has a 10-day notification to the Air District been submitted for any demolition?
    - Will work involve jack hammering, roto-hammering, or other operations that may generate silica dust?
        - Describe how dust will be controlled and/or workers protected from silica hazards.
    - Is there a possibility that asbestos containing materials will be encountered?
        - Has a 10-day notification to the Air District been submitted for renovations involving asbestos containing material greater than or equal to 100 linear feet, 100 square feet, or 35 cubic feet prior to renovation?
    - Will adequate measures be taken to prevent discharge of hazardous and regulated materials to the environment?

In addition, the Environmental Protection Department provides guidance on construction projects, reviews the task identification process prior to construction, and routinely inspects construction sites to ensure adherence to project-specific requirements.

O.4 ACTIVITIES AND ACCOMPLISHMENTS

This section includes descriptions of the various pollution prevention activities and projects recently completed and ongoing.

O.4.1 Air Quality

LLNL controls its air emissions in compliance with stringent Federal, state, and local requirements. To maintain emissions below air quality standards, LLNL uses control measures, monitoring, new source pre-planning, and sustainable design planning for new facilities and buildings. In addition, LLNL has implemented pollution prevention activities as described below. These prudent measures have allowed LLNL to maintain its mid-size facility ranking (ranked on amount of total emissions), as confirmed by the site's continued eligibility to receive offset air release credits from the local air quality planning district.

Air quality issues targeted by the LLNL pollution prevention programs are discussed below. See Chapter 4 of the main document for more information on air quality at LLNL and more complete lists of types and levels of air emissions.

O.4.1.1 *Reduction of Stratospheric Ozone-Depleting Substances*

LLNL has actively pursued programs to reduce the use of stratospheric ozone-depleting substances, which include methylene chloride, 1,1,1-trichloroethane, the family of chemicals referred to as Freons, and halons. By 1997, ozone-depleting halogenated solvents had been replaced with nonhalogenated alternatives (e.g., acetone, ethyl acetate) in slurry coating plastic-

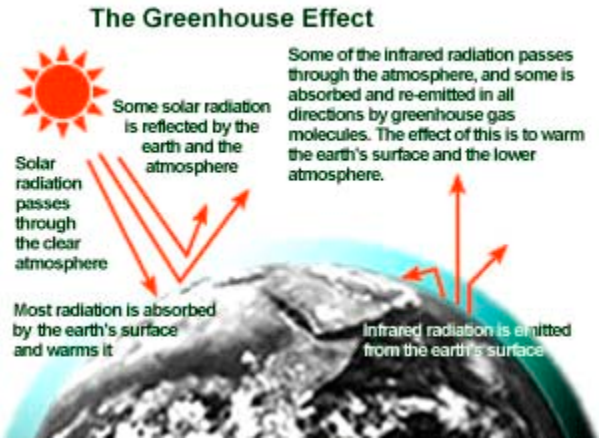
bonded explosives (LLNL 1997a). The replacement of Freons has been a priority, and dramatic reductions in Freon use have been documented. Freon-113 from cleaning operations was reduced approximately 32 percent between 1994 and 1995. The largest user of Freon-113, the Atomic Vapor Laser Isotope Separation Program, ceased operations in 1999. Upon decommissioning of this project's facility, 10,000 gallons of Freon-113 was removed from LLNL (LLNL 2003bl). DOE targeted the reduction of chemicals subject to Toxic Chemical Release Inventory (TRI) reporting in Goal 2 of its pollution prevention goals (Richardson 1999a). Due to these reduction efforts, Freon-113 is no longer reported by LLNL (DOE 2003m).

DOE targeted Class I ODSs used in cooling systems for phaseout in pollution prevention Goals 9 and 10 (Richardson 1999a). Class I ODSs have the highest ozone-depleting potential and include chlorofluorocarbon, halons, carbon tetrachloride, methyl chloroform, hydrobromofluorocarbon, and methyl bromide. LLNL has replaced or retrofitted all but seven of its chillers with greater than 150 tons of cooling capacity that use Class I refrigerants. The remaining seven chillers are scheduled for replacement by fiscal year (FY) 2007 (LLNL 2001q). Other LLNL chillers that contain Class I ODSs will also be replaced. The schedule for these replacements is FY2004 and FY2010 through FY2015. Some packaged air conditioning units and condensers also contain Class I refrigerants. LLNL has retrofitted or replaced all but 10 of these units and condensers (LLNL 2001q). LLNL plans to replace the eight units located at the Livermore Site by 2005. The two remaining units at Site 300 are being evaluated for replacement or removal from service (LLNL 2003bu).

In addition to chillers, some LLNL fire suppression systems contain halon, a Class I ODS. DOE's Goal 10 (Richardson 1999a) calls for the elimination of all Class I ODSs at DOE facilities. LLNL began removing fire suppression systems containing halon from service prior to Goal 10 being established. By 2001, only 15 systems remained at LLNL and all but one of these are scheduled to be replaced or upgraded by 2010 to eliminate the use of halon (LLNL 2001q). The remaining system using halon is being evaluated for replacement, upgrade, or removal from service (King 2003a).

O.4.1.2 *Reduction of Greenhouse Gases*

DOE listed the reduction of greenhouse gas production attributed to facility energy use as Goal 11 of its pollution prevention and energy efficiency goals (Richardson 1999a). LLNL reduces its contribution to greenhouse gases in the atmosphere through its energy efficiency efforts. LLNL has reduced its consumption of electricity, fuel oil, and natural gas in the past several years (see Chapter 4 of the main document for consumption levels and reduction percentages). When compared to the baseline year, FY1990, LLNL had achieved a 23-percent reduction in energy use per square foot of floorspace (LLNL 2002bi) and a 25-percent reduction in greenhouse gas emissions (FEMP 2002a). The following text box describes the greenhouse effect and greenhouse gases.



What Are Greenhouse Gases?

Energy from the sun drives the Earth's weather and climate, and heats the Earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat similar to the glass panels of a greenhouse. Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the Earth's average temperature is a more hospitable 60°F. However, problems may arise when the atmospheric concentration of greenhouse gases increases.

Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30 percent; methane concentrations have more than doubled; and nitrous oxide concentrations have risen by about 15 percent. These increases have enhanced the heat-trapping capability of the Earth's atmosphere. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities. Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Certain human activities, however, add to the levels of most of these naturally occurring gases.

It's well accepted by scientists that greenhouse gases trap heat in the Earth's atmosphere and tend to warm the planet. By increasing the levels of greenhouse gases in the atmosphere, human activities are strengthening the Earth's natural greenhouse effect. The key greenhouse gases emitted by human activities remain in the atmosphere for periods ranging from decades to centuries.

A warming trend of about 1°F has been recorded since the late 19th century.

Carbon dioxide is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned.

Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.

Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.

Very powerful greenhouse gases that are not naturally occurring include *hydrofluorocarbons* (HFCs), *perfluorocarbons* (PFCs), and *sulfur hexafluoride* (SF_6), which are generated in a variety of industrial processes.

Source: EPA 2003e.

O.4.1.3 *Vehicular Activity and Transportation Demand Management*

In efforts to improve air quality, decrease traffic congestion, and conserve fossil fuels, LLNL has been active in promoting alternative, environmentally responsible options for employee commuting. LLNL has a transportation systems management program that provides the following (LLNL 2001s):

- A pre-tax benefit program for transit and vanpool commuters, which enables employees to set aside a fixed amount of their pre-tax salary each month to reduce transportation costs
- Participation in the local air quality organization's "Spare the Air" Program
- Active participation in meetings with local transportation planners, other large employers, local school districts, and community outreach programs to mitigate transportation-related air pollution and congestion-management issues
- Participation in DOE's Clean Cities Coalition to increase availability and use of alternative-fueled vehicles for LLNL employees

Specifically, the transportation systems management program helps employees find ways to join a carpool, vanpool, take public transportation, or ride a bike to work. LLNL provides preferential parking and a guaranteed ride home for carpool and vanpool riders who miss their rides. In addition, vanpools or "vanpool participants" with seven or more passengers can buy fuel at LLNL, taking advantage of lower fuel costs afforded to LLNL due to its bulk buying power. Shuttle service is provided between LLNL and train stations, bus stops, and the Sandia National Laboratories/California. Free bus passes are also available under certain circumstances (LLNL 2003bk). The impact to air quality has not been quantified, but according to the EPA, the average car driving 12,500 miles in one year emits 80 pounds of hydrocarbons, 600 pounds of carbon monoxide, 40 pounds of nitrogen oxides, and 10,000 pounds of carbon dioxide (LLNL 2003bm).

O.4.1.4 *Recent Air Emissions Reduction Projects*

Precursor Organic Solvent Use and Recycling

In order to reduce environmental risk associated with the use of many problematic cleaning solvents, LLNL conducted an in-depth analysis of 75 chemical alternatives and evaluated each according to cleaning performance, health effects, and environmental impacts. As a result, 25 laboratory shops stopped using the more problematic chemicals and switched to safer alternatives, many of them nonhazardous products that generate no toxic air emissions or liquid wastes (LLNL 1997a).

Within the Energetic Materials Program, hexane has been replaced with ice water in chemical processes for producing mock high explosives. In-process distillation and condensation of solvents driven off during the formulation of plastic explosives has also reduced air emissions, together with recycling and reusing solvents and explosives recovered in experiments, and screening all chemicals introduced into experiments to encourage the use of more

environmentally compatible input chemicals. Within the Aerogel Manufacturing Process, a project was undertaken to evaluate and successfully reuse spent methanol solvent (LLNL 1997a).

At Site 300 maintenance and automotive fleet operations, oil-based paints have been replaced with environmentally compatible water-based substitutes to reduce volatile emissions, and paint is applied with high-volume, low-pressure applicators to reduce the amount of paint required for each job. In addition, lacquer thinner has been substituted for methyl ethyl ketone and paint thinner as a cleaner. Spent lacquer thinner is reclaimed with an onsite solvent recovery unit, and reused in paint shop operations, thus reducing hazardous waste.

Dry Powder Coating Paint Process

The liquid spraying operation for solvent and water-based paints, polyurethanes, and epoxies at a paint spray booth was replaced with a dry powder coating process. The dry powder process eliminated the emission of all volatile organic compounds (VOCs) from the paint booth since powdercoating materials do not contain VOCs. The VOC reduction has been estimated at 450 kilograms per year (LLNL 2003bn). This process change also eliminated the hazardous waste associated with partially used paint containers, use of solvents, and solvent rags from cleaning the spray equipment. The hazardous waste reduction is estimated at 500 kilograms per year (LLNL 2003bn).

Contained Firing Facility

The Contained Firing Facility replaced an outdoor firing table. Moving the facility indoors resulted in reduced air emissions (LLNL 2003bm).

O.4.2 Water

LLNL prevents pollution of surface water and groundwater by following operating procedures, permit requirements, and best management practices, and by maintaining equipment. LLNL also has a Spill Prevention Control and Countermeasures Plan to address potential contamination sources. Surface water and groundwater are also protected by reducing pollutants in stormwater runoff. The LLNL Stormwater pollution prevention plans have been prepared to identify pollutant sources that affect the quality of industrial stormwater discharges and to describe implementation practices to reduce pollutants in the discharges.

LLNL is also committed to using water in a conservative manner. Beginning in 1988, LLNL began curtailing water use by implementing water conservation measures, including reducing landscape watering and reducing blowdown in cooling towers to minimal operable levels. LLNL has also replaced and upgraded water distribution lines at various locations, reducing water use at the site. Many areas of LLNL are landscaped with plants that require only small amounts of water (xeric plants) to reduce the amount of water required for irrigation. In addition, LLNL continues to monitor water use to discourage waste or unnecessary use. LLNL has also undertaken site-specific projects to reduce water consumption. As a result of conservation efforts, LLNL currently uses about 14 percent less water than in FY1993 per building square foot (LLNL 2002bi). Chapter 4 has more information on water quality at LLNL, a discussion on sewer discharges, and a discussion of industrial wastewater. Pollution prevention projects that reduce wastewater discharges and conserve water are discussed below.

O.4.2.1 *Building 322 Evaporator*

The Building 322 cold evaporator recycles rinsewater from plating operations. The evaporator allows the reuse of approximately 99 percent of the rinsewater. Additionally, the plating shop converted continuous flow rinses into spray stations and uses ultrasonic cleaning techniques. All of these activities have reduced the quantity of wastewater and conserved water (LLNL 2003bq).

O.4.2.2 *Drain-Down Water Recovery*

LLNL developed and implemented a new pollution prevention and cost savings approach to traditional chilled and hot water circulating system maintenance drain and refill practice. A mobile trailer with 1,000-gallon storage capacity and pumping capability was built using mainly surplus equipment. The mobile trailer is towed to the building to receive repairs or preventative maintenance. The chemically treated water is drained out of the building's system and stored in the mobile trailer. After maintenance is completed the water is pumped back into the system. This pollution prevention activity has created several benefits including reduced water consumption, recovery and reuse of water treatment chemicals, elimination of chemically treated circulating water discharges, elimination of monitoring of these discharges to the public sewer, and reduced labor costs and building system down time. This activity conserves approximately 72,600 gallons of water, reduces wastewater discharged to the sewer by the same amount, and reduces the use of corrosion and scale inhibiting chemicals by 590 gallons, annually (LLNL 2003bn).

O.4.2.3 *Vehicle Wash Reclamation System*

A water reclamation system at the LLNL Fleet Maintenance vehicle wash facility recycles approximately 70 percent of the water. This system conserves approximately 440,000 gallons of water, reduces wastewater discharged to the sewer by the same amount, and reduces the use of soap by 77 gallons, annually (LLNL 2003bn).

O.4.2.4 *Retrofit of Ultra Low-Flow Toilets and Sensor Type Urinal Flush Valves*

During FY2000 and FY2001, the Energy Management Program, in partnership with the Facility Maintenance Division, retrofitted 154 ultra low-flow toilets and 77 sensor-type urinal flush valves in existing buildings. Estimated annual water and cost savings are 6.8 million gallons and $40,000, respectively. Cost savings account for reduced water purchases, electricity demand for water pumping, and sewer discharge fees (LLNL 2003bp).

O.4.2.5 *Waterless Urinal Pilot Project*

During FY2003, 10 waterless urinals were installed in selected office buildings as a pilot project to assess employee acceptance. The pilot project is estimated to save about 200,000 gallons of water annually. Even before the pilot project was completed, plans were developed to install waterless urinals in two additional office buildings (LLNL 2003bp).

O.4.3 Energy Management

The Energy Management Program is responsible for promoting reduced energy consumption and reducing the impact of energy costs on LLNL operations. This responsibility is primarily accomplished through energy conservation awareness and retrofitting building systems to improve energy efficiency. To achieve this goal, the Energy Management Program performs studies and conducts surveys to identify opportunities for applying energy management principles, including:

- Energy conservation
- Electrical load management—Revising operations so that high energy demand operations are done during offpeak hours. Offpeak energy is usually less expensive and results in a cost savings. This does not reduce energy use, but could eliminate/postpone the need for additional power generation facilities in the region, thus reducing potential for environmental impacts to air and water.
- Use of alternative "green energy" sources (does not reduce the amount of energy used, but utilizes environmentally friendly generation resources)

The Energy Management Program draws on all three of these principles as discussed in the following subsections.

O.4.3.1 *Energy Conservation*

Through energy conservation efforts, LLNL has achieved a 23-percent energy use reduction per square foot of floorspace based on the baseline year of FY1990 (LLNL 2002bi). DOE set a goal for reducing energy consumption through life-cycle, cost-effective measures by 20 percent by 2005 and 25 percent by 2010 (Richardson 1999a). LLNL achieved the 2005 goal 3 years ahead of schedule. Table O.4.3–1 presents energy consumption for FY2000 through FY2002. The energy consumption amounts do not include the energy used for construction of facilities or buildings.

TABLE O.4.3–1.—*Energy Consumption at the Lawrence Livermore National Laboratory*

Energy Type	Baseline Year 1990	FY2000	FY2001	FY2002
Electricity (million kilowatt hours)	350	270	290	300
Natural gas (million cubic feet)	430,000	450,000	440,000	460,000
Fuel oil (thousand gallons)	63	9.9	11	12

Source: FEMP 2002a.

Seven energy efficiency projects were completed during FY2002. These projects involved retrofits for energy efficiency in building heating, ventilation, and air conditioning systems, vending machine systems, central compressed air plant and distribution system piping, and boiler/chilled water system repair procedures. Expected energy savings are about 2.13 million kilowatt hours per year of electric power and 97,200 therms per year of natural gas (LLNL 2002bi).

The Energy Management Program worked with plant engineering organizations to change procurement practices for greater energy efficiency in building boiler systems. Building boiler equipment specifications now require modulating-condensing boiler systems for new and replacement boilers whenever life-cycle cost effective. The boilers are up to 95 percent energy efficient.

The Energy Management Program is working with other LLNL organizations in integrating sustainable design principles for new facilities leading to energy efficient facilities equipped with energy efficient lighting, electronics, machinery, and building automation systems. The Terascale Simulation Facility, the Building 140 project, and new office buildings were and are being designed using sustainable design principles.

O.4.3.2 *Load Management*

Given California's electrical energy situation, LLNL initiated a voluntary plan that included load management and conservation measures. The implementation of this plan reduced annual consumption by 8 percent and earned LLNL a DOE energy management award (FEMP 2002b). The plan was developed by a team from the Site Utilities Division and then marketed by its management to all building facility managers and building coordinators. Changes included:

- Large water pumping operations changed their operating hours to offpeak periods
- Several LLNL experimenters changed to off-hour operations
- Numerous building locations use only the minimal lighting at all times
- Thermostat settings were lowered during the heating season and raised during the cooling season
- Building controls were set to schedule operations

O.4.3.3 *Renewable Energy Use*

DOE also set a goal to increase the purchase of electricity from clean energy sources (Richardson 1999a). DOE plans to seek renewable energy sources when contracts for power use in 2004 and beyond are negotiated.

LLNL has also made efforts to use renewable energy sources whenever possible. Selected groundwater treatment systems at the Livermore Site and Site 300 use solar power. Building 543 has a solar-heated domestic water system; two other renewable energy projects at LLNL use photovoltaic technology. The Energy Management Program is investigating additional renewable energy projects.

LLNL's Pollution Prevention Team and Energy Management Program worked together to implement a photovoltaic technology exhibit at the LLNL Discovery Center. A range of configurations and panel types were installed, allowing LLNL guests to view several outdoor settings and to better understand the value of photovoltaic power systems. An interactive computer display shows instantaneous and historical performance of each system. The

generating capacity is currently around 3.5 kilowatts, but has the ability to expand up to 7.5 kilowatts (LLNL 2003bn).

Twenty-one photovoltaic powered lights illuminate a parking lot and walkways at the Livermore Site, improving safety at night. The effort was funded primarily by rebates received from electricity suppliers for energy efficiency projects from the previous years (LLNL 2002bi).

O.4.4 Transportation

To conserve fossil fuels and reduce the generation of greenhouse gases as related to transportation, LLNL Fleet Management reduces petroleum consumption, uses alternative fuels, and encourages carpooling and vanpooling, and use of mass-transit by LLNL employees.

O.4.4.1 *Lawrence Livermore National Laboratory Fleet*

LLNL maintains a fleet of vehicles for transportation both on site and offsite. DOE targeted vehicle fleets in its Pollution Prevention and Energy Efficiency Leadership Goals (Richardson 1999a). The Pollution Prevention Team and LLNL Fleet Management have been working together on pollution prevention and fossil fuel reduction efforts.

LLNL is pursing a broad strategy to reduce fossil fuel consumption including use of alternatively-fueled vehicles, the acquisition of and increased reliance on vehicles with higher fuel economy, use of small electric vehicles and carts and bicycles for onsite transportation, and incorporation of electric cars into the fleet for onsite and offsite transportation. With reduced gasoline consumption comes pollution prevention benefits including smaller amounts of air pollutants and greenhouse gases being released to the atmosphere. LLNL currently has vehicles that can run on compressed natural gas or gasoline. These vehicles are fueled onsite (LLNL 2001q).

The LLNL Bike Program supports transportation by bicycle on the 1 square mile Livermore Site. LLNL owns and maintains about 800 bicycles for use by LLNL employees. The program saves an estimated 34,000 gallons of gasoline and 10,000 gallons of diesel fuel annually (LLNL 2003bk).

The latest strategy to reduce gasoline consumption and air pollution is the incorporation of 20 electric cars into the LLNL fleet. This pilot project began in FY2003 to evaluate if these automobiles can effectively meet LLNL transportation needs while reducing fossil fuel consumption. The pilot project was successful and led to the purchase of additional electric cars. LLNL estimates that the original 20 cars could reduce gasoline usage onsite by more than 6,000 gallons per year. The California Air Resources Board estimates that zero emission vehicles such as these in use at LLNL are approximately 95 percent cleaner than the lowest emitting conventional vehicle (LLNL 2003bo).

Executive Order 13149 requires DOE with reducing petroleum consumption of its entire fleet (LLNL and all other DOE sites) at least 20 percent by the end of FY2005, compared with FY1999 petroleum consumption levels. DOE developed a strategy for achieving this goal (OTT 2003). Strategies for reducing petroleum consumption include use of biodiesel (see text box, “What is Biodiesel?”), which could decrease conventional diesel fuel use by 18 percent (OTT

2003). LLNL is investigating a pilot project to use biodiesel fuel in some LLNL vehicles. An additional strategy named in this Executive Order is the use of hybrid vehicles. Hybrid vehicles operate on electricity and gasoline. LLNL plans to evaluate the lease of hybrid vehicles.

O.4.4.2 *Lawrence Livermore National Laboratory Commuters*

LLNL helps employees discover ways to join a carpool, vanpool, take public transportation, or ride a bike to work. LLNL provides preferential parking and a guaranteed ride home program for carpool and vanpool riders who miss their rides. In addition, vanpools or "vanpool participants" with seven or more passengers can buy fuel at LLNL, taking advantage of reduced fuel costs afforded to LLNL due to its bulk buying power. More than 400 carpools and 30 vanpools have been formed for commuting to LLNL (LLNL 2003bk). Shuttle service is provided between train stations, bus stops, and Sandia National Laboratories/California. Free bus passes are also available under certain circumstances. Annual savings to the employees is estimated at 540,000 gallons of gasoline with an additional 5,500 gallons of diesel fuel expended by bus and train services (LLNL 2003bk).

What is Biodiesel?

Biodiesel (fatty acid alkyl esters) is a cleaner-burning diesel replacement fuel made from natural, renewable sources such as new and used vegetable oils and animal fats. Just like petroleum diesel, biodiesel operates in compression-ignition engines. Blends of up to 20 percent biodiesel (mixed with petroleum diesel fuels) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. These low level blends, 20 percent and less, don't require any engine modifications and can provide the same payload capacity and as diesel. Users should consult their engine warranty statement.

Higher blends, even pure biodiesel (100 percent biodiesel, or B100), can be used in many engines built since 1994 with little or no modification. Transportation and storage, however, require special management. Material compatibility and warrantee issues have not been resolved with higher blends.

Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulfates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter. These reductions increase as the amount of biodiesel blended into diesel fuel increases. The best emissions reductions are seen with B100.

The use of biodiesel decreases the solid carbon fraction of particulate matter since the oxygen in biodiesel enables more complete combustion to carbon dioxide and reduces the sulfate fraction (biodiesel contains less than 24 parts per million sulfur), while the soluble, or hydrocarbon, fraction stays the same or increases. Therefore, biodiesel works well with new technologies such as diesel oxidation catalysts, which reduce the soluble fraction of diesel particulate but not the solid carbon fraction.

Emissions of nitrogen oxides increase with the concentration of biodiesel in the fuel. Some biodiesel produces more nitrogen oxides than others, and some additives have shown promise in modifying the increases. More Research and development is needed to resolve this issue.

Biodiesel has physical properties very similar to conventional diesel.

Source: DOE 2003n.

O.4.5 Materials and Waste Management

O.4.5.1 *Affirmative Procurement of Materials*

The Affirmative Procurement Program at LLNL is a cooperative effort between everyone with purchasing responsibilities. The categories of products included in the Affirmative Procurement Program are listed in Table O.4.5.1–1 along with the percentage of the total dollars of purchased products that had recycled-content. In FY2002, 59 percent of the funds LLNL spent on these products were for recycled-content products (DOE 2003d).

TABLE O.4.5.1–1.—*Affirmative Procurement FY2002 Purchases*

Product Category	Total Purchases	Percentage of Dollars Spent on Recycled-Content Products
Construction	$760,000	52%
Landscaping	$0	NA
Nonpaper office supplies	$590,000	35%
Paper and paper products	$1,100,000	79%
Parks and Recreation materials	$0	NA
Transportation related products (e.g., traffic cones)	$3,000	100%
Vehicular maintenance products	$120,000[a]	16%
Miscellaneous	$100,000	91%

Source: DOE 2003d.
[a] Includes cost of re-refined oil provided by LLNL 2003br.
NA = Not applicable.

A few highlights of the Affirmative Procurement Program that contributed to this achievement include (LLNL 2003bx):

- Virgin paper at Central Supply can only be purchased after a consultation with the Pollution Prevention Team that does not result in identifying an acceptable recycled-content product.
- Ninety-nine percent of the paper used by the LLNL Print Plant is recycled-content paper.
- EPA-designated construction products were incorporated into the master construction specifications that must be followed during all construction projects at LLNL.
- LLNL Fleet Management exclusively uses re-refined oil and recycles antifreeze in-house.
- LLNL does not have to purchase compost and mulch products (virgin or recycled-content) because LLNL produces its compost from landscaping trimmings and its mulch from chipping donated Christmas trees.

In addition, to promote the purchase of recycled-content products beyond the LLNL procurement organizations, the Pollution Prevention Team trains technical release representatives on affirmative procurement. Technical release representatives are individuals within the various LLNL directorates who can directly purchase products offsite (LLNL 2003bx).

O.4.5.2 *Waste Minimization*

Since 1993, LLNL implemented many waste minimization practices, changed processes, added recycling systems, and made chemical substitutions to dramatically lower the amount of waste generated and increase the amount of material recycled. Table O.4.5.2–1 presents routine waste generation amounts and the reduction percentages achieved. The baseline year, 1993, was established in the pollution prevention leadership goals (Richardson 1999a). The low-level radioactive, hazardous, and mixed wastes reduction percentages are 57, 57, and 89 percent, respectively. Some of the more recent pollution prevention projects that have contributed to these reductions are described below. More information on waste generation is presented in Chapter 4 and Appendix B.

TABLE O.4.5.2–1.—*Routine Waste Generation Amounts and Reduction Percentages*

Waste Category	FY1993 Baseline	FY2001	FY2002	Reduction Achieved
Low-level radioactive (cubic meters)	188	65	81	57%
Hazardous (metric tons)	615	195	262	57%
Mixed (cubic meters)	98	17	10	89%

Source: DOE 2002s.

LLNL also focuses waste minimization and recycling efforts on sanitary solid waste and nonroutine, nonhazardous waste from construction and decommissioning projects. DOE's pollution prevention goals (Richardson 1999a) address the need to reduce and recycle these wastes. The amount of sanitary waste generated in FY2002 was 5,800 metric tons, which is only 1 percent less than that generated in 1993. However, 4,000 metric tons (69 percent) was diverted into recycling and reuse opportunities (LLNL 2003l). LLNL generated 22,000 metric tons of nonroutine, nonhazardous waste in FY2002 of which 15,000 metric tons were reused or recycled (LLNL 2003l). Most of the 15,000 tons were asphalt/concrete and clean or Class 2 contaminated soil. Asphalt/concrete is chipped and used as road base at a local landfill. The soil is beneficially used as daily cover at local landfills and no tipping fee is charged. Table O.4.5.2–2 lists the wastes and amounts that were diverted for recycling or reuse in FY2001 and FY2002.

The LLNL Space Action Team manages decommissioning projects. This team is an integrated, multidisciplinary, multiorganization, cross-trained team specifically designed to perform cradle-to-grave decommissioning projects. This team makes efforts to disposition chemicals and equipment from Decommissioning projects. The Space Action Team was successful in recycling approximately 90 percent of materials including soil, asphalt, concrete, wood, steel, scrap metal, and electromechanical infrastructure and equipment during the demolition of 11 buildings and 11 trailers at LLNL (EPA 2003b). The Space Action Team also had similar waste reduction accomplishments on the decommissioning of the Atomic Vapor Laser Isotope Separation Facility. Waste reduction highlights include the following chemical waste diversions and distribution of equipment to new users (LLNL 2003bl). The Space Action Team also accumulates laboratory glassware during its Decommissioning work for donation to area high schools (LLNL 2003bl).

TABLE O.4.5.2–2.— *Waste Diverted for Recycling and Reuse in FY2001 and FY2002*

Material	FY2001 (metric tons) [a]	FY2002 (metric tons) [b]
Asphalt/concrete	2,800	1,900
Batteries	19	22
Beverages and food containers	20	8
Cardboard	130	147
Compost	470	700
Cooking grease/oil	4.4	2.8
Soil	4,300	12,000
Magazines, newspapers, phone books	28	30
Metals	1,300	1,400
Miscellaneous	NA	1.6
Nonroutine metals	NA	780
Paper	260	300
Pipette boxes	NA	1.0
Recycled by Waste Management	Not reported	230
Surplus sales	Not reported	700
Tires and scrap	24	27
Toner cartridges	1.7	1.5
Wood	440	550

[a] Source: LLNL 2002cc.
[b] Source: LLNL 2003l.

- The sale of 10,000 gallons of Freon 113, after it had been declined for reuse by other areas of DOE and the Department of Defense. In addition to the waste minimization and financial benefits of the Freon sale, removal of the Freon from the LLNL site allowed the cancellation of the associated Bay Area Air Quality Management District air permits and helped LLNL achieve a negative declaration on the required TRI Report for Reporting Year 2000.

- The identification of a company to take approximately 7,000 gallons of 94 percent ethanol from the LLNL site for processing into fuel and industrial grade ethanol at essentially no cost to LLNL (This path of disposition provided a preferable alternative to disposal of the ethanol as hazardous waste).

- The take-back of 575 pounds of calcium and magnesium by the manufacturer (This option was highly favorable in comparison to the estimated cost for disposal of the metals.)

- The take-back of 8,595 pounds of graphite parts by a company in Long Beach, CA. Prior to reuse, the company was able to remove (grind off) sensitive USEC parts numbers

- The sale, rather than disposal, of 100 kilograms of cerium and 540 kilograms of gadolinium

O.4.6 Recent Pollution Prevention Projects

O.4.6.1 *Site 300 Firing Tables*

When designing experiments, Defense and Nuclear Technologies employees consider pollution prevention opportunities. The organization began using reusable steel tables and other steel or aluminum equipment in its experiments instead of one-time use wooden equipment. The steel tables can be used up to 20 times. In addition, equipment is "right-sized" for each experiment, so a minimal amount of material must be discarded after the experiment is completed. These measures, along with previously implemented waste minimization techniques, have reduced the wastes from this program area by more than 95 percent (LLNL 2003bl).

O.4.6.2 *Tritium Recovery and Reuse*

LLNL's Tritium Facility, in cooperation with the U.S. Army, is recovering tritium from field devices. The project involves disassembling the units and segregating the tritium-containing ampules from nonradioactive components. The tritium is released from the ampules, captured, and accumulated in shipping containers. The containers are sent to the DOE Savannah River Site facility for reuse of the tritium. During FY2001, this waste minimization project recovered an estimated 27,000 curies of tritium. In addition to providing tritium for reuse by the DOE complex, the U.S. Government benefits by realizing a waste avoidance of approximately 7 tons of radioactive waste (LLNL 2003bl).

O.4.6.3 *Passive Groundwater Treatment Systems*

LLNL has designed and put into use two passive groundwater treatment systems at Site 300: the Passive Aboveground Iron Filings Groundwater Treatment System and the solar-powered Containerized Wetland System. Use of these systems reduces the volume of waste requiring disposal. In addition, they do not use any energy (LLNL 2003bl).

O.4.6.4 *Easy Pump Specific Depth Sampling Device*

An LLNL employee invented the easy pump specific depth sampling device in the early 1990s. LLNL worked to obtain regulatory acceptance in order to substitute the use of this sampling method in well locations previously sampled using traditional protocols and equipment. The Easy Pump is a low-cost, highly effective and safe device that can be used to obtain a groundwater sample without generating any purge water. This waste minimization technology is being transferred to other DOE sites and the private sector.

Since 1997, the Easy Pump has been used increasingly at LLNL. As old, dedicated pump equipment fails or requires significant maintenance, the old equipment may be removed and the Easy Pump used instead. Approximately 50 percent of LLNL wells are sampled using the Easy Pump, greatly reducing the amount of waste generated; approximately 50,000 gallons of contaminated groundwater would not be purged. An average sampling event with the Easy Pump takes 5 minutes compared to an average 50 minutes for an event using standard methods (LLNL 2003bl).

O.4.6.5 *Lawrence Livermore National Laboratory Fleet Maintenance Facility*

The Fleet Maintenance Facility has implemented a number of pollution prevention projects, such as the installation of a recycling machine for reclaiming antifreeze for their use. Recycling antifreeze reduced the waste antifreeze, a hazardous waste, by 98 percent. The facility converted its solvent parts cleaning and its aerosol brake cleaning operations to aqueous cleaning operations, further reducing its hazardous waste stream. Additionally, the vehicle wash water recycling system is utilized by the facility (King 2003b).

O.5 RESEARCH AND DEVELOPMENT OF POLLUTION PREVENTION TECHNOLOGIES

LLNL often conducts research and development (R&D) into technologies that have implications for pollution prevention. The following discussions regard some of the more recent research efforts that hold promise for advancing pollution prevention and energy conservation for government, businesses, and individuals.

O.5.1 Hydrogen Fuel Storage Tank for Automobiles

LLNL has long been involved in R&D of alternative energy technologies for transportation, including hydrogen fuel. Hydrogen-fueled cars can eliminate automotive air pollution and reduce or eliminate greenhouse gas emissions from transportation if the hydrogen fuel is produced from nonfossil energy resources.

A team in LLNL's Energy Technology and Security Program designed and tested a safe and compact system for on-vehicle storage of hydrogen fuel. The tank can safely and simultaneously accommodate three forms of hydrogen fuel—conventional high-pressure hydrogen gas, cryogenic compressed gaseous hydrogen, and liquid hydrogen. It does so while minimizing the storage challenges and maximizing the potential energy efficiency of each (LLNL 2003bt).

Next, this research plans to address installing the insulated cryogenic pressure vessels on vehicles for field testing. A second-generation tank is being developed, which will hold 9 kilograms of liquid hydrogen, energy equivalent to 9 gallons of gasoline. The work involves collaboration with a manufacturer of pressure vessels and the mass transit agency serving the Palm Springs, California, area (LLNL 2003bt).

O.5.2 Reducing Aerodynamic Drag on Heavy Duty Tucks to Improve Fuel Efficiency

For more than 5 years, LLNL has led a DOE project to examine possible ways to make heavy trucks more aerodynamic, reducing air resistance and thus increasing fuel efficiency. LLNL engineers estimate that truck drag could be reduced by as much as 25 percent over the next 20 years. In the future, such a reduction would save billions of gallons of diesel fuel annually, or 12 percent of the fuel used (LLNL 2003bw).

LLNL is working with a consortium of research institutions and tractor manufacturers to address two major components of drag in heavy trucks: (1) the gap between the tractor and the trailer, and (2) low pressure in the trailer's wake. LLNL is developing computer simulations of various

parts of a truck's airflow. LLNL has also developed new devices for reducing aerodynamic drag that are undergoing wind tunnel testing (LLNL 2003bw).

O.5.3 Solid-Oxide Fuel Cell Development

In 1999, DOE formed the Solid State Energy Conversion Alliance to accelerate the development and commercialization of fuel cells. Fuel cells are clean, quiet, efficient, and compact and generate electricity through chemical reactions instead of combustion. Fuel cells show promise to helping to reduce global warming, air pollution, and U.S. dependence on foreign oil.

LLNL is helping Solid State Energy Conversion Alliance with fuel cell development. LLNL has extensive experience in developing several types of fuel cells, including the zinc-air fuel cell, the unitized regenerative fuel cell, the direct carbon conversion fuel cell, and the solid-oxide fuel cell.

Some of the LLNL research has focused on solid-oxide fuel cell development. Solid-oxide fuel cells are particularly attractive because they have the highest efficiencies of any conventional fuel cell design and the potential to use many fuels—including gasoline and diesel—without expensive external reformers that create more volatile chemicals. Solid-oxide fuel cells can operate at high temperatures, producing high-grade waste heat, or exhaust, which can be recovered and used for other applications, such as space heating and cooling, supplying homes with hot water, and even generating electricity by spinning a gas turbine linked to the unit.

LLNL research has improved the solid-oxide fuel cell, increasing the power output of the cell. The researchers have also developed a three-cell stack prototype that generated 50 percent more power than previous development efforts (LLNL 2002bn).

LLNL is working on streamlining the solid-oxide fuel cell energy source. LLNL developed a means of eliminating an expensive process in creating the fuel to be utilized by the fuel cell when generating electricity. LLNL is continuing its efforts to improve the solid-oxide fuel cell with the goal of making it a cost-effective, environmentally friendly means of generating electricity commercially (LLNL 2002bn).

O.5.4 Carbon Dioxide Sequestration

More carbon dioxide, a greenhouse gas, is making its way into our atmosphere as fossil fuels are burned and tropical lands are deforested. A strategy to reduce excess carbon dioxide in the atmosphere is to capture excess carbon dioxide and inject it underground (carbon dioxide sequestration), where it will remain sequestered from the atmosphere for thousands of years. This strategy is being used at an oil drilling platform in the North Sea, the Sleipner site. LLNL is developing criteria for identifying subsurface geologic formations that could be used for carbon dioxide sequestration (LLNL 2000c).

Starting with simulations of carbon dioxide injection at the Sleipner site, LLNL is developing a general modeling capability for analyzing carbon dioxide sequestration in geologic formations. The research has begun to identify the geochemical, hydrologic, and structural constraints on successful geologic carbon dioxide sequestration. Eventually, the research will correlate these constraints with the characteristics of potential geologic formations, rank their overall

sequestration performance based on this correlation, and thus identify optimal injection sites (LLNL 2000c).

O.5.5 Direct Carbon Conversion

LLNL developed a breakthrough method for converting carbon directly into electricity without the need for steam or turbines (LLNL 2001az). Direct carbon conversion can use fuel derived from many different sources, including coal, lignite, petroleum, natural gas, and even biomass (peat, rice hulls, corn husks). If adopted on a large scale, direct carbon conversion would help to conserve fossil resources by allowing more power to be harnessed from the same amount of fuel. It would also improve the environment by substantially decreasing the generated amount of pollutants emitted into the atmosphere (per kilowatt hour of electrical energy) and decrease emissions of carbon dioxide, which contributes to global warming.

Direct carbon conversion requires a unique kind of fuel cell. A fuel cell is an electrochemical device that efficiently converts a fuel's chemical energy directly to electrical energy without burning the fuel. However, instead of using gaseous fuels, which is typically the case, the new technology uses aggregates of extremely fine carbon particles. The overall cell reaction is carbon and oxygen (from ambient air) forming carbon dioxide and electricity (LLNL 2001az).

The thermodynamic efficiency of the direct carbon conversion cell exceeds 70 percent. In contrast, conventional coal- and natural-gas-fired power plants are typically between 35 and 40 percent efficient. Combined-cycle pilot plants that burn natural gas in multistage turbines now operate at 57-percent efficiency, based on the higher heating value of the fuel. High temperature fuel cell hybrid systems (fuel cells combined with turbines) are expected to operate on natural gas at 60-percent efficiency.

In addition, a byproduct of the process is a pure stream of carbon dioxide that can be captured without incurring additional costs of collection and separation from smokestack exhausts. The stream of carbon dioxide can be stored for later use as input to another industrial process or used for oil and gas recovery through existing pipelines (see Section O.5.4 Carbon Dioxide Sequestration).

O.6 REFERENCES

40 CFR Part 247 — Council on Environmental Quality (CEQ), "Protection of the Environment, Comprehensive Procurement Guideline for Products Containing Recovered Materials," *Code of Federal Regulations*, Office of the Federal Register National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised January 1, 2003.

42 U.S.C. 13101 et seq. — The Public Health and Welfare, "Pollution Prevention Act of 1990," *United States Code*, Title 42, Chapter 133. Sec. 13101, 1990.

42 U.S.C. 6962 — The Public Health and Welfare, "Resource Conservation and Recovery Act Section," *United States Code*, Title 42, Chapter 82, Sec. 6962.

California Health and Safety Code 25244.12-25 — California Health and Safety Code, "Hazardous Waste Source Reduction and Management Review Act of 1989," Division 20, Chapter 6.5, Article 11.9, §25244.12-25, Sacramento, CA, 1989.

DOE O 430.2A — U.S. Department of Energy (DOE), *Departmental Energy and Utilities Management*, U.S. Department of Energy, Washington, DC.

DOE O 450.1 — DOE, Office of Environmental Protection and Guidance, *Environmental Protection Program*, U.S. Department of Energy, Washington, DC, 2003.

DOE 2002s — DOE, *2002 Waste Generation Trending Report for DOE Reporting Site showing Routine Waste Generation Reported for Lawrence Livermore National Laboratory for CY1993, CY1994, CY1995, CY1996, CY 1997, CY1998, CY1999, FY2000, FY2001, FY2002*, U.S. Department of Energy, Washington, DC, Available online at http://tis.eh.doe.gov/p2/wastemin/NewTrendSite.Asp?wherefrom=SITE, 2002, Accessed May 14, 2003.

DOE 2003d — DOE, FY 2002 Executive Order 13101 Affirmative Procurement Results: Oakland-Lawrence Livermore National Laboratory FY 2002 Data, U.S. Department of Energy, Washington, DC, Available online at http://tis.eh.doe.gov/p2/apsitedata2002.cfm, 2002, Accessed 2003.

DOE 2003m — DOE, Executive Order 13148, Greening the Government through Leadership in Environmental Management Annual Progress Report, Appendix E, Toxic Release Inventory Reporting, U.S. Department of Energy, Washington, DC, Available online at http://tis.eh.doe.gov/ocpa/data/eo13148/2003.pdf, Accessed September 3, 2003.

DOE 2003n — DOE, *Alternative Fuels Data Center Website*, U.S. Department of Energy, Washington, DC, Available online at http://www.afdc.doe.gov/altfuel/bio_general.html, Accessed September 12, 2003.

EO 13101 — Executive Order 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition," Issued on September 14, 1998 by President William J. Clinton.

EO 13123 — Executive Order 13123, "Greening the Government Through Efficient Energy Management," Issued on June 3, 1999 by President William J. Clinton.

EO 13148 — Executive Order 13148, "Greening the Governmental Through Leadership in Environmental Management Annual Progress Report," Issued on April 21, 2000 by President William J. Clinton.

EO 13149 — Executive Order 13149, "Greening the Government Through Federal Fleet and Transportation Efficiency," Issued on April 21, 2000 by President William J. Clinton.

EO 13150 — Executive Order 13150, "Federal Workforce Transportation," Issued on April 21, 2000 by President William J. Clinton.

EPA 2003b — Environmental Protection Agency (EPA), Region 9 Federal Facilities, Champions of Green Government: 2001 Recipients, U.S. Environmental Protection Agency, Washington, DC, Available online at http://www.epa.gov/region09/cross_pr/fedfac/01awards.html, January 14, 2003, Accessed September 25, 2003.

EPA 2003e — EPA, *Global Warming - Emissions Website*, U.S. Environmental Protection Agency, Washington, DC, Available online at http://yosemite.epa.gov/oar/globalwarming.nsf/content/emissions.html, Last Modified on August 15, 2003, Accessed September 12, 2003.

FEMP 2002a — Federal Energy Management Program (FEMP), Comparison Emissions Report for FY 2002 with base year FY 1990 for Lawrence Livermore National Laboratory, U.S. Department of Energy, Federal Energy Management Program, Washington, DC, 2002.

FEMP 2002b — FEMP, Department of Energy Management Awards: 2001 Award Winners, U.S. Department of Energy, Federal Energy Management Program, Washington, DC, Available online at http://www.eere.energy.gov/femp/aboutfemp/2001_winners.html, Accessed September 25, 2003.

King 2003a — King, Karin, Email from Karin King, U.S. Department of Energy to Mary Hoganson, Tetra Tech, NUS, dated October 8, 2003, regarding the Pollution Prevention Appendix, 2003.

King 2003b — King, Karin, Email from Karin King, U.S. Department of Energy to Mary Hoganson, Tetra Tech, NUS, dated October 8, 2003, regarding the LLNL Fleet Maintenance Shop P2 Efforts Write-Up, 2003.

LLNL 1997a — Lawrence Livermore National Laboratory (LLNL), *LLNL FY97 Pollution Prevention Plan A Strategy for the Future*, UCRL-AR-127073, Lawrence Livermore National Laboratory, Livermore, CA, April 1, 1997.

LLNL 2001q — LLNL, *LLNL Report on Pollution Prevention and Energy Efficiency Leadership Goals*, UCRL-AR-142203, Lawrence Livermore National Laboratory, Livermore, CA, February 2001.

LLNL 2001r — LLNL, *Environment Safety and Health Manual, ES&H Management, Management Requirements, Construction Subcontractor Environment, Safety and Health Program*, Vols. 1-2, Document 2.4, UCRL-MA-133867, Lawrence Livermore National Laboratory, Livermore, CA, April 1, 2001.

LLNL 2001s — LLNL, *Mitigation Monitoring Program at Lawrence Livermore National Laboratory, FY98*, UCRL-AR-123511-98, Lawrence Livermore National Laboratory, Livermore, CA, November 2001.

LLNL 2002ag — LLNL, *Non-Hazardous Waste Diversion at LLNL*, UCRL-7B-120696, Rev. 7, Lawrence Livermore National Laboratory, Livermore, CA, 2002.

LLNL 2001az — LLNL, "Turning Carbon Directly into Electricity," *Science & Technology Review*, Lawrence Livermore National Laboratory, Livermore, CA, June 2001.

LLNL 2002bi — LLNL, *FY02 - Annual In-House Energy Management Report*, Lawrence Livermore National Laboratory, Livermore, CA, November 15, 2002.

LLNL 2003bk — LLNL, Letter from Jacky Angell, LLNL Manager, Mechanical Utilities Division, to Nellie Tibbs-Greer, Office of Federal Energy Management Program, dated May 16, 2003, regarding *LLNL-TSMP Award Nomination Package, Nomination for Organizational-Energy Efficient Mobility Award*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2002bn — LLNL, "Solid-Oxide Fuel Cells Stack Up to Efficient, Clean Power," *Science & Technology Review*, UCRL-52000-02-9, Lawrence Livermore National Laboratory, September 2002.

LLNL 2002cc LLNL, *2001 Site Annual Environmental Report (SAER) for LLNL*, UCRL-50027-01, Lawrence Livermore National Laboratory, Livermore, CA, September 1, 2002.

LLNL 2003l LLNL, *2002 Site Annual Environmental Report (SAER)*, UCRL-50027-02, Lawrence Livermore National Laboratory, Livermore, CA, August 29, 2003.

LLNL 2003bl LLNL, Email from Katharine Gabor, LLNL, to Mary Hoganson, Tetra Tech, Inc., dated September 12, 2003, regarding *Award Nominations for the 2001 DOE Oakland P2 Awards*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bm LLNL, Email from Katharine Gabor, to Mary Hoganson, Tetra Tech NUS, dated September 11, 2003, regarding *ROI Projects Listed in the 2000 SAER*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bn LLNL, Email from Katharine Gabor, LLNL, to Mary Hoganson, Tetra Tech NUS, dated September 11, 2003, regarding *ROI Proposals 2001*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bo LLNL, Email from Katharine Gabor, LLNL, to Mary Hoganson, Tetra Tech, NUS, dated September 11, 2003, regarding *GEM Pilot Project 2002*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bp LLNL, Reviewer comment on the LLNL Draft SWEIS, Appendix O, Lawrence Livermore National Laboratory, Livermore, CA, October 8, 2003.

LLNL 2003bq LLNL, Letter from C. Susi Jackson, LLNL, to Karen King, U.S. Department of Energy, Oakland Operations Office, dated August 22, 2003, regarding t*ransmittal of LLNL Hazardous Waste Management Progress Report for CY2002*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003br LLNL, Email from Beverlee Morales, LLNL, to Mary Hoganson, Tetra Tech, Inc., dated September 24, 2003, regarding *Affirmative Procurement Data Question on Vehicle Products*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bs LLNL, Email from D. Nguyen, LLNL, to Karen King, U.S. Department of Energy, Oakland Operations Office, dated September 11, 2003, regarding the *Addendum to Model Office Building Contract*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bt LLNL, "Flexibly Fueled Storage Tank Brings Hydrogen-Powered Cars Closer to Reality," *Science & Technology Review*, Lawrence Livermore National Laboratory, Livermore, CA, June 2003.

LLNL 2003bu LLNL, Personal communication from R. Schonfeld, LLNL, to Karen King, U.S. Department of Energy, Oakland Operations Office, dated September 30, 2003, regarding *LLNL Plant Engineering Facility and Maintenance Management Division*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL 2003bv LLNL, *Pollution Prevention Efforts Earn EPA Awards*, Lawrence Livermore National Laboratory, Chemistry and Materials Science, Livermore, CA, Available online at http://www-cms.gov/s_t/pollition_prev.htms, Accessed September 24, 2003.

LLNL 2003bw LLNL, "Reducing Aerodynamic Drag," S*cience & Technology Review*, UCRL-52000-03-5, Lawrence Livermore National Laboratory, Livermore, CA, May 2003.

LLNL 2003bx LLNL, Email from K. Wilson, LLNL, to Mary Hoganson, Tetra Tech, Inc., dated September 23, 2003, regarding *Affirmative Procurement*, Lawrence Livermore National Laboratory, Livermore, CA, 2003.

LLNL/EPD 2003 LLNL/EPD, *About the EPD*, Lawrence Livermore National Laboratory, Livermore, CA, Available online at http://www.llnl.gov/epd.about_epd.html, Accessed September 25, 2003.

OTT 2003 *OTT, United States Department of Energy Compliance Strategy for EO 13149*, U.S. Department of Energy, Office of Transportation Technologies, June 2003.

Richardson 1999a Richardson, Bill, Memorandum from Bill Richardson, Secretary of DOE to the Heads of Department Elements, dated November 12, 1999, regarding *Pollution Prevention and Energy Efficiency Leadership Goals for FY2000 and Beyond*, Washington DC, 1999.

APPENDIX P: NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE *SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR CONTINUED OPERATION OF LAWRENCE LIVERMORE NATIONAL LABORATORY AND SUPPLEMENTAL STOCKPILE STEWARDSHIP AND MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT*

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).

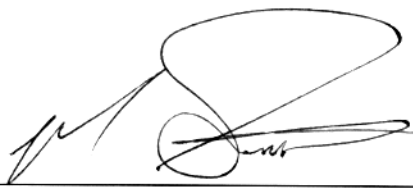
(a) __X__ Offeror and any proposed subcontractor have no financial or other interest in the outcome of the project.

(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.



Certified by

Signature

Mark E. Smith, Director

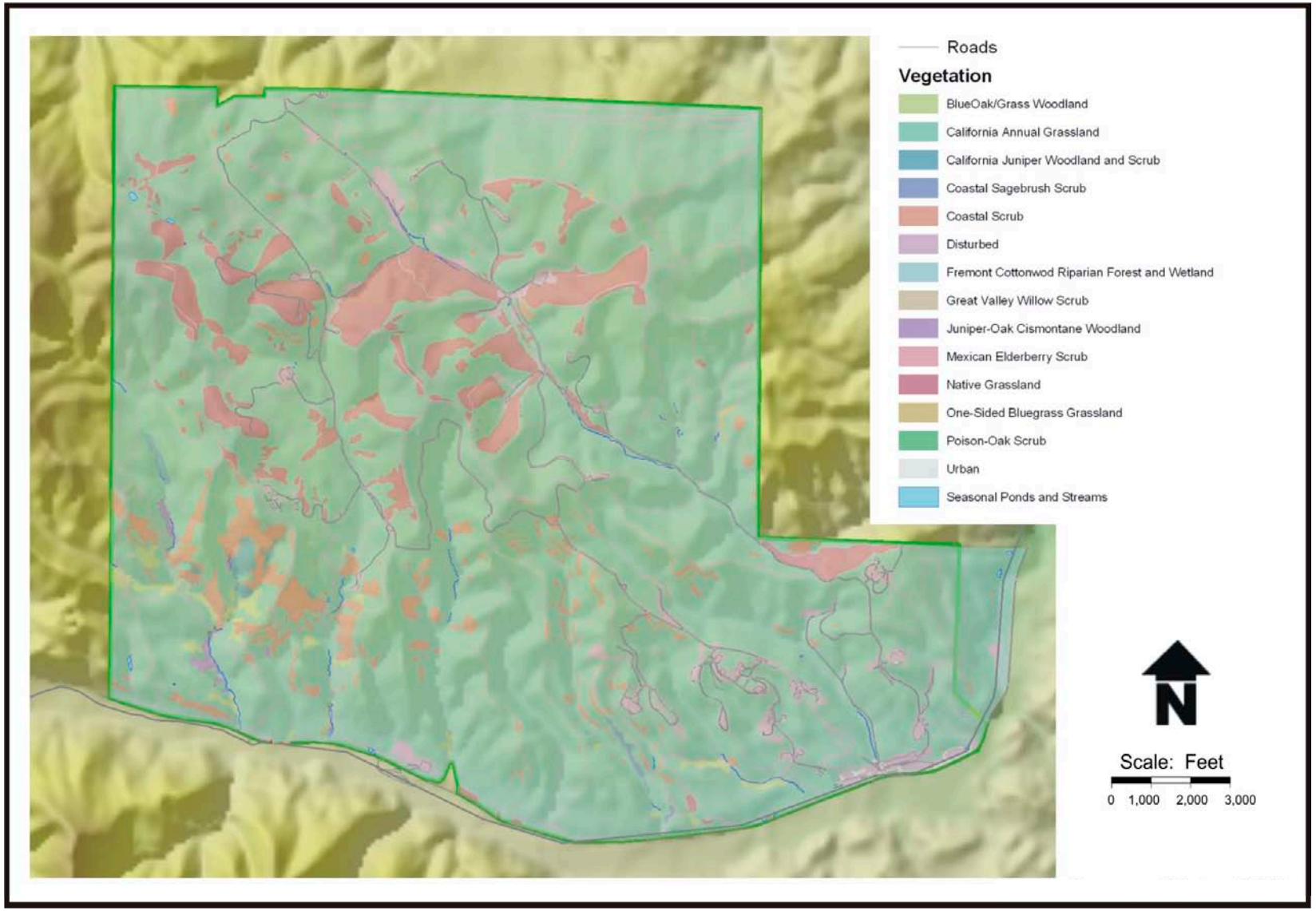
Printed Name and Title

Tetra Tech, Inc.

Company

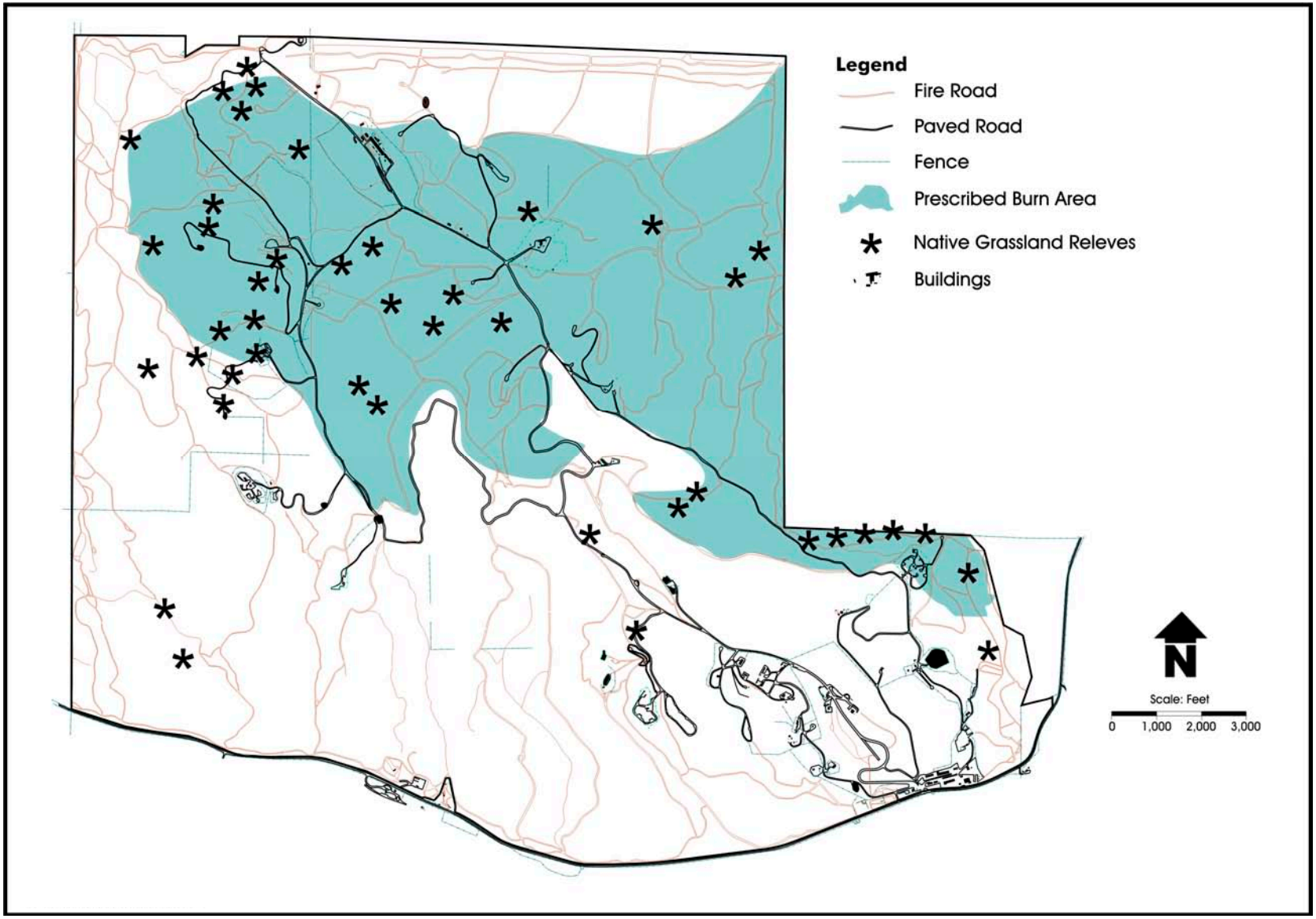
2·3·04

Date



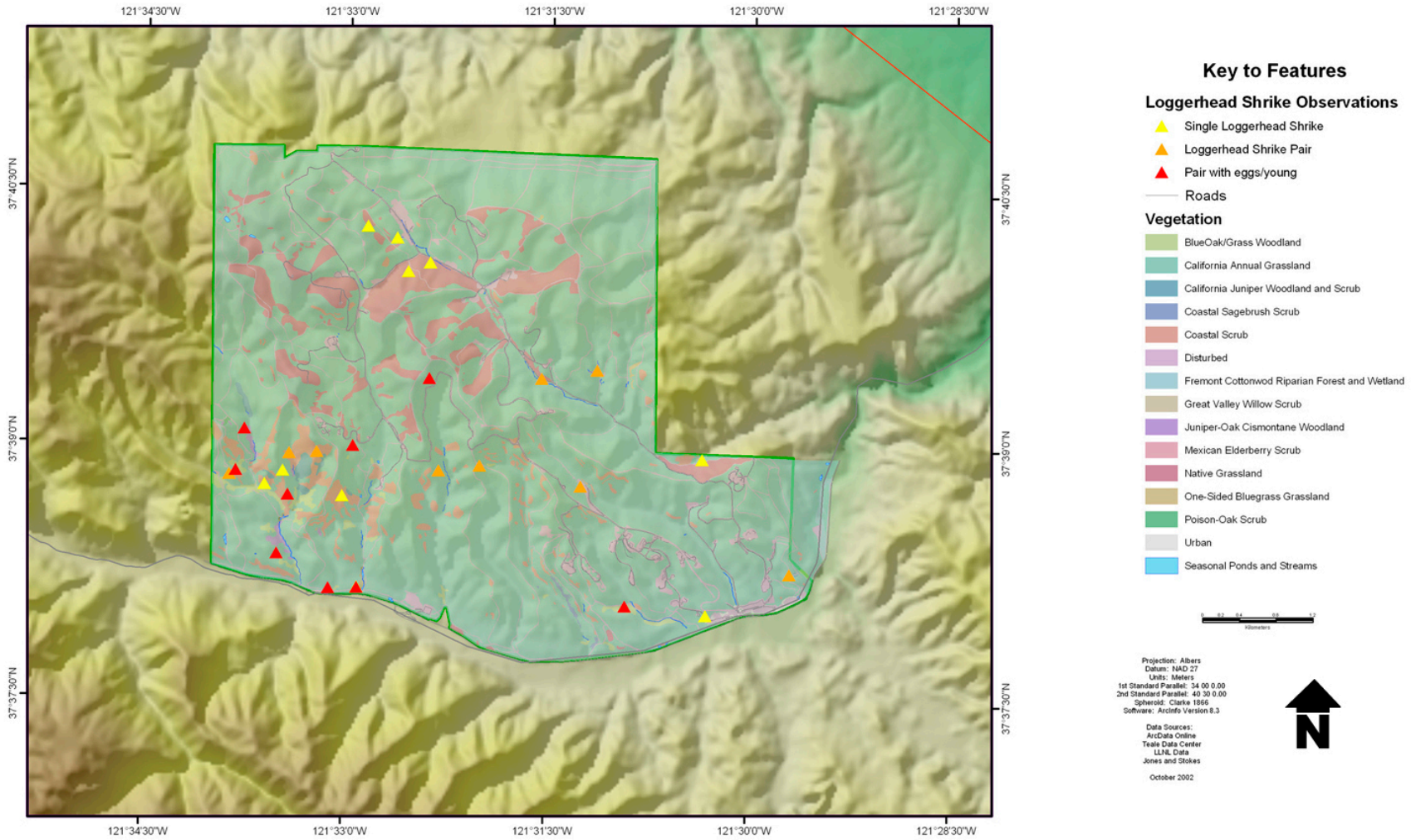
Source: Jones and Stokes 2002a.

FIGURE E.1.1.2–1.—*Plant Community Types Observed at Site 300 in 2002*



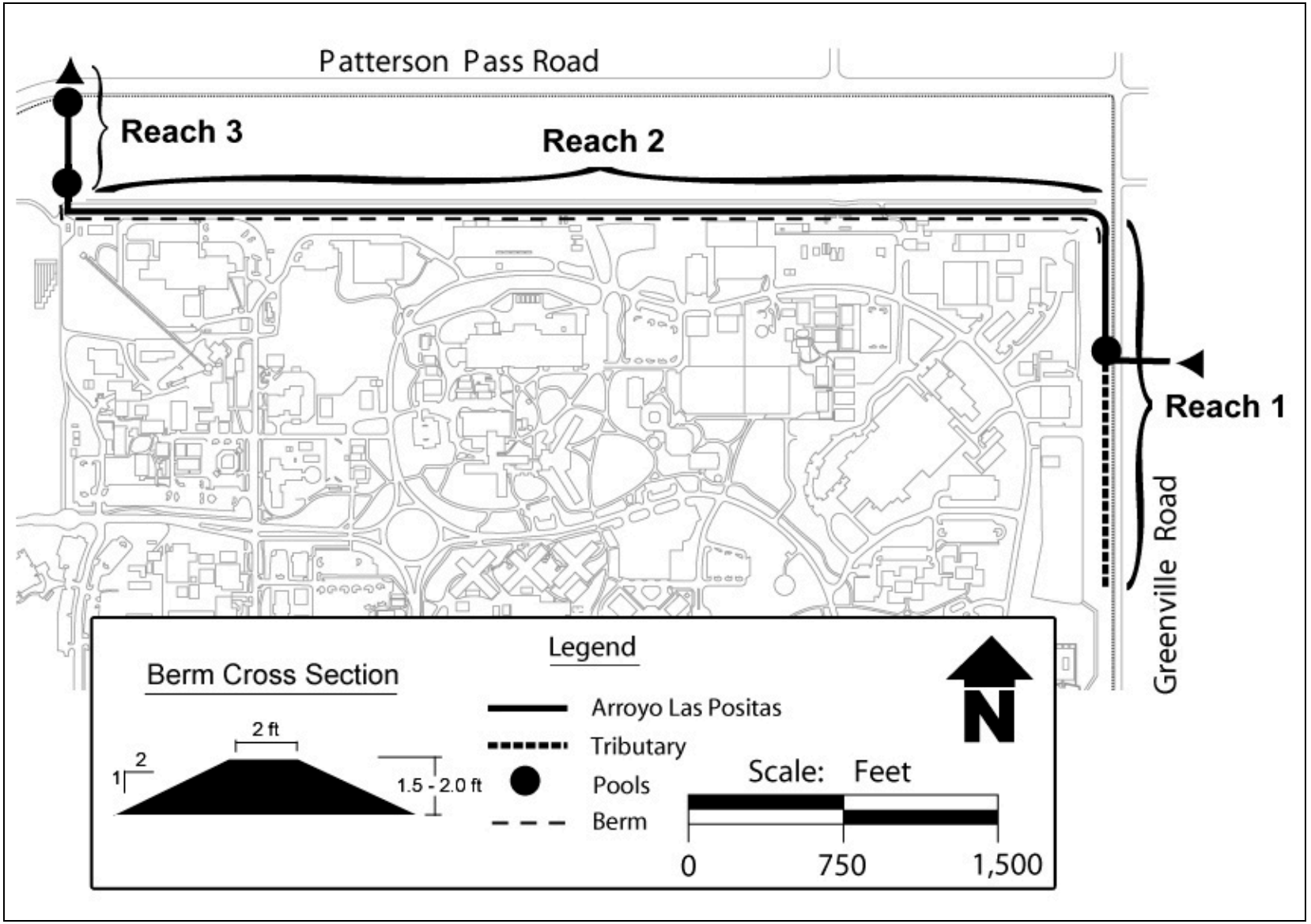
Source: BioSystems 1986.

FIGURE E.1.1.3–1.—*Distribution of Native Grassland Plant Communities in Relation to Prescribed Burns at Site 300 in 1986*



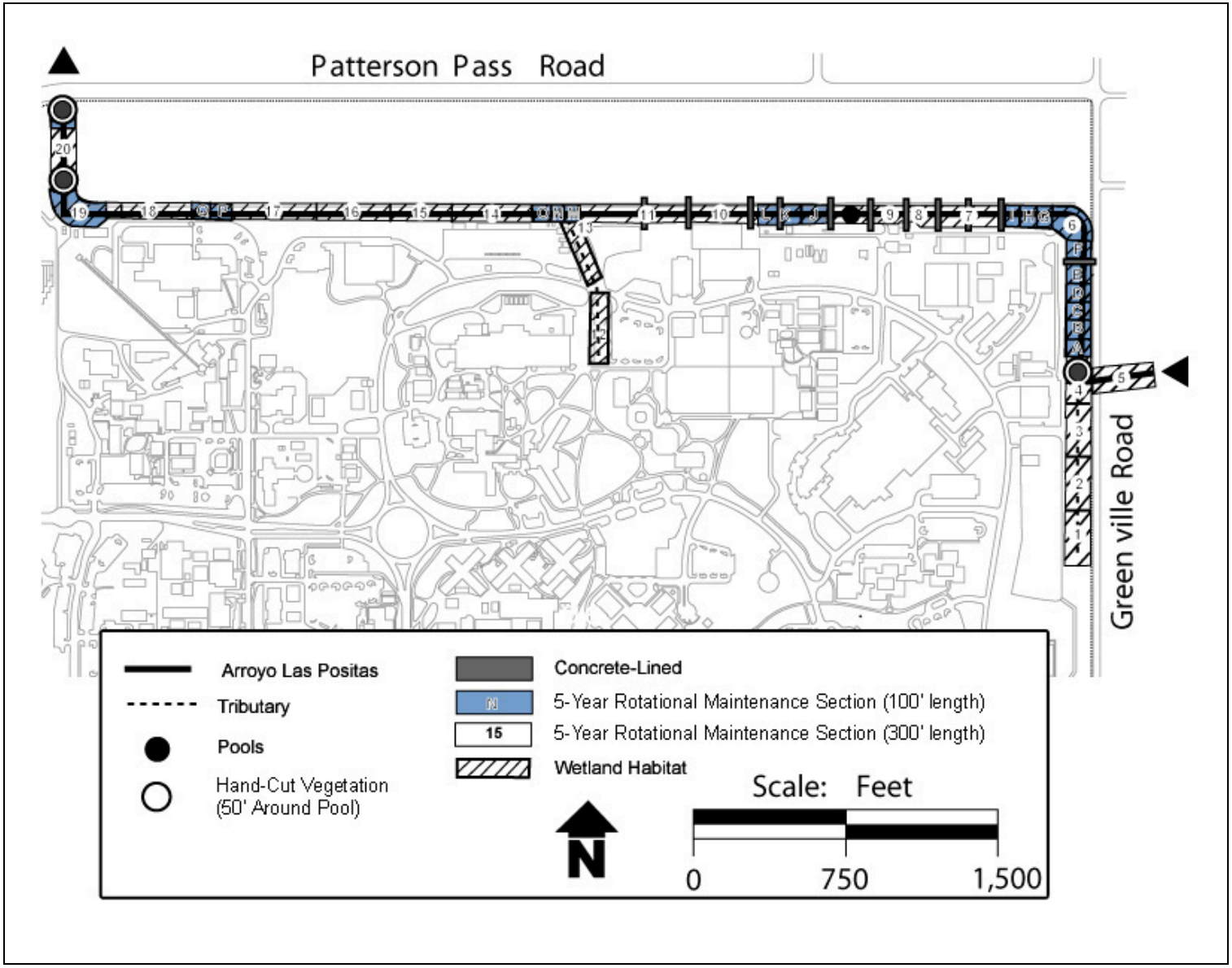
Source: Bloom 2002.

FIGURE E.1.2.2–1.—*Loggerhead Shrike Nesting Locations at Site 300 in 2002*



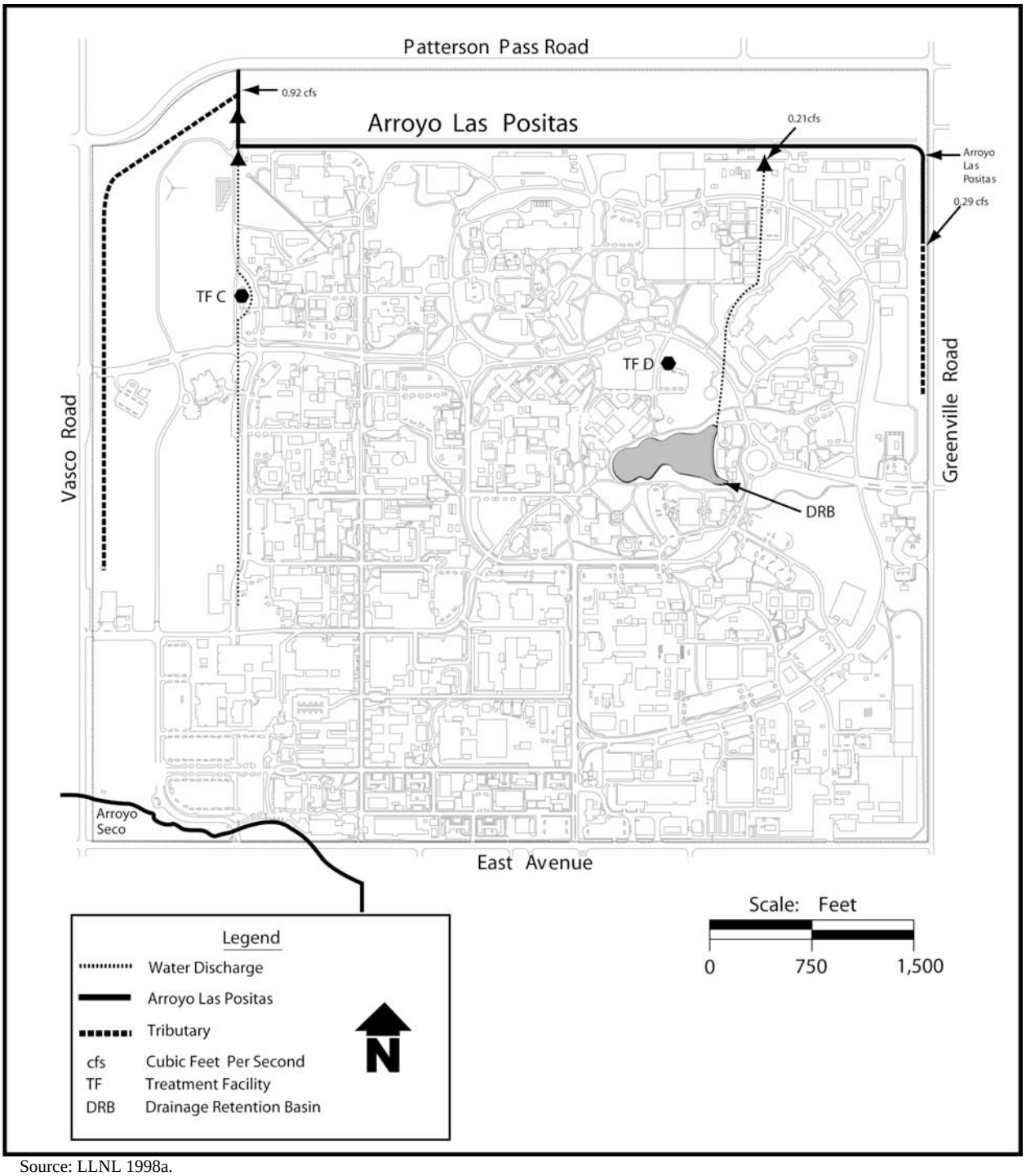
Source: LLNL 1998a.

FIGURE E.2.1.5.1–1.—*Arroyo Las Positas Maintenance Project, Reach 2 Berm Design*



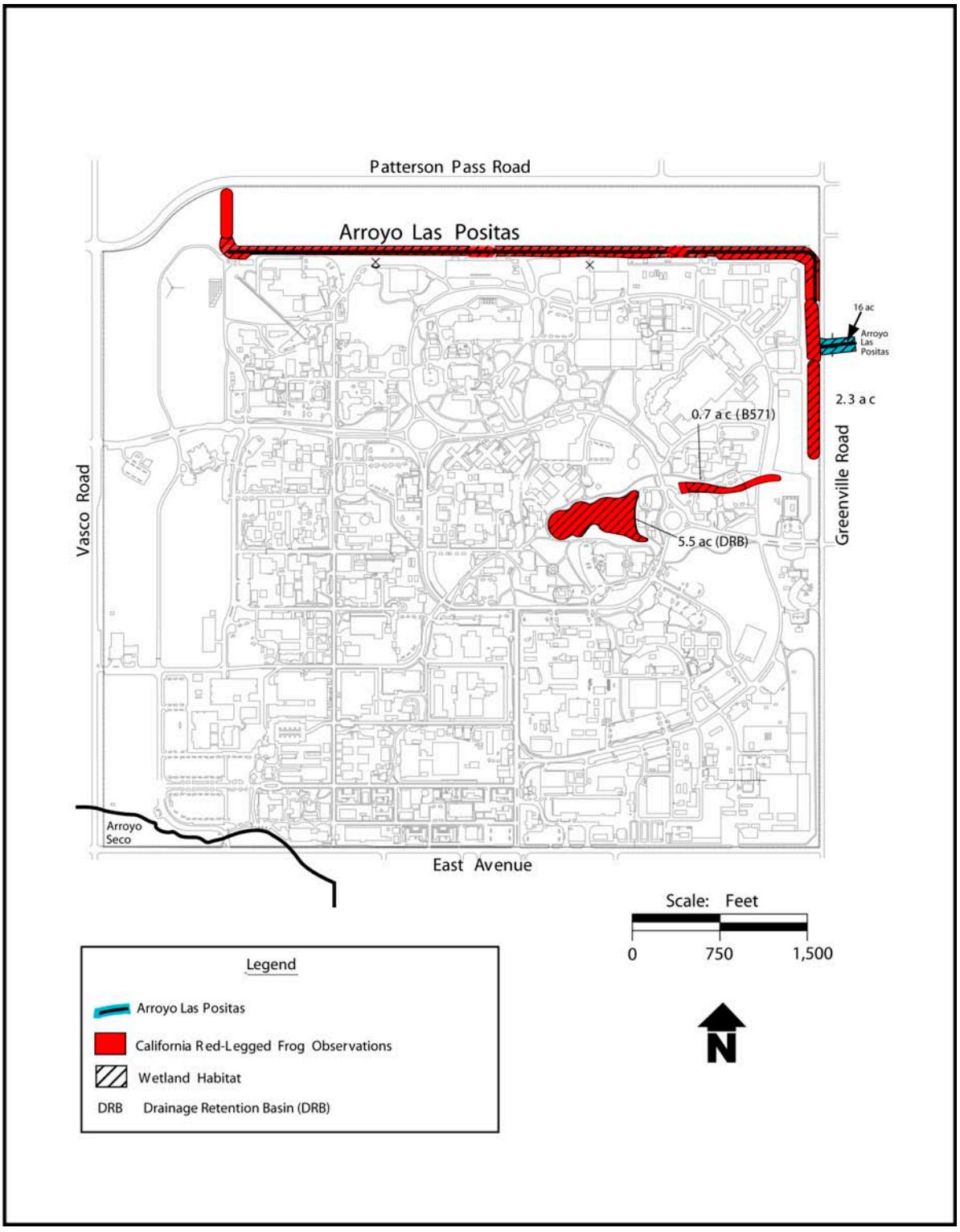
Source: LLNL 1998a.

FIGURE E.2.1.5.1–2.—*Arroyo Las Positas Maintenance Project (Wetland Features)*



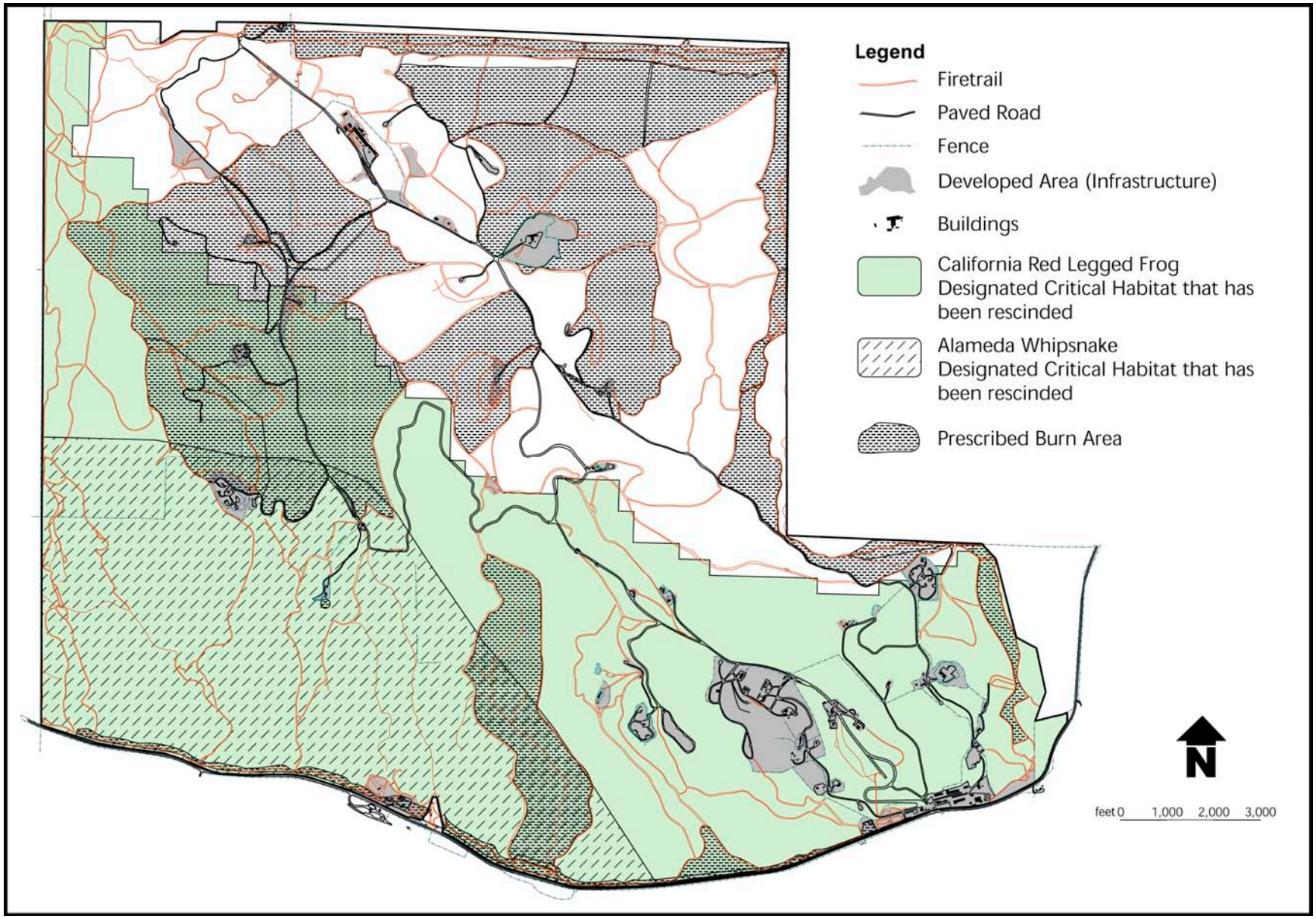
Source: LLNL 1998a.

FIGURE E.2.1.5.1–3.—*Arroyo Flows and Augmentations in June 1998*



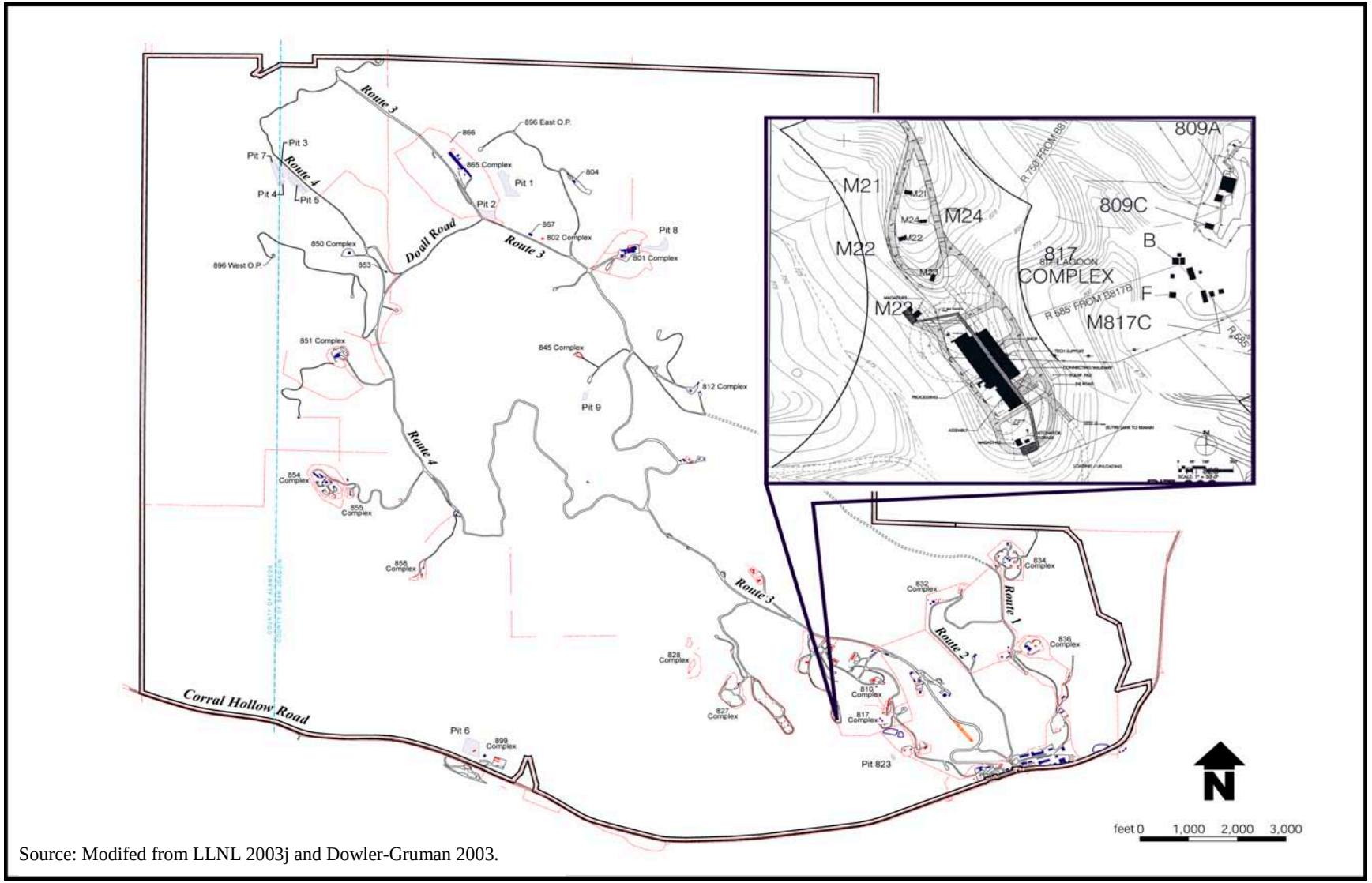
Source: Adapted from LLNL 1998a, LLNL 2003ab.

FIGURE E.2.1.5.2–1.—*Special Status Species Locations and Wetland Acreage in 2002*



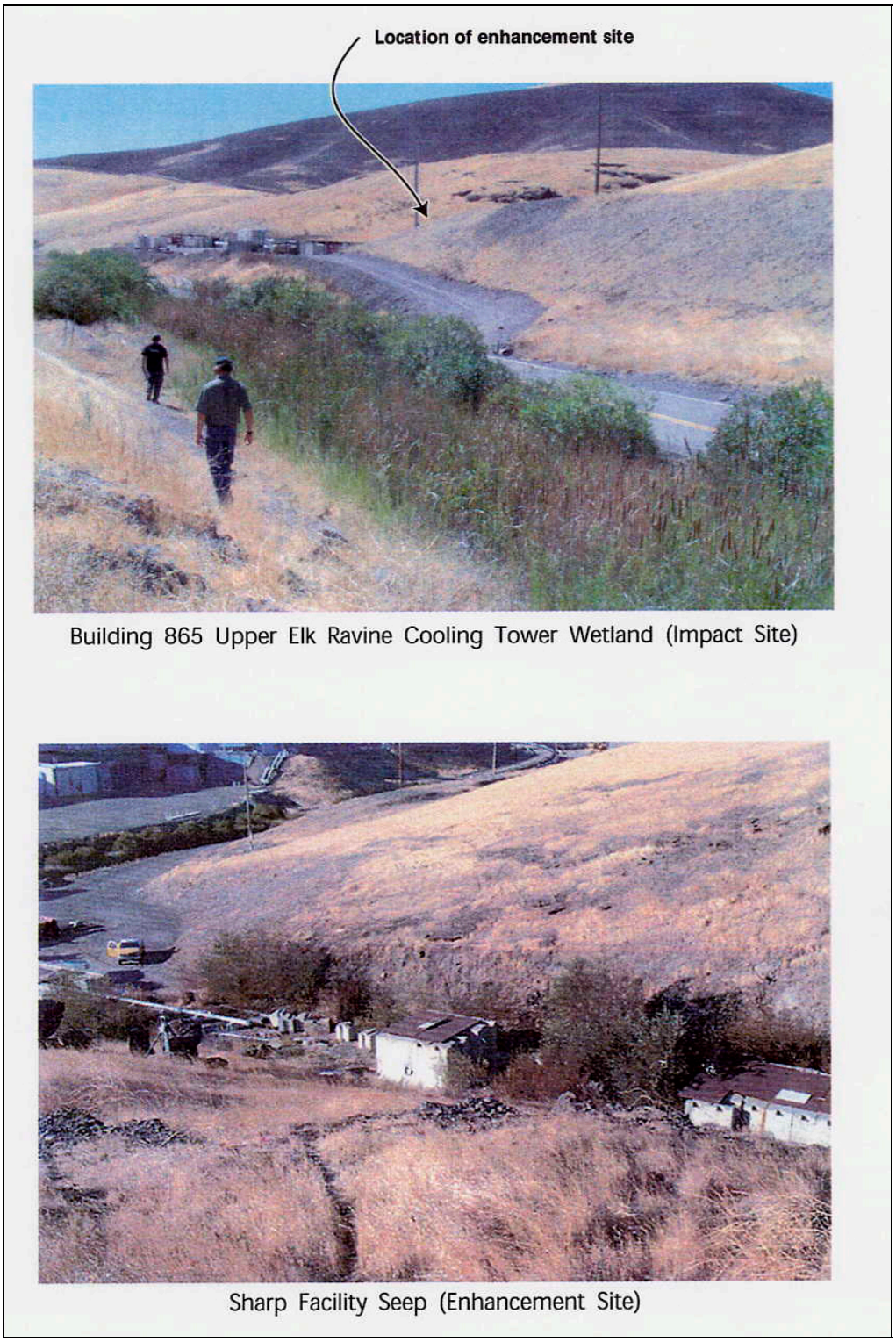
Source: Jones and Stokes 2001.

FIGURE E.2.2.5.4–1.—*Prescribed Burn Areas at Site 300*



Source: Modifed from LLNL 2003j and Dowler-Gruman 2003.

FIGURE E.2.2.5.6–1.— *Proposed Energetics Materials Processing Center at Site 300*



Source: Jones and Stokes 2001.

FIGURE E.2.2.6.1.1.4–1.—*Photographs of Upper Elk Ravine Area (Enhancement and Impact Area)*

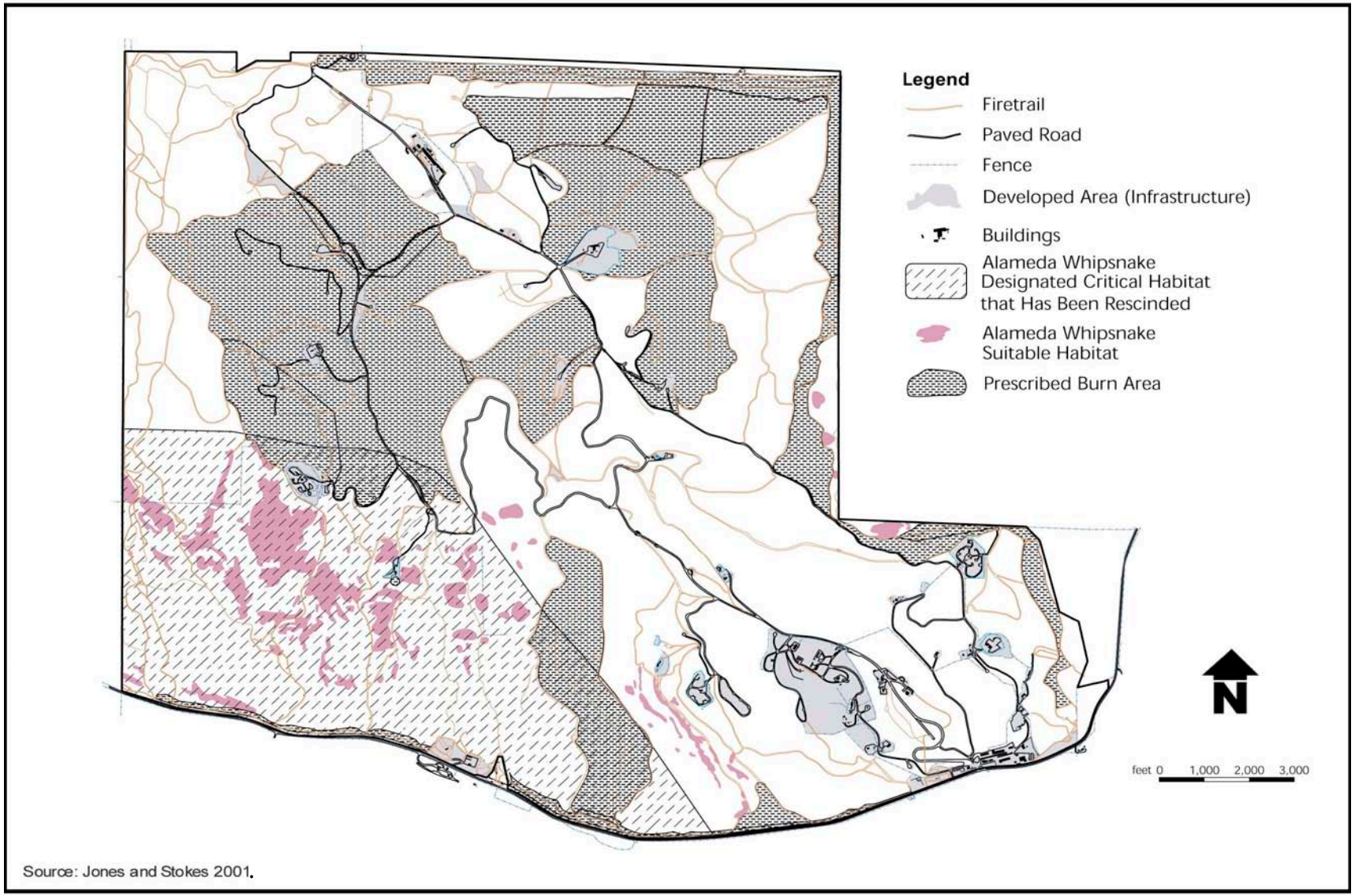
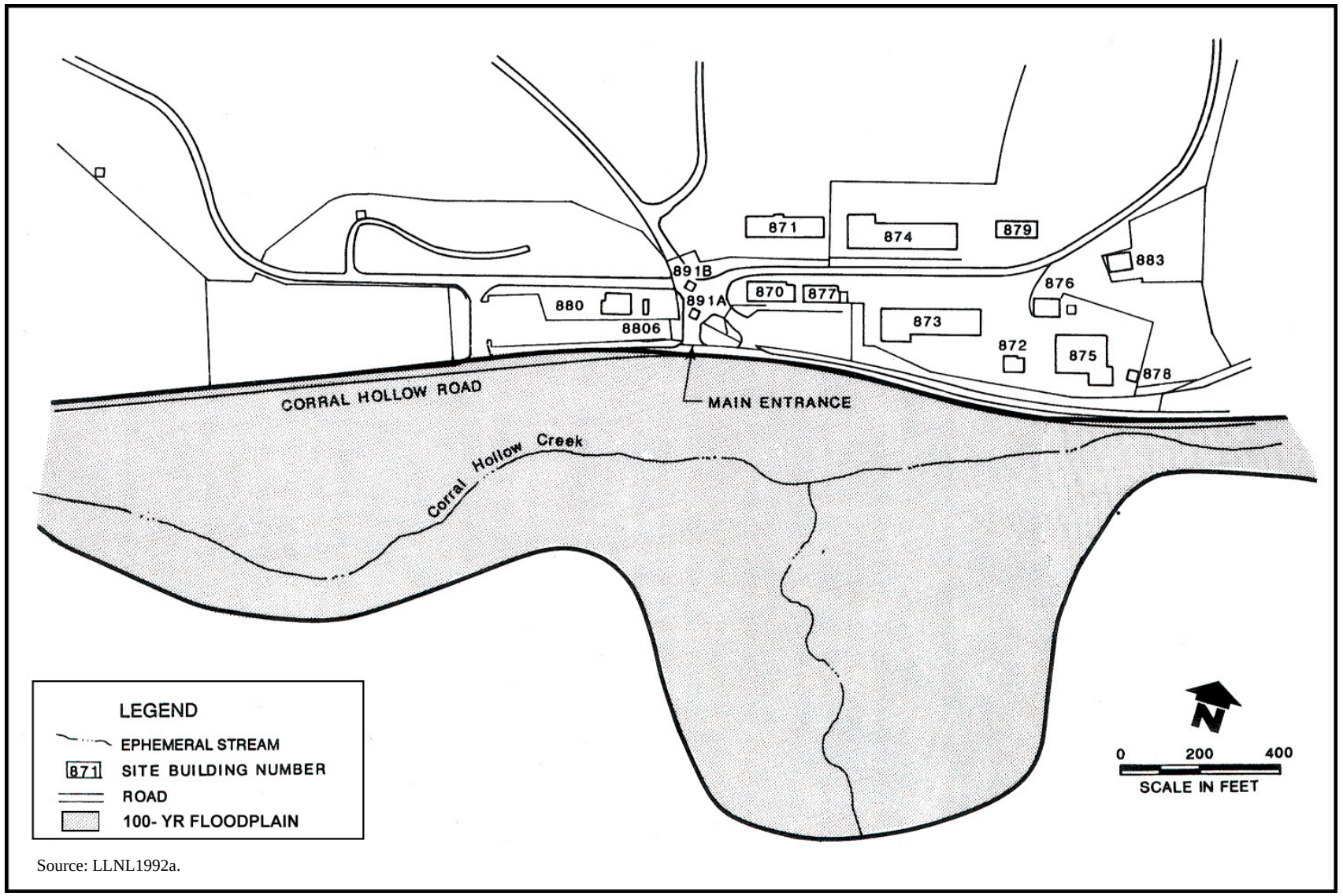
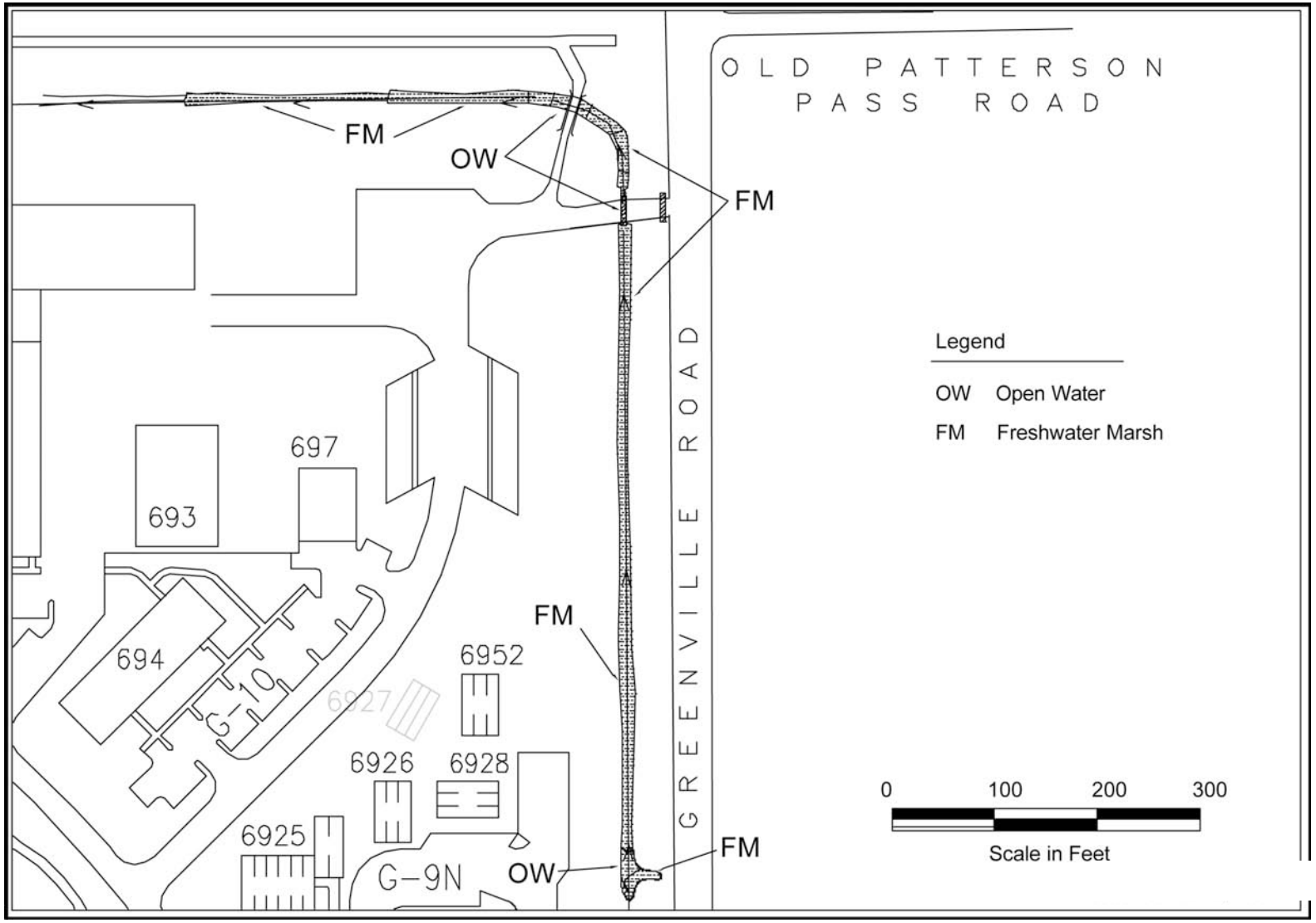


FIGURE E.2.2.6.2.1.3–1.—*Formerly Designated Critical Habitat and Suitable Habitat for Alameda Whipsnake at Site 300*



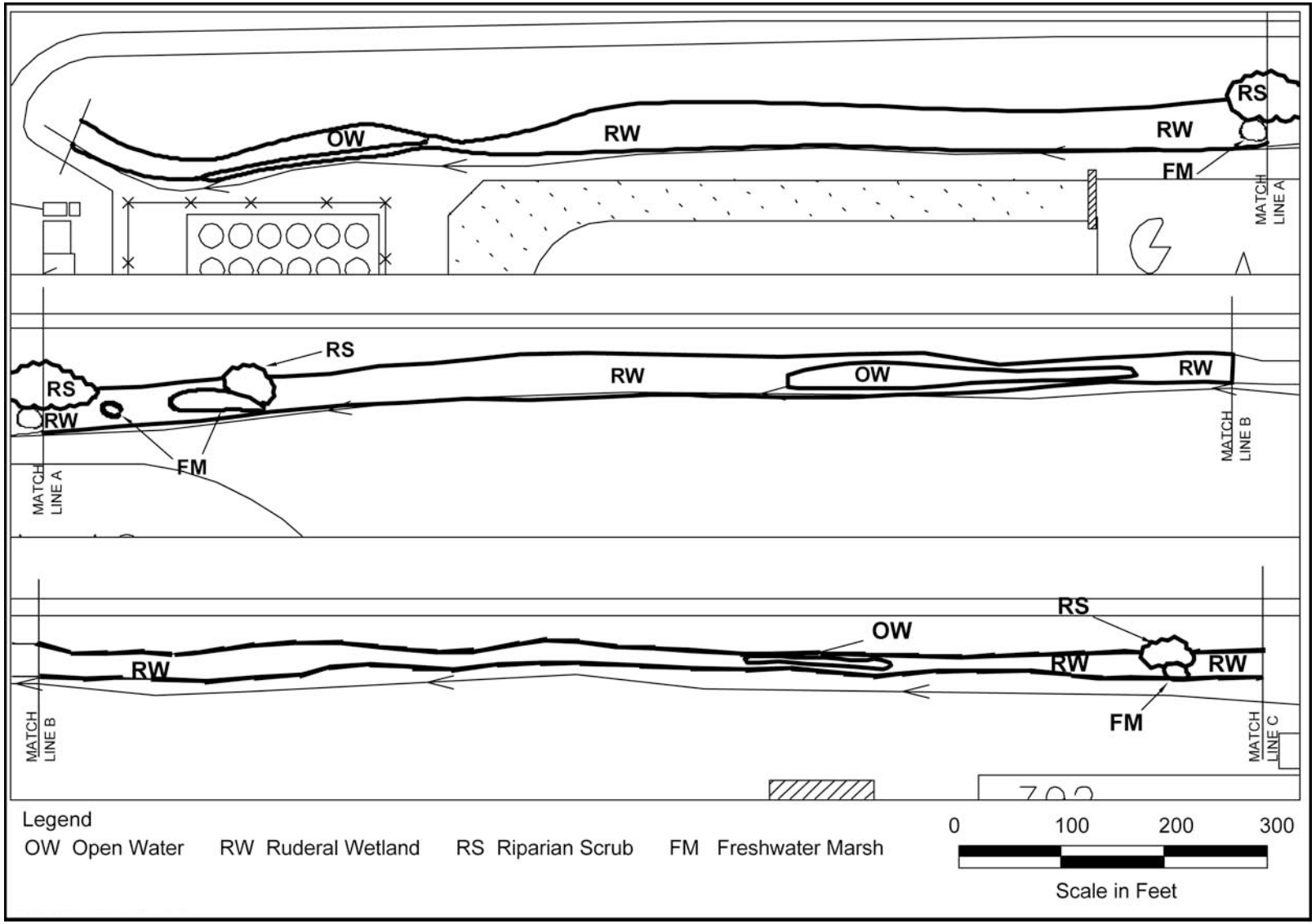
Source: LLNL1992a.

FIGURE F.2.1–2. —*100-Year Floodplain Along Corral Hollow Creek in the Area of Site 300 Main Entrance*



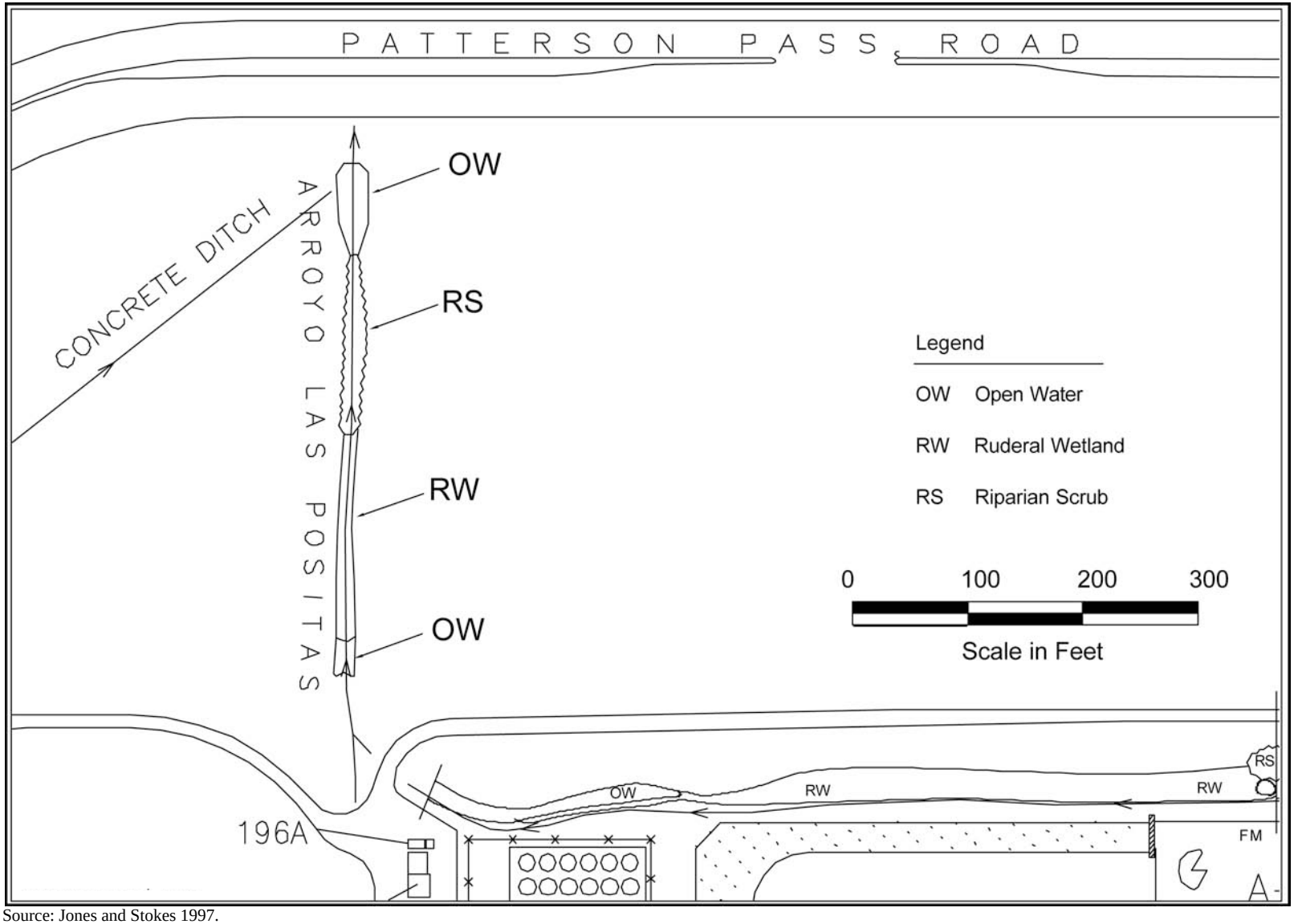
Source: Jones and Stokes 1997.

FIGURE F.3.1.1–1.—*Location of Wetlands in Arroyo Las Positas, North Arroyo (Map 1)*



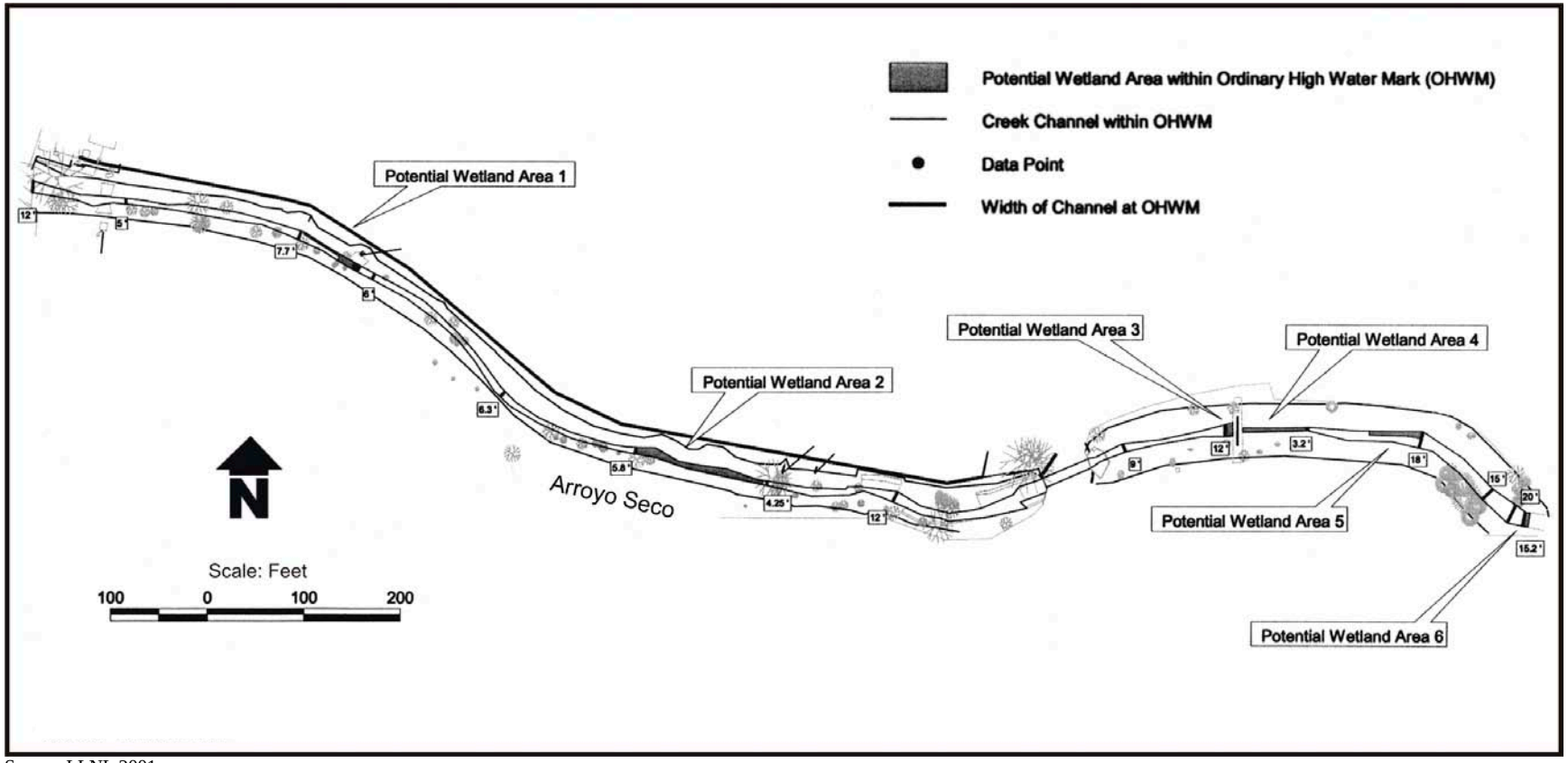
Source: Jones and Stokes 1997.

FIGURE F.3.1.1–2.—*Location of Wetlands in Arroyo Las Positas, North Arroyo (Map 2)*



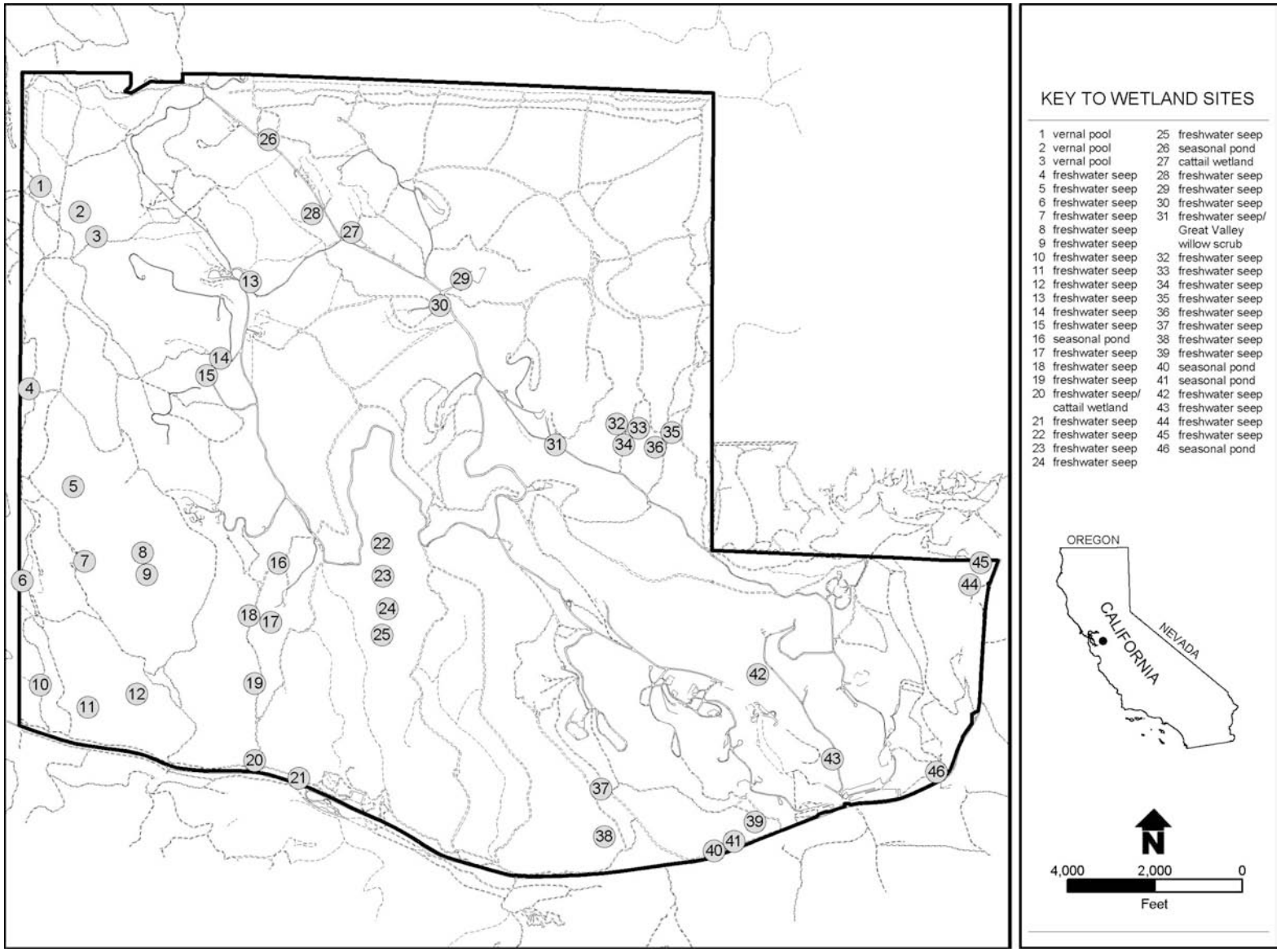
Source: Jones and Stokes 1997.

FIGURE F.3.1.1–3.—*Location of Wetlands in Arroyo Las Positas, Northwest Arroyo to Patterson Pass Road*



Source: LLNL 2001ap.

FIGURE F.3.1.1–4.—*Location of Potential Wetlands in Arroyo Seco*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–1.—*Index of Site 300 Wetlands*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–10.—*Wetland Delineation (Wetland 13)*



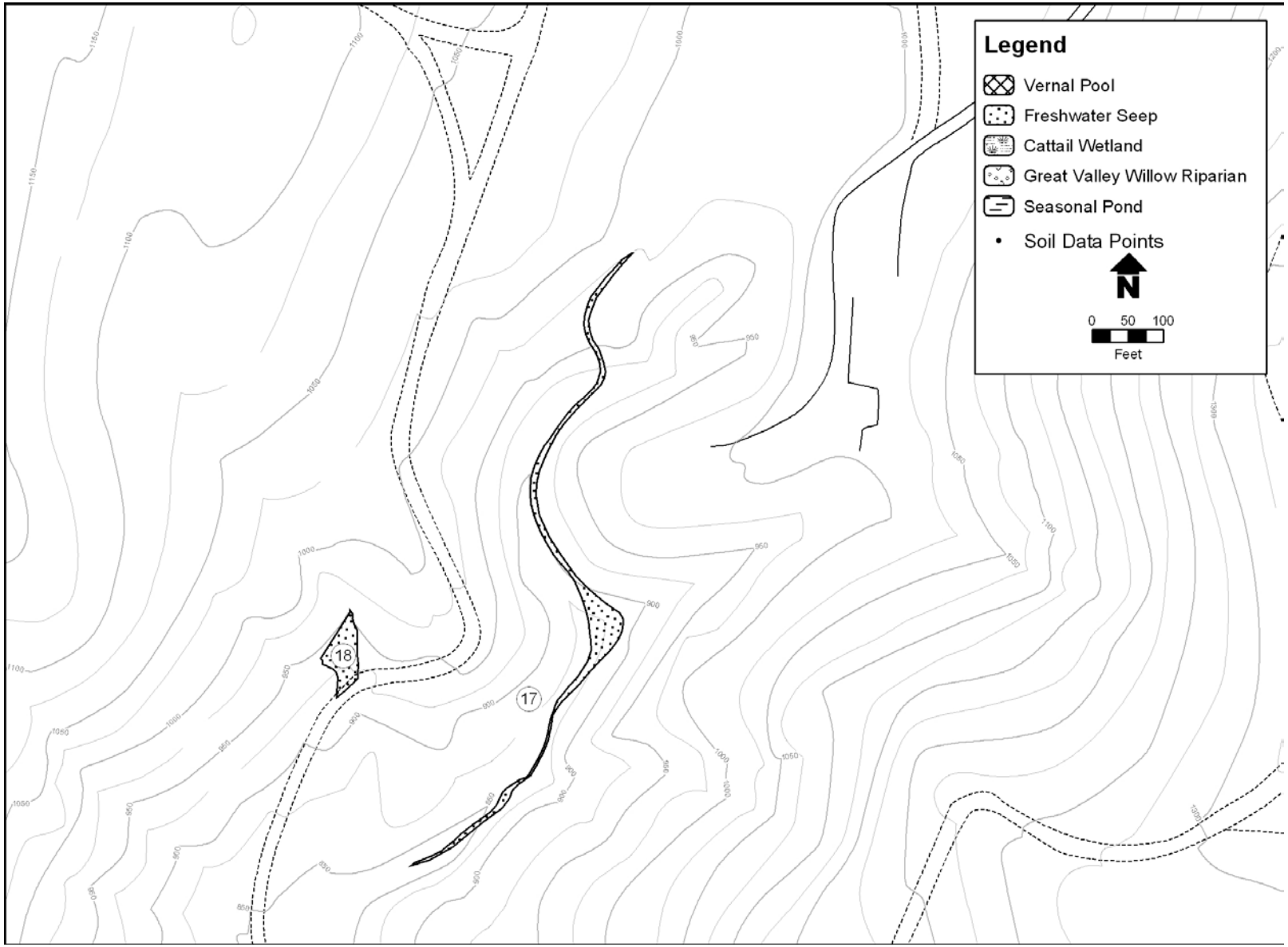
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–11.—*Wetland Delineation (Wetlands 14 and 15)*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–12.—*Wetland Delineation (Wetland 16)*



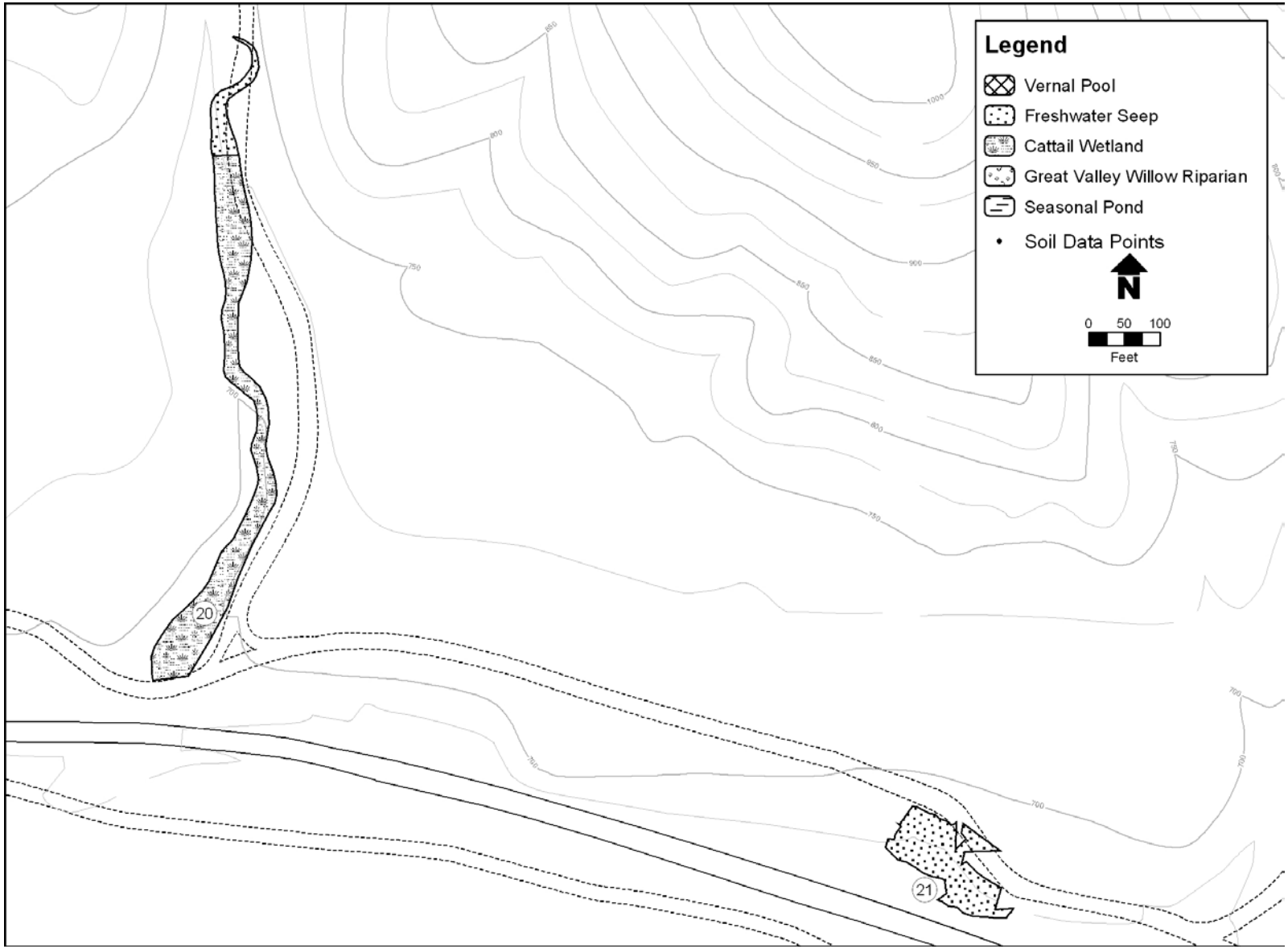
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–13.—*Wetland Delineation (Wetlands 17 and 18)*



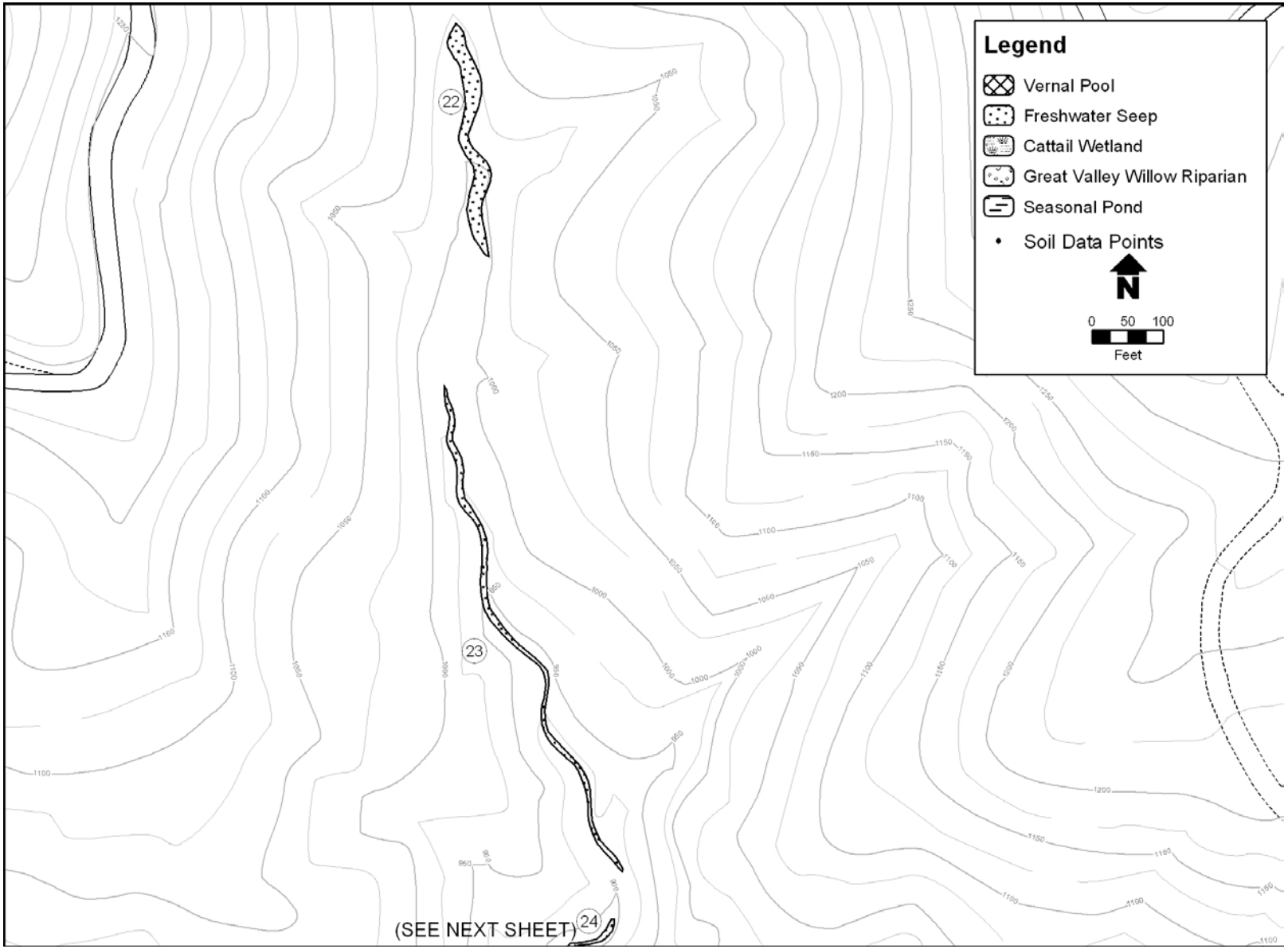
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–14.—*Wetland Delineation (Wetland 19)*



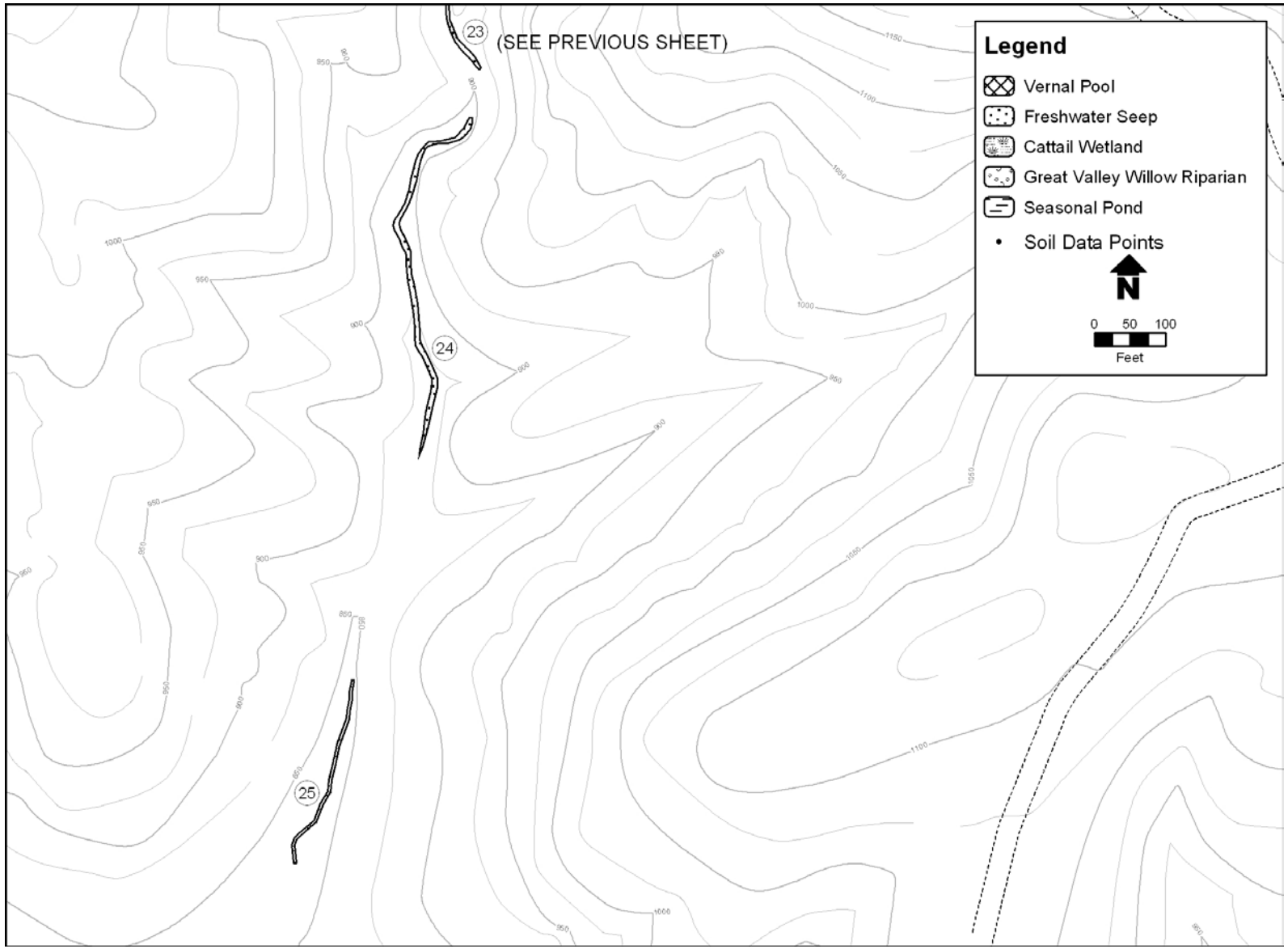
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–15.—*Wetland Delineation (Wetlands 20 and 21)*



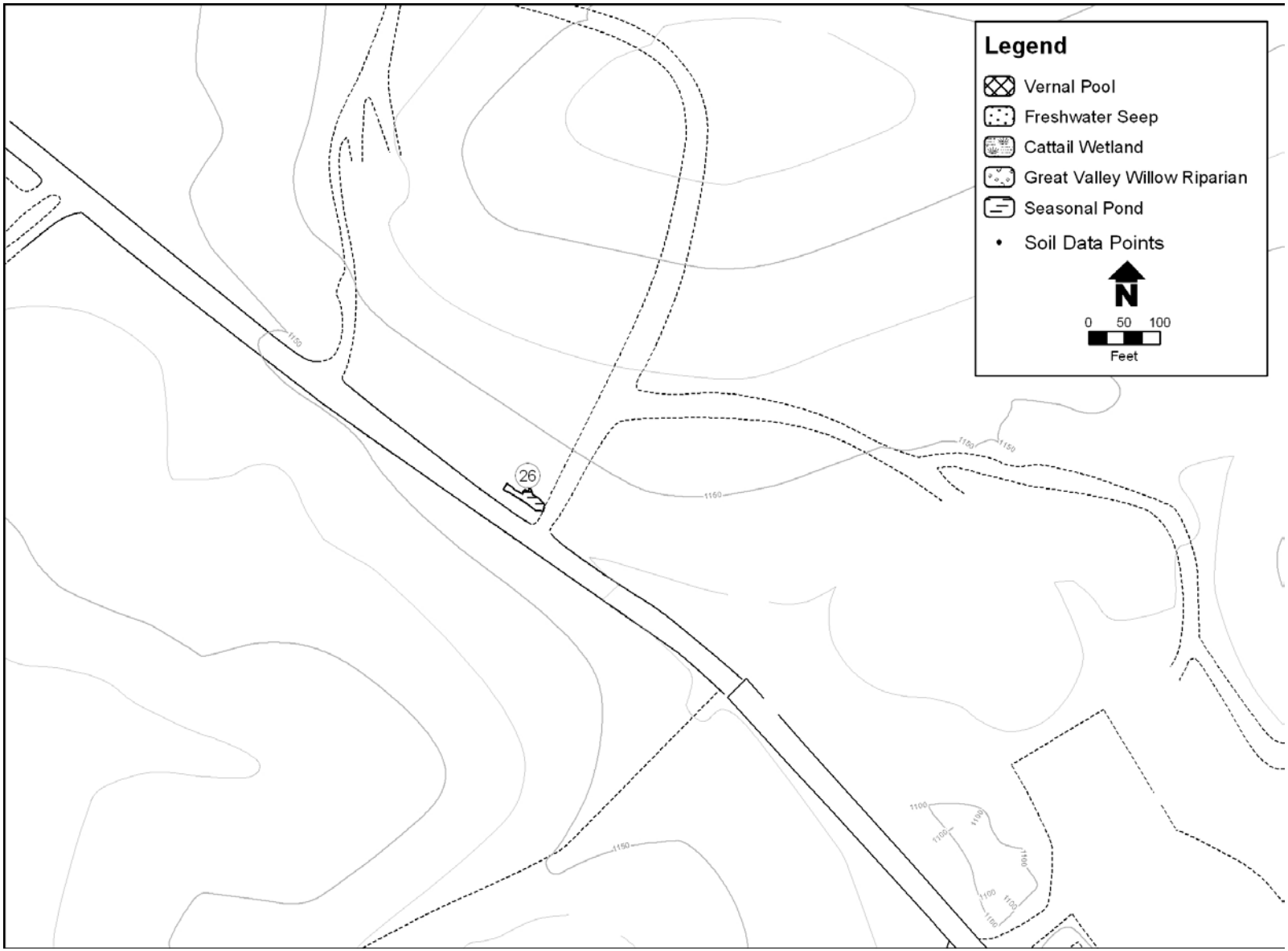
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–16.—*Wetland Delineation (Wetlands 22, 23, and 24)*



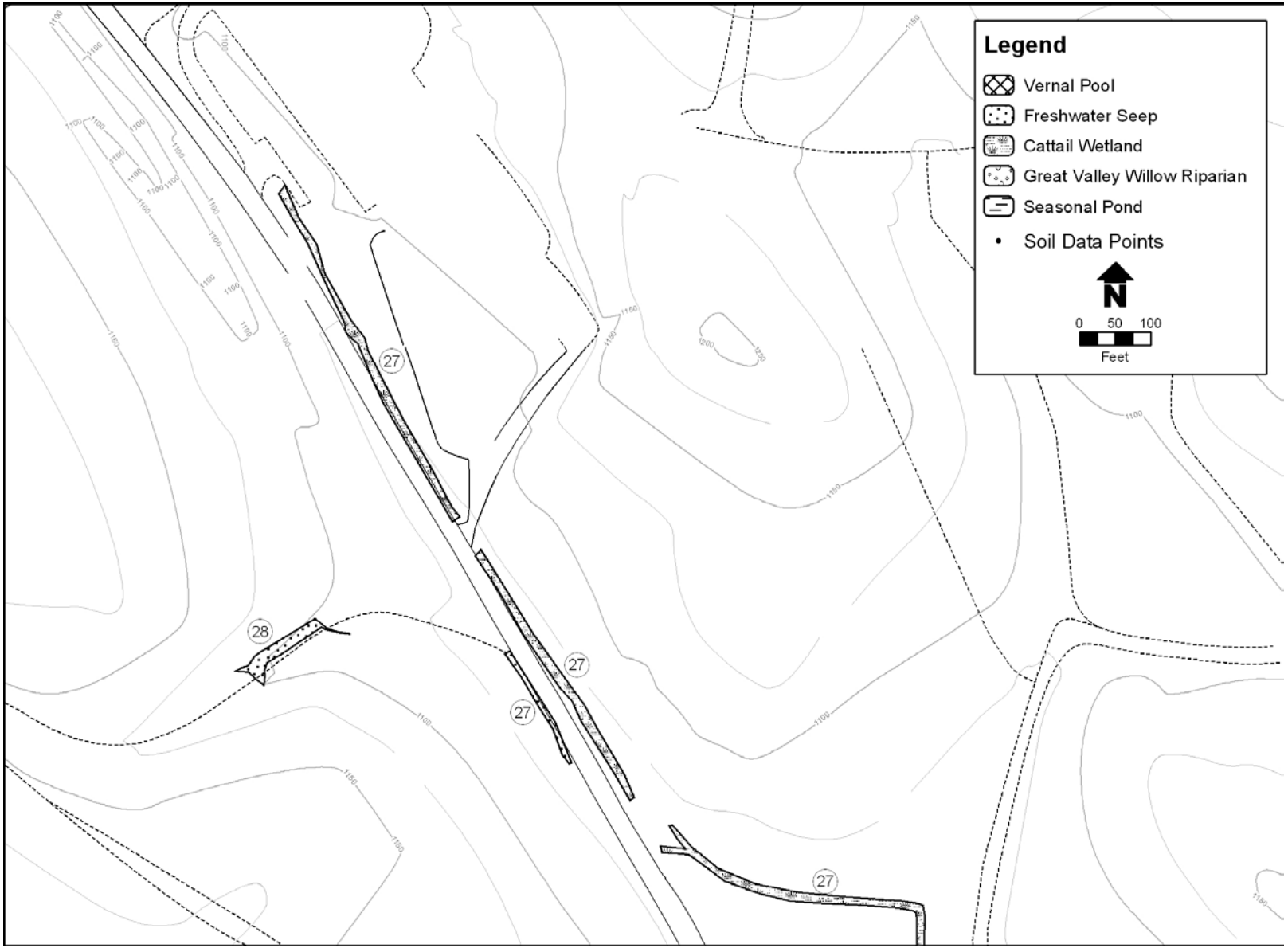
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–17.—*Wetland Delineation (Wetlands 23, 24, and 25)*



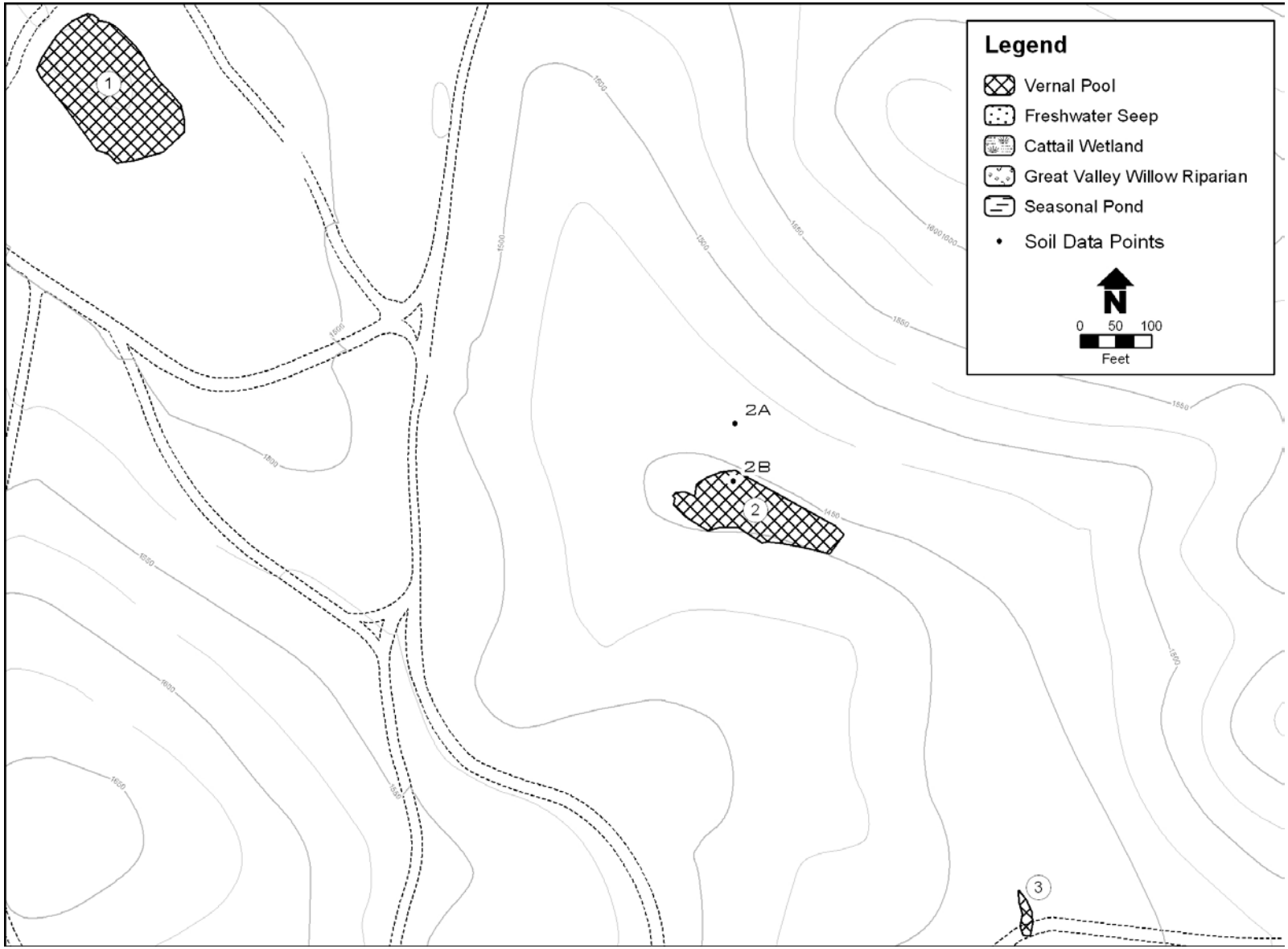
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–18.—*Wetland Delineation (Wetland 26)*



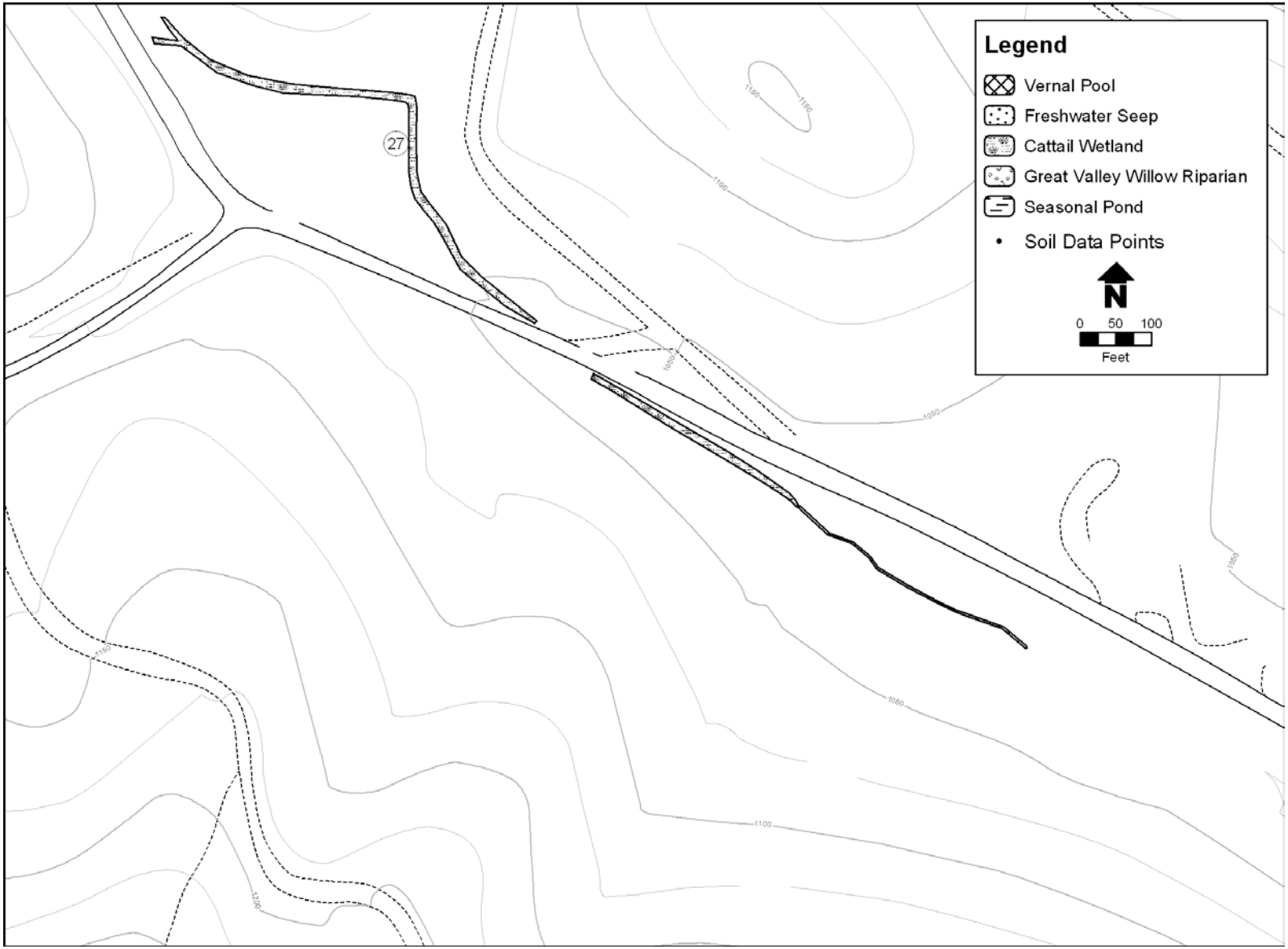
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–19.—*Wetland Delineation (Wetlands 27 and 28)*



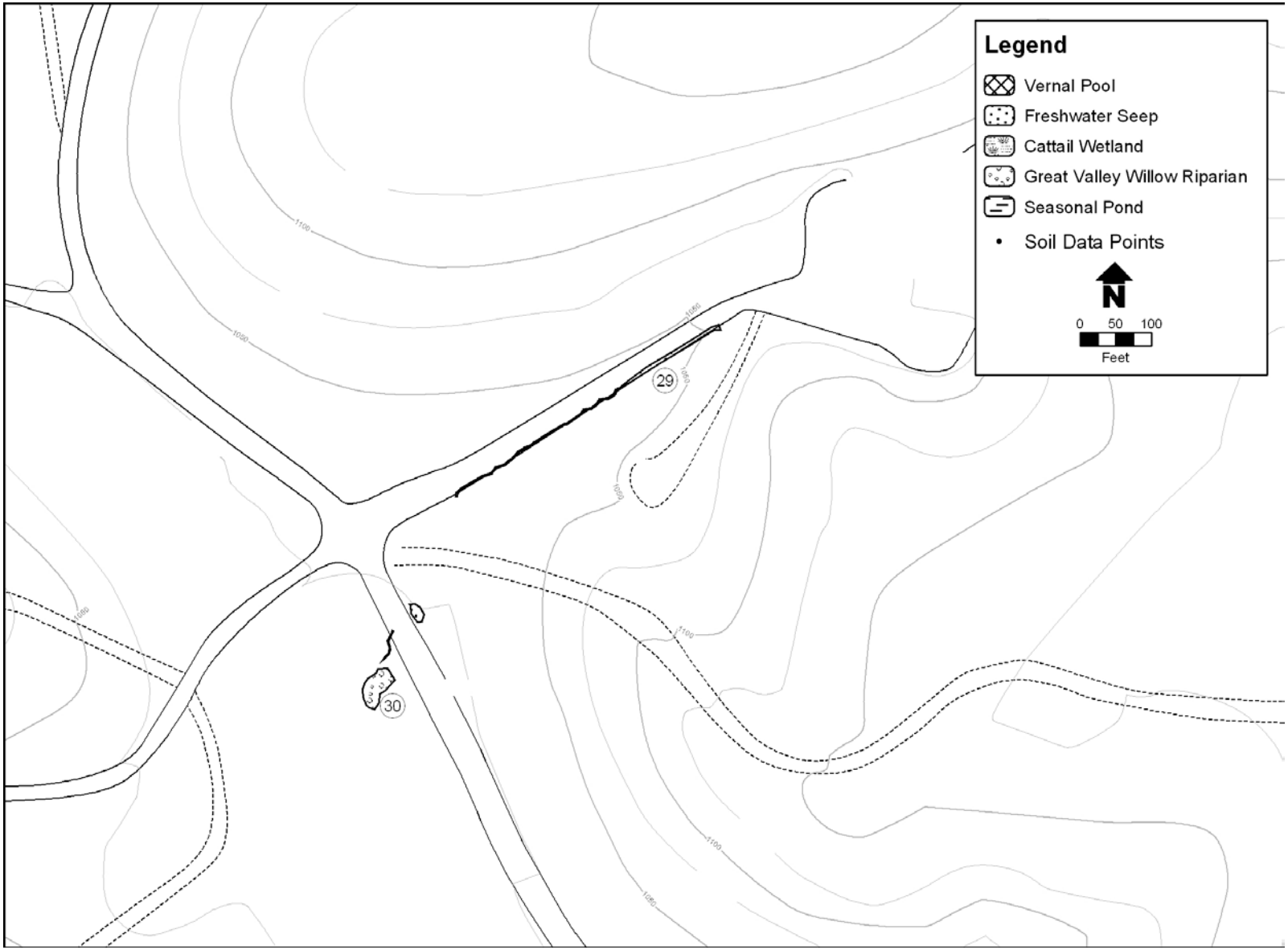
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–2.—*Wetland Delineation (Wetlands 1, 2, and 3)*



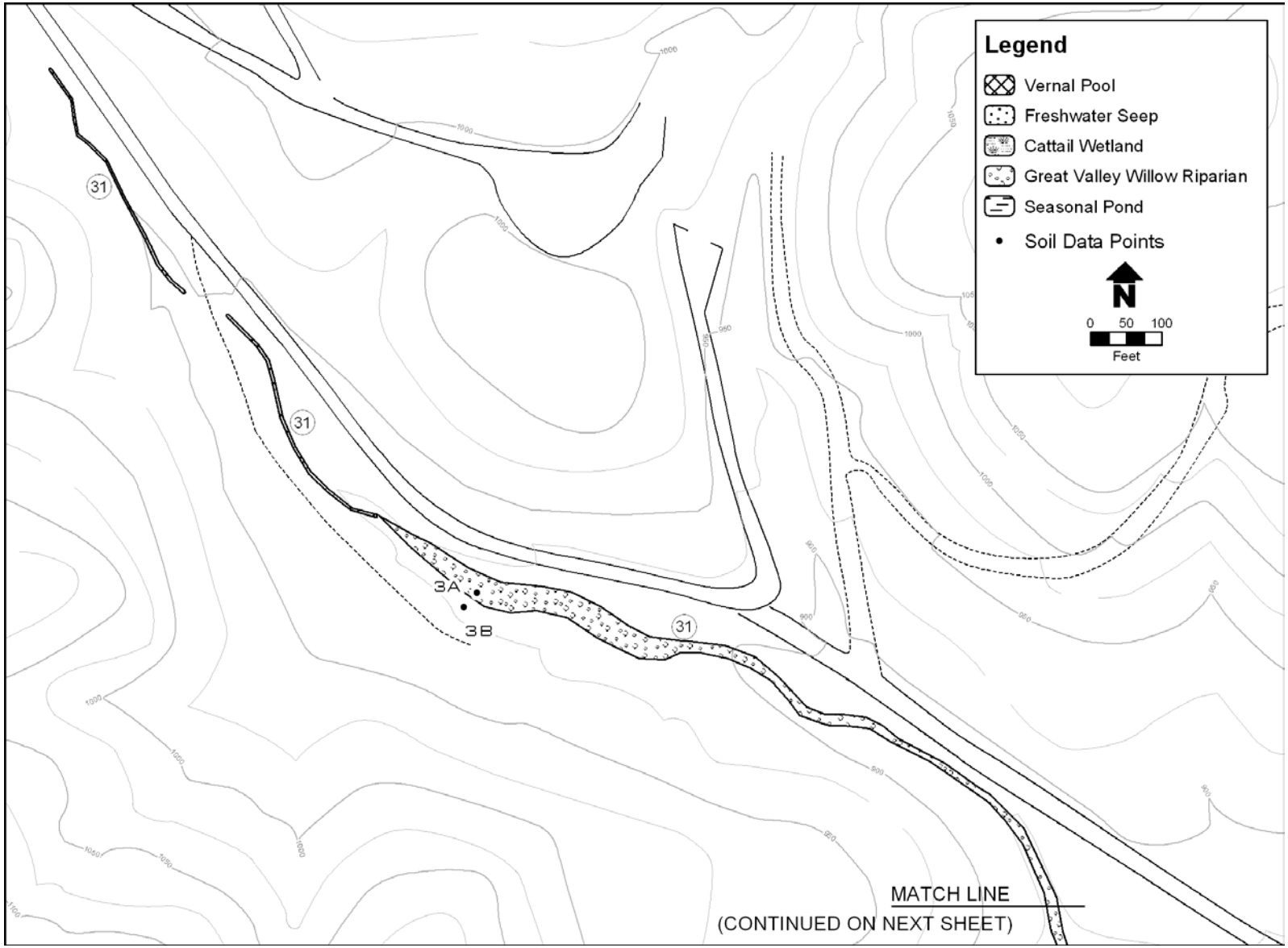
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–20.—*Wetland Delineation (Wetland 27)*



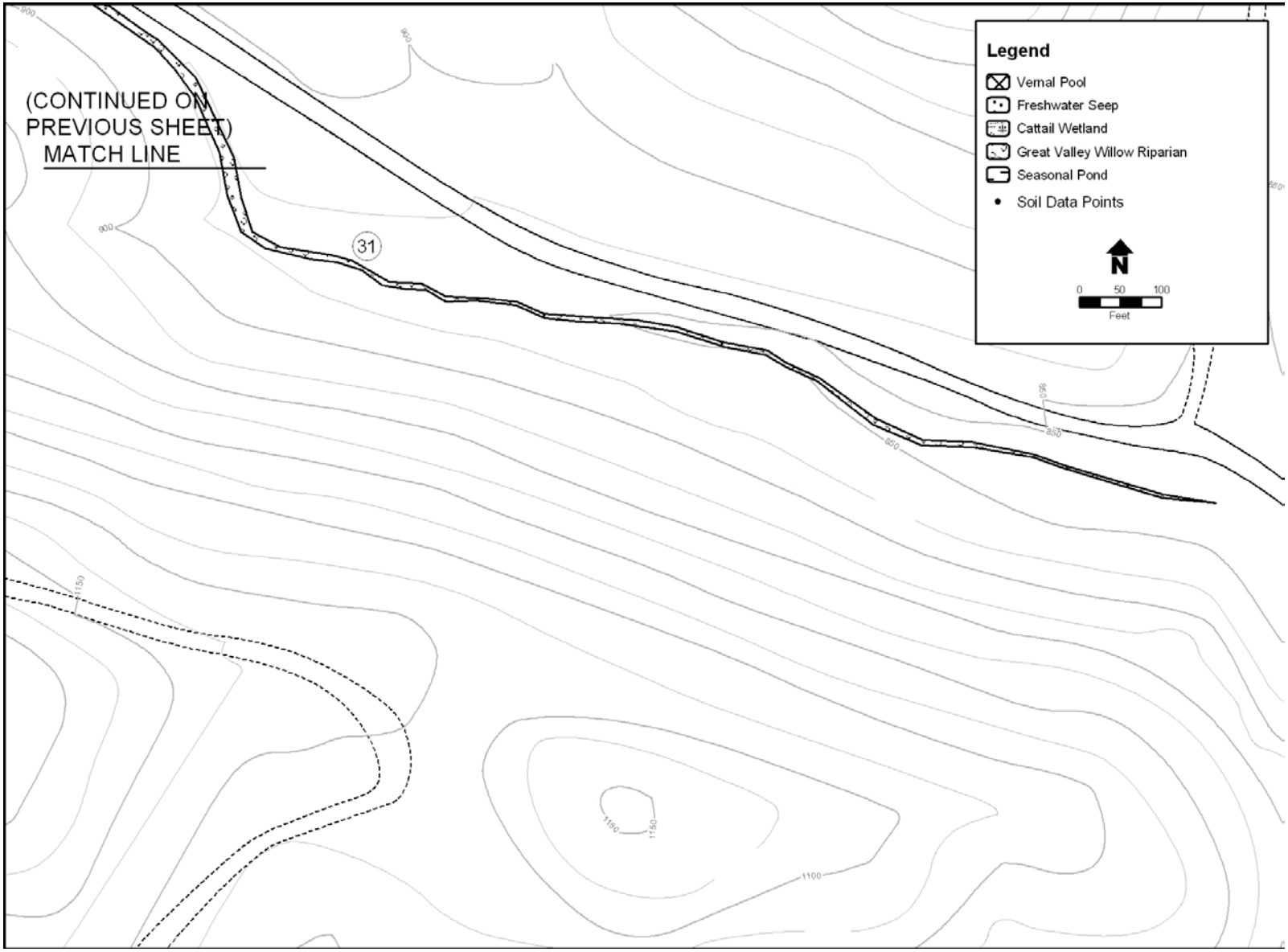
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–21.—*Wetland Delineation (Wetlands 29 and 30)*



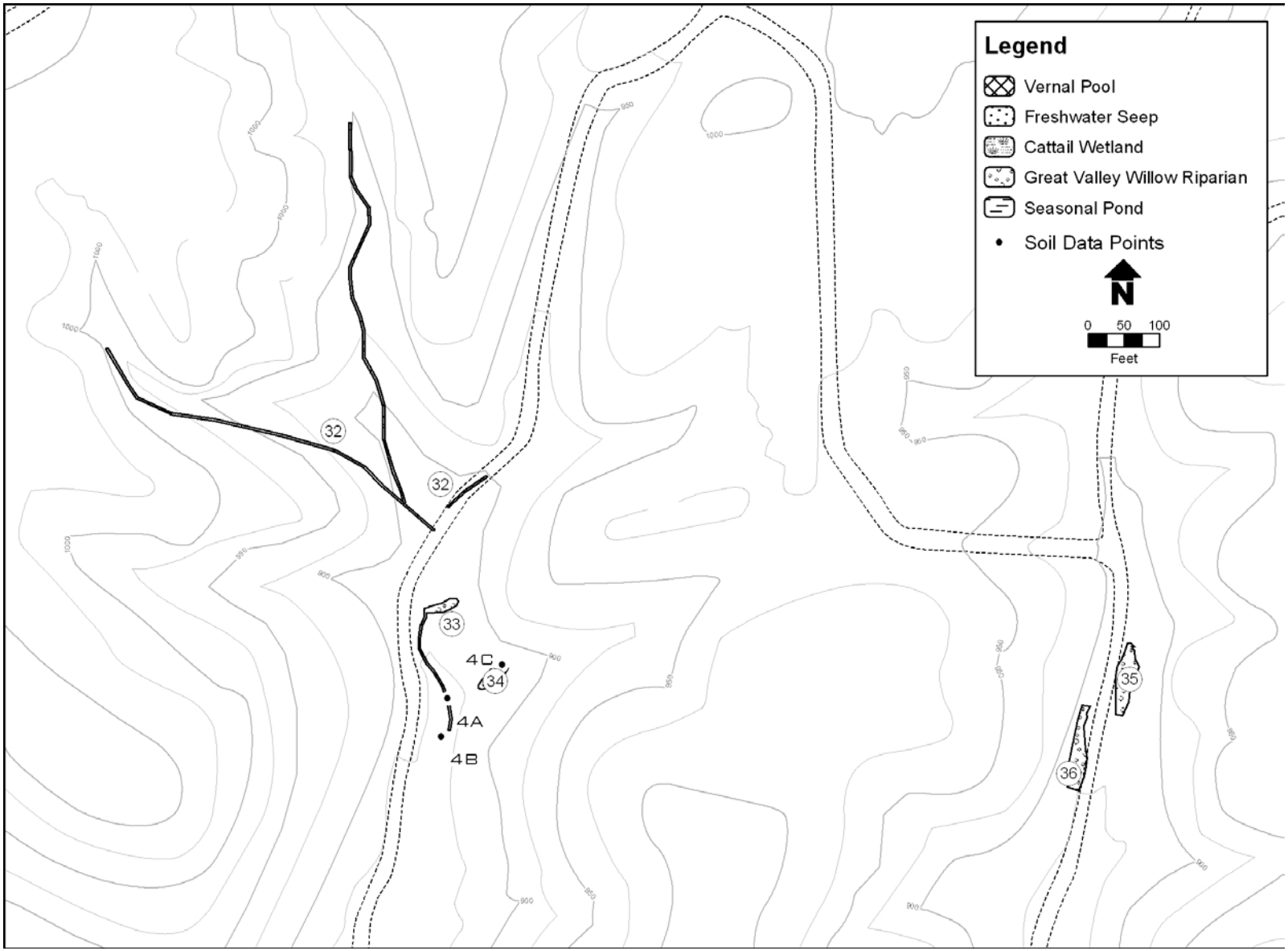
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–22.—*Wetland Delineation (Wetland 31)*



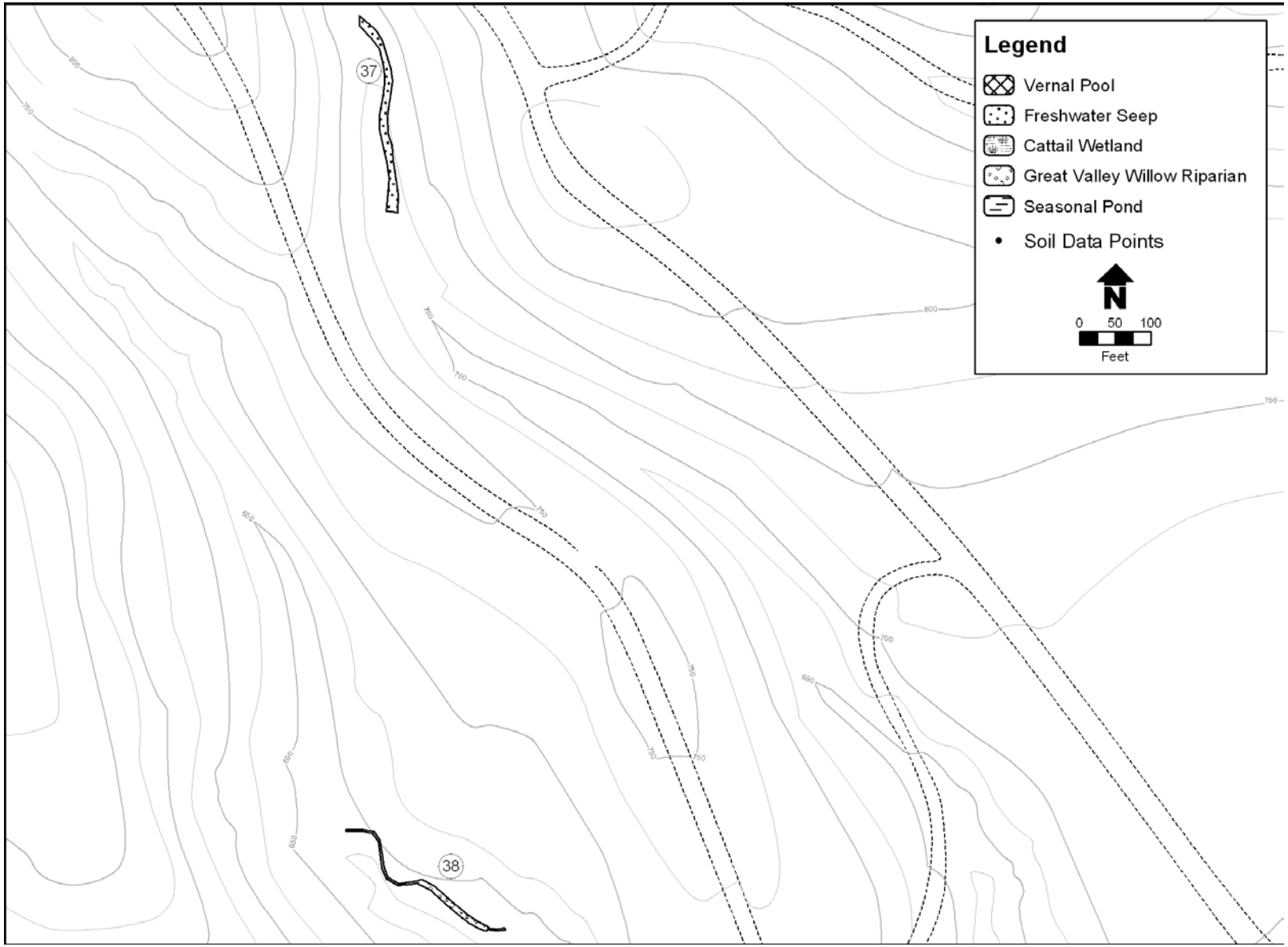
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–23.—*Wetland Delineation (Wetland 31) (continued)*



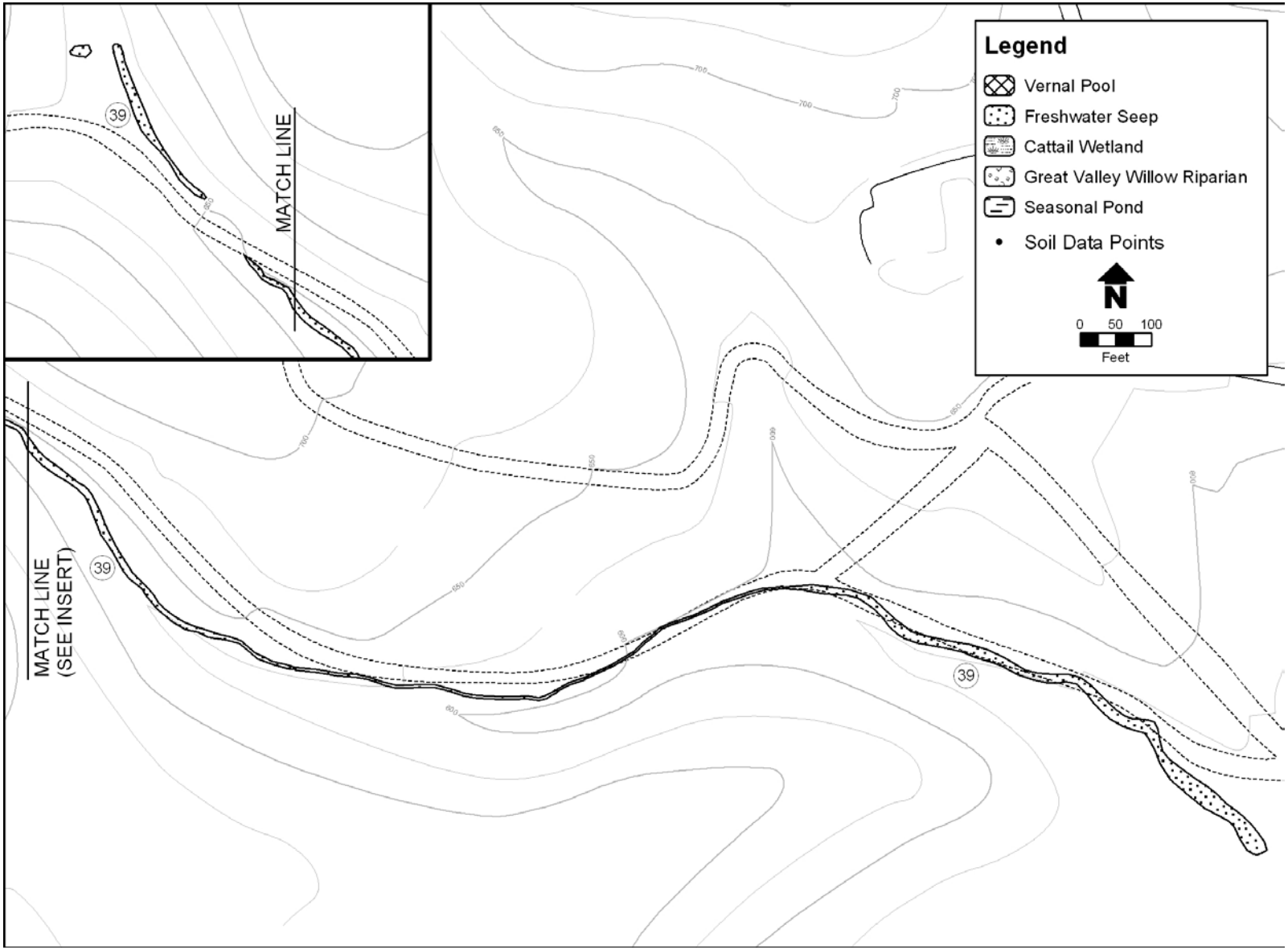
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–24.—*Wetland Delineation (Wetlands 32, 33, 34, 35, and 36)*



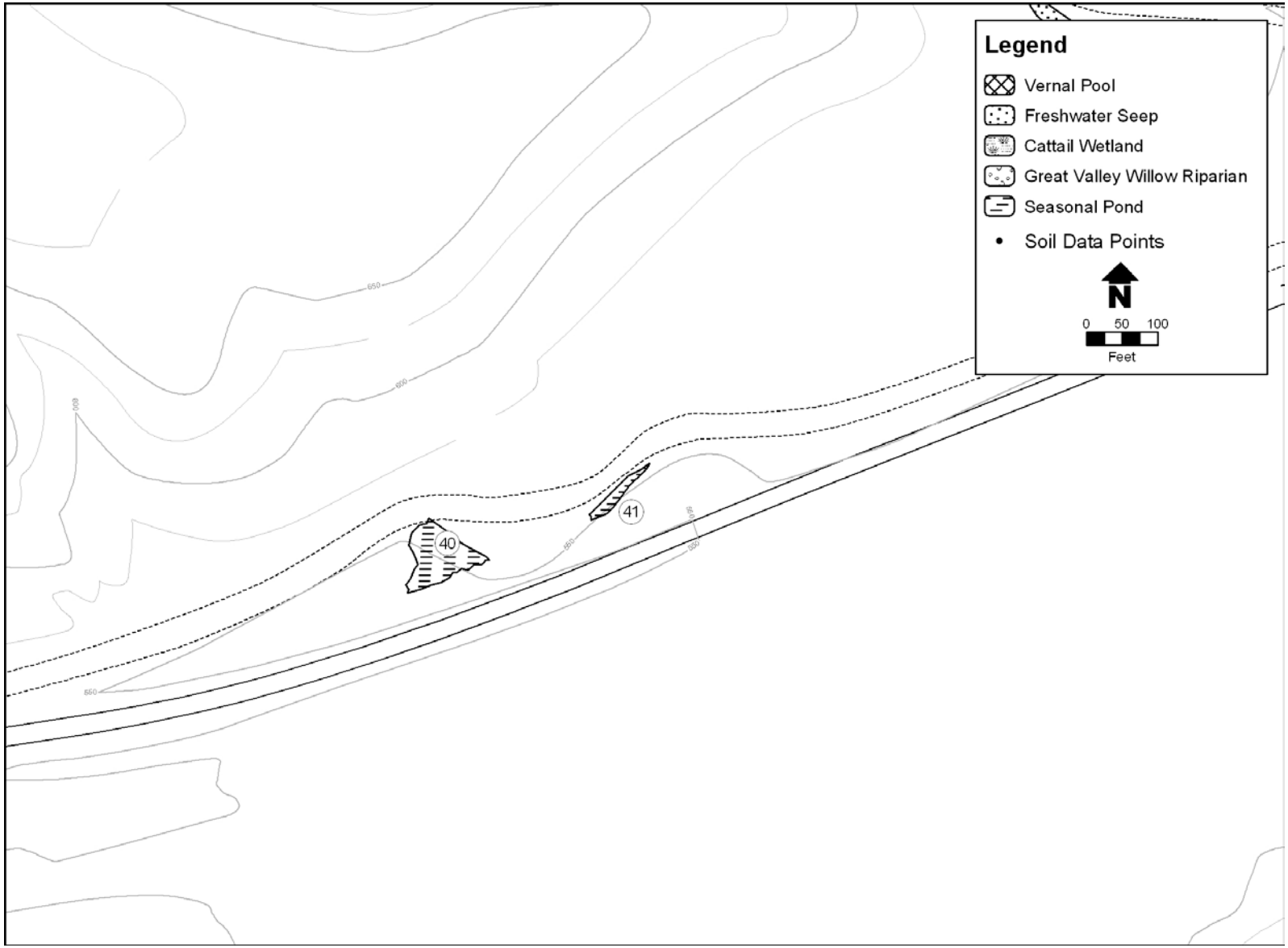
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–25.—*Wetland Delineation (Wetlands 37 and 38)*



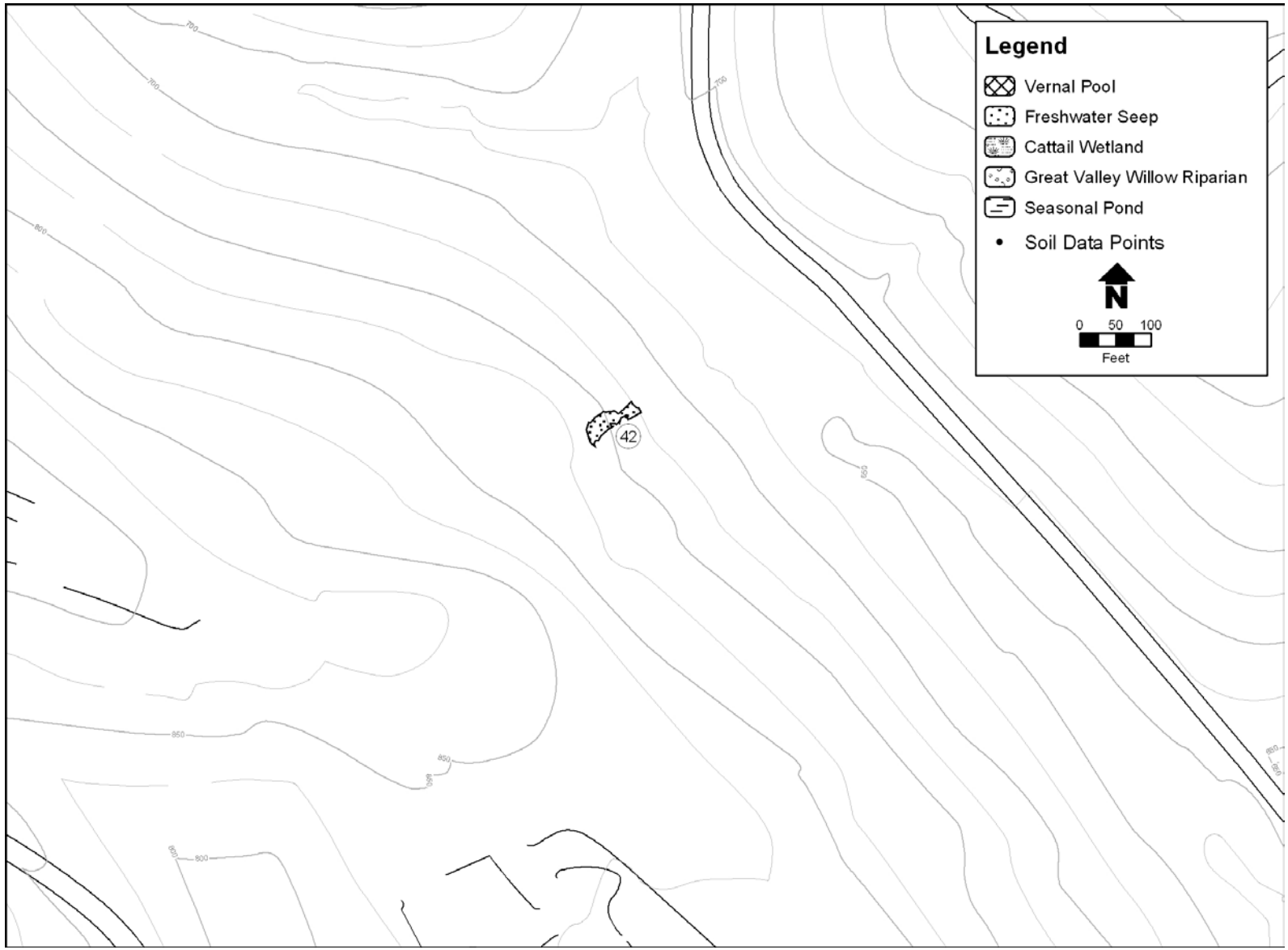
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–26.—*Wetland Delineation (Wetland 39)*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–27.—*Wetland Delineation (Wetlands 40 and 41)*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–28.—*Wetland Delineation (Wetland 42)*



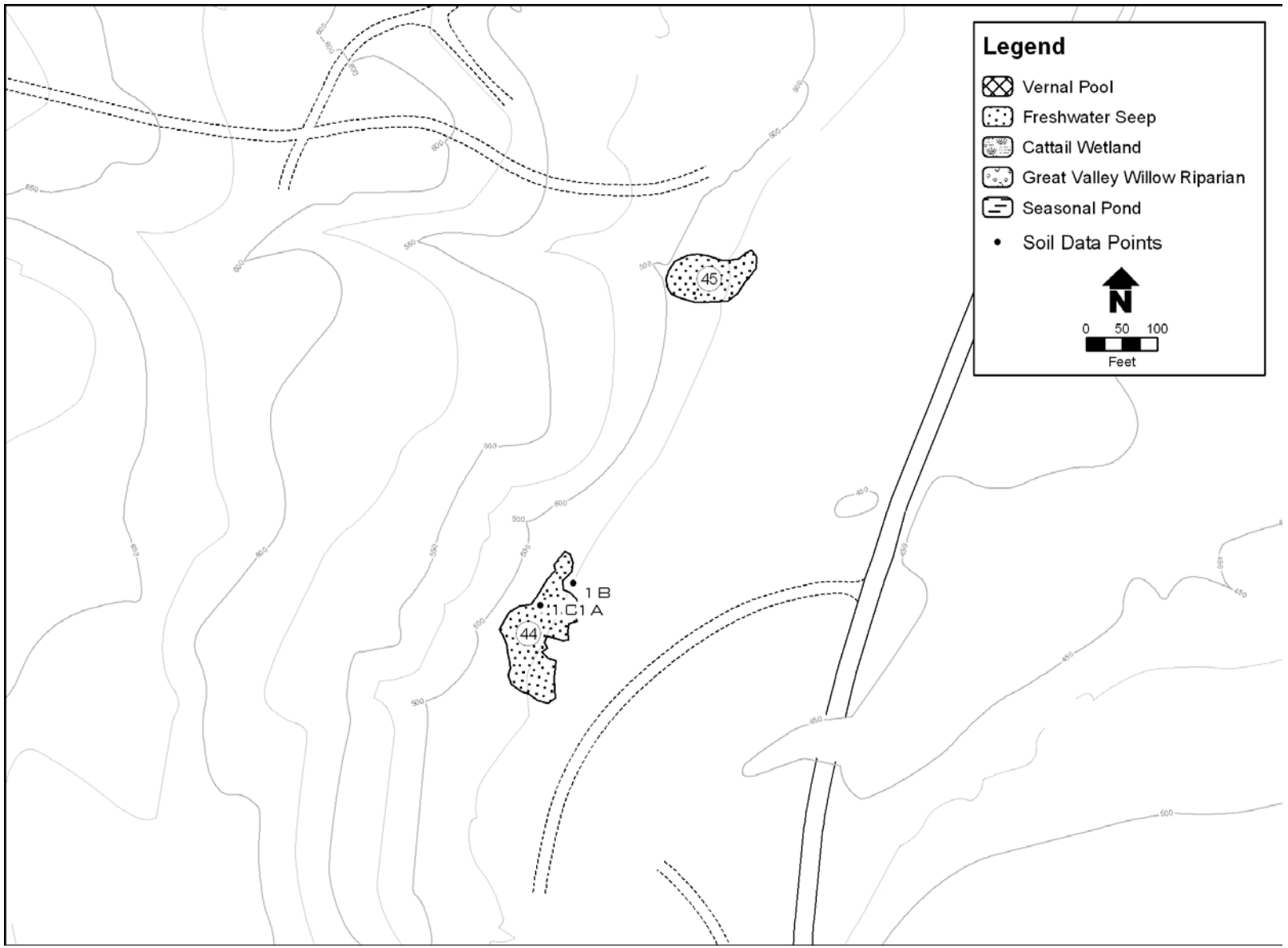
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–29.—*Wetland Delineation (Wetland 43)*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–3.—*Wetland Delineation (Wetland 4)*



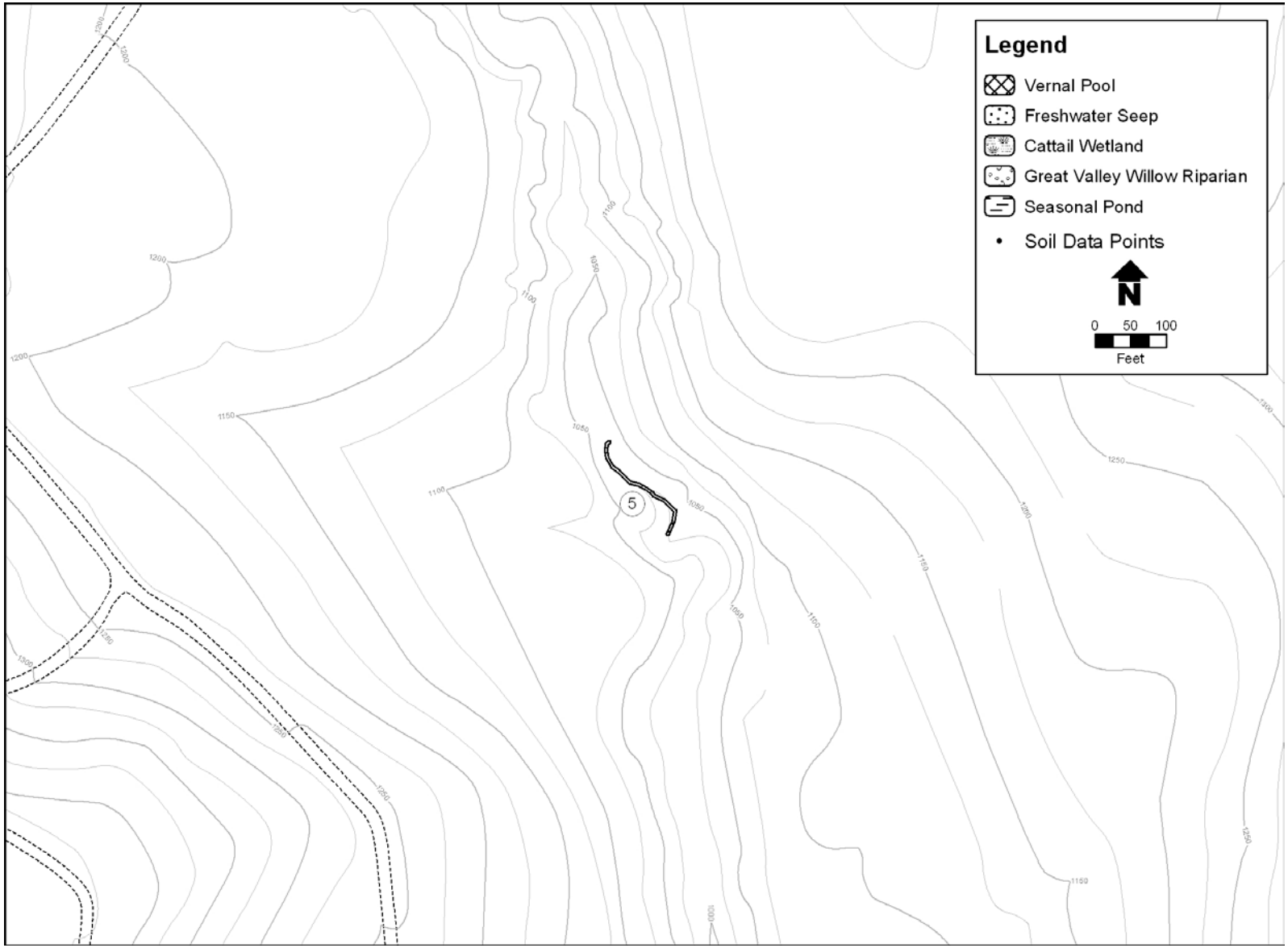
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–30.—*Wetland Delineation (Wetlands 44 and 45)*



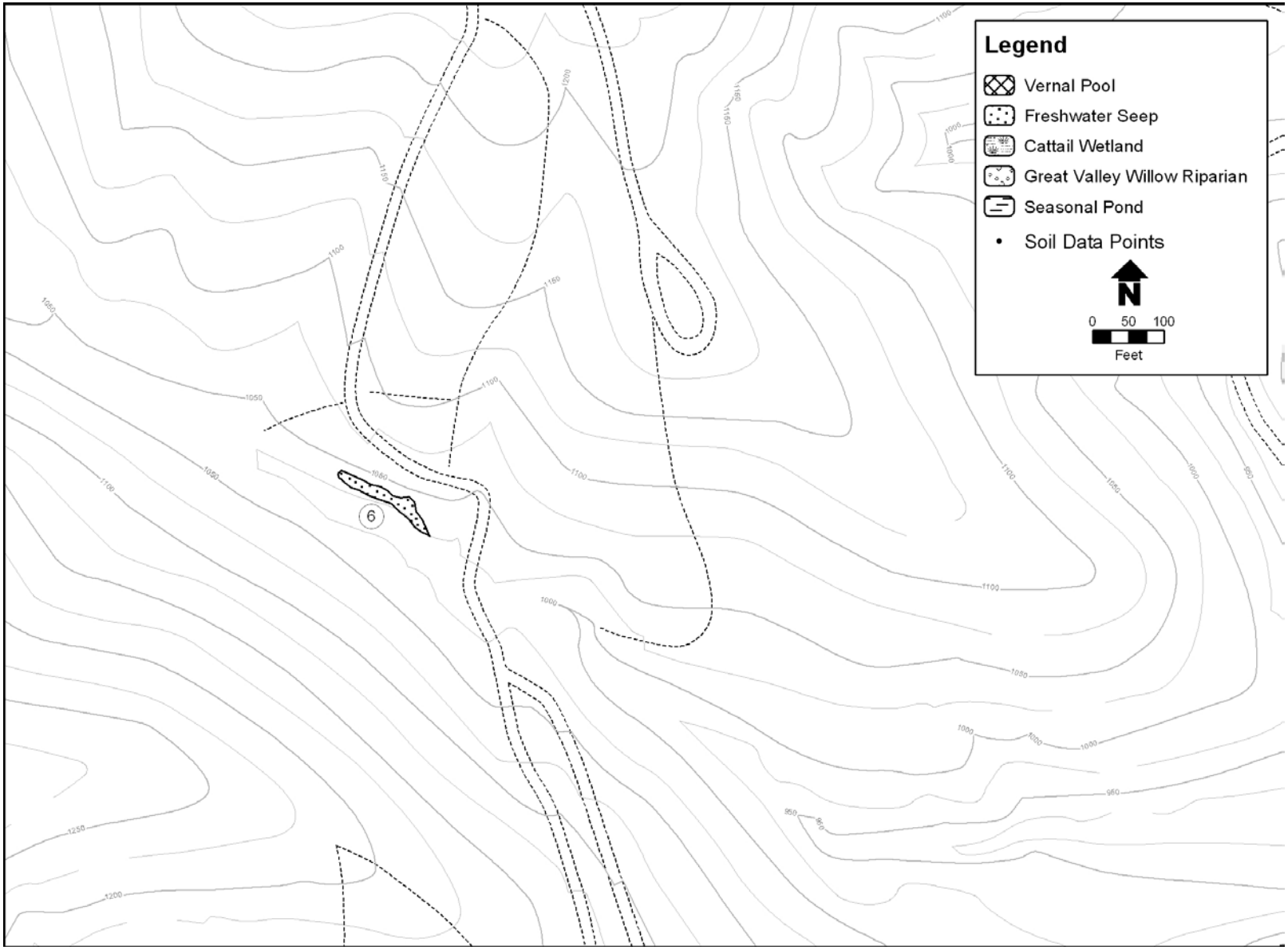
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–31.—*Wetland Delineation (Wetland 46)*



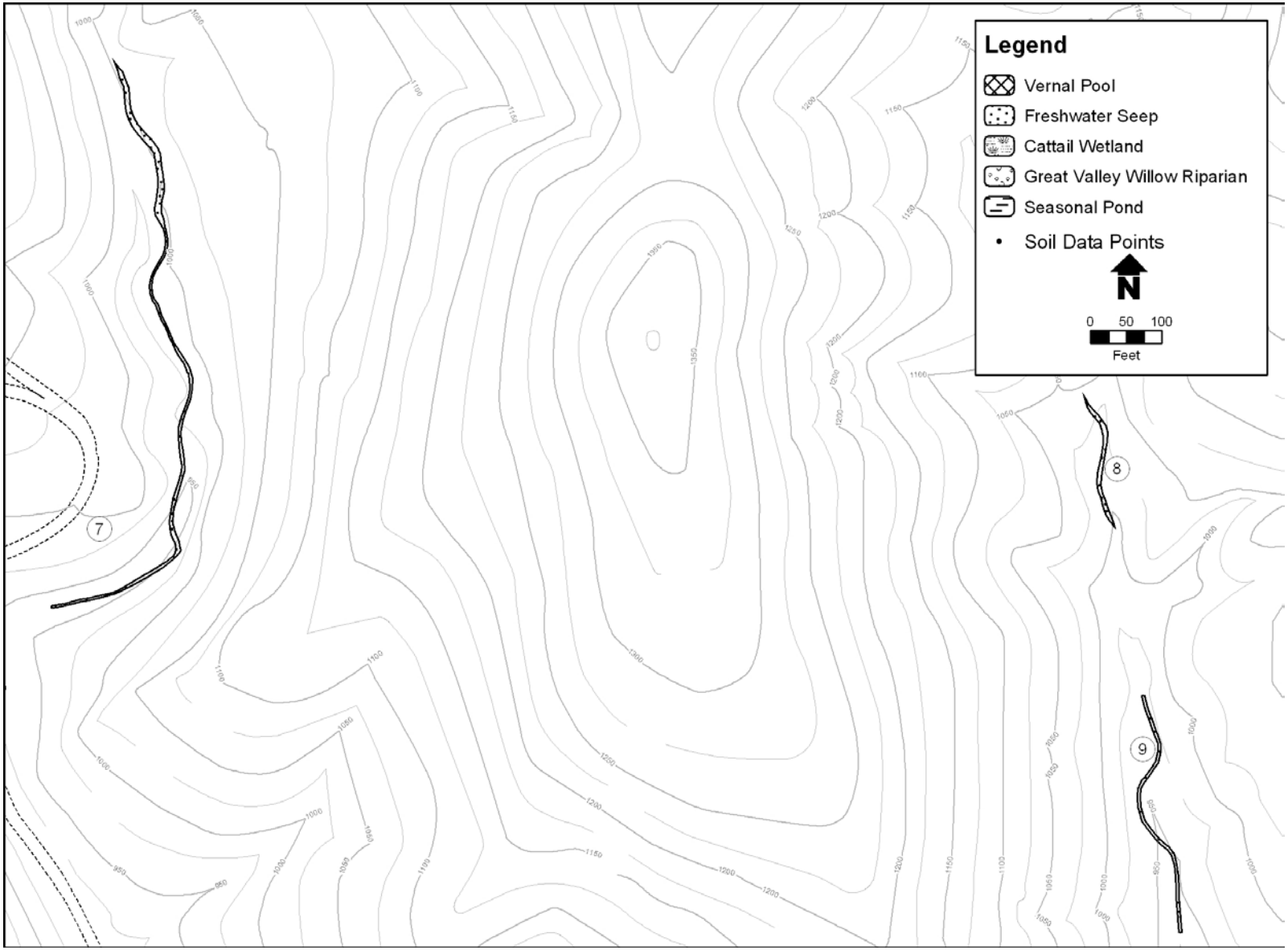
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–4.—*Wetland Delineation (Wetland 5)*



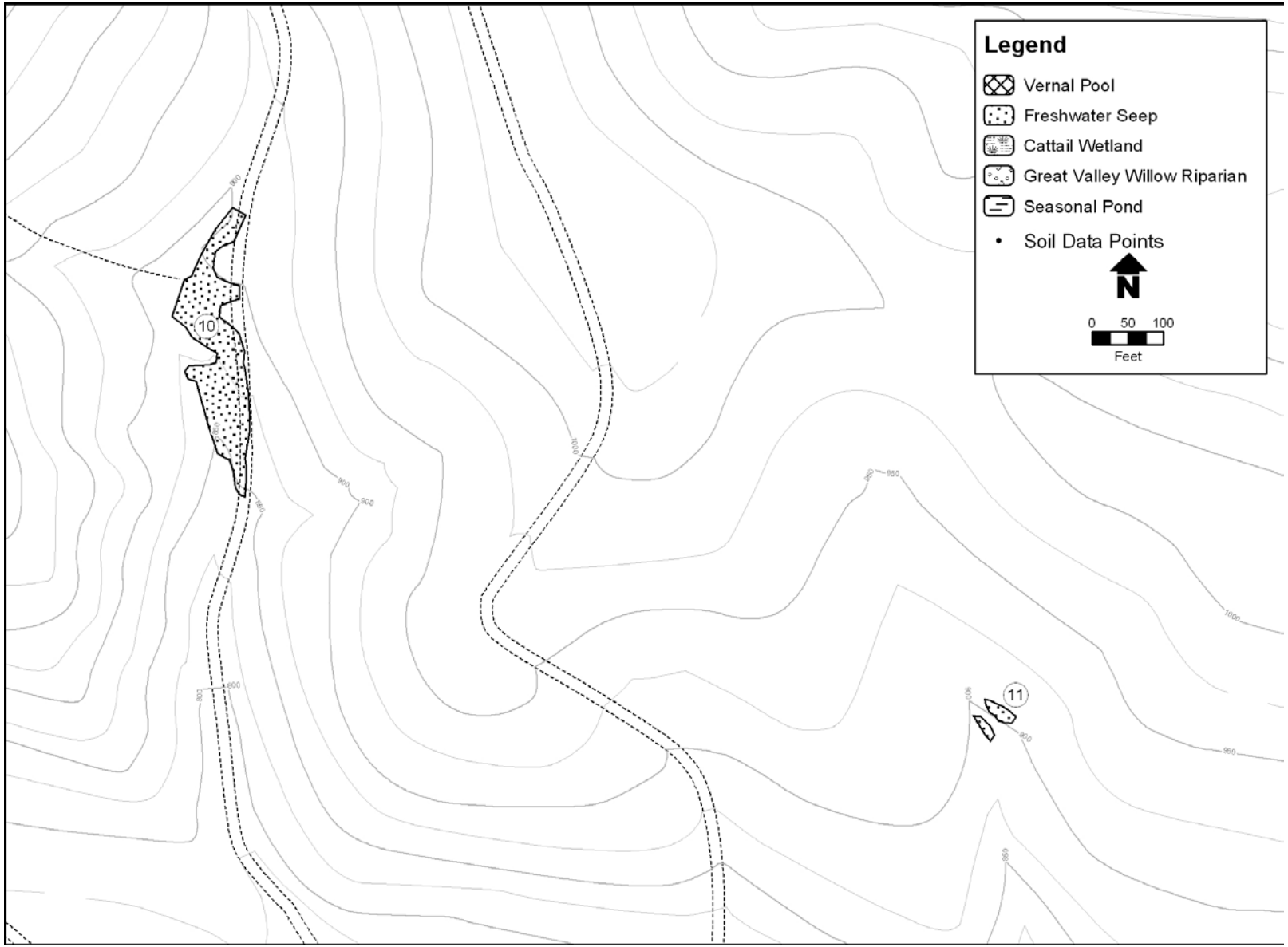
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–5.—*Wetland Delineation (Wetland 6)*



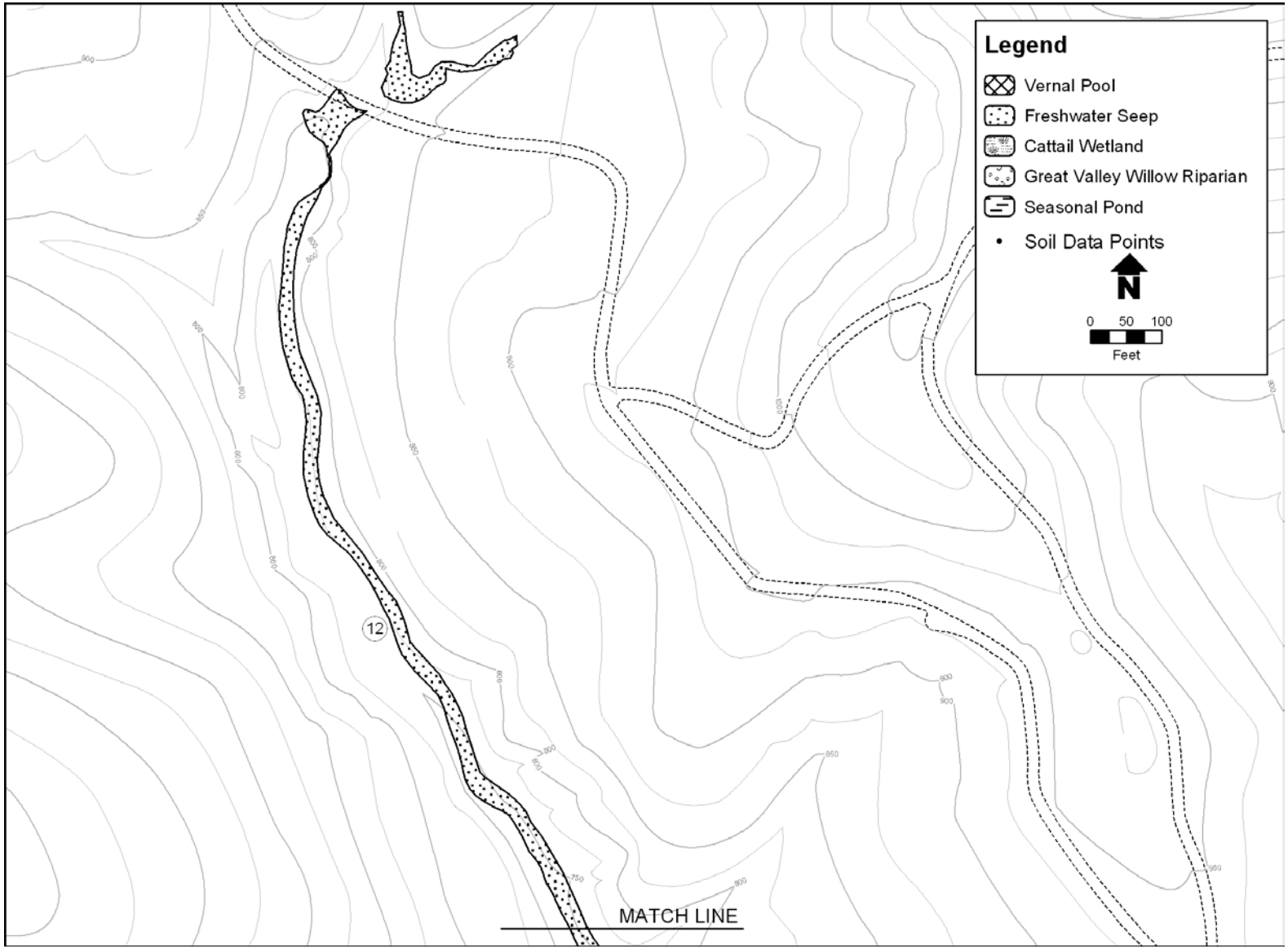
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–6.—*Wetland Delineation (Wetlands 7, 8, and 9)*



Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–7.—*Wetland Delineation (Wetlands 10 and 11)*



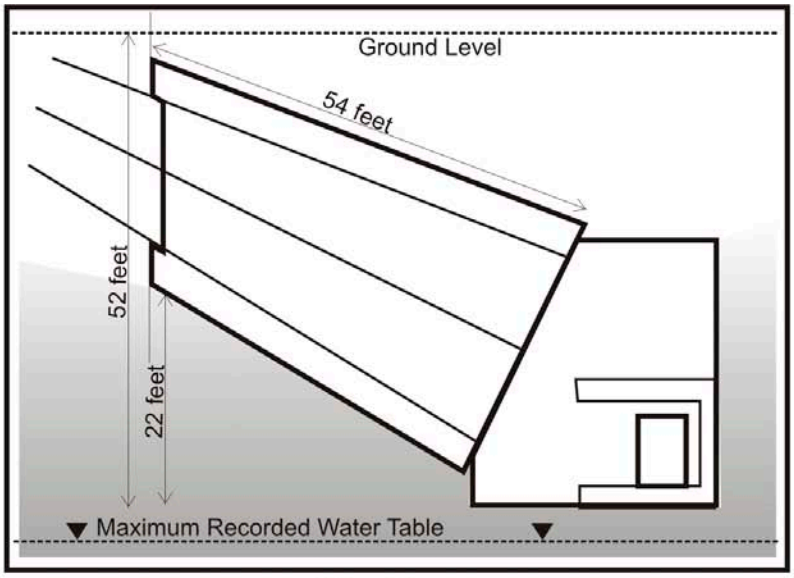
Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–8.—*Wetland Delineation (Wetland 12)*

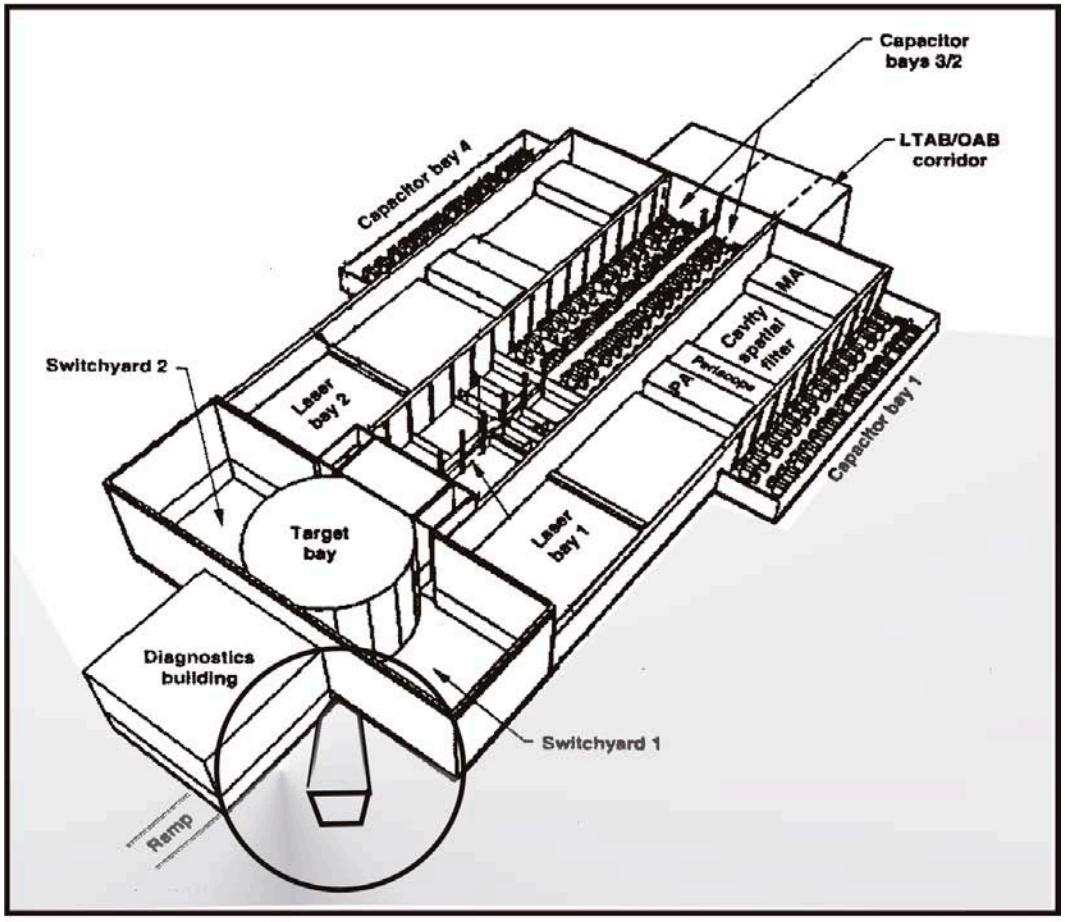


Source: Jones and Stokes 2002c.

FIGURE F.3.2.2–9.—*Wetland Delineation (Wetland 12) (continued)*



Side View



Aerial View

Source: Original.

FIGURE M.3.2.4–1.—*Location of the Neutron Spectrometer at the National Ignition Facility and Cross Section of the Neutron Spectrometer*

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Avena barbata	87.62	36.66	2.17	124.28
Bromus hordeaceus	73.85	7.27	0.72	81.12
Bromus diandrus	62.84	11.73	1.25	74.57
Erodium cicutarium	65.60	3.62	0.58	69.21
Bromus madritensis rubens	61.47	6.17	0.68	67.64
Vulpia myuros	55.96	5.66	0.68	61.62
Poa secunda	38.53	7.98	1.33	46.52
Trifolium willdenovii	43.12	2.44	0.44	45.56
Orthocarpus exerta	39.91	0.89	0.39	40.80
Lotus wrangellianus	38.07	0.87	0.18	38.94
Amsinckia intermedia	36.70	1.26	0.26	37.95
Gutierrezia bracteata	27.52	1.43	0.31	28.95
Brassica geniculata	27.52	0.93	0.23	28.45
Sanicula bipinnata	26.61	0.23	0.07	26.83
Grindelia camporum	25.69	1.04	0.27	26.73
Vulpia microstachys	23.85	1.71	0.31	25.56
Trifolium gracilentum	22.94	1.33	0.37	24.26
Triteleia laxa	22.02	0.57	0.17	22.58
Herniaria cinerea	20.64	0.35	0.13	20.99
Lupinus bicolor	19.73	0.41	0.17	20.14
Artemisia californica	17.89	1.69	0.38	19.58
Astragalus didymocarpus	18.81	0.69	0.22	19.49
Holocarpha obconica	18.81	0.59	0.37	19.40
Clarkia purpurea	18.81	0.12	0.03	18.93
Achillea millefolium	16.97	0.47	0.12	17.44
Amsinckia testillata	15.14	0.13	0.04	15.27
Galium aparine	14.68	0.26	0.07	14.94
Elymus triticoides	9.63	3.25	0.96	12.88
Eriogonum fasciculatum	11.93	0.88	0.25	12.80
AIlium serra	12.39	0.08	0.03	12.46
Matricaria matricarioides	11.93	0.35	0.19	12.28
Marah fabaceus	11.47	0.10	0.03	11.56

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey (continued)*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Crassula connata	11.47	0.09	0.05	11.55
Nassella pulchra	10.55	0.70	0.23	11.25
Stellaria nitens	11.01	0.09	0.05	11.10
Delphinum hesperium	10.55	0.10	0.04	10.65
Dichelostemma capitata	10.58	0.03	0.01	10.57
Deinandra kelloggii	10.09	0.47	0.30	10.56
Claytonia perfoliata	10.09	0.32	0.13	10.41
Carduus pychnocephalus	10.09	0.23	0.12	10.33
Lupinus succulentus	10.09	0.17	0.05	10.27
Sonchus oleraceus	10.09	0.04	0.02	10.13
Senecio vulgaris	10.09	0.01	0.00	10.11
Eschscholzia californica	9.63	0.23	0.11	9.86
Collinsia heterophylla	9.17	0.26	0.12	9.43
Eriogonum nudum	9.17	0.21	0.08	9.38
Lupinus microcarpus densiflorus lacteus	9.17	0.14	0.04	9.31
Chlorogalum pomeridianum	8.72	0.15	0.06	8.86
Sonchus aspera	8.72	0.03	0.02	8.75
Pterostegia drymerioides	8.72	0.04	0.02	8.75
Guillenia lasiophyllus	8.72	0.03	0.01	8.75
Croton setigerus	8.72	0.03	0.01	8.74
Lasthenia californica	8.26	0.28	0.16	8.53
Eriogonum angulosum	7.80	0.11	0.05	7.91
Delphinium gypsophilum	7.34	0.32	0.17	7.65
Gilia tricolor	7.34	0.10	0.05	7.44
Juniperus californicus	6.88	0.47	0.28	7.35
Polypogon interruptus	6.42	0.70	0.36	7.13
Monolophia major	6.88	0.24	0.13	7.12
Erodium botrys	6.88	0.10	0.05	6.98
Silene antirrhinam	6.88	0.10	0.04	6.98
Brassfca nigra	6.88	0.08	0.05	6.96
Bromus madritensis	6.42	0.42	0.16	6.84
Melica California nevadensis	6.42	0.29	0.13	6.71
Centaurea melatensis	6.42	0.22	0.13	6.64

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey (continued)*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Trifolium oliganthum	6.42	0.13	0.05	6.55
Stylocfine gnaphalioides	6.42	0.07	0.03	6.49
Typha latifolia	5.05	1.26	0.48	6.30
Microseris lindleyi	5.96	0.01	0.01	5.98
Elymus elymoides	5.51	0.34	0.14	5.84
Salvia mellifera	5.05	0.68	0.26	5.72
Mimulus guttatus	5.51	0.20	0.12	5.70
Microseris douglasii	5.51	0.15	0.08	5.66
Linanthus bicolor	5.51	0.16	0.09	5.66
Claytonia parviflora	5.51	0.05	0.03	5.56
Quercus douglasii	5.05	0.50	0.20	5.55
Logfia gallica	5.51	0.04	0.02	5.55
Calochortus invenustus	5.51	0.02	0.01	5.52
Hordeum murinum leporinum	5.05	0.12	0.06	5.16
Amsinckia menziesii	5.05	0.03	0.02	5.08
Delphinium patens	5.05	0.03	0.02	5.08
Stylocline filaginea	5.05	0.03	0.01	5.07
Microsteris gracilis	5.05	0.02	0.01	5.07
Achyrachoena mollis	4.59	0.22	0.21	4.81
Silene gaffica	4.59	0.08	0.05	4.67
Schismus arabicus	4.59	0.07	0.03	4.65

Source: BioSystems 1986a.

The proportion and relative importance of native versus introduced species in the vegetation on Site 300 are similar to patterns documented in other cismontane annual grassland communities, where a handful of introduced species dominate and native species are less common (Heady 1958, Pitt 1975, Talbot et al. 1939).

Poa secunda (scabrella) was the most important native grass identified, occurring on nearly 39 percent of all relevés with an average cover of about 8 percent. Other important native species included the annual herbs *Trifolium tridentatum, Orthocarpus purpurascens, Lotus subpinnatus,* and *Amsinckia intermedia* (BioSystems 1986b).

TABLE E.1.2.2–1.—*Amphibians and Reptile Species Observed at the Livermore Site and Site 300 in 1986, 1991, and 2001 Surveys*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Ambystoma californiense	California tiger salamander	X	
Batrachoseps attenuatus	California slender salamander	X	
Bufo boreas	Western toad	X	X
Hyla regilla	Pacific treefrog	X	X
Rana aurora draytonii	California red-legged frog	X	X
Rana catesbeiana	Bullfrog		X
Sceloporus occidentalis	Western fence lizard	X	X
Sceloporus graciosus	Sagebrush lizard	X	
Uta stansburiana	Side-blotched lizard	X	
Phrynosoma coronatum frontale	California horned lizard	X	
Eumeces skiltonianus	Western skink	X	
Eumeces gilberti	Gilbert's skink	X	
Cnemidophorus tigris	Western whiptail	X	
Gerrhonotus coeruleus	Northern alligator lizard	X	
Coluber constrictor	Racer	X	
Coluber constrictor mormon	Western yellow-bellied racer		X
Masticophis lateralis euryxanthus	Alameda whipsnake	X	
Masticophis lateralis lateralis	Chaparral whipsnake	X	
Masticophis flagellum ruddocki	San Joaquin whipsnake	X	
Anniella pulchra pulchra	Silvery legless lizard	X	
Tantilla planiceps	California black-headed snake	X	
Pituophis melanoleucus	Gopher snake	X	X
Lampropeltis getulus	Common king snake	X	
Thamnophis sirtalis	Common garter snake	X	
Arizona elegans	Glossy snake	X	
Rhinocheilus lecontei	Long-nosed snake	X	
Crotalus viridis	Western rattlesnake	X	

Sources: BioSystems 1986c, LLNL 1992a, LLNL 2003ab, LLNL 2003bz, Swaim 2002a.

TABLE E.1.2.2–2.—*Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Bucephala clangula	Common goldeneye	X	X
Bucephala albeola[a]	Bufflehead	X	X
Branta Canadensis	Canada goose		X
Anas platyrhynchos	Mallard	X	X
Anas clypeata[a]	Northern shoveller	X	
Anas cuamptera[a]	Cinnamon teal	X	
Aythya collatis	Ring-necked duck		X
Sterna forsteri	Forster's tern		X
Rallus limicola[b]	Virginia rail	X	
Ardea herodias[b]	Great blue heron		X
Ardea alba [a]	Great egret	X	X
Egretta thula	Snowy egret		X
Butorides striatus[b]	Green-backed heron	X	X[b]
Nycticorax nycticorax	Black-crowned night-heron	X	X[b]
Phalacrocorax auritus[a]	Double-crested cormorant	X	X
Podilymbus podiceps[a]	Pied-billed grebe	X	X
Gallinago gallinago[a]	Common snipe	X	X
Tringa meanoleuca[a]	Greater yellowlegs	X	X
Cathartes aura	Turkey vulture	X	X
Elanus leucurus[a]	White-tailed kite	X	X
Circus cyaneus	Northern harrier	X	
Buteo jamaicensis	Red-tailed hawk	X	X
Buteo lagopus[a]	Rough-legged hawk	X	
Buteo lineatus[a]	Red-shouldered hawk	X	X
Buteo regalis	Ferruginous hawk	X	
Buteo swainsoni	Swainson's hawk	X	
Accipiter cooperii	Cooper's hawk	X	X
Accipiter striatus	Sharp-shinned hawk	X	X
Aquila chrysaetos	Golden eagle	X	X
Pandion minimus	Osprey	X	X
Fulica American	Coot		X

TABLE E.1.2.2–2.—*Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Falco sparverius	American kestrel	X	X
Falco mexicanus	Prairie falcon	X	
Callipepla californica	California quail	X	
Charadrius vociferous	Killdeer	X	X
Columba livia	Rock dove	X	X
Zenaida macroura	Mourning dove	X	X
Geococcyx californianus	Greater roadrunner	X	
Tyto alba	Barn owl	X	X
Bubo virginianus	Great horned owl	X	
Athene cunicularia[c]	Burrowing owl	X	X
Asio flammeus	Short-eared owl	X	
Otus kennicottii[a]	Western screech owl	X	
Chordeiles minor	Common nighthawk	X	
Aeronautes saxatalis	White-throated swift	X	X
Calypte anna	Anna's hummingbird	X	X
Calypte costae	Costa’s hummingbird	X	
Selasphorus rufus	Rufous hummingbird	X	
Selasphorus sasin	Allen's hummingbird	X	
Melanerpes formicivorus	Acorn woodpecker	X	X
Colaptes auratus	Northern flicker	X	X
Picoides nuttallii	Nutall’s woodpecker	X	X
Tyrannus verticalis	Western kingbird	X	X
Tyrannus vociferans[a]	Cassin’s kingbird	X	
Myiarchus cinerascens	Ash-throated flycatcher	X	
Contopus sordidulus	Western wood-pewee	X	X
Empidonax difficilis	Pacific-slope flycatcher	X	
Empidonax traillii[d]	Willow flycatcher	X	
Sayornis nigricans	Black phoebe	X	X
Sayornis saya	Say's phoebe	X	X
Eremophila alpestris	Horned lark	X	
Petrochelidon (Hirundo) pyrrhonota	Cliff swallow	X	X

TABLE E.1.2.2–2.—*Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Hirundo rustica[b]	Barn swallow	X	X
Stelgidopterxyx serripennis[a]	Northern rough winged swallow	X	X
Tachycineta bicolor[a]	Tree swallow	X	
Aphelocoma coerulescens	Western scrub jay	X	X
Corvus brachyrhynchos	American crow	X	X
Corvus corax	Common raven	X	X
Parus inornatus	Plain titmouse	X	X
Parus rufescens	Chestnut-backed chickadee		X
Sitta carolensis	White-breasted nuthatch		X
Salpinctes obsoletus	Rock wren	X	
Thyothorus ludovicianus[a]	Bewick's wren	X	X
Thyothorus aedon[a]	House wren	X	
Turdus migratorius	American robin	X[b]	X
Catharus guttatus	Hermit thrush	X	
Catharus ustulatus[a]	Swainson's thrush	X	
Ixoreus naevius[a]	Varied thrush	X	
Sialia currucoides[a]	Mountain bluebird	X	
Sialia mexicana[a]	Western bluebird	X	
Mimus polyglottos	Northern mockingbird	X	X
Toxostoma redivivum	California thrasher	X	
Anthus rubescens	American pipit	X	
Himantopus mexicanus	Black-necked stilt		X
Lanius ludovicianus	Loggerhead shrike	X	X
Sturnus vulgaris	European starling	X	X
Vireo huttoni	Hutton's vireo	X	
Dendroica petechia	Yellow warbler	X	
Dendroica coronata	Yellow-rumped warbler	X	X
Dendroica nigrescens[a]	Black-throated gray warbler	X	
Geothlypis trichas[a]	Common yellowthroat	X	
Oporornis tolmiei	MacGillivray's warbler	X	

TABLE E.1.2.2–2.—*Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Vermivora bachmanii	Orange-crowned warbler	X	
Wilsonia pusilla	Wilson's warbler	X	
Piranga ludoviciana	Western tanager	X	
Guiraca caerulea[a]	Blue-grosbeak	X	
Passerina amoena	Lazuli bunting	X	
Pheucticus melanocephalus	Black-headed grosbeak	X	
Pipilo crissalis	California towhee	X	
Amphispiza belli[a]	Bell's sage sparrow	X	
Amphispiza bilineata[a]	Black-throated sparrow	X	
Aimophila ruficeps	Rufous-crowned sparrow	X	
Pooecetes grammineus	Vesper sparrow	X	
Chondestes grammacus	Lark sparrow	X	
Passerculus sandwichensis	Savannah sparrow	X	
Passerella iliaca	Fox sparrow	X	
Ammodramus savannarum[a]	Grasshopper sparrow	X	
Junco hyemalis[a]	Oregon junco	X	X
Melospiza lincolnii	Lincoln's sparrow	X	
Melospiza melodia	Song sparrow	X	X
Zonotrichia atricapilla	Golden-crowned sparrow	X	X
Zonotrichia leucophrys	White-crowned sparrow	X	X
Agelaius phoeniceus	Red-winged blackbird	X	X
Agelaius tricolor	Tricolored blackbird	X	
Sturnella magna (neglecta)	Western meadowlark	X	X
Euphagus cyanocephalus	Brewer's blackbird	X	X
Molothrus ater	Brown-headed cowbird	X[b]	X
Icterus bullockii	Bullock's oriole	X	
Icterus galbula[b]	Northern oriole	X	X
Carpodacus mexicanus	House finch	X	X
Carpodacus psaltia	Lesser goldfinch	X	
Carduelis tristis	American goldfinch	X	X

TABLE E.1.2.2–2.—*Bird Species Observed at the Livermore Site and Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**Livermore Site**
Passer domesticus[b]	House sparrow	X	X
Psaltriparus minimus[a]	Bushtit	X	X
Bombycilla garrulus[a]	Cedar waxwing	X	X
Phalaenoptilus nuttallii[a]	Common poorwill	X	
Baeolphus inornatus[a]	Oak titmouse	X	
Meleagris gallopavo[a]	Wild turkey	X	
Phainopepla nitens	Phainopepla	X	
Ceryle alcyon	Belted kingfisher		X
Regulus calendula	Ruby-crowned kinglet	X	X

Sources: BioSystems 1986a; LLNL 2003by, LLNL 2003bz.
[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 (LLNL 2003ai).
[d] The willow flycatcher was observed at Site 300 in 2003 (LLNL 2003cc).

Oak woodlands and a few cottonwoods provide nesting habitat for the western kingbird (*Tyrannus verticalis*), northern oriole (*Icterus galbula*), loggerhead shrike (*Lanius ludovicianus*), and American goldfinch (*Carduelis tristis*). Coastal sage scrub supports the scrub jay (*Aphelocoma coerulescens*), California thrasher (*Toxostoma redivivum*), Bell's sage sparrow (*Amphispiza belli*), Anna's hummingbird (*Calypte anna*), rufous-crowned sparrow (*Aimophila ruficeps*), and white-crowned sparrow (*Zonotrichia leucophrys*). Ecotones of sage scrub and grassland provide ideal habitat for the mourning dove, California quail, lazuli bunting (*Passerino amoena*), and lark sparrow (*Chondestes grammacus*). Rocky outcrops and cliffs provide breeding sites for white-throated swift (*Aeronautes saxatalis*), cliff swallow, Say's phoebe (*Sayornis saya*), and rock wren (*Salpinctes obsoletus*).

Site 300 also supports a population of nesting raptors. A breeding raptor survey, conducted at Site 300 in April and July 2002, identified four species of diurnal raptors and four species of owls. The raptors included the turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), and American kestrel (*Falco sparverius*), the most frequently observed raptor on Site 300. Owls observed included the barn owl (*Tyto alba*), western screech owl (*Otus kennicottii*), great horned owl (*Bubo virginianus*), and western burrowing owl (*Athene cunicularia*). The survey detected the presence of four active red-tailed hawk, four great horned owl, and three burrowing owl nests, although LLNL biologists have observed as many as 18 nesting pairs of burrowing owls in previous years. One inactive barn owl nest was found on the exterior of the Advanced Test Accelerator (ATA) Building. Also, numerous recently fledged American kestrels and one young western screech owl were observed. Blue oaks and conglomerate cliffs were the most frequently used nest structures. The numbers of breeding pairs and diversity of these birds of prey were relatively low compared to those identified on other large land units in the State of California. A pair of turkey vultures was

TABLE E.1.2.2–5.—*Small Mammal Trapping Results at Site 300 in 2002*

	Vegetative Community and Trapping Period									
	Nonwetland								Seep/Spring Wetland	
	Annual Grassland		Native Grassland		Oak Savannah	Riparian	Coastal Scrub	Grid 1 & Trapline 1	Seep Channel Trapline	Seep Channel Trapline
Species	**6/20-6/22**	**4/17-4/19**	**Post-burn 16/20-6/22**	**Post-burn 27/30-8/1**	**6/20-6/22**	**5/14-5/16**	**5/14-5/16**	**5/17-5/19**	**Post-burn 16/20-6/22**	**Post-burn 27/30-8/1**
Valley pocket gopher		1				1				
California pocket mouse							1			
San Joaquin pocket mouse	2				3					
Heerman's kangaroo rat	4						22			
Western harvest mouse	13					7			4	6
Deer mouse	8	1	4	4	1	7	10	3	3	7
Brush mouse		2				32	10	11		
California vole	1			2		4				
Dusky-footed woodrat						13	20	3		1
House mouse						1				
No. species captured	5	3	1	2	2	7	5	3	2	3
Total captures	28	4	4	6	4	65	63	17	7	14
No. trap-nights	300	300	4	300	300	300	300	300	39	150
Captures/100 trap-nights	9.33	1.33	1.33	2.00	1.33	21.67	21.00	5.67	4.67	9.33

Source: Jones and Stokes 2002b.

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species Known to Occur at the Livermore Site and Site 300 in 2001 and 2002*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Plants			
Big tarplant	*Blepharizonia plumosa*	-	X	-	CNPS List 1 B
Hogwallow starfish	*Hesperevax caulescens*	-	X	-	CNPS List 4
Large-flowered fiddleneck	*Amsinckia grandiflora*	-	X	FE (CH)	CNPS List 1 B
Round-leaved filaree	*Erodium macrophyllum*	-	X	-	CNPS List 2
Stinkbells	*Fritillaria agrestis*	-	X	-	CNPS List 4
Diamond-petaled poppy	*Eschscholzia rhombipetala*	-	X	FSC	CNPS List 1 B
Gypsum rock jasmine	*Androsace elongata* ssp. *acuta*	-	X	-	CNPS List 4
Gypsum loving larkspur	*Delphinium gypsophilum* ssp. *gypsophilum*	-	X	-	CNPS List 4
		Invertebrates			
Valley elderberry longhorn beetle	Desmocerus californicus Dimorphus	-	X	FT	-
California linderiella fairy shrimp	Linderiella occidentalis	-	X	FSC	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species Known to Occur at the Livermore Site and Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Amphibians			
California tiger salamander	*Ambystoma californiense*	-	X	FPT	CASSC
California red-legged frog	*Rana aurora draytonii*	X	X	FT (CH rescinded)	CASSC
Western spadefoot toad	*Spea hammondii*	-	X	FSC	CASSC
		Reptiles			
Alameda whipsnake	*Masticophis lateralis euryxanthus*	-	X	FT (CH rescinded)	FT
California horned lizard	*Phrynosoma cornatum frontale*	-	X	-	CASSC
San Joaquin coachwhip (whipsnake)	*Masticophis flagellum ruddocki*	-	X	FSC	CASSC
Silvery legless lizard	*Anniella pulchra pulchra*	-	X	FSC	CASSC
		Birds			
Cooper's hawk	*Accipiter cooperii*	X	X	MBTA	CASSC
Sharp-shinned hawk	*Accipiter striatus*	-	X	MBTA	CASSC
Golden eagle	*Aquila chrysaetos*	X	X	MBTA	CASSC
Red-tailed hawk	*Buteo jamaicensis*	X	X	MBTA	-
Rough-legged hawk	*Buteo lagopus*	-	X	MBTA	-
Red-shouldered hawk	*Buteo lineatus*	X	X	MBTA	-
Ferruginous hawk	*Buteo regalis*	-	X	FSC, MBTA	CASSC
Swainson's hawk	*Buteo swainsoni*	-	X	MBTA	ST, MBTA
Northern harrier	*Circus cyaneus*	-	X	MBTA	CASSC
White-tailed kite	*Elanus leucurus*	X	X	MBTA	CASSC
Osprey	*Pandion haliaetus*	-	X	MBTA	CASSC

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at the Livermore Site and Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Bushtit	*Psaltriparus minimus*	-	X	MBTA	-
Horned lark	*Eremophila alpestris*	-	X	MBTA	CASSC
Northern shoveler	*Anas clypeata*	-	X	MBTA	-
Cinnamon teal	*Anas cuamptera*	-	X	MBTA	-
Mallard	*Anas platyryynchos*	X	X	MBTA	-
Bufflehead	*Blucephala albeola*	X	X	MBTA	-
Common goldeneye	*Bucephala clangula*	-	X	MBTA	-
White-throated swift	*Aeronautes saxatalis*	-	X	MBTA	-
Great egret	*Ardea alba*	X	X	MBTA	-
Cedar waxwing	*Bombycilla garrulus*	X	X	MBTA	-
Common poorwill	*Phalaenoptilus nuttallii*	-	X	MBTA	-
Blue-grosbeak	*Guiraca caerulea*	-	X	MBTA	-
Lazuli bunting	*Passerina amoena*	-	X	MBTA	-
Turkey vulture	*Cathartes aura*	X	X	MBTA	-
Killdeer	*Charadrius vociferus*	X	X	MBTA	-
Mourning dove	*Zenaida macroura*	X	X	MBTA	-
Western scrub jay	*Aphelocoma californica*	X	X	MBTA	-
American crow	*Corvus brachyrhynchos*	X	X	MBTA	-
Common raven	*Corvus corax*	X	X	MBTA	-
Greater roadrunner	*Geococcyx californianus*	-	X	MBTA	-
Bell's sage sparrow	*Amphispiza belli*	-	X	FSC, MBTA	-
Black-throated sparrow	*Amphispiza bilineata*	-	X	MBTA	-
Rufous crowned sparrow	*Aimophila ruficeps*	-	X	MBTA	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at the Livermore Site and Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Grasshopper sparrow	*Ammodramus savannarum*	-	X	FSC, MBTA	-
Lark sparrow	*Chondestes grammacus*	-	X	MBTA	-
California towhee	*Carpodacus mexicanus*	-	X	MBTA	-
Oregon junco	*Junco hyemalis*	X	X	MBTA	-
Lincoln's sparrow	*Melospiza lincolnii*	-	X	MBTA	-
Song sparrow	*Melospiza melodia*	X	X	MBTA	-
Fox sparrow	*Passerella iliaca*	-	X	MBTA	-
Savannah sparrow	*Passerculus sandwichensis*	-	X	MBTA	-
Golden-crowned sparrow	*Zonotrichia atricapilla*	X	X	MBTA	-
White-crowned sparrow	*Zonotrichia leucophrys*	X	X	MBTA	-
American kestrel	*Falco columbarius*	X	X	MBTA	-
Prairie falcon	*Falca mexicanus*	-	X	MBTA	CASSC
House finch	*Carpodacus mexicanus*	X	X	MBTA	-
Lesser goldfinch	*Carduelis psaltria*	X	X	MBTA	-
Cliff swallow	*Petrochelidon pyrrhonota*	X	X	MBTA	-
Northern rough winged swallow	*Stelgidopteryx serripennis*	X	X	MBTA	-
Tree swallow	*Tachycineta bicolor*	-	X	MBTA	-
Red-winged blackbird	*Agelaius phoeniceus*	X	X	MBTA	-
Tricolored blackbird	*Agelaius tricolor*	-	X	FSC, MBTA	CASSC
Brewer's blackbird	*Euphagus cyanocephalus*	X	X	MBTA	-
Bullock's oriole	*Icterus bullockii*	-	X	MBTA	-
Brown-headed cowbird	*Molothrus ater*	X	X	MBTA	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at the Livermore Site and Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Western meadowlark	*Sturnella magna*	X	X	MBTA	-
Loggerhead shrike	*Lanius ludovicianus*	X	X	FSC, MBTA	CASSC
Northern mockingbird	*Mimus polyglottos*	-	X	MBTA	-
California thrasher	*Toxostoma redivivum*	-	X	FSC, MBTA	-
California quail	*Callipepla californica*	-	X	MBTA	-
Oak titmouse	*Baeolphus inornatuss*	-	X	FSC, MBTA	-
Yellow-rumped warbler	*Dendroica coronata*	X	X	MBTA	-
Black-throated gray warbler	*Dendroica nigrescens*	-	X	MBTA	-
Yellow warbler	*Dendroica petechia*	-	X	MBTA	CASSC
Common yellowthroat	*Geothlypis trichas*	-	X	MBTA	CASSC
MacGillivary's warbler	*Oporornis tolmiei*	-	X	MBTA	-
Orange-crowned warbler	*Vermivora bachmanii*	-	X	MBTA	-
Wilson's warbler	*Wilsonia pusila*	-	X	MBTA	-
Double-crested cormorant	*Phalacrocorax auritus*	-	X	MBTA	CASSC
Northern flicker	*Colaptes auratus*	-	X	MBTA	-
Nuttall's woodpecker	*Picoides nuttallii*	X	X	FSC, MBTA	-
Pied-billed grebe	*Podilymbus podiceps*	X	X	MBTA	-
Phainopepla	*Phainopepla nitens*	-	X	MBTA	-
Ruby-crowned kinglet	*Regulus calendula*	X	X	MBTA	-
Common snipe	*Gallinago gallinago*	X	X	MBTA	-
Greater yellowlegs	*Tringa melanoleuca*	X	X	MBTA	-
Burrowing owl	*Athene cunicularia*	X[a]	X	FSC, MBTA	CASSC
Short-eared owl	*Asio flammeus*	-	X	FSC, MBTA	CASSC

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at the Livermore Site and Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Great horned owl	*Bubo virginianus*	-	X	MBTA	-
Western screech owl	*Otus kennicottii*	-	X	MBTA	-
Barn owl	*Tyto alba*	-	X	MBTA	-
Western tanager	*Piranga ludoviciana*	-	X	MBTA	-
Anna's hummingbird	*Calypte anna*	X	X	MBTA	-
Costa's hummingbird	*Calypte costae*	-	X	FSC, MBTA	-
Rufous hummingbird	*Selasphorus rufus*	X	X	FSC, MBTA	-
Rock wren	*Salpinctes obsoletus*	-	X	MBTA	-
Bewick's wren	*Thyothorus ludovicianus*	X	X	MBTA	-
House wren	*Troglodytes aedon*	-	X	MBTA	-
Hermit thrush	*Catharus guttatus*	-	X	MBTA	-
Swainson's thrush	*Catharus ustulatus*	-	X	MBTA	-
Varied thrush	*Ixoreus naevius*	-	X	MBTA	-
Mountain bluebird	*Sialia currucoides*	-	X	MBTA	-
Western bluebird	*Sialia mexicana*	-	X	MBTA	-
American robin	*Turdus migratorius*	X	X	MBTA	-
Pacific-slope flycatcher	*Empidonax difficillis*	-	X	MBTA	-
Willow flycatcher	*Empidonax traillii*	-	X	MBTA	SE
Ash-throated flycatcher	*Myiarchus cinerascens*	-	X	MBTA	-
Black phoebe	*Sayornis nigricans*	-	X	MBTA	-
Say's phoebe	*Sayornis saya*	X	X	MBTA	-
Western kingbird	*Tyrannus verticalis*	-	X	MBTA	-
Cassin's kingbird	*Tyrannus vociferans*	-	X	MBTA	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at the Livermore Site and Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**Livermore Site**	**Site 300**	**Federal Status Code**	**State Status Code**
		Mammals			
Pallid bat	*Antrozous pallidus*	-	X		CASSC
Long-legged myotis	*Myotis volans*	-	X	FSC	-
Yuma myotis	*Myotis yumaensis*	-	X	FSC	-
San Joaquin pocket mouse	*Perognathus inornatus inornatus*	-	X	FSC	-
San Joaquin kit fox [b]	*Vulpes macrotis mutica*	-	X	FE	ST

Sources: Jones and Stokes 2001, CDFG 2002a, CDFG 2002b, LLNL 2003ab, LLNL 2003by, LLNL 2003ac.
[a] The burrowing owl was observed at the Livermore Site prior to 1998.
[b]Although the San Joaquin kit fox has not been observed in surveys from 1986 to the present, monitoring efforts continue to watch for the presence of this species onsite, due to confirmed sighting near Site 300.
X = Indicates the presence of a species at the Livermore Site or Site 300.
- = Indicates the absence of a species at the Livermore Site or Site 300.
FE = Federal-listed endangered (any species which is in danger of extinction throughout all or a significant portion of its range).
FT = Federal-listed threatened (any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range).
FPT = Federal-listed proposed threatened (a proposal to list a species as likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range pending release of a final rule).
CH = Critical habitat (the USFWS may establish critical habitat for threatened or endangered species consisting of a geographic area determined essential for the conservation of the species).
FSC = Federal species of concern for Alameda and San Joaquin Counties. May be endangered or threatened. Not enough biological information has been gathered to support listing at this time (U.S. Fish and Wildlife Service 1-1-03-SP-0162).
CASSC = California species of special concern (CA Dept. of Fish and Game 2001).
SE = State-listed endangered (CA Dept. of Fish and Game 2001).
ST = State-listed threatened (CA Dept. of Fish and Game 2001).
MBTA = *Migratory Bird Treaty Act.*
CNPS List 1A = Plants presumed extinct in California.
CNPS List 1B = Plants rare, threatened, or endangered in California and elsewhere.
CNPS List 2 = Plants rare, threatened, or endangered in California, but more common elsewhere.
CNPS List 3 = Plants about which we need more information – a review list.
CNPS List 4 = Plants of limited distribution – a watch list.

TABLE F.3.2.2–1.—*Characteristics of Site 300 Wetlands*

Wetland	Type	Characteristic Species	Acreage	Jurisdictional Assessment	Jurisdictional Acreage
1	Vernal pool	*Crypsis schoenoides, Gnapahalium palustre, Amaranthus albus. Polypogon monspeliensis, Epilobium cleistogamum*	0.597	CRLF breeding site	0.597
2	Vernal pool	*Plagiobothrys stipitatus, Deschampsia danthonioides, Epilobium cleistogamum, Eleocharis macrostachya*	0.325	CRLF breeding site	0.325
3	Vernal pool	*Hordeum marinum ssp. gussoneanum, Polypogon monspeliensis*	0.018	Isolated	
Vernal pool acreage, subtotal			**0.94**		**0.922**
4	Freshwater seep		0.199	Tributary	0.199
5	Freshwater seep	*Baccharis salicifolius, Leymus triticoides*	0.017	Tributary	0.017
6	Freshwater seep	*Leymus triticoides*	0.054	CRLF nonbreeding site	0.054
7	Freshwater seep	*Polypogon monspeliensis, Leymus triticoides, Typha angustifolia*	0.101	Tributary, CRLF breeding site	0.101
8	Freshwater seep	*Utica dioica, Polypogon onspeliensis, Typha angustifolia*	0.023	Isolated	
9	Freshwater seep	*Urtica dioica*	0.033	Isolated	
10	Freshwater seep	*Typha angustifolia, Distichlis spicata*	0.443	Isolated	
11	Freshwater seep	*Typha angustifolia, Polypogon monspeliensis*	0.025	Isolated	
12	Freshwater seep	*Typha angustifolia, Stachys albens, Distichlis spicata, Leymus triticoides, Baccharis salicifolius, Urtica urens*	1.141	Tributary, CRLF breeding & nonbreeding sites	1.141
13	Freshwater seep	*Urtica dioica*	0.099	Isolated	
14	Freshwater seep		0.008	Artificial	
15	Freshwater seep		0.013	Artificial	

TABLE F.3.2.2–1.—*Characteristics of Site 300 Wetlands (continued)*

Wetland	Type	Characteristic Species	Acreage	Jurisdictional Assessment	Jurisdictional Acreage
17	Freshwater seep	*Leymus triticoides, Baccharis salicifolius*	0.217	CRLF nonbreeding site	0.217
18	Freshwater seep	*Typha angustifolia, Leymus triticoides*	0.078	Isolated	
19	Freshwater seep	*Baccharis salicifolius, Leymus triticoides*	0.111	Isolated	
20	Freshwater seep	*Typha angustifolia, Baccharis salicifolius, Leymus triticoides, Salix laevigata, Populus fremontii*	0.689	CRLF nonbreeding site	0.689
21	Freshwater seep	*Typha angustifolia, Baccharis salicifolius, Leymus triticoides, Nicotiana glauca*	0.288	Isolated	
22	Freshwater seep	*Typha angustifolia, Stachys albens, Leymus triticoides*	0.147	Isolated	
23	Freshwater seep	*Typha angustifolia, Stachys albens, Leymus triticoides*	0.118	Isolated	
24	Freshwater seep	*Typha angustifolia, Leymus triticoides*	0.082	Isolated	
25	Freshwater seep	*Typha angustifolia, Leymus triticoides*	0.026	Isolated	
27	Freshwater seep	*Typha angustifolia, T. latifolia*	0.575	Artificial, CRLF breeding site	
28	Freshwater seep	*Salix laevigata, Typha angustifolia, Uritica Dioica, Nasturtium officinale*	0.056	Isolated	
29	Freshwater seep	*Typha angustifolia, Polypogon monspeliensis*	0.031	Artificial	
30	Freshwater seep	*Polypogon monspeliensis, Baccharis salicifolius*	0.043	Artificial	
31	Freshwater seep/Great Valley willow scrub	*Typha angusutifolia/latifolia, Urtica dioica, Salix laevigata, Nasturtium officinale*	0.774	CRLF nonbreeding site	0.774
32	Freshwater seep	*Typha angustifolia, Urtica dioica, Leymus triticoides*	0.076	Isolated	
33	Freshwater seep	*Typha angustifolia, Urtica dioica, Leymus triticoides*	0.029	Isolated	
34	Freshwater seep	*Typha angustifolia, Urtica dioica, Leymus triticoides*	0.018	Isolated	
35	Freshwater seep	*Utica dioica, Marrubium vulgare*	0.046	Isolated	

TABLE F.3.2.2–1.—*Characteristics of Site 300 Wetlands (continued)*

Wetland	Type	Characteristic Species	Acreage	Jurisdictional Assessment	Jurisdictional Acreage
36	Freshwater seep	*Utica dioica, Marrubium vulgare, Polypogon monspeliensis, Typha angustifolia, Cyperus eragrostis*	0.048	Isolated	
37	Freshwater seep	*Baccharis salicifolius, Polypogon monspeliensis, Typha angustfolia*	0.071	Isolated	
38	Freshwater seep	*Leymus triticoides, Typha angustifolia, Polypogon monspeliensis*	0.034	Isolated	
39	Freshwater seep	*Typha angustifolia, Urtica dioica, Polypogon monspeliensis, Xanthium strumarium, Leymus triticoides*	0.498	Isolated	
42	Freshwater seep	*Typha angustifolia, Polypogon monspeliensis, Rumex crispus, Asclepias fascicularis, Carduus pycnocephalus*	0.036	Isolated	
43	Freshwater seep	*Typha angustifolia, Salix laevigata, Polypogon monspeliensis, Baccharis salicifolius, Leymus triticoides*	0.492	Isolated	
44	Freshwater seep	*Typha angustifolia, Leymus triticoides, Distichlis spicata*	0.266	Isolated	
45	Freshwater seep	*Leymus triticoides, Juncus balticus*	0.153	Isolated	
Freshwater seep, subtotal			**7.158**		**3.192**
16	Seasonal pond	*Conyza canadensis, Leymus triticoides, Baccharis salicifolius*	0.094	Isolated	
26	Seasonal pond	*Polypogon monspeliensis*	0.018	CRLF nonbreeding site	0.018
40	Seasonal pond	*bare*	0.029	CRLF breeding site	0.029
41	Seasonal pond	*bare*	0.139	Isolated	
46	Seasonal pond	*Lepidium latifolium, Heliotropium curassavicum (sparse vegetation)*	0.227	CRLF breeding site	0.227
Seasonal pond, subtotal			**0.507**		**0.274**
Wetlands, Total			**8.605**		**4.388**

Source: Jones and Stokes 2002c.
CRLF = California red-legged frogs

TABLE F.3.2.2–2.—*Plant Species Observed During Wetland Delineation at Lawrence Livermore National Laboratory, Site 300*

Scientific Name	Common Name	Wetland Indicator Status
Amaranthus albus	White amaranth	FACU
Artemisia californica	California sagebrush	--
Asclepias fascicularis	Narrow-leaved milkweed	FAC
Avena barbata	Slender wild oat	--
Avena fatua	Wild oat	--
B. diandrus	Ripgut brome	--
B. madritensis subsp. rubens	Red brome	--
Baccharis salicifolius	Mulefat	FACW
Bromus hordeaceus	Soft chess	FACU
Carduus pycnocephalus	Italian thistle	--
Conyza canadensis	Horseweed	FAC
Crypsis schoenoides	Swamp timothy	OBL
Cyperus eragrostis	Umbrella sedge	FACW
Deschampsia danthonioides	Annual hairgrass	FACW
Distichlis spicata	Saltgrass	FACW
Eleocharis macrostachya	Creeping spikerush	OBL
Epilobium cleistogamum	Cleistogamous spike-primrose	OBL
Gnaphalium palustre	Marsh cudweed	FACW
Gutierrezia californica	California matchweed	--
Heliotropium curassavicum	Salt heliotrope	OBL
Hordeum murinum subsp. leporinum	Foxtail barley	NI
Juncus balticus	Baltic rush	OBL
Juniperus californicus	California juniper	--
Lepidium latifolium	Perennial peppercress	FACW
Leymus triticoides	Creeping wild rye	FAC
Lupinus albifrons	Bush lupine	--
Marrubium vulgare	Horehound	FAC
Nassella cernua	Nodding needlegrass	--
Nassella pulchra	Needlegrass	--
Nasturtium officinale	Watercress	OBL
Nicotiana glauca	Tree tobacco	FAC
Plagiobothrys stipitatus	Stipitate popcorn-flower	OBL
Poa secunda	One-sided bluegrass	--
Polypogon monspeliensis	Annual rabbit's-foot grass	FACW+
Populus fremontii	Fremont cottonwood	FACW
Quercus douglasii	Blue oak	--
Quercus lobata	Valley oak	FAC
Rumex crispus	Curly dock	FACW-
Salix laevigata	Red willow	FACW+
Salvia nielliera	Black sage	--
Stachys albens	White hedgenettle	OBL
Toxicodendron diversilobum	Poison oak	--
Typha angustifolia	Narrow-leaved cattail	OBL
Typha latifolia	Broad-leaved cattail	OBL
Urtica dioica	Hoary nettle	FACW
Vulpia bromoides	Foxtail fescue	FACW
Vulpia myuros	Rattail fescue	FACU
Xanthium strumarium	Common cocklebur	FAC+

Source: Jones and Stokes 2002c.

Wetland indicator status (USFWS 1988): OBL = obligate, 99% occurrence in wetlands; FACW = Faculative Wetland, 66-99% occurrence in wetlands; FAC = Faculative, 33-66% occurrence in wetlands; FACU = Faculative upland, 1-33% occurrence in wetlands; Positive sign (+) = a frequency toward higher end of the category (more frequently found in wetlands); Negative sign (-) = a frequency toward lower end of the category (less frequently found in wetlands); -- = no indicator status, assumed to be upland species.

TABLE M.3.4–1.—*Comparison of Potential Environmental Consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative*

SSM PEIS[a]	No Action Alternative	Proposed Action	Reduced Operation Alternative
Land Use and Applicable Plans			
Determined land use for the NIF site.	Land use consistent with LLNL uses	No change to land use around NIF or LLNL	No change to land use around NIF or LLNL
Socioeconomics and Environmental Justice			
Socioeconomics			
330 long-term employees	400 total long-term employees 180 direct employees 220 support personnel	426 total long-term employees 186 direct employees 240 support personnel	367 total long-term employees 172 direct employees 195 support personnel
All new hires	Almost all already employed ~20 new hires	Almost all already employed ~46 new hires	All already employed reduction of 13 employees
	No construction employment	20 temporary construction jobs	No construction employment
No strain on local housing	No impact to local housing	No change to local housing	No change to local housing
One additional teacher One additional doctor	No impact to school or medical services	No change to school or medical services	No change to school or medical services
Environmental Justice			
No disproportionate impacts	No disproportionately high and adverse impacts	Same as No Action Alternative	Same as No Action Alternative
Community Services			
No change in fire or police services. Increased demand for general services	No impact in fire, emergency, police, or security services	No change in fire, emergency, police, or security services	No change in fire, emergency, police, or security services
Projected increase of 6,000 m^3/yr of nonhazardous waste. Represents a 100% increase in LLNL waste generation. (Overly conservative estimate: current site rate is 4,600 m^3/yr; NIF current rate is 380 m^3/yr.)	Most nonhazardous waste already being generated. Total of 400 m^3/yr. The increase of 20 m^3/yr would be ~0.4% of current site waste generation.	Most nonhazardous waste already being generated. Total of 426 m^3/yr. The increase of 46 m^3/yr would be ~1% of site waste generation.	Most nonhazardous waste already being generated. Total of 367 m^3/yr. The decrease of 13 m^3/yr would be ~0.3% of site waste generation.

TABLE M.3.4–1.—*Comparison of Potential Environmental Consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative (continued)*

SSM PEIS[a]	No Action Alternative			Proposed Action	Reduced Operation Alternative
Prehistoric and Historic Cultural Resources					
No impacts projected	No impacts projected			No impacts projected	No impacts projected
Aesthetics and Scenic Resources					
Impacts related to construction activities only	No impacts projected			No impacts projected	No impacts projected
Geology					
25 acres disturbed during construction of NIF	No new disturbance			Construction of neutron spectrometer will disturb 176,000 ft^3 of previously disturbed land	No new disturbance
Ecology					
No adverse impact to biological resources from construction of operation of NIF	No adverse impact			No adverse impact	No adverse impact
Air Quality					
Criteria Air Pollutants			% of LLNL		
PM_{10}	0.16 t/yr	PM_{10}	0.0042 t/yr	0.19	Same as No Action Alternative	Same as No Action Alternative
VOC	0.56 t/yr	VOC	1.18 t/yr	15		
CO	0.43 t/yr	CO	0.094 t/yr	1.7		
NO_x	1.79 t/yr	NO_x	0.076 t/yr	0.35		
SO_2	0.03 t/yr	SO_2	0.0017 t/yr	0.68		
Pb	Negligible	Pb	Negligible			
Hazardous/Toxic Air Pollutants						
No impacts from hazardous chemicals should occur because only minute quantities of hazardous VOCs are expected to be emitted.	Beryllium emissions below Toxic Air Contaminant threshold. No impacts from other hazardous/toxic air emissions			Greater beryllium emissions. Still below Toxic Air Contaminant threshold. No impacts from other hazardous/toxic air emissions	Beryllium emissions below Toxic Air Contaminant threshold. No impacts from other hazardous/toxic air emissions

TABLE M.3.4–1.—*Comparison of Potential Environmental Consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative (continued)*

SSM PEIS[a]	No Action Alternative	Proposed Action	Reduced Operation Alternative
Air Quality (continued)			
Radiological Air Pollutants			
Receptor / Annual Dose / Annual LCF Risk	**Annual Dose / Annual LCF Risk**	**Annual Dose / Annual LCF Risk**	**Annual Dose / Annual LCF Risk**
MEI: 0.1 mrem / 6.0×10^{-8}	0.04 mrem / 2.4×10^{-8}	0.07 mrem / 4.2×10^{-8}	0.03 mrem / 1.8×10^{-8}
Population: 0.2 person-rem / 1.2×10^{-4}	0.26 person-rem / 1.6×10^{-4}	0.29 person-rem / 1.7×10^{-4}	0.24 person-rem / 1.4×10^{-4}
Water			
Impacts would be minimal.	Impacts would be minimal.	Impacts would be minimal. Construction of neutron spectrometer would not contaminate groundwater.	Impacts would be minimal.
Noise			
Noise from construction up to 69 dBA to offsite receptor	Noise equivalent to light industrial facility, ~85 dB	Noise equivalent to light industrial facility, ~85 dB Temporary noise during construction of neutron spectrometer	Noise equivalent to light industrial facility, ~85 dB
Traffic and Transportation			
Traffic			
902 new trips daily on local roads from construction and operations employment	Most of employment in place. Less than 0.3 % increase in local traffic	Most of employment in place. Less than 0.4 % increase in local traffic	Slight reduction in current employment. Less than 0.3 % decrease in local traffic
Transportation			
No impacts expected from routine transportation of tritium targets. No detectable levels of radiation outside of transport packages.	No radiation dose to drivers or public from routine transportation	No radiation dose to drivers or public from routine transportation Use of disposable inner containment vessel increases LLW shipments to NTS	No radiation dose to drivers or public from routine transportation
Onsite transportation risks from tritium targets were assumed to be negligible compared to risks from offsite transportation.	No impact from onsite transportation	No impacts from onsite transportation, including movement of inner containment vessel	No impact from onsite transportation

TABLE M.3.4–1.—*Comparison of Potential Environmental Consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative (continued)*

SSM PEIS[a]	No Action Alternative	Proposed Action	Reduced Operation Alternative
Utilities and Energy			
Water Use			
152 million L/yr	27.6 million L/yr 3.5% increase in LLNL usage	27.6 million L/yr	Slightly less than 27.6 million L/yr
Energy			
122,640 MWh/yr	131,400 MWh/yr 42% increase in LLNL usage	131,400 MWh/yr	131,400 MWh/yr
Sewer			
18 million L/yr	13.2 million L/yr 5.2% increase in LLNL usage	13.2 million L/yr	Slightly less than 13.2 million L/yr
Natural Gas			
2.03×10^5 therms/yr	2.03×10^5 therms/yr 2.6% increase in LLNL usage	2.03×10^5 therms/yr	Slightly less than 2.03×10^5 therms/yr
Materials and Waste Management			
Materials Management			
Would involve use of radioactive, hazardous, toxic materials including deuterium, tritium, mercury, cleaning fluids, and caustic chemicals.	Would involve use of radioactive, hazardous, toxic materials including tritium, depleted uranium, activated particulates, beryllium, mercury, cleaning fluids, and caustic chemicals.	Would involve use of radioactive, hazardous, toxic materials including tritium, depleted uranium, activated particulates, beryllium, mercury, cleaning fluids, and caustic chemicals. Additional materials would include plutonium, HEU, lithium hydride, and greater amounts of beryllium. Polyvinyl toluene and lead would be used in the neutron spectrometer.	Would involve use of radioactive, hazardous, toxic materials including tritium, depleted uranium, activated particulates, beryllium, mercury, cleaning fluids, and caustic chemicals.

Waste Management (quantities in m^3)

SSM PEIS			No Action Alternative			Proposed Action			Reduced Operation Alternative		
LLW solid (liquid)	**Mixed solid (liquid)**	**Hazardous solid (liquid)**	**LLW solid (liquid)**	**Mixed solid (liquid)**	**Hazardous solid (liquid)**	**LLW solid (liquid)**	**Mixed solid (liquid)**	**Hazardous solid (liquid)**	**LLW solid (liquid)**	**Mixed Solid (liquid)**	**Hazardous solid (liquid)**
6.65 (1.6)	0.9 (5.0)	8.0 (4.6)	70 (1.6)	1.8 (5.1)	8.5 (6.3)	190 (1.6)	1.8 (5.1)	8.5 (6.3)	49 (0.95)	1.6 (3.5)	8.5 (6.3)

TABLE M.3.4–1.—*Comparison of Potential Environmental Consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative (continued)*

SSM PEIS[a]	No Action Alternative	Proposed Action	Reduced Operation Alternative
Accidents			
For the bounding radiological accident **Median Meteorology** • Noninvolved worker population not calculated • 0.6 latent cancer fatalities to the offsite population **Unfavorable Meteorology** • Not calculated.	For the bounding radiological accident **Median Meteorology** • 0.00013 latent cancer fatalities to the noninvolved worker population • 0.00012 latent cancer fatalities to the offsite population **Unfavorable Meteorology** • 0.0013 latent cancer fatalities to the noninvolved worker population • 0.0018 latent cancer fatalities to the offsite population	For the bounding radiological accident **Median Meteorology** • 0.00045 latent cancer fatalities to the noninvolved worker population • 0.00033 latent cancer fatalities to the offsite population **Unfavorable Meteorology** • 0.005 latent cancer fatalities to the noninvolved worker population • 0.005 latent cancer fatalities to the offsite population	Same as the No Action Alternative.
Occupational Protection			
Radiological Exposure			
Receptor / **Annual Dose** / **Annual LCF Risk**	**Annual Dose** / **Annual LCF Risk**	**Annual Dose** / **Annual LCF Risk**	**Annual Dose** / **Annual LCF Risk**
Involved worker(s) — <10 person-rem — 6.0×10^{-3}	<15 person-rem — 0 cancers in population (calculated risk = 9×10^{-3})	<19 person-rem — 0 cancers in population (calculated value = 1.1×10^{-2})	<10 person-rem — 0 cancers in population (calculated risk = 6×10^{-3})
Non-involved worker(s) — 0.2 person-rem — 1.2×10^{-4}	1 mrem/yr — 6×10^{-7}	1 mrem/yr — 6×10^{-7}	1 mrem/yr — 6×10^{-7}
Public MEI — 0.1 mrem — 6.0×10^{-8}	0.24 mrem — 1.4×10^{-7}	0.27 mrem — 1.6×10^{-7}	0.16 mrem — 9.6×10^{-8}
Population Dose — 0.2 person-rem — 1.2×10^{-4}	0.26 person-rem — 1.6×10^{-4}	0.29 person-rem — 1.7×10^{-4}	0.24 person-rem — 1.4×10^{-4}

TABLE M.3.4–1.—*Comparison of Potential Environmental Consequences of the No Action Alternative, Proposed Action, and Reduced Operation Alternative (continued)*

SSM PEIS[a]	No Action Alternative	Proposed Action	Reduced Operation Alternative
Nonradiological Exposure			
Hazards in the NIF for workers would include chemicals, electrical shock, and industrial accidents.	Hazards in the NIF for workers would include chemicals, beryllium exposure, electrical shock, and industrial accidents.	Hazards in the NIF for workers would include chemicals, beryllium exposure, electrical shock, and industrial accidents.	Hazards in the NIF for workers would include chemicals, beryllium exposure, electrical shock, and industrial accidents.

Source: Original.
[a] DOE 1996b
CO = carbon monoxide; dBA = decibels, A-weighted; ft^3 = cubic feet; HEU = highly enriched uranium; L = liter; LCF= latent cancer fatality; LLNL = Lawrence Livermore National Laboratory; LLW = low-level waste; m^3 = cubic meters; MEI = maximally exposed individuals; mrem – millirem; MWh = megawatt hours; NIF – National Ignition Facility; NO_x = nitrogen oxidizes; Pb = lead; PM_{10} = particulate matter less than10 microns in diameter; SO_2 = sulfur dioxide; SSM PEIS = Stockpile Stewardship Management Programmatic Environmental Impact Statement; t = ton(s); VOC = volatile organic compound; yr = year.

TABLE M.5.2.13.1–1.—*Bounding Annual Radionuclide Particulate Inventories in the Target Chamber (No Action Alternative)*

Isotope	Quantity (curies)
Activated particulates[a]	
Sodium-24	4.0×10^{-1}
Manganese-56	1.3
Cobalt-60	7.4×10^{-2}
Manganese-54	1.4×10^{-1}
Scandium-48	3.6×10^{-2}
Iron-55	7.1×10^{-1}
Scandium-46	4.6×10^{-2}
Calcium-45	1.0×10^{-1}
Scandium-44	2.0×10^{-1}
Tantalum-182	2.5×10^{-2}
Scandium-44m	6.4×10^{-2}
Gadolinium-153	2.5×10^{-2}
Nickel-65	2.0×10^{-1}
Copper-64	1.5
Cobalt-62m	1.6×10^{-1}
Lead-203	1.6×10^{-2}
Scandium-47	2.4×10^{-2}
Potassium-42	1.8×10^{-2}
Gallium-72	2.8×10^{-3}
Hafnium-181	2.8×10^{-3}
Gadolinium-159	8.6×10^{-2}
Chromium-51	4.7×10^{-2}
Dysprosium-159	4.2×10^{-3}
Europium-156	7.9×10^{-4}
Nickel-63	8.8×10^{-3}
Depleted uranium[b]	
Uranium-234	8.6×10^{-7}
Uranium-235	4.0×10^{-8}
Uranium-238	1.6×10^{-6}

Source: LLNL 2003d.
[a] After one year of operation without cleanup; corresponds to a final 45-MJ experiment, ending a year with 1,200-MJ total yield.
[b] The assumed composition is: 99.64% uranium-238, 0.36% uranium-235, and 0.0028% uranium-234. The quantities listed correspond to the maximum use over a year of 5 g.
Ci = curies; g = grams; MJ = megajoules.

Tritium

Tritium would arrive at the facility in individual targets, containing up to 5 curies each: 2 curies in the capsule and up to 3 curies in the associated hardware. If direct drive were implemented, each target would contain up to 70 curies. The maximum annual tritium throughput at the NIF would be limited to 1,750 curies per year. The in-process inventory limit for tritium for the NIF would total no more than 500 curies at any time.

Items exposed to tritium are subject to tritium contamination. After an experiment, unburned tritium would be exhausted from the target chamber to the vacuum system and then processed and retained in the tritium collection system. Residual tritium on the first wall surface and on

TABLE M.5.2.13.2–2.— *National Ignition Facility Estimated Important Chemical Inventories*

Chemical	Source	Quantity	Exposure Criteria[a]
Acetone	Cleaners, etc.	210 L (165 kg) + OAB 13 L (10 kg)	500 mg/m^3 (ACGIH)
Alcohol, ethyl (ethanol)	Cleaners, etc.	276 L (258 kg) + OAB 10.7 L (10 kg)	1,000 mg/m^3 (ACGIH)
Alcohol, isopropyl	Cleaners, etc.	20.5 L (16.2 kg) + OAB 25.3 L (20 kg) 10 kg (wipes)	400 mg/m^3 (ACGIH)
Argon	Beam tubes	10,100 kg	—
Castor oil (ricinus oil)	Dielectric fluid in capacitors	227,000 L	—
Chloroform	Cleaners, etc.	0.5 L (0.7 kg)	10 mg/m^3 (ACGIH)
Decontamination Acid Bath Nitric acid + phosphoric acid (1 M each)	First wall decontamination	8000 L (10624 kg), 2520 kg as HNO_3, 3920 kg as H_3PO_4	5.2 mg/m^3 HNO_3 (ACGIH) 1 mg/m^3 H_3PO_4 (ACGIH)
Ethylene glycol	PAM coolant	170 kg	127 mg/m^3 (ACGIH)
Mercury, metallic	192 PAM switches	3.5 L[b] (47 kg)	0.025 mg/m^3 (ACGIH)
Methylene chloride	Cleaners, etc.	1 L (1.32 kg)	174 mg/m^3 (ACGIH)
Nitric acid (70% solution)	Supply on hand for replenishing decontamination solution	400 L (540 kg), 420 kg as HNO_3	5.2 mg/m^3 (ACGIH)
Nitrogen	Cleaning propellant, dry box purging, beam tubes, amplifier cooling, cryogen	96,000 kg	—
Phosphoric acid (87% solution)	Supply on hand for replenishing decontamination solution	400 L (691 kg), 639 kg as H_3PO_4	1 mg/m^3 (ACGIH)
Sodium hydroxide (1 M)	Decontamination (caustic bath)	8000 L (8320 kg), 1600 kg as NaOH	2 mg/m^3 (ACGIH)
Sodium hydroxide (50% solution)	Supply on hand for replenishing decontamination solution	400 L (612 kg), 306 kg as NaOH	2 mg/m^3 (ACGIH)
Toluene	Cleaners, etc.	18 L (16 kg)	375 mg/m^3 (NIOSH)
Xylene	Cleaners, etc.	18 L (16 kg)	435 mg/m^3 (NIOSH)

Source: LLNL 2003d.

[a] All criteria are 8-hour time weighted averages, unless otherwise stated.

[b] Single ignitron inventories are approximately 14 pounds (0.125 gallons).

ACGIH = American Conference of Governmental Industrial Hygienists; H_3PO_4 = phosphoric acid; HNO_3 = nitric acid; kg = kilogram; L = liter; M = molar; NaOH = sodium hydroxide; NIOSH = National Institute of Occupational Safety and Health; OAB = optics assembly building; PAM = preamplified module.

TABLE M.5.3.13.1–1.—*Bounding Annual Radionuclide Particulate Inventories in the Target Chamber (Proposed Action)*

Material	Maximum Inventory
Depleted Uranium	2.2 g/experiment[a]
	100 g/yr[b]
Uranium-234	1.8×10^{-5} Ci/yr
Uranium-235	7.8×10^{-7} Ci/yr
Uranium-238	3.4×10^{-5} Ci/yr
Highly enriched uranium[c, f]	1.2 g/experiment[a]
	100 g/yr
Uranium-234	6.9×10^{-3} Ci/yr
Uranium-235	2.0×10^{-4} Ci/yr
Urantium-238	1.8×10^{-6} Ci/yr
Thorium-232	7.9 g/experiment
	450 g/yr
	1.0×10^{-5} Ci/yr
Tracer elements, iodine is representative[d]	1.7×10^{-3} g/experiment
	0.1 g/yr
Inner containment vessel	
Weapons-grade plutonium	3 g/experiment (non-yield)[e]
Plutonium-238	1.0×10^{-2} Ci
Plutonium-239	1.8×10^{-1} Ci
Plutonium-240	4.0×10^{-2} Ci
Plutonium-241	9.1×10^{-1} Ci
Plutonium-242	2.4×10^{-6} Ci
Americium-241	1.6×10^{-3} Ci
Weapons-grade plutonium	1 g/experiment (yield)
Plutonium-238	3.4×10^{-3} Ci
Plutonium-239	5.8×10^{-2} Ci
Plutonium-240	1.3×10^{-2} Ci
Plutonium-241	3.0×10^{-1} Ci
Plutonium-242	7.9×10^{-7} Ci
Americium-241	5.2×10^{-4} Ci
Inner containment vessel particulates	225 g

Source: LLNL 2003d.

[a] The single-experiment inventory limit would result from the fission products created during a single high-yield experiment (45 MJ) as well as the buildup of the longer-lived fission products during one year of 1,200-MJ operation. Trace quantities of solid fission products would also be produced; they are not included here because of their very small impact.

[b] This is the total quantity of depleted uranium that could be in the NIF target chamber at any one time. Individual targets for yield experiments would be limited to 2.2 g for depleted uranium.

[c] Assumed composition is 93.5 wt% uranium-235, 5.4 % uranium-238, and 1.1 % uranium-234. Individual targets for yield experiments would be limited to 1.2 g for highly enriched uranium.

[d] Other possible tracer elements include: beryllium, lithium, oxygen, neon, chlorine, argon, titanium, chromium, nickel, copper, arsenic, bromine, krypton, rubidium, yttrium, zirconium, niobium, molybdenum, rhodium, silver, iodine, xenon, neodymium, samarium, europium, thulium, lutetium hafnium tantalum, tungsten, rhenium, iridium, gold, thallium, bismuth These are bounded by the representative tracer and could be used in similar quantities. The quantity in the table assumes 60 experiments/yr, each at 1.7 mg.

[e] This is the maximum quantity of plutonium in a single experiment and present in the facility at any one time.

[f] Bounds the use small quantities of specially prepared plutonium.

Ci = curies; g = grams; MJ = megajoules; yr = year.

TABLE M.5.3.13.1–2.—*Estimated Maximum Mobilizable Radionuclide Inventories (Proposed Action)*

Isotope	Quantity (Ci)
Depleted uranium[a]	
Uranium-234	1.8×10^{-5}
Uranium-235	7.8×10^{-7}
Uranium-238	3.4×10^{-5}
Krypton-83m	1.6×10^{-1}
Krypton-85	1.3×10^{-4}
Krypton-85m	4.4×10^{-1}
Krypton-87	2.5
Krypton-88	1.7
Niobium-98	1.3×10^{3}
Iodine-131	6.2×10^{-2}
Iodine-132	1.6×10^{-1}
Iodine-132m	2.0×10^{-3}
Iodine-133	6.7×10^{-1}
Iodine-133m	1.1×10^{1}
Iodine-134	7.9
Iodine-134m	4.0
Iodine-135	2.3
Iodine-136	2.9×10^{2}
Tellurium-134	2.3×10^{1}
Xenon-133	1.3×10^{-1}
Xenon-133m	5.2×10^{-3}
Xenon-134m	1.6×10^{1}
Xenon-135	7.1×10^{-1}
Xenon-135m	3.2×10^{-1}
Xenon-137	1.7×10^{2}
Xenon-138	5.6×10^{2}
Highly enriched uranium[b, e]	
Uranium-234	6.9×10^{-3}
Uranium-235	2.0×10^{-4}
Uranium-238	1.8×10^{-6}
Krypton-87	4.1
Krypton-88	2.6
Niobium-98	1.2×10^{3}
Iodine-131	5.1×10^{-2}
Iodine-132	1.3×10^{-1}
Iodine-132m	3.0×10^{-2}
Iodine-133	6.1×10^{-1}
Iodine-133m	9.8×10^{1}
Iodine-134	7.9
Iodine-134m	1.7×10^{1}
Iodine-135	2.1
Iodine-136	1.8×10^{2}
Tellurium-134	2.0×10^{1}
Xenon-133	1.2×10^{-1}
Xenon-133m	4.9×10^{-3}
Xenon-134m	3.2×10^{2}
Xenon-135	6.7×10^{-1}
Xenon-135m	1.7
Xenon-137	1.6×10^{2}
Xenon-138	5.6×10^{1}

TABLE M.5.3.13.1–2.—*Estimated Maximum Mobilizable Radionuclide Inventories (Proposed Action) (continued)*

Isotope	Quantity (Ci)
Thorium-232[c]	
Thorium-232	1.0×10^{-5}
Krypton-83m	9.2×10^{-1}
Krypton-85	8.7×10^{-4}
Krypton-85m	3.0
Krypton-87	1.1×10^{1}
Krypton-88	5.6
Niobium-98	8.2×10^{2}
Iodine-131	3.4×10^{-2}
Iodine-132	9.1×10^{-2}
Iodine-132m	2.3×10^{-3}
Iodine-133	4.6×10^{-1}
Iodine-133m	1.3×10^{1}
Iodine-134	6.2
Iodine-134m	4.3
Iodine-135	2.0
Iodine-136	2.5×10^{2}
Tellurium-134	1.8×10^{1}
Xenon-133	9.0×10^{-2}
Xenon-133m	3.7×10^{-3}
Xenon-134m	2.2×10^{1}
Xenon-135	6.2×10^{-1}
Xenon-135m	2.8×10^{-1}
Xenon-137	1.8×10^{2}
Xenon-138	6.2×10^{1}
Tracers: iodine is bounding and representative	
Iodine-124	6.2×10^{-2}
Iodine-125	6.4×10^{-2}
Iodine-126	1.5×10^{-1}
Inner containment vessel, weapons-grade plutonium (nonyield)	3 g
Plutonium-238	1.0×10^{-2}
Plutonium-239	1.8×10^{-1}
Plutonium-240	4.0×10^{-2}
Plutonium-241	9.1×10^{-1}
Plutonium-242	2.4×10^{-6}
Americium-241	1.6×10^{-3}
Inner containment vessel, weapons-grade plutonium (with yield[d])	1 g
Plutonium-238	3.4×10^{-3}
Plutonium-239	5.8×10^{-2}
Plutonium-240	1.3×10^{-2}
Plutonium-241	3.0×10^{-1}
Plutonium-242	7.9×10^{-7}
Americium-241	5.2×10^{-4}
Krypton-83m	1.1×10^{-1}
Krypton-85	3.0×10^{-6}
Krypton-85m	2.6×10^{-1}
Krypton-87	1.6
Krypton-88	9.6×10^{-1}
Niobium-98	1.2×10^{3}

TABLE M.5.3.13.1–2.—*Estimated Maximum Mobilizable Radionuclide Inventories (Proposed Action) (continued)*

Isotope	Quantity (Ci)
Iodine-131	3.7×10^{-2}
Iodine-132	1.5×10^{-1}
Iodine-132m	1.8×10^{-1}
Iodine-133	6.4×10^{-1}
Iodine-133m	3.4×10^{2}
Iodine-134	8.3
Iodine-134m	4.1×10^{1}
Iodine-135	2.1
Iodine-136	1.3×10^{2}
Tellurium-134	1.5×10^{1}
Xenon-133	8.3×10^{-2}
Xenon-133m	4.8×10^{-3}
Xenon-134m	1.7×10^{3}
Xenon-135	7.6×10^{-1}
Xenon-135m	6.0
Xenon-137	1.7×10^{2}
Xenon-138	4.6×10^{1}
Inner containment vessel particulates	
Aluminum-28	2.1×10^{-1}
Silicon-31	8.1×10^{-5}
Phosphorus-30	4.5×10^{-4}
Vanadium-49	1.3×10^{-6}
Chromium-49	2.0×10^{-4}
Chromium-51	1.3×10^{-4}
Manganese-52m	1.5×10^{-5}
Manganese-54	8.7×10^{-6}
Manganese-56	5.8×10^{-2}
Iron-55	2.0×10^{-5}
Cobalt-57	1.5×10^{-5}
Cobalt-58	3.5×10^{-5}
Cobalt-58m	5.1×10^{-3}
Cobalt-60m	3.2×10^{-2}
Cobalt-61	2.2×10^{-4}
Cobalt-62m	4.8×10^{-4}
Nickel-57	1.3×10^{-4}
Nickel-65	1.6×10^{-5}
Niobium-96	3.9×10^{-6}
Niobium-97	2.8×10^{-5}
Niobium-97m	5.5×10^{-4}
Niobium-98	1.6×10^{-2}
Molybdenum-93m	1.3×10^{-6}
Molybdenum-99	5.5×10^{-5}
Technetium-99m	2.2×10^{-5}

TABLE M.5.3.13.1–2.—*Estimated Maximum Mobilizable Radionuclide Inventories (Proposed Action) (continued)*

Isotope	Quantity (Ci)

Source: LLNL 2003d.

[a] Depleted uranium is already slightly radioactive; the half-life of uranium-238 (dominant isotope) is 4.5×10^9 yrs. The assumed composition would be 99.64% uranium-238, 0.36% uranium-235, and 0.0028% uranium-234. The quantities listed correspond to the maximum quantity that would be used under the Proposed Action of 100 g. Fission products would result from a single target (maximum of 2.2 g) subject to 45-MJ fusion yield (4.6×10^{16} fissions) and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories provided would be peak post-experiment inventories.

[b] HEU is already slightly radioactive; the half-life of uranium-235 (dominant isotope) is 7.0×10^8 yrs). The assumed composition would be 93.5 wt% uranium-235, 5.4 % uranium-238, and 1.1 % uranium-234. The quantity listed corresponds to the maximum quantity that would be used under the Proposed Action of 100 g. Fission products would result from a single target (maximum of 1.2 g) subject to a 45MJ fusion yield (4.6×10^{16} fissions) and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories provided would be peak post-experiment inventories.

[c] Thorium-232 is already slightly radioactive, with a half-life of 1.4×10^{10} yrs). The quantity listed corresponds to the maximum quantity that would be used under the Proposed Action of 450 g. Fission products would result from a single target (maximum of 7.9 g) subject to a 45-MJ fusion yield (5.3×10^{16} fissions) and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories provided would be peak post-experiment inventories.

[d] The assumed composition of weapons-grade material would be 0.02% plutonium-238, 93.85% plutonium-239, 5.8% plutonium-240, 0.3% plutonium-241, 0.015% americium-241, and 0.02% plutonium-242. Other isotopic mixes could be used as long as their impacts are within the bounds described here. The fission products would result from a single target (maximum of 1 g) subject to a 45-MJ fusion yield (3.2×10^{16} fissions). Because only a single experiment would occur within an inner containment vessel, only the fission products resulting from this single experiment would be included. The fission product inventories would be peak post-experiment inventories.

[e] Bounds the use of small quantities of specially prepared plutonium.

Ci = curies; g = grams; MJ = megajoules; wt% = percent by weight.

Plutonium Experiment Containment Vessel

For most tests with plutonium[8], an inner containment vessel, presently assumed to be fabricated from stainless steel, would be used to prevent the weapons-grade plutonium[9] and associated fission products from being deposited on the main NIF target chamber, first wall, target positioner, or diagnostics. This inner containment vessel would be brought from the Tritium Facility as a sealed and assembled unit. The vessel would be placed into the target chamber through the large port at the waist of the target chamber or through the bottom of the NIF target chamber. The inner containment vessel would be positioned so that the target would be placed at the target chamber center and the experiment performed using all or a subset of the laser beams. Once the experiment is complete, the inner containment vessel would be returned to the Tritium Facility for post-experiment examination and processing.

Depleted Uranium

Depleted uranium would arrive at the facility in individual targets, each with up to 2.2 grams of depleted uranium. The maximum annual depleted uranium throughput at the NIF under the Proposed Action would be limited to 100 grams. Depleted uranium is slightly radioactive; the half-life of uranium-238 [(dominant isotope]) is 4.5×10^9 years). Depleted uranium is also considered to have toxic properties.

[8] If other fissile materials were required for NIF experiments, the inventories of these materials would be limited such that their environmental impact (offsite accidents, worker exposure, etc.) would not exceed the bounds defined in this document.

[9] The assumed composition of weapons-grade material would be 0.02% plutonium-238, 93.85% plutonium-239, 5.8% plutonium-240, 0.3% plutonium-241, 0.015% americium-241, and 0.02% plutonium-242. Other isotopic mixes could be used as long as their impacts are within the bounds described here.

TABLE M.5.6.1.2–1.—*Possible Additional Bounding Radiological Accident Source Terms under the Proposed Action*

Radionuclide	Quantity Present (Ci)	Release Fraction	Quantity Released (Ci)
Depleted uranium[a]			
Uranium-234	1.7×10^{-5}	1×10^{-3}	1.7×10^{-8}
Uranium-235	7.4×10^{-7}	1×10^{-3}	8.0×10^{-10}
Uranium-238	3.2×10^{-5}	1×10^{-3}	3.2×10^{-8}
Krypton-83m	1.5×10^{-1}	1.0	1.5×10^{-1}
Krypton-85	1.2×10^{-4}	1.0	1.2×10^{-4}
Krypton-85m	4.2×10^{-1}	1.0	4.2×10^{-1}
Krypton-87	2.4	1.0	2.4
Krypton-88	1.6	1.0	1.6
Niobium 98	1.2×10^{3}	1×10^{-3}	1.2
Iodine-131	5.9×10^{-2}	0.5	3.0×10^{-2}
Iodine-132	1.5×10^{-1}	0.5	7.5×10^{-2}
Iodine-132m	1.9×10^{-3}	0.5	9.5×10^{-4}
Iodine-133	6.4×10^{-1}	0.5	3.2×10^{-1}
Iodine-133m	1.0×10^{1}	0.5	5.0
Iodine-134	7.5	0.5	3.8
Iodine-134m	3.8	0.5	1.9
Iodine-135	2.2	0.5	1.1
Iodine-136	2.8×10^{2}	0.5	1.4×10^{2}
Technetium -134	2.2×10^{1}	1×10^{-3}	2.2×10^{-2}
Xenon-133	1.2×10^{-1}	1.0	1.2×10^{-1}
Xenon-133m	5.0×10^{-3}	1.0	5.0×10^{-3}
Xenon-134m	1.5×10^{1}	1.0	1.5×10^{1}
Xenone-135	6.7×10^{-1}	1.0	6.7×10^{-1}
Xenon-135m	3.0×10^{-1}	1.0	3.0×10^{-1}
Xenon-137	1.6×10^{2}	1.0	1.6×10^{2}
Xenone-138	5.3×10^{1}	1.0	5.3×10^{1}

TABLE M.5.6.1.2–1.—*Possible Additional Bounding Radiological Accident Source Terms under the Proposed Action (continued)*

Radionuclide	Quantity Present (Ci)	Release Fraction	Quantity Released (Ci)
Highly enriched uranium[b]			
Uranium-234	6.9×10^{-3}	1×10^{-3}	6.9×10^{-6}
Uranium-235	2.0×10^{-4}	1×10^{-3}	2.0×10^{-7}
Uranium-238	1.8×10^{-6}	1×10^{-3}	1.8×10^{-9}
Krypton-87	4.1	1.0	4.1
Krypton-88	2.6	1.0	2.6
Niobium 98	1.2×10^{3}	1×10^{-3}	1.2
Iodine-131	5.1×10^{-2}	0.5	2.6×10^{-2}
Iodine-132	1.3×10^{-1}	0.5	6.5×10^{-2}
Iodine-132m	3.0×10^{-2}	0.5	1.5×10^{-2}
Iodine-133	6.1×10^{-1}	0.5	3.1×10^{-1}
Iodine-133m	9.8×10^{1}	0.5	4.9×10^{1}
Iodine-134	7.9	0.5	4.0
Iodine-134m	1.7×10^{1}	0.5	8.5
Iodine-135	2.1	0.5	1.1
Iodine-136	1.8×10^{2}	0.5	9.0×10^{1}
Te-134	2.0×10^{1}	1×10^{-3}	2.0×10^{-2}
Xenon-133	1.2×10^{-1}	1.0	1.2×10^{-1}
Xenon-133m	4.9×10^{-3}	1.0	4.9×10^{-3}
Xenon-134m	3.2×10^{2}	1.0	3.2×10^{2}
Xenon-135	6.7×10^{-1}	1.0	6.7×10^{-1}
Xenon-135m	1.7	1.0	1.7
Xenon-137	1.6×10^{2}	1.0	1.6×10^{2}
Xenon-138	5.6×10^{1}	1.0	5.6×10^{1}
Tracers: iodine is bounding and representative			
Iodine-124	6.2×10^{-2}	0.5	3.1×10^{-2}
Iodine-125	6.4×10^{-2}	0.5	3.2×10^{-2}
Iodine-126	1.5×10^{-1}	0.5	7.5×10^{-2}

TABLE M.5.6.1.2–1.—*Possible Additional Bounding Radiological Accident Source Terms under the Proposed Action (continued)*

Radionuclide	Quantity Present (Ci)	Release Fraction	Quantity Released (Ci)
Inner containment vessel, weapons-grade plutonium (nonyield[c])	3 g		
Plutonium-238	1.0×10^{-2}	1×10^{-3}	1.0×10^{-5}
Plutonium-239	1.8×10^{-1}	1×10^{-3}	1.8×10^{-4}
Plutonium-240	4.0×10^{-2}	1×10^{-3}	4.0×10^{-5}
Plutonium-241	9.1×10^{-1}	1×10^{-3}	9.1×10^{-4}
Plutonium-242	2.4×10^{-6}	1×10^{-3}	2.4×10^{-9}
Americium-241	1.6×10^{-3}	1×10^{-3}	1.6×10^{-6}
Inner containment vessel, weapons-grade plutonium (with yield[d])	1 g		
Plutonium-238	3.4×10^{-3}	1×10^{-3}	3.4×10^{-6}
Plutonium-239	5.8×10^{-2}	1×10^{-3}	5.8×10^{-5}
Plutonium-240	1.3×10^{-2}	1×10^{-3}	1.3×10^{-5}
Plutonium-241	3.0×10^{-1}	1×10^{-3}	3.0×10^{-4}
Plutonium-242	7.9×10^{-7}	1×10^{-3}	7.9×10^{-10}
Nickel-65	1.6×10^{-5}	1×10^{-3}	1.6×10^{-8}
Niobium 96	3.9×10^{-6}	1×10^{-3}	3.9×10^{-9}
Niobium-97	2.8×10^{-5}	1×10^{-3}	2.8×10^{-8}
Niobium-97	5.5×10^{-4}	1×10^{-3}	5.5×10^{-7}
Niobium-98	1.6×10^{-2}	1×10^{-3}	1.6×10^{-5}
Molybdenum-93m	1.3×10^{-6}	1×10^{-3}	1.3×10^{-9}
Molybdenum-99	5.5×10^{-5}	1×10^{-3}	5.5×10^{-8}
Technetium-99	2.2×10^{-5}	1×10^{-3}	2.2×10^{-8}

Source: LLNL 2003d.

[a] Depleted uranium is already slightly radioactive; the half-life of uranium-238 (dominant isotope) is 4.5×10^{9} years. The assumed composition is 99.64% uranium-238, 0.36% uranium-235, and 0.0028% uranium-234. The quantities listed correspond to the maximum additional quantity used for the proposed action of 100 g. Fission products would result from a single target (maximum of 2.2 g) subject to a 45-MJ fusion yield, 4.6×10^{16} fissions, and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories would be peak post-experiment inventories.

[b] Highly enriched uranium is already slightly radioactive; the half-life of uranium-235 (dominant isotope) is 7.0×10^{8} years. The quantity listed corresponds to the maximum quantity used for the proposed action of 100 g. Fission products would result from a single target (maximum of 1.2 g) subject to a 45-MJ fusion yield, 4.6×10^{16} fissions, and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories would be peak post-experiment inventories.

[c] Thorium-232 is already slightly radioactive, with a half-life of 1.4×10^{10} yrs. The quantity listed corresponds to the maximum quantity used under the Proposed Action of 450 g. Fission products would result from a single target (maximum of 7.9 g) subject to a 45-MJ fusion yield, 5.3×10^{16} fissions, and would include residual fission products from previous yield experiments (60 @ 20 MJ). The fission product inventories would be peak post-experiment inventories.

[d] The assumed composition of weapons-grade material is 0.02% plutonium-238, 93.85% plutonium-239, 5.8% plutonium-240, 0.3% plutonium-241, 0.015% americium-241, and 0.02% plutonium-242. Other isotopic mixes could be used as long as their impacts would be within the bounds described here. The fission products would result from a single target (maximum of 1 g) subject to a 45-MJ fusion yield, 3.2×10^{16} fissions. Because only a single experiment would occur within a containment vessel, only the fission products resulting from this single experiment are included. The fission product inventories would be peak post-experiment inventories.

Ci = curies; g = gram; MJ = megajoules.

TABLE M.5.6.1.2–2.—*Potential Source Terms for Radiological Accident Scenarios*

Accident	Frequency (per year)	Source Term or Hazard (No Action Alternative)	Source Term or Hazard (Proposed Action)
Earthquake during No Action Alternative operations	2×10^{-8}	500 Ci tritium plus activated gases and particulates	500 Ci tritium plus activated gases and particulates
Earthquake during depleted uranium experiment	2×10^{-9}	0.005 g depleted uranium plus 500 Ci tritium plus fission products plus activated gases and particulates	0.1 g depleted uranium plus 500 Ci tritium plus fission products plus activated gases and particulates
Earthquake during highly enriched uranium experiment	2×10^{-9}	Not applicable	0.1 g highly enriched uranium plus 500 Ci tritium plus fission products plus activated gases and particulates
Earthquake during thorium experiment	2×10^{-9}	Not applicable	0.45 g thorium-232 plus 500 Ci tritium plus fission products plus activated gases and particulates
Earthquake during tracer experiment	2×10^{-9}	Not applicable	0.031 Ci iodine-124 0.032 Ci iodine-125 0.075 Ci iodine-126 500 Ci tritium plus activated gases and particulates
Earthquake during plutonium without yield experiment	2×10^{-9}	Not applicable	0.003 g weapons-grade plutonium plus 500 Ci tritium plus activated gases and particulates
Earthquake during plutonium with yield experiment	2×10^{-9}	Not applicable	0.001 g weapons-grade plutonium plus 500 Ci tritium plus fission products, plus activation gases and particulates

Source: LLNL 2003d.

Estimated Health Effects and Risk

Tables M.5.6.1.2–3 and M.5.6.1.2–4 show the frequencies and consequences of the postulated set of NIF accidents for a noninvolved worker, assumed to be a worker located 100 meters from the release point; the population of noninvolved workers; and the public, maximally exposed offsite individual and the general population living within 50 miles of LLNL; for both median and unfavorable meteorological conditions.

TABLE M.5.6.1.2–3.—*National Ignition Facility Accident Frequency and Consequences (Median Meteorology)*

		MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	Frequency (per year)	Dose (rem)	LCFs [b]	Dose (person-rem)	LCFs [c]	Dose (rem)	LCFs [b]	Dose (person-rem)	LCFs [c]
Earthquake during No Action Alternative operations	2.0×10^{-8}	4.78×10^{-4}	2.87×10^{-7}	1.96×10^{-1}	1.18×10^{-4}	1.43×10^{-3}	8.60×10^{-7}	2.08×10^{-1}	1.25×10^{-4}
Earthquake during depleted uranium shot	2.0×10^{-9}	9.68×10^{-4}	5.81×10^{-7}	2.40×10^{-1}	1.44×10^{-4}	2.55×10^{-3}	1.53×10^{-6}	3.48×10^{-1}	2.09×10^{-4}
Earthquake during highly enriched uranium shot	2.0×10^{-9}	1.02×10^{-3}	6.09×10^{-7}	2.47×10^{-1}	1.48×10^{-4}	2.64×10^{-3}	1.59×10^{-6}	3.59×10^{-1}	2.16×10^{-4}
Earthquake during thorium shot	2.0×10^{-9}	1.04×10^{-3}	6.24×10^{-7}	2.43×10^{-1}	1.46×10^{-4}	2.65×10^{-3}	1.59×10^{-6}	3.57×10^{-1}	2.14×10^{-4}
Earthquake during tracer shot	2.0×10^{-9}	5.44×10^{-4}	3.26×10^{-7}	2.09×10^{-1}	1.26×10^{-4}	1.63×10^{-3}	9.80×10^{-7}	2.29×10^{-1}	1.38×10^{-4}
Earthquake during plutonium without yield shot	2.0×10^{-9}	1.65×10^{-3}	9.89×10^{-7}	5.46×10^{-1}	3.28×10^{-4}	4.99×10^{-3}	3.00×10^{-6}	7.41×10^{-1}	4.45×10^{-4}
Earthquake during plutonium with yield shot	2.0×10^{-9}	9.01×10^{-4}	5.41×10^{-7}	3.16×10^{-1}	1.90×10^{-4}	2.69×10^{-3}	1.62×10^{-6}	3.96×10^{-1}	2.38×10^{-4}

Source: LLNL 2003d..

[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.

[b] Increased likelihood of a latent cancer fatality.

[c] Increased number of latent cancer fatalities.

LCFs = latent cancer fatalities; MEI = maximally exposed individual.

TABLE M.5.6.1.2–4.—*National Ignition Facility Accident Frequency and Consequence (Unfavorable Meteorology)*

		MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	Frequency (per year)	Dose (rem)	LCFs [b]	Dose (person-rem)	LCFs [c]	Dose (rem)	LCFs [b]	Dose (person-rem)	LCFs [c]
Earthquake during No Action Alternative operations	2.00×10^{-8}	6.15×10^{-3}	3.69×10^{-6}	3.05	1.83×10^{-3}	1.33×10^{-2}	8.01×10^{-6}	2.22	1.33×10^{-3}
Earthquake during depleted uranium shot	2.00×10^{-9}	1.10×10^{-2}	6.57×10^{-6}	4.51	2.71×10^{-3}	2.25×10^{-2}	1.35×10^{-5}	3.74	2.24×10^{-3}
Earthquake during highly enriched uranium shot	2.00×10^{-9}	1.14×10^{-2}	6.84×10^{-6}	4.67	2.80×10^{-3}	2.33×10^{-2}	1.40×10^{-5}	3.83	2.30×10^{-3}
Earthquake during thorium shot	2.00×10^{-9}	1.14×10^{-2}	6.86×10^{-6}	4.76	2.86×10^{-3}	2.31×10^{-2}	1.39×10^{-5}	4.10	2.46×10^{-3}
Earthquake during tracer shot	2.00×10^{-9}	7.02×10^{-3}	4.21×10^{-6}	3.26	1.95×10^{-3}	1.52×10^{-2}	9.14×10^{-6}	2.44	1.46×10^{-3}
Earthquake during plutonium without yield shot	2.00×10^{-9}	2.16×10^{-2}	1.30×10^{-5}	8.33	5.00×10^{-3}	4.69×10^{-2}	2.82×10^{-5}	8.23	4.94×10^{-3}
Earthquake during plutonium with yield shot	2.00×10^{-9}	1.16×10^{-2}	6.96×10^{-6}	4.98	2.99×10^{-3}	2.50×10^{-2}	1.50×10^{-5}	4.27	2.56×10^{-3}

Source: LLNL 2003d.

[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL.

[b] Increased likelihood of a latent cancer fatality.

[c] Increased number of latent cancer fatalities.

LCFs = latent cancer fatalities; MEI = maximally exposed individual.

TABLE M.5.6.1.2–5. —*National Ignition Facility Accident Frequency and Risk (Median Meteorology)*

		MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	Frequency (per year)	Dose (rem)	LCFs [b]	Dose (person-rem)	LCFs [c]	Dose (rem)	LCFs [b]	Dose (person-rem)	LCFs [c]
Earthquake during No Action Alternative operations	2.00×10^{-8}	9.56×10^{-12}	5.74×10^{-15}	3.92×10^{-9}	2.35×10^{-12}	2.87×10^{-11}	1.72×10^{-14}	4.17×10^{-9}	2.50×10^{-12}
Earthquake during depleted uranium shot	2.00×10^{-9}	1.94×10^{-12}	1.16×10^{-15}	4.80×10^{-10}	2.88×10^{-13}	5.11×10^{-12}	3.06×10^{-15}	6.97×10^{-10}	4.18×10^{-13}
Earthquake during highly enriched uranium shot	2.00×10^{-9}	2.03×10^{-12}	1.22×10^{-15}	4.94×10^{-10}	2.97×10^{-13}	5.29×10^{-12}	3.17×10^{-15}	7.19×10^{-10}	4.31×10^{-13}
Earthquake during thorium shot	2.00×10^{-9}	2.08×10^{-12}	1.25×10^{-15}	4.86×10^{-10}	2.92×10^{-13}	5.31×10^{-12}	3.18×10^{-15}	7.15×10^{-10}	4.29×10^{-13}
Earthquake during tracer shot	2.00×10^{-9}	1.09×10^{-12}	6.53×10^{-16}	4.19×10^{-10}	2.51×10^{-13}	3.27×10^{-12}	1.96×10^{-15}	4.59×10^{-10}	2.75×10^{-13}
Earthquake during plutonium without yield shot	2.00×10^{-9}	3.30×10^{-12}	1.98×10^{-15}	1.09×10^{-9}	6.55×10^{-13}	9.99×10^{-12}	5.99×10^{-15}	1.48×10^{-9}	8.90×10^{-13}
Earthquake during plutonium with yield shot	2.00×10^{-9}	1.80×10^{-12}	1.08×10^{-15}	6.32×10^{-10}	3.79×10^{-13}	5.39×10^{-12}	3.23×10^{-15}	7.93×10^{-10}	4.76×10^{-13}

Source: LLNL 2003d.
[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL
[b] Increased likelihood of a latent cancer fatality.
[c] Increased number of latent cancer fatalities.
LCFs = latent cancer fatalities; MEI = maximally exposed individual.

TABLE M.5.6.1.2–6. — ***National Ignition Facility Accident Frequency and Risk (Unfavorable Meteorology)***

		MEI		Offsite Population [a]		Individual Noninvolved Worker		Noninvolved Worker Population	
Accident	**Frequency (per year)**	**Dose (rem)**	**LCFs [b]**	**Dose (person-rem)**	**LCFs [c]**	**Dose (rem)**	**LCFs [b]**	**Dose (person-rem)**	**LCFs [c]**
Earthquake during No Action Alternative operations	2.00×10^{-8}	1.23×10^{-10}	7.38×10^{-14}	6.10×10^{-8}	3.66×10^{-11}	2.67×10^{-10}	1.60×10^{-13}	4.44×10^{-8}	2.66×10^{-11}
Earthquake during depleted uranium shot	2.00×10^{-9}	2.19×10^{-11}	1.31×10^{-14}	9.02×10^{-9}	5.41×10^{-12}	4.51×10^{-11}	2.71×10^{-14}	7.48×10^{-9}	4.49×10^{-12}
Earthquake during highly enriched uranium shot	2.00×10^{-9}	2.28×10^{-11}	1.37×10^{-14}	9.34×10^{-9}	5.61×10^{-12}	4.66×10^{-11}	2.80×10^{-14}	7.66×10^{-9}	4.60×10^{-12}
Earthquake during thorium shot	2.00×10^{-9}	2.29×10^{-11}	1.37×10^{-14}	9.52×10^{-9}	5.71×10^{-12}	4.62×10^{-11}	2.77×10^{-14}	8.20×10^{-9}	4.92×10^{-12}
Earthquake during tracer shot	2.00×10^{-9}	1.40×10^{-11}	8.42×10^{-15}	6.52×10^{-9}	3.91×10^{-12}	3.05×10^{-11}	1.83×10^{-14}	4.88×10^{-9}	2.93×10^{-12}
Earthquake during plutonium without yield shot	2.00×10^{-9}	4.33×10^{-11}	2.60×10^{-14}	1.67×10^{-8}	1.00×10^{-11}	9.39×10^{-11}	5.63×10^{-14}	1.65×10^{-8}	9.88×10^{-12}
Earthquake during plutonium with yield shot	2.00×10^{-9}	2.32×10^{-11}	1.39×10^{-14}	9.96×10^{-9}	5.98×10^{-12}	5.01×10^{-11}	3.01×10^{-14}	8.54×10^{-9}	5.12×10^{-12}

Source: LLNL 2003d.

[a] Based on the population of approximately 6,900,000 persons residing within 50 miles of LLNL

[b] Increased likelihood of a latent cancer fatality.

[c] Increased number of latent cancer fatalities.

LCFs = latent cancer fatalities; MEI = maximally exposed individual.