Final

ENGINEERING EVALUATION/COST ANALYSIS

LASSEN VOLCANIC NATIONAL PARK

FORMER FIRING RANGE
SHASTA COUNTY, CALIFORNIA

Prepared for:

NATIONAL PARK SERVICE
NPS, Lassen Volcanic NP
38050 Hwy 36 E
Mineral, California 96063
Order No. P16PD03298

August 2017

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS

ALM	Adult Lead Model
ARAR	Applicable or Relevant and Appropriate Requirement
AUF	area use factor
Avatar	Avatar Environmental, LLC
BERA	baseline ecological risk assessment
CalEPA	California Environmental Protection Agency
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CSM	Conceptual Site Model
CWA	Clean Water Act
CWB ESL	California Water Board Environmental Screening Levels
DOI	Department of the Interior
DTSC	Department of Toxic Substances Control
DU	Decision Unit
EE/CA	Engineering Evaluation/Cost Analysis
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ESL	ecological screening level
ESSL	ecological soil screening level
ESV	ecological screening values
Geocon	Geocon Consultants, Inc.
HERO	Human Health and Ecological Risk Office
HH	Human Health

HI	hazard index
HQ	hazard quotient
HRS	Hazard Ranking Score
IEUBK	Integrated Exposure Uptake Biokinetic
ISM	incremental sampling methodology
LANL	Los Alamos National Laboratory
LDR	Land Disposal Restrictions
LOAEL	lowest observed effect level
mg/kg	milligram per kilogram
mg/L	milligram per Liter
µg/dL	microgram per deciliter
NCP	National Oil Pollution and Hazardous Substances Contingency Plan
NOAEL	no observed adverse effect level
NPS	National Park Service
NTCRA	Non-time critical removal action
O&M	operation and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OLEM	Office of Land and Emergency Management
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PRG	preliminary remediation goal
RAA	removal action alternatives
RAO	removal action objectives
REMC	Resource Environmental Management Consultants, Inc.
RSL	Regional Screening Level
LAVO	Lassen Volcanic National Park
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SI	Site Inspection
Site	Former Firing Range
SLs	screening levels

SLERA	screening level ecological risk assessment
SMDP	scientific/management decision points
Soil-GW SSL	soil to groundwater soil screening level
SPLP	Synthetic Precipitation Leaching Procedure
SRE	Streamlined Risk Evaluations
STLC	Solubility Threshold Limit Concentration
TCLP	Toxicity Characteristic Leaching Procedure
T&E	threatened and endangered species
THQ	target hazard quotient
TR	target risk
TRW	Technical Review Work Group for Lead
USEPA	United States Environmental Protection Agency

Executive Summary

Avatar Environmental, LLC (Avatar) was retained by the National Park Service (NPS) to conduct an Engineering Evaluation/Cost Analysis (EE/CA) at the Former Firing Range located within the Lassen Volcanic National Park (LAVO) (Site) in Shasta County, California (see Figure 1). Using their authority under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA), the NPS is engaging in a non-time critical removal action (NTCRA) at the Site.

The Former Firing Range was operated under conditions of a Special Use Permit from the Forest Service from 1974 to 2002 (ENPLAN, 2013). The Site has been closed since 2002, and has remained unused from approximately 2003 to the present. Prior to 1974, the property consisted of undeveloped land. No prior uses of the firing range are known.

In December 2013, a Preliminary Assessment (PA) was conducted at the Site. The investigation estimated roughly 10,000 rounds of lead ammunition were used during the operation period. Due to the large amounts of estimated contamination and noticeable bullets on the Site, the PA recommended a Site Inspection be conducted. In January 2016, Resource Environmental Management Consultants, Inc. (REMC) performed a Site Inspection to investigate the extent of lead contamination. During the Site Inspection, the sampling process determined that lead concentrations in soils at the Site exceeded background concentrations and human health and ecological screening values by large margins. The analysis of the samples classified backstop berm soils as hazardous waste per Title 22 of the California Code of Regulations; therefore, concluding the Site contains unacceptable risks to both human and ecological receptors. In response to these findings, REMC recommended the preparation of an EE/CA for the Site.

The Human Health and Ecological Streamlined Risk Evaluations (SREs) completed as part of this EE/CA concluded that leaving the waste material associated with the Site in place in its present condition could pose an unacceptable risk to human health and ecological receptors

based on exposure to lead in Site soil and potential impacts to groundwater based on exceedances of screening values for the protection of groundwater pathway.

Removal actions evaluated in this EE/CA are based on the following removal action objectives:

1. Remove lead debris and lead containing soil above site-specific calculated cleanup levels from the Site,
2. Prevent or reduce the potential for human and ecological receptor exposure to contaminants of concern (COCs) in soil, and
3. Prevent or reduce potential migration of COCs via surface runoff, erosion, and wind dispersion.

The removal action alternatives (RAAs) based on the above RAOs for this EE/CA included Alternative 1, No Action and Alternative 2, Excavation and Off-Site Disposal. These RAAs were evaluated based on the following criteria:

The effectiveness of RAAs were evaluated using the following criteria:

- Overall protection of public health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long term effectiveness and permanence
- Reduction of toxicity, mobility or volume through treatment, and
- Short term effectiveness

The implementability of RAAs were evaluated using the following criteria:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials, and
- State and community acceptance

The cost of RAAs were evaluated using the following criteria:

- Direct capital costs
- Indirect capital costs, and
- Ongoing operation and maintenance (O&M) costs

Based on the analysis of RAAs, excavation and disposal of contaminated soils exceeding the human health and ecological screening values (ESVs) for site COCs is the recommended alternative. The excavation and offsite disposal is easy to implement, is the most efficient, provides maximum protection to human health and the environment, complies with ARARs, and is cost effective. Since the selected alternative is estimated to require 6 to 9 months to implement, calculation of present worth and post-removal Site control costs are not presented.

1. INTRODUCTION

Avatar Environmental, LLC (Avatar) was retained by the National Park Service (NPS) to conduct an Engineering Evaluation/Cost Analysis (EE/CA) at the Former Firing Range (hereafter referred to as Site) located within Lassen Volcanic National Park (LAVO) in Mineral, California. Under purchase order # P16PD03298, Avatar Environmental, LLC and Geocon Consultants, Inc. (Geocon), a subcontractor to Avatar, have prepared this EE/CA for response activities at LAVO.

This EE/CA has been prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) and the U.S. Environmental Protection Agency (USEPA) *Guidance on Conducting Non-Time-Critical Removal Actions* (NTCRAs) (USEPA, 1993a). This EE/CA is also prepared in accordance with the requirements provided in Section 300.415(b)(4)(i) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (USEPA, 1994a).

1.1 AUTHORITY

Pursuant to Sections 104(a)(1) and (b)(1) of CERCLA, 42 U.S.C. 9604(a)(1) and (b)(1), whenever there is a release or substantial threat of release of a hazardous substance into the environment, the President is authorized to act, consistent with the NCP, to remove or arrange for the removal of such hazardous substance or take any other response action, including appropriate investigation, deemed necessary to protect public health or welfare or the environment. Section 104(a) and (b) response authority (including the authority to perform an NTCRA) has been delegated to the Secretary of the Department of the Interior (DOI) pursuant to Executive Order 1258, 52 Fed. Reg. 2923 (1987), and further delegated to NPS by DOI Departmental Manual Part 207, Chapter 7, with respect to property under the jurisdiction, custody, or control of NPS.

1.2 PURPOSE AND OBJECTIVES

The NPS has determined that a removal action may be required at the Site and therefore an EE/CA must be completed for NTCRAs. The objectives of an EE/CA are the following:

- Site Characterization
    - Evaluate the existing Site information and data and identify any data gaps,
    - Fill data gaps to ensure that sufficient data are available to identify the source, nature and extent of contamination and to assess potential human health and ecological risks posed by the Site,
    - Perform screening level human health and ecological risk assessments,
    - Calculate preliminary risk-based remediation goals (PRGS),
    - Identify removal action objectives (RAOs),
    - Identify and analyze removal action alternatives (RAAs),
    - Conduct a comparative analysis of RAAs for cost, effectiveness, and implementability, and
    - Recommend an RAA.

Section 300.415(b)(2) of the NCP establishes the criteria for determining the appropriateness of a removal action. The following are applicable criteria that support the determination to consider a removal action at the Site:

- Actual or potential exposure to nearby human population, animals, or the food chain from hazardous substances or pollutants or contaminants;
- Actual or potential contamination of drinking water supplies or sensitive ecosystems;
- High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface that may migrate and;
- Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.

Previous Site investigations found lead contaminants exceeding screening criteria, posing a potential risk to the human population and the surrounding environment. Based on these findings, NPS has determined that the use of removal action authority at LAVO to investigate, abate, prevent, minimize, stabilize, mitigate, and/or eliminate the release or threat of release of hazardous substances at or from the Site may be appropriate. Additionally, NPS has determined that a planning period of at least six months exists before on-site activities may be initiated. Therefore, NPS is authorized to conduct an EE/CA pursuant to and in accordance with Section 300.414(b)(4) of the NCP. The Approval Memorandum (Appendix A) provides the authorization for this EE/CA.

2. SITE CHARACTERIZATION

2.1 SITE DESCRIPTION AND BACKGROUND

The area of investigation consists of a former firing range located approximately 1,500 feet west of the western boundary of Lassen Volcanic National Park on Federal lands managed by the Hat Creek Ranger District, Lassen National Forest (Figure 1). A Special Use permit was in place between the Forest Service and the National Park Service during the use of the site as a pistol range. The permit expired in 2002 and the site has not been used since that time. The Site is located approximately a quarter mile southwest of the Manzanita Lake Housing Compound, and is accessed via a dirt road originating at the Manzanita Lake Housing Compound in Lassen Volcanic National Park, Shasta County, California. The firing range is located in the northeast quarter of Section 13, Township 31 North, Range 3 East, Mount Diablo Base and Meridian. The geographic coordinates are 40° 32’ 17.52” North latitude and -121° 35’ 1.32” West longitude. The elevation of the property is approximately 5,680 feet above sea level.

The firing range is located approximately 0.6 miles west of Manzanita Lake. Snow covers much of Lassen Volcanic National Park from approximately mid-October through early June, making the firing range inaccessible by vehicle, often for more than six months of the year. The Site consists of approximately 0.31 acres of land surrounded by forest. It is rectangular and measures approximately 205 feet by 65 feet (Figure 2). The Site is relatively flat, with an earthen berm that was used as a backstop located on the southern end. The backstop berm measures approximately 65 feet long, 8 feet wide and 6 feet high. A small out building is located approximately 50 feet west of the backstop berm. Additional features at the Site include a row of 11 treated 6”x 6” wood posts set into the ground, a second row of 13 untreated 6”x 6” wood posts set into the ground and connected by approximately 50 feet of cable used to hold targets, two pieces of galvanized pipe set into the ground, and sixteen 6”x 6” by 2-foot-long concrete blocks used to mark shooting places.

2.2 SITE HISTORY

The Site was operated under conditions of a Special Use Permit from the Forest Service from 1974 to 2002 (ENPLAN, 2013). The Site has been closed since 2002, and has remained unused from approximately 2003 to the present. Prior to 1974, the property consisted of undeveloped land. No prior uses of the firing range are known. During the period of use, the entrance to the firing range was gated and closed to the public. The firing range was used solely by National Park Service Rangers, Fish and Game Wardens, and Forest Service Law Enforcement Officers. During use of the range, lead bullets accumulated in the backstop berm and were not removed from the Site. Some are still visible on the surface of the backstop berm.

2.3 SITE ENVIRONMENTAL CONDITIONS

2.3.1 Geology

LAVO is located within the Cascade Range geomorphic province which extends from northern California, through Oregon and Washington (ENPLAN, 2013). This range is made up of volcanic flows, pyroclastic rocks and sedimentary rocks, with underlying accumulations of olivine-bearing basaltic lavas. These rock units in the Cascade Range are highly permeable. Surface runoff in some areas of the province is completely absent, suggesting water infiltration to the underlying rock (ENPLAN, 2013). The underlying rock at the Site is dacite, known to be of volcanic origin (ENPLAN, 2013).

2.3.2 Hydrology

With highly permeable rock units, hazardous constituents from the lead bullets could potentially leach into the groundwater due to the porous geology of the area (ENPLAN, 2013). According to the California Department of Water Resources, there are no groundwater supply aquifers within the vicinity of the Site. The nearest aquifer is the Viola unit roughly four miles west of the Site with typical groundwater depths ranging from 100 to 150 feet. Public and private wells are not located near the vicinity of the Site (REMC, 2016). Groundwater sampling was not conducted within the previous SI and not recommended in the PA.

LAVO does not have any surface water located at the firing range, surface runoff in the area is often absent, and the Site is not located within a 100- or 500-year flood zone, making it difficult to transport contaminants via the surface water pathway (ENPLAN, 2013). The nearest body of water, Manzanita Creek, is located 750 feet (ft) south and cross-gradient to the firing range. Manzanita Creek is a tributary to Battle Creek which eventually feeds into the Sacramento River. All nearby residents use Manzanita Creek for their drinking water. The water intake is approximately 1.3 miles upstream and 230 feet higher in elevation from the Site. Although Manzanita Creek is nearby, migration of lead contaminants to Manzanita Creek would likely only occur over a long time span due to the area's permeable geology (ENPLAN, 2013). Therefore, as concluded in the PA, there is low potential for release of lead contaminants to surface waters.

2.3.3 Climate, Vegetation, and Wildlife

2.3.3.1 Climate

Local climate within LAVO fluctuates based on time of year and elevation. Average summer temperatures near Manzanita Lake (approximately ¼ mile from the Site; elevation 5,850') can range from 70°F - 85 °F, whereas average lows in the winter typically fall between 13°F and 15°F (NPS, 2017b). The average annual precipitation at Manzanita Lake is 42.48 inches and average snowfall is roughly 191.0 inches annually. From mid-October to early June much of LAVO is covered with snow.

2.3.3.2 Vegetation

LAVO has multiple elevation-defined Life Zones which represent a variety of different species. Based on the NPS species list database maintained on the Public Lands Flora web site (*http://symbiota.org/nps/checklists/checklist.php?cl=3997&pid=104*) (NPS, No date), approximately 789 different vascular plants are present within LAVO.

At elevations below 6,500 feet (elevation in which the Site occupies) the dominant vegetation community is the mixed conifer forest. The conifer forest includes species such as Ponderosa

and Jeffrey pines, sugar pine, white fir as well as gooseberry, manzanita, iris, spotted coralroot and pyrola (NPS, 2017a).

Above this zone, the red fir forest occurs between elevations of 6,500 and 8,000 feet. Species such as red fir, mountain hemlock, woolly mule's-ears, and pinemat manzanita dominate the landscape.

In the subalpine zone, from 8,000 feet to the treeline, the environment is harsh limiting the overall number of plants. Trees within this community include the whitebark pine and mountain hemlock. Exposed patches of bare ground occur throughout the area with species such as Rock spirea, lupine, Indian paintbrush, and penstemon. Large-scale threats to LAVO's vegetation include climate change, invasive plants and fire suppression (NPS, 2017a).

There are roughly 70 different species of vascular plants which occur at abundant levels within LAVO. Included in this species list are the following (NPS, 2017c):

- Common dandelion
- Western Sweet-cicely
- Changeable scorpionweed
- Red-stemmed Miner's-lettuce
- Lemmon's catchfly
- Three-leaved Lewisia
- Pinemat Manzanita
- Spreading phlox
- Shasta clover
- Pinewoods Lousewort
- Wright's Collinsia
- Purple Fritillary
- Dimorphic Violet
- Rough Bentgrass

The whitebark pine is a candidate for federally threatened and endangered status under the Endangered Species Act (ESA). Species of concern within LAVO include slender water-

nymph and Sierra perennial cryptantha (NPS, 2017c). All candidate species and species of concern are not known to occupy the area of the Site and solely found in other areas of LAVO.

2.3.3.3 Wildlife

Mammals

Based on the NPS LAVO species list database (Appendix B, Table B-2), currently there are approximately 57 different mammal species present within LAVO (NPS, 2017c). Commonly observed species include the following:

- Golden-mantled ground squirrel
- Mule Deer
- Long-eared Myotis
- Little Brown Myotis bat
- Long-legged Myotis bat
- Yuma Myotis
- North American Deermouse
- Mountain Pocket Gopher
- Long-tailed vole
- Montane Vole
- Allen's chipmunk
- Douglas's squirrel
- Trowbridge's shrew
- Vagrant Shrew

Mammals throughout the park are diverse; however, the orders Rodentia and Carnivora hold a large majority of residents within LAVO. There is a total of 18 different rodent species including chipmunks, squirrels, marmots, rats, gophers, mice, voles, muskrats and beavers. Thirteen different carnivorous mammal species reside in the park including black bears, minks, weasels, skunks, cougars, bobcats, and foxes. Of all the species within the park, the Silver-haired bat, Long-eared Myotis, Fringed Myotis, Yuma Myotis, Aplodontia rufa and the Preble's Shrew are identified as species of concern and considered important to monitor. The Sierra Nevada Red Fox is a candidate for California state threatened species. Although these species may be found throughout LAVO, there are no known occurrences of concerned,

candidate, threatened or endangered species within the Site (D. Hanners, personal communication, 2/27/2017).

The Gray Wolf, not considered to be currently present in the park, has occupied the area historically. As stated in the SI, a lone wolf was mapped on and within a four-mile radius of the Site (Appendix C, Figure 4). However, on March 13, 2013 the California Department of Fish and Wildlife (CDFW) confirmed the wolf had returned to Oregon, found a mate and established a territory. On November 2, 2016, the CDFW confirmed two more gray wolves present near LAVO in western Lassen County. The gray wolf species is listed as federally endangered as well as California state endangered (NPS, 2017c).

Birds

LAVO provides habitat for approximately 206 different bird species as presented in Appendix B, Table B-3 (NPS, 2017c). Most of the species that occur in the park are neotropical migrants. These birds use the park in summer to breed and forage and then fly to Central and South America to spend the winter. There are over 60 commonly observed species which include the following:

- California yellow warbler
- Mallard
- Bufflehead
- Common Merganser
- Anna's Hummingbird
- Rufous Hummingbird
- Common Nighthawk
- Killdeer
- California Gull
- Wilson's snipe
- Belted Kingfisher
- Mountain Quail
- Blue Grouse
- American Coot
- Lazuli Bunting
- Western Tanager
- Brown creeper

- Northern Raven
- Steller's Jay
- Cassin's Finch
- Red Crossbill
- Red-winged Blackbird
- Mountain Chickadee
- Hermit Warbler

There are 33 species of concern within the LAVO bird community as presented in Appendix B (NPS, 2017b). These species include the Rufous Hummingbird, Brown creeper, Lincoln's Sparrow, Red Crossbill, Tree Swallow, MacGillivray's Warbler, Nashville Warbler, Wilson's Warbler, and the olive sided flycatcher. The Bald Eagle and the Willow Flycatcher are both listed as California state endangered species. The Black-backed Woodpecker is a candidate for California listed threatened and endangered species of concern (NPS, 2017c). Although these species may be found within the territories of LAVO, these species of concern and endangered species are not known to occupy the Site.

Amphibians, Fish, and Reptiles

Few amphibian, fish, and reptile species occur within LAVO based on the NPS LAVO species list database (Appendix B, Table B-4). Currently, approximately 5 amphibian, 9 fish, and 8 reptile species are actively present within LAVO (NPS, 2017c). Commonly or occasionally observed species include the following:

Amphibians
- Western Toad
- Northern Pacific Treefrog

Fish
- Brook Trout

Reptiles
- Sagebrush Lizard
- Western pond turtle
- Western Skink

- Rubber Boa

Species of concern within LAVO include the Western toad and the Rough-skinned Newt. The Cascades frog was once prevalent in the park but now only a few remain. The reason for the decline is currently unknown and the species is under review for potential listing. The Rainbow Trout is considered federally threatened (NPS, 2017c). Due to the lack of surface water at the Site, these specific species are not of concern within Site boundaries.

2.4 PREVIOUS INVESTIGATIONS

2.4.1 Preliminary Assessment

In December 2013, a Preliminary Assessment (PA) was conducted (ENPLAN, 2013). The investigation estimated roughly 10,000 rounds of lead ammunition were used during the operation period from 1974 to 2002. Due to the geologic layout of the site with porous volcanic rock formations, surface water contamination was considered unlikely. Rainfall soaked into the soils greatly limiting runoff, which most likely allowed for contamination to be carried deeper down. Therefore, it was predicted that infiltration of lead into the groundwater is likely. The Site was given a preliminary Hazard Ranking System (HRS) Score of 11.59. The Site is remote with no residential population, allowing for a lower score. With the findings depicted in the PA, completion of a Site Inspection (SI) was recommended to determine the full extent of lead contamination.

2.4.2 Site Inspection

A SI was performed in January 2016 (REMC, 2016) to quantify the concentration of lead as recommended in the PA. No other contaminants of potential concern (COPCs) were identified. Soil samples were collected during the SI using incremental sampling methodology (ISM) techniques at three locations; background, the firing line area, and the backstop berm. Decision units (DUs) are employed during ISM sampling in which numerous, equal volume increments of substrate are obtained and combined to form one or more ISM samples per DU. ISM samples have been shown to result in better estimates of the mean value for a specific area than discrete samples. ISM soil sampling conducted for the SI determined that lead concentrations

in soils at the Site exceeded background concentrations and human health and ecological screening values by large margins. The SI sampling also determined that the backstop berm soils would be classified as hazardous waste per Title 22 of the California Code of Regulations; therefore, concluding the Site contains unacceptable risks to both human and ecological receptors. REMC recommended the preparation of an EE/CA to select a non-time critical removal action (NTCRA) at the Site.

2.5 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

The sampling process and methodology is detailed in the previous SI (REMC, 2016) (Appendix C). As noted in section 2.4.2, ISM was utilized for sample collection. Two DUs were identified in areas of expected or noted contamination at the Site. One ISM surface soil sample (0-2 inches) was collected from DU-1 located at the firing line area soils, with one replicate ISM sample collected from the same location noted in the SI as DU-4 (for clarity as a replicate, DU-4 will be referenced as DU-1A from this point forward). Another ISM surface soil sample (0-2 inches) was collected from the backstop berm soil (DU-2), with one replicate from the same location noted in the SI as DU-5 (for clarity as a replicate, DU-5 will be referenced as DU-2A from this point forward). In addition to these two DUs, one ISM sample was collected outside of the site boundaries (DU-3) for background comparisons. Figure 3 presents the sampling locations for each DU. All samples obtained from each DU were only analyzed for lead.

As shown in Table 1 (below), lead was detected in all samples. Samples LAVO-DU-2 and LAVO-DU-2A resulted in concentrations greater than 50 mg/kg and were subjected to solubility testing via the Soluble Threshold Limit Concentration (STLC) procedure. STLC results are presented in Table 1 and indicate the backstop berm soils would be classified as hazardous waste per Title 22 of the California Code of Regulations. Due to the fact that LAVO-DU-2 and LAVO-DU-2A STLC results exceeded STLC regulatory limits (>5 mg/L), these samples were also subjected to solubility testing via the Synthetic Precipitation Leaching Procedure (SPLP). SPLP results for both samples were non-detect at a reporting limit of 0.01

mg/L, indicating lead present in the backstop berm soils is non-soluble under normal weathering conditions (REMC, 2016).

Table 1 – Laboratory Results for ISM Samples

Location	Sample	Lead (mg/kg)	STLC (mg/kg)	SPLP (mg/kg)
DU – 1	LAVO-DU-1	18.8	NA	NA
	LAVO-DU-1A	16.1	NA	NA
DU – 2	LAVO-DU-2	567	60	ND
	LAVO-DU-2A	4,570	58.9	ND
DU – 3	LAVO-DU-3	5.5	NA	NA

NA=Not analyzed.
ND = Not detected.

During the SI sampling, two at-depth (three to six inches below surface) grab samples were collected at each decision unit (DU) and analyzed with a field-portable X-Ray Fluorescence Meter (XRF). Below are the results of the XRF measurements.

Table 2 - Field XRF results for at-depth samples

Location	Sample	Lead Concentration (mg/kg)
DU – 1	LAVO-DU1-1	ND
	LAVO-DU1-2	ND
DU – 2	LAVO-DU2-1	ND
	LAVO-DU2-2	209
DU – 3	LAVO-DU3-1	ND
	LAVO-DU3-2	ND

ND = not detected.
Practical Quantitation Limit (PQL) = 10 mg/kg

As shown in Table 2 above, samples for both DU-1 and DU-3 did not contain detected lead concentrations. One grab sample at DU-2 displayed elevated levels of lead exceeding the NPS

ESVs for mammals, birds and plants. Due to the low occurrence of lead concentrations in subsurface soils, the SI concluded lead contamination remains confined to surface soils. Although XRF sampling of single grab samples should not be considered reliable enough to rule out subsurface soils based on this data alone, combined with other information obtained during the PA and SI subsurface soil contamination was removed from consideration for the EE/CA.

2.6 DATA QUALITY AND USABILITY

The data used within this EE/CA was obtained from the SI prepared in 2016. No new data was collected. The ISM technique conducted in the SI followed ITRC 2012 guidance as cited in the SAP which can be found as an appendix to the SI (Appendix C), with the exception noted in the SI that only two replicates were collected from each DU rather than three. The Data Laboratory Report and quality assurance review is presented in Appendix D.

Overall, the results of the quality assurance review indicate the analytical data are of good quality and acceptable for use based on the following:

- Deviations from the Sampling and Analysis Plan are detailed in Section 3.2 of the SI (Appendix C). The deviations do not affect the integrity of the data collected.
- All sample preservation requirements and holding times were met.
- No contaminants were detected for any method blank results reported in the laboratory data package.
- Relative percent differences (RPDs) for laboratory duplicate sample results were within acceptable ranges.
- Matrix spike results were within recovery acceptance limits.
- RPDs for field replicate sample pairs for DU-1 were within acceptable ranges. RPD values for DU-2 total lead analysis exceeded the acceptable range (Appendix C;

Sampling and Analysis Plan). However, RPDs of Soluble Threshold Limit Concentration lead analyses were within the acceptable range. RPD values could not be calculated for SPLP lead analyses due to both sample results being non-detect (REMC, 2016)

3. STREAMLINED RISK EVALUATION (SRE)

3.1 HUMAN HEALTH SRE

As discussed in USEPA's *Guidance on Non-Time-Critical Removal Actions Under CERCLA* (USEPA, 1993a), the Human Health (HH) SRE is intermediate in scope between the limited risk evaluation undertaken for emergency removal actions and the conventional baseline assessment typically conducted for remedial actions. The SRE is intended to identify what current or potential exposure should be prevented based on the potential risk if no cleanup action is taken at the Site. The results of the SRE inform decision makers about whether a cleanup action is required at the Site and what exposures need to be addressed by the action, and if necessary, define appropriate risk-based cleanup levels. This HH SRE specifically addresses the extent of lead contamination, as well as classification of the firing range material and impacted soil for potential off-site disposal.

3.1.1 Exposure Mechanisms and Exposure Routes

The primary sources of contamination at the Site are related to the former firing range activities that occurred from 1974 to 2002 as discussed in Section 2.3. Generally, contaminants may be released from soil by mechanisms such as storm water runoff, wind erosion of surface soil, leaching and infiltration to the subsurface, migration through the subsurface soil to the water table, or excavation within areas of contamination. Once released from the source, contaminants are transported to and in media such as groundwater, air, surface water, or sediment.

Based on the review of the current and potential land and water uses and the results of previous investigations, the primary exposure media of potential concern to human receptors at the Site consists of surface soils.

As discussed in section 2.3.2., due to the depth to groundwater, distance from the nearest aquifer and the lack of public and/or private wells near the site, the groundwater exposure pathway is likely not a complete exposure pathway and was not quantitatively evaluated for human health receptors. The SPLP analysis determined lead present at the Site is non-soluble

under normal weathering conditions (REMC, 2016) lowering the probability of lead release to groundwater. Additionally, as discussed in the PA and SI, contaminant migration to surface waters is unlikely with low quantities of surface runoff and no surface water bodies used for drinking water sources located within 15 downstream miles of the Site. Direct contact with soils (soil ingestion and dermal absorption) are the potential complete exposure routes for current and future human health receptors.

3.1.2 Receptors

As shown on Figure 4, potentially complete exposure pathways (source(s), release and transport mechanism(s), contaminated media, potential exposure routes, and receptors) exist at the Site. Potential current and future exposed human health receptors include Site workers (NPS staff and subcontractors) and recreational visitors.

3.1.2.1 Selection of Contaminants of Potential Concern

The COPC screening process was conducted in this EE/CA to identify which, if any, DUs had lead concentrations detected in the soil that could pose a potential risk to human receptors coming in contact with the affected media. The screening criteria that were used in this HH SRE to determine if lead was a COPC included:

- A comparison of the detected lead concentrations to health-based screening levels –
    - USEPA Residential and Industrial Regional Screening Levels (RSLs, USEPA, 2016). As discussed in the USEPA RSLs User Guide (USEPA, 2016), EPA has not reached a consensus on lead toxicity criteria (reference doses or cancer slope factors). An EPA Office of Solid Waste and Emergency Response (OSWER) directive: *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (USEPA, 1994b) recommends that based on the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model results, residential soil lead levels less than 400 mg/kg are generally safe for residential soils (USEPA, 1994b). The USEPA screening level of 800 mg/kg

for non-residential receptors exposed to lead is based on the National Health and Nutrition Examination Survey (NHANES III).

  - California Department of Toxic Substances Control Residential and Industrial Screening Levels (DTSC-SLs, DTSC, 2016) and CalEPA Office of Environmental Health Hazard Assessment (OEHHA) Residential and Industrial Human Health Screening Levels (CHHSLs, CalEPA, 2010). Both of these references include the residential and industrial lead SLs as presented in CalEPA's *Revised California Human Health Screening Levels for Lead* (CalEPA, 2009). The DTSC LeadSpread model was used to estimate the residential child SL of 80 mg/kg based on a concentration in soil that would lead to increased blood lead levels of up to 1 microgram per deciliter (µg/dL) in a child resident. The USEPA Adult Lead Model (ALM) was used to derive the industrial SL of 320 mg/kg based on a concentration in soil that would lead to increased blood lead levels of up to 1 µg/dL in the fetus of an exposed adult worker.
  - Final Screening Level (SL) – The Final SL is based on the minimum of all available screening levels. Although the residential value is usually the more conservative value, the industrial values were included based on the current and future use of the site and for informational purposes.

- If the maximum detected lead concentration was less than the Final SL, lead was eliminated from further consideration in the HH SRE. If the maximum concentration exceeded the Final SL, it was identified as a COPC.

Soil to Groundwater Soil Screening Levels (Soil-GW SSLs) – The USEPA Soil-GW SSLs are included for the protection of groundwater pathway (USEPA, 2016). These values are based on the minimum of both the risk-based and MCL-based values presented in the RSL table. For the protection of groundwater pathway, all samples analyzed for lead, except for background, exceeded their respective Soil-GW SSL. Table 3 presents the COPC selection process for the

DUs analyzed for lead in soil. Based on detected concentrations in exceedance of the Final SL, lead was determined to be a Site COPC for human health within DU-2.

Table 3 - Laboratory Analytical Results and Screening Evaluation – Human Health

LAVO Former Firing Range	Reporting Units	Human Health							EPA Soil-GW SSLs	DU-1		DU-2		Background DU-3	Human Health COPC[a]	Exceeds Soil-GW SSL
		EPA RSLs (Residential)	EPA RSLs (Industrial)	DTSC-SLs (Residential)	DTSC-SLs (Industrial)	CHHSLs (Residential)	CHHSLs (Industrial)	Final SL		LAVO-DU-1	LAVO-DU-1A	LAVO-DU-2	LAVO-DU-2A	LAVO-DU-3*		
Sample Date										11/12/2015	11/12/2015	11/12/2015	11/12/2015	11/12/2015		
Metals																
Total Lead	mg/kg	400	800	80	320	80	320	80	14	18.8	16.1	567	4570	5.5	YES DU-2	YES DU-1/DU-2
Soluable Lead (STLC)	mg/L											60	58.9			
Soluable Lead (SPLP)	mg/L											ND	ND			

Notes:

EPA RSLs = Environmental Protection Agency (EPA) Regional Screening Levels (RSL) (May, 2016)

EPA Soil-GW SSLs = EPA soil to groundwater screening values obtained from the RSL Table (May, 2016).

CHHSLs = California Human Health Screening Levels (CHHSL) (CalEPA, 2010)

DTSC-SLs = California Department of Toxic Substances Control Human Health Screening Levels (June 2016).

Final SL = Minimum of available human health residential and industrial screening levels.

[a] Human Health Contaminants of Potential Concern (HH COPCs) selected based on detected concentrations in exceedance of Final SL. Shaded values indicate HH COPCs.

*LAVO-DU-3 D from Site Investigation was not included. Sample is a laboratory duplicate and not representative of the sample set. LAVO-DU-3 is site specific background concentration.

ND = not detected.

Shaded values indicate exceedences of Final SL.

3.1.2.2 Exposure Point Concentrations (EPCs)

EPCs are the COPC concentrations that a receptor is assumed to contact during exposure to site COPCs. Since ISM sample techniques were used, the sample size of the study is relatively small. Each DU contains one sample and one replicate, so the limited sample size prevents the use of ProUCL to calculate a 95% UCL. Therefore, EPCs were determined through ITRC guidelines for ISM, Decision Mechanism 2. Under this guidance, the mean concentration of the replicates is calculated and compared to the action level. Per ITRC Guidance, averaging replicate samples may likely be closer to the true mean of the DU than the result from a single ISM sample and could consequently be considered to provide a more reliable estimate of the mean (ITRC, 2017).

3.1.2.3 Risk Characterization

Based on current and reasonably anticipated future use of the Site, lead exposure to a residential receptor was not evaluated. Reasonably anticipated receptors include Site workers (NPS staff and subcontractors) and recreational visitors. In order to address the lead exposure to these receptors, the following evaluations have been conducted:

- Site Workers: the lead EPC was compared against the USEPA Industrial Soil RSL and the California Water Board Environmental Screening Level (CWB ESL) to develop noncancer hazard quotients (HQs). The USEPA ALM was also run in order to address the fetus of an exposed Site worker;

- Recreational Visitors: The USEPA IEUBK model was run in order to address potential exposure to the child recreational visitor and the ALM was run in order to address the fetus of an exposed adult recreational visitor.

In order to address potential lead exposure to Site workers, the lead EPC was compared against the USEPA Industrial Soil RSL and the CWB Construction Worker ESL to develop a noncancer HQ. Both the USEPA RSLs and the CWB ESLs for lead were calculated using blood lead models rather than the standard USEPA algorithms for calculating risk and noncancer health effects to COPCs. As discussed previously in Section 2.7.1.3, the USEPA

Industrial Soil RSL for lead is based on a recent analysis of the combined phases of the National Health and Nutrition Examination Survey (NHANES III) that choose a cleanup goal protective for all subpopulations. The CWB ESL was also included in the risk evaluation for a future potential construction worker as an additional line of evidence in accordance with California DTSC guidance. The toxic endpoint used to derive the CWB ESLs is based on the relationship between blood-lead levels and cognitive ability; where an increase of 1 µg/dL in blood lead is calculated as having no more than a 2.5 percent probability of decreasing intelligence quotient by more than 1 point in a child or fetus at the 90th percentile of the blood lead distribution in the general population. The LeadSpread Model was used to estimate the concentration in soil that would lead to a 1 µg/dL increase in blood lead for people exposed to lead in soil (CWB, 2016). The construction worker was assumed to be exposed during an 8-hour workday for the duration of one year.

The noncancer HQs were derived by dividing the EPC by its noncancer-based screening criteria as is presented in the following equation:

Hazard Quotient = EPC/RSL or ESL

Where:

EPC	=	COPC-specific exposure point concentration as mg/kg.
RSL	=	COPC-specific Noncancer-Based USEPA Industrial Soil RSL as mg/kg.
ESL	=	COPC-specific Noncancer-Based California Water Board Construction Worker ESL as mg/kg.

HQs of less than one indicate that adverse health effects associated with the exposure scenario are unlikely to occur. Hazard Indices (HIs) are typically derived by summing the HQs of all COPCs. However, since only one analyte was sampled in this investigation and only the soil pathway was assessed, an HI was not calculated.

The noncancer HQ derived for lead resulted in a value of 3.2 and 16 based on the USEPA Industrial Soil RSL and the CWB Construction Worker ESL, respectively (see Table 4). Both HQs exceeded the noncancer benchmark of 1.0. A HI was not calculated due to the absence of additional noncancer COPCs.

Table 4 – Human Health Streamlined Risk Evaluation Hazard Quotient Summary

Lassen Volcanic National Park Former Firing Range	**Lead at DU-2* (mg/kg)[a]**
Background[b]	5.5
Minimum Concentration	567
Maximum Concentration	4570
Average Concentration	2569
Standard Deviation	2831
Exposure Point Concentration[c]	2569
EPA RSL - Industrial[d]	800
CWB ESL - Construction Worker[e]	160
Hazard Quotient (HQ) - EPA RSL - Industrial Cancer Risk	**3.2**
HQ - CWB ESL - Construction Worker Cancer Risk	**16**

Notes:

[a] Additional Lead evaluation available, see Appendix E for the EPA Adult Lead Model output.

[b] Site specific background concentration.

[c] Average concentration used following ITRC guidelines.

[d] EPA Industrial Worker Soil RSL (May 2016); TR of 1E-6/THQ of 0.1.

[e] California Water Board Construction Worker Environmental Screening Levels (ESLs) (February 2016).

*DU-2 had one primary sample and one replicate for a total of two data points.

Bold values indicate HQs greater than 1.0.

Although the DTSC-SLs and CHHSLs screening criteria presented in Table 3 were based on the CalEPA LeadSpread Model, the DTSC does not recommend adult exposures to lead be evaluated using the LeadSpread model at this time, and additional revision of the model is planned to ensure it is adequately protective of women of child-bearing age (DTSC, 2011). Therefore, in order to address exposure to lead to the fetus of an exposed Site worker, the USEPA ALM (USEPA, 2009) was used to characterize lead risk. The ALM is a slope-factor

approach developed by the USEPA Technical Review Work Group for Lead (TRW) (USEPA, 2003). The ALM slope factor approach focuses on estimating fetal blood lead concentrations in women exposed to lead-contaminated soil in non-residential scenarios. The ALM estimates the 95th percentile blood lead concentration among fetuses born to women having site exposures. Blood lead levels are compared to the established blood lead level of concern of 10 µg/dL. An additional step in the process estimates the probability that blood lead levels will exceed 10 µg/dL. USEPA's risk reduction goal for lead is that individuals exposed would have no more than a 5 percent probability of exceeding the level of concern of 10 µg/dL.

The lead EPC (2,569 mg/kg), as well as default parameters recommended by the TRW were used in the ALM. Although the default soil ingestion rate for the ALM is 50 mg/kg, this value is based on a central tendency value for non-contact-intensive activities. For this evaluation, it was assumed that an outdoor worker may have more contact-intensive activities at the Site and therefore a soil ingestion rate of 100 mg/kg was assumed (USEPA, 2014). Default recommended values were assumed for all of the remaining input criteria. The ALM estimated that the 95th percentile blood lead concentration among fetuses born to women Site workers exposed to soil at the Site would be 22.4 µg/dL (Appendix E, Table E-1). This estimate is higher than USEPA's established level of concern of 10 µg/dL. The probability that the fetal blood lead concentration exceeds 10 µg/dL is 39.11% for pregnant Site workers exposed to soil. USEPA's target probability is 5 percent or less. Because of recent scientific evidence that has demonstrated adverse health effects at blood lead concentrations below 10 µg/dL down to 5 µg/dL, and possibly lower, the USEPA Office of Superfund Remediation and Technology Innovation (OSRTI) is developing a new soil lead policy to address this new information (USEPA, 2009). The results of the ALM indicate that adverse effects are anticipated for fetuses of pregnant workers exposed to lead in soil at the Site.

In 2007, CalEPA's OEHHA developed a new and more conservative toxicity evaluation of lead replacing the 10 µg/dL threshold blood concentration with a source-specific "benchmark change" of 1 µg/dL (DTSC, 2011). One µg/dL is the estimated incremental increase in children's blood lead that would reduce IQ by up to 1 point. When comparing the results of

the ALM to the OEHHA threshold of 1 µg/dL, there is even stronger evidence for the occurrence of adverse effects for fetuses of pregnant workers exposed to lead in soil at the Site.

In order to address child recreational visitor exposure to lead in soil at the Site, the USEPA IEUBK model was evaluated (USEPA, 1994c and 2007). The IEUBK Model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure under a residential scenario. Therefore, the IEUBK model represents a conservative approach to evaluating recreational visitor exposure to lead at the Site. A soil ingestion rate of 200 mg/kg and an age range of 0-84 months were assumed for the recreational child IEUBK evaluation. Default recommended values were assumed for all of the remaining input criteria. The model results estimated that the geometric mean blood lead concentration among child recreational visitors exposed to soil at the Site would be 3.026 µg/dL (Appendix E, Table E-2). This estimate is less than EPA's established level of concern of 10 µg/dL but is greater than the OEHHA threshold of 1 µg/dL. The probability that the child's blood lead concentration exceeds 10 µg/dL is 0.549%, which is less than EPA's target probability of 5% or less.

As with the Site worker scenario, in order to address exposure to lead to the fetus of an exposed adult recreational visitor, the USEPA ALM was used to characterize blood lead levels. The lead EPC of 2,569 mg/kg, a soil ingestion rate of 50 mg/kg, an exposure frequency of 52 days/year (professional judgement of 2 days/week for 6 months of the year), and default parameters recommended by the TRW were used. The ALM estimated that the 95th percentile blood lead concentration among fetuses born to adult recreational visitors exposed to soil at the Site would be 4.4 µg/dL (Appendix E, Table E-3), which is less than USEPA's level of concern of 10 µg/dL but greater than the OEHHA threshold of 1 µg/dL. The probability that the fetal blood lead concentration exceeds 10 µg/dL is 0.12% for pregnant recreational visitors exposed to soil, which is less than USEPA's target probability of 5% or less. Therefore, exposure to lead in Site soil to adult and child recreational visitors does not exceed EPA's target level of concern but would be a concern based on the OEHHA threshold.

The input parameters used, the results of the ALM and IEUBK, and estimated blood lead levels are presented in Appendix E.

3.1.3 Site-Specific Background

As presented in Table 3, one background surface soil sample (DU-3) was collected following ISM sampling protocols with a total of 30 increments, during the SI sampling event (Appendix C). The site-specific background concentration is used for comparison purposes within this EE/CA. All data points obtained from the Site exceed the site-specific background concentration (5 mg/kg), in some instances by up to three orders of magnitude. For comparison, regional background values were obtained from the USGS for lead. According to the USGS professional paper titled "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States", the northwestern portion of California depicts average surficial lead values ranging from 16 mg/kg to roughly 20 mg/kg (Shacklette, 1984).

3.1.4 Human Health Preliminary Remediation Goals

The ALM was used to calculate a human health PRG based on exposure to lead to the fetus of an exposed adult Site worker and/or child recreational visitor. Because the exposure assumptions were more conservative, the Site worker, rather than the pregnant adult or child recreational visitor, was used for the PRG calculation. As presented in Appendix E Table E-4, the lead PRG for the fetus of a pregnant Site worker is 981 mg/kg.

3.1.5 Uncertainty Analysis

The goal of an uncertainty analysis in a risk assessment is to provide to the decision makers (i.e., risk managers) information about the key assumptions, their inherent uncertainty and variability, and the impact of this uncertainty and variability on the estimates of risk. The uncertainty analysis shows that risks are relative in nature and do not represent an absolute quantification. The discussion below identifies the relevant uncertainties in the HH SRE process to determine if the calculated risks may have been overestimated or underestimated, and the approximate degree to which this may have occurred. A summary of these uncertainties can be found in Table 5 below.

There are multiple areas of uncertainty within this risk evaluation, most of which correspond to sampling techniques. For example, the small number of samples collected brings about uncertainty to the true characterization of the site and could cause an over- or under-estimation. Unfortunately, during the SI sampling event a miscommunication caused two replicates to be obtained rather than a triplicate set. A triplicate set could have brought about less uncertainty within DU-2 since the two samples obtained at this DU displayed a large difference in contamination. In addition, there is uncertainty associated with the background value due to the collection of solely one background ISM sample.

The true extent of contamination at the site is uncertain since the only metal analyzed was lead. Bullets contain other metal constituents such as copper and antimony which could cause additional risk at the site. Since lead was the only analyte, additive effects from additional analytes were not accounted for. The depth of contamination is an additional uncertainty within this risk evaluation. The sampling and analysis method used to rule out subsurface soil was not sufficient or reliable enough method to make a final decision in extent of contamination. In order to properly rule out an area of potential contamination, laboratory analysis of samples should be utilized. Lastly, the IEUBK Model brings uncertainty to the risk evaluation because it is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure under a residential scenario. Therefore, the IEUBK model represents a conservative approach to evaluating the recreational visitor exposure to lead at the Site and may overestimate risks.

Table 5 – Summary of Major Uncertainties in the Human Health Streamlined Risk Evaluation

Assessment Component	Uncertainty Description	Likely Direction of Effect on Risk Estimates	Likely Magnitude of Effect on Risk Estimates
Nature and Extent of Contamination	Lead was the only contaminant analyzed even though bullets contain other metal constituents.	Likely underestimate	Could be significant
	Only one background sample was collected limiting the confidence in the site-specific background value.	Unknown	Could be significant
	Sampling method and analysis for depth contamination is not necessarily reliable enough to assume uncontaminated subsurface soil.	Unknown	Could be significant
Exposure Assessment	Some exposure pathways not evaluated. (Inhalation)	Underestimate	Unknown; not expected to be significant
Risk Characterization	The HQ approach indicates potential for risk but not true magnitude.	Unknown	Unknown
	Synergistic, antagonistic, or additive effects of contaminant mixtures are not accounted for since lead was the only contaminant evaluated.	Unknown	Variable
	IEUBK input parameters are based on a residential receptor.	Overestimate	Could be significant

3.2 ECOLOGICAL SRE

The ecological SRE documents the potential exposure and risks to ecological receptors exposed to soil contamination within the Site. During the SRE process, contaminants of potential ecological concern (COPECs) are identified, the potential for wildlife exposure to COPECs is evaluated, and a conservative analysis of the consequent ecological risk is conducted. The SRE provides one of the bases for risk management decisions for the Site.

This SRE was conducted in accordance with the USEPA requirements. The primary sources of guidance used to develop this SRE include:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (hereafter, referred to as the EPA Guidance) (USEPA, 1997).*
- *NPS Protocol for the Selection and Use of Ecological Screening Values for Non-Radiological Analytes,* Rev. 2, Feb. 18, 2016 *(hereafter, referred to as NPS Protocol)* (NPS, 2016).

The USEPA guidance (USEPA, 1997) describes a progressive and iterative process that is consistent with and incorporates the basic and fundamental approach to performing ecological risk assessments (ERAs) outlined in USEPA's Risk Assessment Forum in its Framework for Ecological Risk Assessment (Framework) (USEPA, 1992) and Guidelines for Ecological Risk Assessment (USEPA, 1998). The NPS (2016) describes the hierarchy and final selection of ecological screening values (ESVs) to be used in this SRE. These ESVs are not cleanup goals and are only intended to facilitate the identification of chemicals of potential ecological concern (COPECs).

The USEPA Guidance outlines an 8-step process and several scientific/management decision points (SMDPs). An SMDP represents a significant communication point for the interaction of the risk manager and the risk assessment team. The purpose of the SMDP is to evaluate the relevant information and to re-evaluate the scope, focus, and direction of the ERA.

This SRE covers Step 1 – Screening-level problem formulation and ecological effects evaluation and Step 2 – Screening-level preliminary exposure estimates and risk calculation and the first SMDP outlined in the 8-step ERA process (Figure 5).

In Step 1, the following information is provided:

1) a habitat description of areas potentially affected;
2) a discussion of the ecological conditions and potential receptors present at the Site;
3) the preliminary conceptual site model (CSM) (e.g., pathways by which the receptors may be exposed);
4) the preliminary assessment and measurement endpoints;
5) the data available to evaluate the Site; and
6) the medium-specific, screening-level ESVs appropriate for screening ecological risk.

In Step 2, site-specific contaminant concentration data are compared with the screening-level ESVs to determine the potential for ecological risk and, if a potential risk is indicated, the COPECs are identified.

The following documents were also used in the development of the SRE:

- *Guidelines for Ecological Risk Assessment* (USEPA, 1998);
- *Framework for Ecological Risk Assessment* (USEPA, 1992);
- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001);
- *Wildlife Exposure Factors Handbook, Volumes I and II* (USEPA, 1993b); and
- *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (USEPA, 1999);
- *SLERA guidance EPA 540/F-01/014* (USEPA, 2001).

The site-specific SRE is discussed in detail below.

3.2.1 Screening-Level Problem Formulation and Ecological Effects Evaluation

The initial Problem Formulation step in the SRE and USEPA's SLERA includes the evaluation and aggregation of information available for the Site. This initial step provides the basis for the streamlined assessment and consists of a variety of technical components including:

- Description of the Ecological Setting;
- Development of a Preliminary CSM;
- Selection of Preliminary Assessment Endpoints;
- Description of Site Studies and Available Data;
- Evaluation of Data and Reduction;
- Selection of Ecological Screening Values;
- Identification of COPECs.

3.2.1.1 Ecological Setting

This SRE focuses on the Former Firing Range, Lassen Volcanic National Park, Shasta County, California (LAVO) (Figure 1). As previously discussed, the Site is composed of approximately 0.31 acres of land surrounded by forest. It is rectangular in size, relatively flat with an earthen berm at the southern end used as a backstop where lead bullets were observed during previous site visits (ENPLAN, 2013). A detailed site description is presented in Section 2.1. During the PA, no evidence was seen of stressed vegetation, discolored water, stained soils or other obvious paths of contamination. Most of the Site is a soil and gravel field covered with pine needles. From approximately mid-October to early June the Site is regularly covered with snow. The tree canopy is made of mixed conifers such as sugar pine, white fir, and Ponderosa and Jeffrey pines. Some shrubs may be found at the Site including manzanita, gooseberry and ceanothus (see PA photo log in Appendix C). At the Site elevation of 5,680 ft, wildflowers including iris, spotted coralroot, violets and lupine may be present from late May to early July (NPS, 2017a). A detailed description of natural habitats and species at the Site is provided in section 2.4. Potential threatened and endangered species (T&E) are highlighted below.

Use of the NPSpecies database (NPS, 2017c) for species occurrence at LAVO, allowed for the development of a T&E species list. A search was done for T&E species, species of concern, and candidate animal, bird, reptile, amphibian, fish and vascular plant species found to be present within LAVO. Results of the search indicate that the rainbow trout (*Oncorhynchus mykiss*) is the only federally threatened or endangered species known to be present in the park. Manzanita Lake, approximately 0.62 miles upgradient of the Site is an impoundment of the nearby Manzanita Creek. This lake is known to support rainbow trout which allows for the possibility of rainbow trout presence in Manzanita Creek during the winter and spring seasons when water is present (ENPLAN, 2013).

There is also one candidate plant species and two plant species of concern. There are six mammals (Table B-2), 33 birds (Table B-3), one reptile and one amphibian found to be species of concern (Table B-4). The Sierra Nevada Red Fox, Willow Flycatcher and the Bald Eagle are all listed as California state T&E.

The search only identifies species that occur or are expected to occur throughout the entirety of LAVO. As the Site is a total of 0.31 acres, the presence of species of concern, threatened, or candidate species is unlikely and assumed limited to insignificant transient occurrences. Communication with LAVO's Environmental Protection Specialist further concluded there are no known occurrences of threatened or endangered species at the Site (D. Hanners, personal communication, 2/27/2017).

3.2.1.2 Preliminary Conceptual Site Model

Based on the study area and potential contaminant migration, a preliminary ecological CSM was developed and is presented as Figure 6. The ecological CSM describes contaminant source(s), ecological exposure pathways, exposure media and routes of exposure, and ecological receptors.

As discussed in the SI, due to lead's general tendency to strongly adsorb to soil particles and colloids and the low concentrations of lead observed in subsurface soils, there is low potential for a release of lead from the Site into groundwater (REMC, 2016). Therefore, the groundwater

exposure pathway is likely incomplete and will not be quantitatively evaluated for ecological receptors in the EE/CA. Additionally, LAVO does not have any surface water located at the firing range, surface runoff in the area is often absent, and the Site is not located within a 100- or 500-year flood zone, making it difficult to transport contaminants via surface water (ENPLAN, 2013). Similarly, the sediment exposure pathway is likely incomplete due to lack of occurrence at the Site. The inhalation of contaminants in fugitive dust by birds and mammals is expected to be a relatively minor source of exposure; and, therefore was not included in the quantitative evaluation.

Selection of Ecological Receptors

Multiple tropic levels were evaluated in this SRE. Primary producers (terrestrial plants) were evaluated by comparing soil concentrations to phytotoxicity ESVs; primary, secondary, and tertiary consumers (soil invertebrates, invertivorous birds and mammals) were evaluated by comparing soil concentrations to their respective ESVs, as directed by NPS Protocol. The SRE cannot evaluate potential adverse effects to every individual plant, animal, or community present and potentially exposed to chemical contamination at the Site. As part of the SRE, plant and animal (birds and mammals) species are selected to serve as surrogates by which risk to these taxa are evaluated. The following is a list of communities evaluated in this SRE.

- Vascular plants
- Soil invertebrates
- Invertivorous birds
- Invertivorous mammals

Section 2.4.1.3 describes species found in the park, however, suitable habitat necessary to support amphibian, reptile and fish populations is not present at the Site and they were not evaluated in this SRE.

3.2.1.3 Preliminary Assessment Endpoints and Measures of Effect

Endpoints are defined as ecological characteristics (e.g., invertebrate survival) that may be adversely affected by site contaminants (USEPA, 1992). In the ERA process, two distinct types of endpoints are identified: assessment endpoints and measures of effect (previously named measurement endpoints).

Assessment endpoints are "explicit expressions of environmental values to be protected, operationally defined as an ecological entity and its attributes" (USEPA, 1998). A measure of effect is defined as "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint." Measures of effect link the conditions existing on site to the goals established by the assessment endpoints through the integration of modeled, literature, field, or laboratory data (Maughan, 1993).

In the SRE and USEPA's SLERA (i.e., Steps 1 and 2 of the ecological risk assessment process), the COPEC selection process facilitates the timely identification of those chemicals at levels with the potential to cause harm to the ecological receptors on site. As such, the preliminary measures of effect for Screening Level 1 (i.e., Step 1) are limited to medium-specific ESVs that were used as conservative screening levels to determine initial COPECs as noted below (Table 6).

Table 6 – Level 1 Screening

Level 1 Screening		
Receptor	**Assessment Endpoint**	**Measure of Effect**
Terrestrial plants	Plant growth, yield, or germination	HQ based on COPEC soil concentration comparison with literature-based phytotoxicity values.
Soil Invertebrates	Support of a functioning soil invertebrate community	HQ based on COPEC soil concentration comparison with literature-based effect values.
Invertivorous Birds	Support of a functioning invertivorous bird community	HQ based on dietary intake of COPECs by birds using site-specific soil concentrations, media and chemical-specific uptake factors, dietary exposure models, and literature-based effect values.
Invertivorous Mammals	Support of a functioning invertivorous mammal community	HQ based on dietary intake of COPECs by mammals using site-specific soil concentrations, media and chemical-specific uptake factors, dietary exposure models, and-literature based effect values.

3.2.1.4 Available Data

The soil data summary is presented in Table 7. Soil data were collected from three DUs, one DU in each of the following locations: the backstop berm, the firing line area, and an area adjacent to the Site in order to determine background contamination (see Figure 3). All samples were analyzed for lead and those samples with values higher than 50 mg/kg were analyzed for soluble lead using STLC and SPLP (Section 2.6). A more detailed description of sample collection, analysis, and justification for their collection is provided in the 2016 SI, which is included in Appendix C (see Appendix C; Section 3).

Table 7 – Laboratory Analytical Results and Screening Evaluation - Ecological

LAVO Former Firing Range	Reporting Units	Ecological			DU-1		DU-2		Background DU-3	Ecological COPEC[b]
		NPS ESVs (Plants & Soil Invertebrates)	NPS ESVs (Birds & Mammals)	Final ESV	LAVO-DU-1	LAVO-DU-1A	LAVO-DU-2	LAVO-DU-2A	LAVO-DU-3*	
Sample Date					11/12/2015	11/12/2015	11/12/2015	11/12/2015	11/12/2015	
Metals										
Total Lead	mg/kg	50	0.94	0.94	**18.8**	**16.1**	**567**	**4570**	5.5	YES DU-1/DU-2
Soluable Lead (STLC)	mg/L						60	58.9		
Soluable Lead (SPLP)	mg/L						ND	ND		

Notes:
NPS ESV = National Park Service Ecological Screening Value for SLERA COPEC Selection (NPS February 2016 Revision 2, Tables 5 and 6).
NPS ESV Final = Minimum of plants and soil invertebrates ESV and birds and mammals ESV.
[b] Ecological Contaminants of Potential Ecological Concern (COPECs) selected based on detected concentrations in exceedance of Final ESV. Bolded values indicate Ecological COPECs.
*LAVO-DU-3 D from Site Investigation was not included. Sample is a laboratory duplicate and not representative of the sample set. LAVO-DU-3 is site specific background concentration.
ND = not detected.
Bold values indicate exceedences of Final ESV.

3.2.1.5 COPEC Selection

The direct exposure medium at the Site is soil. Soil concentrations are compared to soil-based ESVs to identify potential COPECs. ESVs are not cleanup goals. ESVs for the COPEC screening were obtained from NPS (2016), and are presented as "SLERA COPEC Selection ESVs" in Tables 5 and 6 of the Protocol. For the COPEC screening of plants and soil invertebrates, the minimum ESV of plant and soil invertebrate "SLERA COPEC Selection ESV" from the NPS Protocol was used. Similarly, for the birds and mammals, the lower of the two ESVs was determined and reported in Table 7 of this report. These ESVs were used to select COPECs and not intended to be used as cleanup goals. As illustrated in Table 7, lead is a COPEC in DUs 1 and 2.

3.2.1.6 Level 2 Screening – Exposure and Effects Evaluation / Risk Calculation

Receptors selected for a Level 2 screening are described in Table 8 along with the associated assessment and measurement endpoints. The assessment endpoints are defined as the ability of the soil environment to support a functioning community containing multiple trophic levels.

Table 8 – Level 2 Screening

Refined SRE HQ Calculation (Level 2 Screening)		
Receptor	**Assessment Endpoint**	**Measurement Endpoint**
Terrestrial Plants	Support of a functioning plant community	HQ based on intake of COPECs by plants using site-specific soil concentrations and literature-based effect values.
Soil Invertebrates	Support of a functioning soil invertebrate community	HQ based on dietary intake of COPECs by soil invertebrates using site-specific soil concentrations and literature-based effect values.
Invertivorous Birds	Support of a functioning invertivorous bird community	HQ based on dietary intake of COPECs by birds using site-specific soil concentrations and literature-based effect values.
Invertivorous Mammals	Support of a functioning invertivorous mammal community	HQ based on dietary intake of COPECs by mammals using site-specific soil concentrations and-literature based effect values.

3.2.1.7 ESV for Abiotic Media and Wildlife

The ecological effects evaluation is the qualitative and quantitative description of the relationship between the stressor and response (effects) in the exposed individuals, populations, or ecosystems (Sheehan et al., 1994), and, more specifically, the relationship between stressors and the assessment and measures of effect identified during the problem formulation step (Norton et al., 1992). The ESVs used in the characterization of ecological effects were taken from the NPS Protocol for plants, soil invertebrates, birds, and mammals, presented as “Refined SLERA ESVs” in Tables 5 and 6 of the NPS protocol (NPS, 2016).

3.2.1.8 Ecological Effects Evaluation, Risk Estimation, and SRE Hazard Quotient Calculation

The risk estimation discusses the likelihood that floral and faunal populations inhabiting the Site may be affected by potential exposure to chemical stressors (i.e., COPECs) in soil. The risk evaluation integrates information presented in the exposure assessment and the effects (i.e., stressor/response profile) evaluation to estimate the potential ecological risk. In this

screening assessment, risks were estimated by comparing estimates of exposure (i.e., a concentration) with respective ESVs.

3.2.1.8.1 EPC Calculation – Plant and Soil Invertebrate Communities

EPCs are the COPEC concentrations that a plant or soil invertebrate receptor is assumed to be exposed to within the Site. EPCs were calculated as described in Section 2.8.1.4 and presented in Table 9.

Table 9 – Ecological Streamlined Risk Evaluation – Plants and Soil Invertebrates

Lassen Volcanic National Park Former Firing Range	**Lead at DU-1* (mg/kg)**	**Lead at DU-2* (mg/kg)**
Background[a]	5.5	5.5
Minimum Concentration	16.1	567
Maximum Concentration	18.8	4570
Average Concentration	17	2569
Standard Deviation	2	2831
Exposure Point Concentration[b]	17	2569
Ecological Screening Value (ESV) (Plants)[c]	120	120
ESV (Soil Invertebrates)[c]	1700	1700
Hazard Quotient (HQ) - Plants	0.15	**21**
HQ - Soil Invertebrate	0.010	**1.5**

Notes:

[a] Site specific background concentration.

[b] Average concentration used following ITRC guidelines.

[c] ESVs are Refined SLERA ESVs taken from Table 5 in NPS Ecological Protocol, Feb. 2016, Revision 2).

*Each DU had one primary sample and one replicate for a total of two data points.

Bold values indicate HQs greater than 1.0.

3.2.1.8.2 EPC Calculation – Bird and Mammal Communities

Similar to the plant and soil invertebrate communities, EPCs are used to evaluate risk in birds and mammal receptors through the hazard quotient calculation. EPCs are the COPEC concentrations that a bird or mammal receptor is assumed to be exposed to within the Site. EPCs were calculated as described in Section 2.8.1.4 and presented in Table 10.

Table 10 – Ecological Streamlined Risk Evaluation – Birds and Mammals

Lassen Volcanic National Park Former Firing Range	Lead at DU-1* (mg/kg)	Lead at DU-2* (mg/kg)
Background[a]	5.5	5.5
Minimum Concentration	16.1	567
Maximum Concentration	18.8	4570
Average Concentration	17	2569
Standard Deviation	2	2831
Exposure Point Concentration[b]	17	2569
ESV (Ecological - Birds)[c]	11	11
ESV (Ecological - Mammalian)[c]	56	56
AUF - Birds	0.16	0.16
AUF - Mammalian	1.0	1.0
Hazard Quotient (HQ) - Birds	0.25	**36**
HQ - Mammalian	0.31	**46**

Notes:

[a] Site specific background concentration.

[b] Average concentration used following ITRC guidelines.

[c] ESVs are Refined SLERA ESVs taken from Table 6 in NPS Ecological Protocol, Feb. 2016, Revision 2).

AUF = Area Use Factor; see table 5 for calculation.

*Each DU had one primary sample and one replicate for a total of two data points.

Bold values indicate HQs greater than 1.0.

3.2.1.8.3 Hazard Quotient Calculation

The HQ approach used for this evaluation simplifies the comparison process and allows for a more standardized interpretation of the results i.e., the HQ reflects the magnitude by which the sample concentration or dose exceeds or is less than the ESV (i.e., soil screening level, ecological benchmark, criterion or estimated dose). In general, if an HQ exceeds 1, the potential for the exposure to elicit an adverse effect is possible. Although the HQ method does not measure risk in terms of likelihood or probability of effects at the individual or population level, it does provide a benchmark for judging potential risk (USEPA, 1994d).

As part of the HQ determination for mammal and avian species, an area use factor (AUF) was developed based on the surrogate bird and mammal species selected for this evaluation (Table 11). The AUF is defined as the ratio of the site area to the receptor's home range. It is the probability that a receptor will be exposed to contamination throughout its home range. Home ranges for the surrogate bird (American robin, *Turdus migratorius; HR=2*) and the surrogate mammal (Ornate shrew, *Sorex ornatus; HR=1*) were obtained from the Wildlife Exposure Factors Handbook (USEPA, 1993b) and Cal/Ecotox, 1999. HQs were calculated as:

Plant/ Soil Invertebrate	**Bird/Mammal**
HQ = (EPC/ESV)	*HQ = (EPC/ESV) * AUF*

Where:

HQ	=	Hazard quotient (unitless)
EPC	=	exposure point concentration (Communities: medium concentration in units of milligram COPEC per kilogram medium) (mg COPEC/kg medium)
ESV	=	ecological screening value (mg COPEC/kg medium)
AUF	=	area use factor (unitless)

Potential risks to the plant, invertebrate, avian, and mammal communities from exposure to COPECs are presented below.

Table 11 – Area Use Factor Determination

Site Area[a] (Acres)	Avian		Mammalian	
	Home Range[b] (Acres)	AUF	Home Range[c] (Acres)	AUF[d]
0.31	2	0.16	0.09	1

Notes:

AUF = Area Use Factor. AUF calculated by dividing site area by home range.

Avian representative species assumed to be the American robin (*Turdus migratorius*).

Mammalian representative species assumed to be ornate shrew (*Sorex ornatus*).

[a] Site area encompasses entire firing range.

[b] EPA Wildlife Exposure Factors Handbook, December 1993 (EPA/500/R-93/187a).

[c] No data available for the Ornate shrew, value for Vagrant shrew used. (Nature Serve, 2017).

[d] AUF assumed to be 1 since calculated AUF was > 1.

3.2.2 Risk Results

3.2.2.1 Plant and Soil Invertebrate Communities

Based on the results of the risk evaluation, the plant community at the former firing range is at risk of phytotoxic effects from exposure to lead at DU-2 (HQ=21; Table 9). The soil invertebrate community also displays a risk for lead exposure at DU-2 with an HQ slightly greater than 1 (HQ=1.5).

3.2.2.2 Avian and Mammal Communities

The avian community and mammalian community are at risk for lead at DU-2 (HQ=36 and HQ=46, respectively) (see Table 10).

3.2.3 Site-Specific Background

Site-specific background data was collected as part of the 2016 SI and is presented in Table 3. The background sampling location is shown in Figure 3. All Site lead concentrations exceeded the Site-specific background lead concentration of 5.5 mg/kg. In addition, the site-specific background exceeded the final lead ESV (Table 7).

3.2.4 Ecological Preliminary Remediation Goals

Site-specific PRGs were developed for lead in DUs that represented the greatest potential for risk. PRGs were developed using the following general approaches:

- Soil PRGs were developed using avian and mammalian receptor dietary exposure modeling with a specified target risk, solving for the medium concentration.
- PRGs were developed using both NOAEL- and LOAEL-based TRVs.

PRG calculations and associated input values are presented in Appendix E, Tables E-5 – E-14.

Contaminant uptake, bioaccumulation, and trophic transfer can expose birds and mammals to COPECs through dietary exposure. As there are no biological data available with which to determine site-specific uptake, bioaccumulation from soil into biological tissue was estimated

using literature-based, chemical-specific uptake factors. Food chain-based PRGs for bioaccumulative contaminants was modeled for invertivorous avian and mammalian species that are expected to potentially forage on or near the Site.

The general soil food chain-based PRG equation is as follows:

$$PRG_{soil} = \frac{THQ \times TRV}{FT \times (FIR \times BCF + SIR)}$$

Where:

PRG_{soil}	=	COPEC concentration in soil (mg/kg DW)
THQ	=	Target hazard quotient (unitless)
TRV	=	Chemical-specific toxicity reference value (mg/kg BW-day)
FT	=	Species specific fraction of foraging time in the exposure area (unitless)
FIR	=	Body weight normalized food intake rate (kg tissue/kg BW-day)
BCF	=	Bioconcentration term (mg COPEC/kg tissue)/(mg COPEC/kg DW)
SIR	=	Species-specific soil ingestion rate (kg DW/kg BW-day)

Ecological PRGs ranged from 113 – 598 mg/kg (Table E-14). The more conservative PRGs were Avian based PRGs which were calculated as 265 mg/kg (NOAEL-based) and 598 mg/kg (LOAEL-based) (Table E-12). The mammalian PRGs were slightly more conservative with a NOAEL-based PRG of 113 mg/kg and a LOAEL-based PRG of 245 mg/kg (Table E-13).

3.2.5 Uncertainty Analysis

It is important to evaluate the results of this SRE within the context of the uncertainties inherent within the ecological risk assessment process. Uncertainties in SREs may be identified as belonging to one or more of the four following categories: conceptual model formulation uncertainty, data and information uncertainty, and natural variability (stochasticity). These are not discrete categories, and overlap does exist among them. USEPA's Framework for

Ecological Risk Assessment (USEPA, 1992) document provides a more detailed discussion of these generic uncertainty categories. A summary of the most important uncertainties for this SRE is presented in Table 12. Some risk estimates can potentially be overestimated or underestimated due to assumptions made in the risk evaluation process. For example, soil concentrations used may not correspond to true bioavailable concentrations and therefore, values used in the assessment may be overestimated. Not all exposure pathways for the various receptors were evaluated (inhalation) this lack of analysis could cause an underestimation of risk for receptors. Other uncertainties are described in Table 12, however due to the high levels of some lead concentrations, small changes from uncertainties would most likely not be significant enough to change the outcome of the risk evaluation.

Table 12 – Summary of Major Uncertainties in the Ecological Streamlined Risk Evaluation

Assessment Component	Uncertainty Description	Likely Direction of Effect on Risk Estimates	Likely Magnitude of Effect on Risk Estimates
Nature and Extent of Contamination	Lead was the only contaminant analyzed even though bullets contain other metal constituents.	Likely underestimate	Could be significant
	Only one background sample was collected limiting the confidence in the site-specific background value.	Unknown	Could be significant
	Sampling method and analysis for depth contamination is not necessarily reliable enough to assume uncontaminated subsurface soil.	Unknown	Could be significant
	Detected concentrations may not be indicative of bioavailable concentrations.	Overestimate	Could be significant
Exposure Assessment	Some exposure pathways not evaluated. (Inhalation)	Underestimate	Unknown; not expected to be significant
	Target receptors were selected to represent a variety of organisms; however, species-specific risk potentials may be different.	Unknown	Not expected to be significant
	Foraging times at the site may be different from those used in the calculations given the availability of higher quality habitat nearby.	Variable	Not expected to be significant
	Calculated doses were assumed to be 100% bioavailable.	Overestimate	Variable; could be significant
	Due to lack of toxicity data, no amphibians or reptiles were evaluated.	Unknown	Unknown
Toxicity Assessment	Sensitivities differ between species.	Unknown	Unknown
	ESVs for plants and soil invertebrates are generally from toxicity tests with highly bioavailable conditions.	Overestimate	Variable; could be significant
	Laboratory studies do not necessarily reflect site-specific field conditions.	Likely overestimate	Could be significant
Risk Characterization	The HQ approach indicates potential for risk but not true magnitude.	Unknown	Unknown
	Synergistic, antagonistic, or additive effects of contaminant mixtures are not accounted for due to lead being the only contaminant analyzed.	Unknown	Variable
	Extrapolation of endpoints between organism-level to population-level effects is uncertain.	Likely overestimate	Could be significant

3.3 RISK SUMMARY

The results of the HH SRE indicate that leaving the waste material associated with the Site in its present condition, could pose an unacceptable risk to human health based on the exposure to lead at DU-2 (indicated by an HQ of 3.2 and ALM blood lead concentration in exceedance of 1 µg/dL). Additionally, even though the groundwater pathway is considered low risk and not thoroughly assessed in this EE/CA, a comparison to the soil-groundwater SSL was conducted for reference of potential fate and transport. The SSL for protection of the soil to groundwater pathway is 14 mg/kg whereas, lead at DU-2 is 2569 mg/kg.

The potential adverse effects indicated in the ecological SRE can be summarized by analyte and community as follows. Lead at DU-2 indicated potential adverse effects for all ecological receptors evaluated. Lead concentrations at DU-1 do not result in an HQ greater than 1, and therefore DU-1 does not pose a risk for ecological receptors.

Table 13 below summarizes the human health and ecological contaminants of concern (COCs).

Table 13 – HH and Ecological COCs

COPEC	HH SRE COC	Ecological SRE COC
Lead at DU-1		
Lead at DU-2	X	X

PRGs for DU-2 were calculated for both human health and ecological receptors. Human health PRGs were based on exposure to lead to the fetus of an exposed adult Site worker and/or child recreational visitor. As presented in Appendix E Table E-4, the lead PRG for the fetus of a pregnant Site worker is 981 mg/kg.

Ecological PRGs were calculated for both an avian and mammalian individual. These PRGs can be found in section 3.2.4 and through Appendix E PRG calculation tables (Table E-12 – Table E-14). Calculated site-specific ecological PRGs ranged from 113 mg/kg to 598 mg/kg.

4. IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

The following sections define the objectives of a remedial action, identify requirements that may pertain to the remedial action goals, evaluate remedial action alternatives (RAAs), and select a preferred RAA for the Site soils. The removal action objectives (RAOs) are based on the reported sources of contamination, the nature and extent of contamination, results of the human health and ecological risk evaluations, and the identified applicable or relevant and appropriate requirements (ARARs) for the Site. RAOs were developed based on these factors, to control the contamination sources and reduce exposure of human and ecological receptors to site contamination.

The reported source of contamination in the 2016 SI is lead projectiles and lead particulates ejected from fire arms within the firing range. No other COPCs were identified.

Lead was the only heavy metal considered, and thus, the only metal identified at the Site. Lead concentrations reported in the SI exceeded US EPA Regional Screen Levels (RSLs), and NPS ecological screening levels for terrestrial plants, invertebrates, mammals and birds within the top 4 inches of approximately 1,053 square feet of soil covering the berm behind the shooting range target area. The volume of lead-impacted material is estimated to be 13 cubic yards. While not noted in the SI, lead concentrations also exceed California Department of Toxic Substances Control (DTSC) Screening Levels (SLs) protective of human health. Lead concentrations were also identified as exceeding 20 times the solubility threshold limit concentration for determining their status for disposal as California and RCRA hazardous waste. Based on these criteria, the RAOs for the Site are:

1. Remove lead debris and lead-containing soil above cleanup levels (PRGs) from the Site,

2. Prevent or reduce the potential for human and ecological exposure to lead, and

3. Prevent or reduce potential migration of lead via surface runoff, erosion, and wind dispersion.

However, we have noted the following concern with the execution and findings of the SI. Per the SI, actionable lead was identified in DU2, the "Eastern Berm." Lead was not identified at or above screening levels in DU1, the "Firing Area." During our site visit, the approximately 180-foot long DU1 "Firing Area" was observed to include a picnic table at its north end, what appeared to be firing positions at posts near its center, and concrete blocks that appeared to have been used to hold targets in its southern portion. Based on our observations, the range firing line appeared to be equivalent to the line of posts near the center of DU1, and the target area at the south end of the DU received fired projectiles. Instead of breaking the "Firing Area" into separate DUs based on their use, DU1 was assessed as one unit; therefore, portions of the DU likely to be elevated in lead were diluted by the portions of the DU where lead impact is not expected to occur, such as behind (north of) the firing line, which is half or more of the area of DU1. A recommendation is also included for reassessment of the DU1 area before implementation of an RAA.

4.1 IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Consistent with CERCLA Section 121(d) and in compliance with NCP Section 300.415(j), CERCLA removal actions must, to the extent practicable considering the exigencies of the situation, attain ARARs under federal or state environmental or facility siting laws at the completion or during the implementation of the removal action, or both depending on the nature of the requirements. In determining whether compliance with ARARs is practicable, the urgency of the situation, and the scope of the removal action to be conducted may be considered. 40 C.F.R. § 300.415(j).

ARARs consist of cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws. See 40 C.F.R. § 300.5. These requirements are either "applicable" or "relevant and appropriate". Applicable requirements are defined by NCP Section 300.5 as those requirements "that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site." 40 C.F.R. § 300.5.

In other words, applicable requirements are laws and regulations that would be enforceable at a particular site even if there was no CERCLA response action taking place. Relevant and appropriate requirements are defined as those requirements "that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their uses are well suited to the particular site."

Only those state standards and requirements that are promulgated, identified in a timely manner, and are more stringent than federal requirements may be applicable or relevant and appropriate. 40 C.F.R. § 300.400(g)(4).

ARARs are normally classified into the following three categories:

1. chemical-specific

2. location-specific, and

3. action-specific.

In addition to ARARs, NCP Section 300.415(j) also provides that other federal and state advisories, criteria or guidance may, as appropriate, be considered in formulating the removal action. Although not legally binding, these considerations are "to be considered" ("TBCs"). Pursuant to its delegated CERCLA lead agency authority, NPS has identified ARARs and other TBCs for the Lassen Former Firing Range EE/CA. The results of the ARAR analysis, including state ARARs and TBCs, are summarized in the following subsections.

4.1.1 Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Table 14 – Chemical Specific ARARs

Chemical Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
USEPA Regional Screening Levels (RSLs)	https://www.epa.gov /risk/regional-screening-levels-rsls	RSLs are used to screen chemicals at Superfund sites and promote national consistency in the adoption of risk-based screening criteria. RSLs are calculated using USEPAs latest toxicity values, default exposure assumptions and physical and chemical properties to provide comparison values for residential and commercial /industrial exposures to soil, air, and tapwater (drinking water).	Provides federal risk-based limits to human exposure to specific chemicals in soil, air and tapwater. (drinking water).
Lead RSLs: Residential – 400 mg/kg, Industrial – 800 mg/kg, Protection of groundwater – 14 mg/kg			
Office of Land and Emergency Management (OLEM)	https://www.epa.gov /aboutepa/about-office-land-and-emergency-management	Formerly known as the OSWER, The US EPA's OLEM mission is restoring land, preventing releases and conserving resources. Within OLEM, the Superfund, Brownfields, Cleanups and Federal Facilities Cleanup programs generally use baseline ecological risk assessments to: "1) identify and characterize the current and potential threats to the environment from a hazardous substance release, 2) evaluate the ecological impacts of alternative remediation strategies, and 3) establish cleanup levels in the selected remedy that will protect those natural resources at risk.	The overarching program responsible for cleaning up federal lands.
Ecological Soil Screening Levels (ESSLs)	US EPA OSWER, Directive 92857-55 (2003)	ESSLs are a set of risk-based ecological soil screening levels for many of the soil contaminants that are frequently of ecological concern for plants and animals at hazardous waste sites that can be used during the Superfund Ecological Risk Assessment process, the screening-level risk calculation. The Eco-SSLs are not designed to be used as cleanup levels and EPA emphasizes that it is inappropriate to adopt or modify these Eco-SSLs as cleanup standards. Guidance for the derivation and use of ESSLs is promulgated by OSWER.	Related to soil protection values used to screen potentially contaminated sites for priority pollutants and as cleanup goals or targets for allowable discharge.
Lead ESSLs: Plants – 120 mg/kg, Soil Invertebrates – 1,700 mg/kg, Avian – 11 mg/kg, Mammalian – 56 mg/kg			

Chemical Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
California Code of Regulations, Title 22	Division 4.5, Chapter 11, Articles 3 and 4	Provides a standard for characterization and management of RCRA and non-RCRA hazardous wastes. A hazardous waste is considered a RCRA hazardous waste if it exhibits any of the characteristics of ignitability, corrosivity, reactivity or toxicity; or if it is listed as a hazardous waste and has not been specifically excluded. A hazardous waste is generally considered a non- RCRA hazardous waste if it exhibits any of the characteristics of corrosivity or toxicity specified by Article, is identified as a potential non-RCRA hazardous waste in Article 3, and is not classified as a RCRA hazardous waste.	Concentrations of metals at the Site approach or exceed criteria for consideration of eligibility as hazardous waste.
Lead Soluble Threshold Limit Concentration (STLC) – 5.0 mg/l Lead Total Threshold Limit Concentration (TTLC) – 1,000 mg/kg			
CalEPA	DTSC Human Health and Ecological Risk Office (HERO)	Promulgates human health screening levels of carcinogenic and non-carcinogenic substances present at hazardous waste sites and permitted facilities, when different from US EPA RSLs.	Provides supplemental state criteria protecting human health.
Lead RSLs: Residential – 80 mg/kg, Industrial – 320 mg/kg			
CalEPA	Office of Environmental Health Hazard Assessment (OEHHA) Health and Safety Code Section 57008	OEHHA is responsible for developing and providing risk managers in state and local government agencies with toxicological and medical information relevant to decisions involving public health. CHHSLs are concentrations of chemicals in soil or soil-gas below an excess lifetime cancer risk of one-in-a-million (10-6) and a hazard quotient of 1.0 for non-cancer health effects. CHHSLs have no regulatory effect and are not intended for use by regulatory agencies that have authority to require remediation of contaminated soil.	Provide supplemental chemical-specific human health risk assessment information.
Lead Soil Screening Numbers: Residential – 150 mg/kg, Commercial/Industrial – 3,500 mg/kg			

Chemical Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
San Francisco Bay Regional Water Quality Control Board Environmental Screening Levels (ESLs)	SFRWQCB	Provide conservative values for assessing human and environmental health impacts in soil, groundwater, soil gas, and surface water that can be directly compared to environmental data collected at a site, thus saving time and money.	Risk-based screening values related to various media, site use and exposure type.
Lead ESLs: Residential – 80 mg/kg, Commercial/Industrial – 160 mg/kg			
National Park Service	Ecological Screening Values	Criteria to be considered for estimated media concentrations which can provide values protective of wildlife.	Provides risk-based criteria addressing site-specific wildlife
Lead ESVs: Plants – 120 mg/kg, Soil Invertebrates – 1,700 mg/kg, Avian – 11 mg/kg, Mammalian – 56 mg/kg			
California Toxics Rule (2000)	65 Federal Register 31681, b 40 Code of Federal Regulations (CFR), Part 131	Establishes numeric aquatic life criteria for 23 priority toxic pollutants and numeric human health criteria for 57 priority toxic pollutants. This regulation is applicable to inland surface waters, bays, and estuaries in California.	May be applicable to potential runoff and groundwater seepage from the Site.
No soil screening values provided.			

4.1.2 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because the response actions occur in special locations. The following ARARs are applicable to the Site based on its location.

Table 15 – Location Specific ARARs

Location Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
Authority of the Secretary of the United States Department of Agriculture	Executive Order 12580, (42 U.S.C. § 9604), (42 U.S.C. § 9606),	Under Executive Order 12580, as amended, the President has delegated authority to the Secretary of the United States Department of Agriculture to conduct certain actions under CERCLA, including investigations and response activities abatement actions cost	Describes the delegation of Authority to cleanup National Forests.

Location Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
	(42 U.S.C. § 9607), (42 U.S.C. § 9622) &	recovery and entering into agreements with potentially responsible parties to perform work with respect to remedial actions for releases or threatened releases not on the National Priorities List ("NPL") and removal actions other than emergencies, when the release or threat of release of hazardous substances is on land or facilities under Forest Service jurisdiction, custody or control. The Secretary of Agriculture has re-delegated the authorities described above to the U.S. Forest Service.	
Federal Endangered Species Act (ESA) - 1973	16 U.S.C. § 1531 et seq.	Authorized the Secretary of the Interior to list endangered domestic fish and wildlife and allowed the United States Fish and Wildlife Service to buy habitats for listed species. It also directed federal land agencies to preserve habitat on their lands.	Federally listed species could be present on or near the Site include the Sierra Nevada Bighorn sheep and the Mountain Yellow-legged frog.
The Migratory Bird Treaty Act	16 U.S.C. §§ 703, et seq.	Provides for the protection of migratory birds and birds in danger of extinction, and their environment.	Applies if the Site is within a migratory bird flyway.
Bald and Golden Eagle Protection Act	16 USC §668, et seq.	Enacted in 1940 as the Bald Eagle Protection Act protects Bald eagles and was later amended to include Golden eagles. It prohibits the taking or possession of and commerce in bald and golden eagles, parts, feathers, nests, or eggs with limited exceptions. The definition of take includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb. Bald eagles may not be taken for any purpose unless a permit is issued prior to the taking.	The site should be evaluated for the presence of Bald and Gold Eagle nests before changing current uses and activities.
California Endangered Species Act (CESA) - 1970	Fish and Game Code Sections 2050-2116	CESA states that all native species of fishes, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats, threatened with extinction and those experiencing a significant decline which, if not halted, would lead to a threatened or endangered designation, will be protected or preserved.	State-listed species include the Swainson's hawk, Bald eagle, Willow flycatcher, and the Great Gray owl
Clean Water Act (CWA) - 1972	Public Law 92-500	The primary federal law in the United States governing water pollution. Its objective is to restore and maintain the chemical, physical, and biological integrity of the	Applicable to the potential impact of lead-containing

Location Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
		nation's waters by preventing point and nonpoint pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands. The CWA does not specifically include groundwater resources.	runoff to surface water.
Safe Drinking Water Act 9SDWA) - 1974	Pub. L. 93-523 88 Stat. 1660	The principal federal law in the United States intended to ensure safe drinking water for the public.[3] Pursuant to the act, the Environmental Protection Agency (EPA) is required to set standards for drinking water quality and oversee all states, localities, and water suppliers who implement these standards. The SDWA includes groundwater resources.	Applicable to the potential impact of leached lead to groundwater
National Historic Preservation Act (1966)	Public Law 89-665; 54 U.S.C. 300101 et seq.	Applies to the site if the selected removal action impacts any historic sites protected by the act.	No cultural resources have been determined to be present at the Site.
National Park Area Nuisance Regulation	36 C.F.R. § 5.13	Prohibits the creation or maintenance of a nuisance upon the federally owned lands of a park area or upon any private lands within a park area under the exclusive legislative jurisdiction of the United States	Nuisances posed by site cleanup include traffic congestion, noise and dust
The Wilderness Act	16 USC §1131	Established a National Wilderness Preservation System composed of federally owned areas designated by Congress as “wilderness areas.” Wilderness areas are administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness.	The Site is not located in wilderness area.
Fish and Wildlife Coordination Act	16 USC §661	Enacted to protect fish and wildlife when federal actions result in the control or structural modification of a natural stream or body of water. The statute requires federal agencies to take into consideration the effect that water-related projects would have upon fish and wildlife and then take action to prevent loss or damage to these resources.	Engineering controls and best management practices (BMP) will be used to stabilize observed site drainage and control storm water runoff from the Site.

Location Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
California Fish and Game Code	5650(a)(b) & (f)	Prohibits the passage of substances or materials into waters of the state deleterious to fish, plant life, or birds. Any removal action taking place in an area that may impact waters of the state will be conducted in such a way as to ensure that materials excavated will not be released into any waters of the state.	May be applicable to potential runoff and groundwater seepage from the Site
California Code of Regulations (CCR)	Title 23, Section 2550.7, and Title 27, Section 20415	Requires general monitoring of all areas at which waste has been discharged to land.	Applicable to current and future site conditions if waste is not removed.
CCR	Title 23, Section 2550.9, and Title 27 Section 20425	Requires an assessment of the nature and extent of the release, including a determination of the spatial distribution and concentration of each constituent.	Applicable if a release occurs at the Site that is heretofore unknown or is the result of the removal action
Forest Plan Standard and Guidelines	Land & Resource Management Plan, Lassen National Forest, 1992	Portions of the Lassen National Forest Land and Resource Management Plan (LRMP) (Forest Service, 1992), is potentially applicable or relevant and appropriate for assessing Site removal alternatives.	May contain standards and guidelines that are potentially relevant and appropriate to actions at the Site
Tehama County Air Pollution Control District	APCD Regulations	Tehama County APCD is charged with implementation of the Clean Air Act. Tehama County APCD Rules include provisions for visible emissions, particulate matter, dust and condensed fumes, accumulation of waste, fugitive dust emissions, nuisances, and fugitive dust, among other topics potentially relevant to disturbance of the Site. A Fugitive Dust Permit may be required from the APCD for construction activities.	Statewide Airborne Toxic Control Measures for Compression Ignition Engines (portable diesel engines) would also apply if diesel powered equipment is brought onsite

4.1.3 Action-Specific ARARs

Action-specific ARARs are technology- or activity-based requirements or limitations on actions taken with respect to hazardous substances. These requirements are triggered by the particular removal activities selected. This section summarizes the action-specific ARARs for the alternatives selected for further evaluation.

The following action-specific ARARs are dependent upon the selected removal action and the characterization of the waste.

Solubility analysis of lead concentrations exceeding 20x the Solubility Threshold Limit Concentration (STLC) are identified as COCs in soil. Lead is a listed waste and could be classified as hazardous if maximum solubility concentration for the Toxicity Characteristic Leaching Procedure (TCLP) is exceeded. The same criteria applies to identified lead concentrations exceeding 10x the California soluble toxicity characteristic (per 22 CCR, Chapter 11), and would be classified as Non-RCRA (California) hazardous waste because the STLC is exceeded.

The federal Clean Water Act requires control of storm water discharges associated with construction activities involving five (5) or more acres of land. If the selected removal action involves the disturbance of five or more acres of land, this is applicable. This Action-specific ARAR does not apply, as the Site is less than five acres in size. If the activities involve less than five acres, the ARAR may still be relevant and appropriate for those activities involving soil disturbance.

Table 16 – Action Specific ARARs

Action Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
Hazardous Waste Disposal Site Approval	Title 27, Section 20210, and Title 23 Section 2520 of the CCR	Requires that wastes identified as hazardous be allowed only at waste management units that have been approved and classified.	Applicable if the wastes created during the selected removal action are identified as hazardous, and are transported to a waste management unit.
Remediation Waste Staging Piles	40 CFR §264.554	A staging pile is an accumulation of solid, nonflowing remediation waste that is not a containment building and is used only during remedial operations for temporary storage at a facility. A staging pile must be located within	Applies to the staging of waste in piles for loading and off-hauling, which is

Action Specific			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
		the contiguous property under the control of the owner/operator where the wastes to be managed in the staging pile originated.	likely to occur during clean up.
Hazardous Waste Labeling	CCR Title 22, Sections 66262.30 through 66262.33 of the CCR	Requires that containers used to contain hazardous wastes are packaged, labeled, marked, and placarded in accordance with RCRA and Department of Transportation requirements.	Applicable if the wastes created during the selected removal action are identified as hazardous, and are transported off site.
Transportation of Hazardous Waste (federal)	Subtitle C of the Resource Conservation and Recovery Act (RCRA)	Defines a hazardous waste transporter as any person engaged in the off-site transportation of the hazardous waste within the United States. Off-site transportation of hazardous waste includes shipments from a hazardous waste generator's facility or property to another facility for treatment, storage, or disposal that requires travel on public roads. Transporter regulations do not apply to the on-site transportation of hazardous waste within a facility's property or boundary.	Applicable if hazardous waste is transported on public roads to a Treatment, Storage and Disposal Facility
Transportation of Hazardous Waste (state)	California Health and Safety Code Division 20, Chapter 6.5, Article 6.5, Article 6.6, and Article 13	In California, unless specifically exempted, it is unlawful for any person to transport hazardous wastes, unless the person holds a valid registration issued by the Department of Toxic Substances Control (DTSC)	Same as above.

Table 17 – Additional ARARs To Be Considered

To be Considered			
Standard, Requirement, Criterial or Limitation	**Citation**	**Description**	**Applicability**
National Environmental Policy Act	42 U.S.C. §4321 et seq. (1969)	The National Environmental Policy Act (NEPA) was one of the first laws ever written that establishes the broad national framework for protecting our environment. NEPA's basic policy is to assure that all branches of government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment.	Disturbance of the surrounding are to the Site could require mitigation under NEPA.
California Environmental Quality Act (CEQA)	California Code of Regulations, Chapter 3 of Title 14	A statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible	Disturbance of the surrounding are to the Site could require mitigation under CEQA.
Property Ownership		The Site is located outside of LAVO on federal land managed by the Hat Creek Ranger District, Lassen National Forest.	

5. IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES (RAA)

Since the scope of work for this project is to address soil contamination, potential removal action alternatives were limited to those which would address the COPC in site soils. No evaluation was conducted for removal action alternatives that directly address surface water or groundwater contamination. As explained in Section 2.4, the risk to groundwater and surface water is considered to be low. However, executing removal action activities for contaminated soil will further protect both surface water and groundwater resources by removing or controlling the primary contaminant source.

This section presents potential removal action alternatives considered for use in site remediation. Each type of alternative is initially screened for effectiveness and implementability. Removal action alternatives initially identified as potentially effective and implementable are further evaluated for their effectiveness, implementability and cost. The screening process for this project follows USEPA guidance for NTCRAs.

RAAs considered for the Site are summarized in the following table with a brief description of each technology and subsequent screening evaluation.

Table 18 - Site RAAs Considered

Removal Action Technology/Screening Evaluation	Summary Description
1. No Action	This action leaves contaminated materials in their current condition and assumes no further intervention will occur. No response activities or monitoring are associated with this technology.
Screening Evaluation	Although No Action will not meet the RAOs or ARARs, it is used as a baseline for measure against other alternatives. For this reason, and because a No Action alternative is required according to EPA guidance, it is retained for further evaluation as a RAA.

Removal Action Technology/Screening Evaluation	Summary Description
2. Institutional Controls	Institutional controls restrict access to or control the use of a site, such as by zoning, deed restrictions, environmental control easements and access restrictions. Enforcement of such controls require periodic inspections and patrols, training for park personnel required to access the contaminated area, as wells as legal action against violators. Institutional controls do not reduce the volume or toxicity of the contaminated material.
Screening Evaluation	This approach does not meet RAOs and ARARs and may not be effective due to the requirement of indefinite, control, training and maintenance costs, and additional impact from migration of contaminants and loss of potential work space.
3. Engineering Controls	Engineering controls are used primarily to reduce the mobility of, and exposure to, contaminants. These goals are accomplished by creating a barrier that prevents direct exposure and transport of waste from the contaminated source area. Engineering controls do not reduce the volume or toxicity of the hazardous material. Typical engineering controls for solid media include: - Surface Controls (grading, re-vegetation, erosion controls, use of a soil binder) - Containment (capping) - On-site and Off-site Disposal (construction of a waste cell, landfilling)
Screening Evaluation	Grading - Due to the presence of hazardous waste concentrations of lead, grading is not further considered. Revegetation - The native ground cover vegetation in this sub-alpine pine forest is sparse due to poor growing conditions. Revegetation is not further considered. Erosion Controls – Erosion controls would be partially effective, but would not prevent mobilization of contaminants into and through the subsurface, would require indefinite maintenance, and would not prevent exposure to trespassers and dust exposure. Does not achieve RAOs.

Removal Action Technology/Screening Evaluation	Summary Description
	Soil Binder – Soil binder application is a temporary measure and would require protection and maintenance and re-application over the treatment area. Use of soil binder is not further considered. Onsite Disposal – The volume of impacted soil described in the SI is approximately 13 cubic yards (cy), and could be accommodated within the area of the former firing range. However, the prospective near and long-term costs of permitting, construction and maintenance of a containment cell far exceeds the cost to remove and dispose of the impacted soil, and is not further considered. Offsite Disposal – Will achieve RAOs. Limits handling of contaminated materials, does not incur long-term or recurring costs and administrative burden. Will impose short-term, minor impacts on park environment, operations and access.
4. Ex-Situ Removal and Treatment	This technology involves removal of contaminated soil and waste and subsequent treatment through processes that chemically, physically, or thermally reduce contaminant toxicity and/or volume. Excavated areas are backfilled with clean soil, returned to original grade, if necessary, and revegetated or otherwise stabilized to prevent erosion. Ex-situ treatment types include: - Chemical Soil Washing - Chemical Solidification/Stabilization - Thermal Treatment Will achieve RAOs. Limits handling of contaminated materials, does not incur long-term or recurring costs and administrative burden. Will impose short-term impacts on park environment, operations and access.
Screening Evaluation	Characterization of Site impacted soil has identified sufficiently contaminated material of a toxicity sufficient to warrant treatment prior to internment as hazardous material within an appropriate solid waste disposal facility; however, RAOs would be achieved. Ex-situ treatment/stabilization can be performed by the receiving waste facility.

Removal Action Technology/Screening Evaluation	Summary Description
5. In-Situ Treatment	Stabilization and fixation of the contamination in-place reduces the mobility of contaminants in soil. The treatment seeks to permanently trap or immobilize the contamination within the soil using non-hazardous chemical binders to prevent erosion. In-situ treatment types include: - Phytoremediation - Chemical Solidification/Stabilization - Thermal Treatment
Screening Evaluation	Phytoremediation is not considered for similar reasons as revegetation. In-situ chemical solidification/stabilization treatment could be performed on Site, but would require retaining a suitable contractor, mobilization of equipment to the Site and preparation of the Site for the stabilization process, permitting, and either removal of the stabilized material from the Site or internment of the stabilized material on Site. On-site stabilization is not justified when off-Site stabilization is available at landfill destinations, and internment of stabilized lead on Site would incur both on-Site stabilization costs and the prospective near and long-term costs of permitting, construction and maintenance of a containment cell, as rejected as an Engineering Control RAA. Thermal treatment is not a lead stabilization technique.

5.1 DESCRIPTION OF ALTERNATIVES AND DETAILED ANALYSIS

USEPA guidance for NTCRAs suggests that only the most qualified technologies for treatment of the source contamination be evaluated. The RAAs outlined below (Alternative 1, No Action and Alternative 2, Excavation and Off-Site Disposal) represent technologies that can protect human health and the environment for a reasonable range of costs.

5.1.1 Alternative 1 - No Action

5.1.1.1 Description

No Action is described as no monitoring or corrective measures being taken at the Site.

5.1.1.2 Analysis

No Action alternative provides a baseline for alternative comparison.

5.1.1.3 Effectiveness

The effectiveness of Alternative 1 is evaluated using the following criteria:

- Overall protection of public health and the environment
- Compliance with ARARs
- Long term effectiveness and permanence
- Reduction of toxicity, mobility or volume through treatment, and
- Short term effectiveness

Overall Protection of Public Health and the Environment – Under this alternative the Site would remain as it currently exists with no active efforts to minimize contaminated areas or migration pathways. No efforts would be made to reduce any potential risks to human health or the environment. If no action is taken, the COCs in soils would continue to pose a risk to human and ecological receptors, groundwater and surface water.

Compliance with ARARs – Alternative 1 is not compliant with chemical-specific ARARs; specifically exceeding ecological screening levels for mammalian and avian wildlife, soil invertebrates and plants, and human health screening levels. Alternative 1 is not compliant with action-specific ARARs in that the material exceeds California and RCRA hazardous waste thresholds. Alternative 1 is also not compliant with location-specific ARARs which require action to conserve endangered species.

Long Term Effectiveness and Permanence - Alternative 1 does not provide long term effectiveness or permanent remedy for the COC-contaminated soils. This alternative does not manage the risks to human health and the environment.

Reduction of Toxicity, Mobility or Volume through Treatment – Alternative 1 does not reduce the toxicity, mobility or volume of contamination at the Site. Site COCs are not biodegradable and will continue to pose a risk to humans and the environment, if not treated.

Short Term Effectiveness – The impact to the environment is not reduced under this alternative. The length of time until protection is achieved is indefinite under this alternative.

5.1.1.4 Implementability

The implementability of Alternative 1 is evaluated using the following criteria:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials, and
- State and community acceptance

No technical or administrative feasibility concerns are associated with this alternative because no action is being taken. No services or materials are required. State and community acceptance is unknown but the alternative is likely to be considered unacceptable based on the exceedances of screening criteria protective of human health and ecological receptors, and its status as a hazardous waste

5.1.1.5 Cost

The cost of Alternative 1 is evaluated using the following criteria:

- Direct capital costs
- Indirect capital costs, and

- Ongoing operation and maintenance (O&M) costs

There are no capital costs or operation and maintenance costs associated with the No Action Alternative. However, there could be significant future costs associated with existing impacts, loss of land use, or future releases from the unsecured site.

5.1.2 Alternative 2 – Excavation and Off-Site Disposal

5.1.2.1 Description

Excavation and off-site disposal involves the removal of the contaminated materials, final classification of the waste as RCRA Subtitle C or other regulated hazardous waste, and subsequent disposal at a facility licensed to accept the waste. The type of facility is dependent on the class and concentration of hazardous materials in the waste. Wastes found to exceed state or federal guidelines for hazardous material must be transported to a RCRA landfill for disposal. Wastes not exceeding the guidelines can be placed in any landfill licensed to accept the waste. All excavated wastes will be managed in accordance with all applicable federal, state and local requirements.

5.1.2.2 Analysis

Off-site disposal is a tested and widely accepted alternative for contaminated soils. The process involves the delineation, excavation, transport and disposal at a facility licensed to accept contaminated soils. While the material has not yet been fully characterized for disposal, the identified concentrations of lead at the Site meet the criteria for non-RCRA (California) and RCRA hazardous waste. The lead-containing material will likely be required to be disposed of in a RCRA Class I landfill unless solubility (TCLP) testing confirms it is not hazardous. The nearest cost-effective RCRA Class I Landfill is the US Ecology Landfill in Beatty, Nevada. This landfill is also equipped to stabilize the lead to reduce its leachability before internment.

The estimated total volume of material assessed in this EE/CA is 115 cubic yards (cy), based on the areas and depths of two impacted areas, DU-1 and DU-2, reported in the 2015 SI. The

estimated volume of site material exceeding the STLC for lead is 13 cy – comprising the shallow soil cover of decision unit, DU-2.

5.1.2.3 Effectiveness

The effectiveness of Alternative 2 is evaluated using the following criteria:

- Overall protection of public health and the environment
- Compliance with ARARs
- Long term effectiveness and permanence
- Reduction of toxicity, mobility or volume through treatment, and
- Short term effectiveness

Overall Protection of Public Health and the Environment – Removal to an off-site facility would provide the highest level of protection to human health and the environment as all contaminated materials would be removed.

Compliance with ARARs – Alternative 2 is compliant with chemical-specific ARARs, removing all material exceeding cleanup goals. Alternative 2 is also compliant with location-specific ARARs which require action to conserve endangered species, and action-specific ARARs.

Long Term Effectiveness and Permanence - Alternative 2 provides the highest level of long term effectiveness and is a permanent remedy for the lead-contaminated soils. This alternative effectively eliminates the risks to human health and the environment, and allows full and unrestricted re-use of the former firing range for other purposes.

Reduction of Toxicity, Mobility or Volume through Treatment – Reduction in the mobility of the contaminants using Alternative 2 would be achieved by removing wastes to a RCRA or

other appropriately licensed facility (based on final characterization), although no reduction of contaminant toxicity or volume would be achieved.

Short Term Effectiveness – The field portions of this removal action alternative could be completed in a relatively short period of time, estimated at 5 work days (1 week), and no permanent facilities would be required. A small increase in short-term risk to human health would be encountered during the excavation and transport phase of this work due to the presence and use of heavy equipment, and dust generation.

The following impacts associated with construction activities are considered short-term, and should not significantly impact human health.

- Short-term air quality impacts to the immediate environment may occur during excavation of contaminated soils.

- Control of fugitive dusts may be required both on-Site and for the truck en route to the disposal facility.

- Noise impacts during daylight hours to visitor and campground areas at and adjacent to Manzanita Lake may occur over an approximately one-week period.

- Brief delays to visitor traffic entering and exiting the north entrance to LAVO, at the intersection of Highways 89 and 44, may occur.

5.1.2.4 Implementability

The implementability of Alternative 2 is evaluated using the following criteria:

- Technical feasibility

- Administrative feasibility

- Availability of services and materials, and

- State and community acceptance

Technical Feasibility - Alternative 2 is considered a technically feasible presumptive remedy, having been implemented with consistent success at numerous sites. The alternative would require technical oversight to ensure complete removal of soils exceeding ARARs and contractors licensed to perform hazardous waste removal.

Administrative Feasibility – Implementation of Alternative 2 would require coordination with administrators and regulatory agencies, but is a common and well understood approach. The work would be performed entirely within the Site and would not require off-Site permitting or coordination.

Availability of Services and Materials – Services and materials for Alternative 2 are readily available.

State and Community Acceptance – Alternative 2 is a presumptive remedy. As such, state and community acceptance of the remedy is considered highly likely.

5.1.2.5 Cost

The cost of Alternative 2 is evaluated using the following criteria:

- Direct capital costs
- Indirect capital costs, and
- O&M costs

The estimated capital cost to implement Alternative 2 is estimated to be $44,562, the low-end (-30%) and high-end (+ 50%) cost ranges are presented in Table 19. The estimated volume of soil requiring removal to meet eco ESVs for site COCs is approximately 13 cubic yards (equivalent to 20 tons). Since the Site is disturbed as it has been maintained as a firing range, Site restoration, beyond limited grading at the time of soil removal, is not anticipated following excavation and removal of contaminated soils for off-Site disposal.

6. COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The following table summarizes the potential for success of RAAs and compares effectiveness, implementability and cost of each alternative. Costs estimated are based on previously determined soil volumes and contaminant concentrations.

Table 19 – RAAs Comparison

EVALUATION **CRITERIA**	**ATERNATIVE 1** **No Action**	**ALTERNATIVE 2** **Excavation and Off-Site Disposal**
EFFECTIVENESS	Does not achieve ARARs or RAOs	Achieves ARARs and all RAOs
Protective of Public Health and Community	No	Yes
Protective of Workers During Implementation	Not Applicable	Yes, with worker safety measures
Protective of Environment	No	Yes
Compliance with All ARARs	No	Yes
Achieves All RAOs	No	Yes
Level of Containment Expected	Moderate. Surface and shallow soil disturbance, precipitation and snow-melt will continue to mobilize contaminant	No containment is necessary.
IMPLEMENTABILITY	Low, easy to implement. Not administratively feasible	High

EVALUATION CRITERIA	**ATERNATIVE 1 No Action**	**ALTERNATIVE 2 Excavation and Off-Site Disposal**
Equipment Availability	High. None required	High
Services Availability	High. None required	High
Site Accessibility	High. None required	Medium. Access is restricted by a short, narrow and uneven road, and weather
Availability of Laboratory Testing Capacity	High. None required	High
Off-site Treatment and Disposal Capacity	High. None required	High. Treatment and disposal facility available within 500 miles of the Site.
Can be Implemented in One Year	High	High
Administrative and Legal Feasibility:	High. None required	High
Acquisition of Permits for Off-Site Work	Not applicable	Not applicable
Administrative and Legal Feasibility: Acquisition of Permits for Site Work	High. None required	High
Administrative and Legal Feasibility: Acquisition of Permits for Easement or Rights-of-Way	High. None required	High. Must be obtained from Forest Service

EVALUATION **CRITERIA**	**ATERNATIVE 1** **No Action**	**ALTERNATIVE 2** **Excavation and Off-Site Disposal**
Administrative and Legal Feasibility: Impact on Adjoining Property	High. None required	High. Must be negotiated with Forest Service
Administrative and Legal Feasibility: Ability to Impose Institutional Controls	High. None required	None required
Ease of Implementation: Regulatory Acceptance	Low. Unlikely	High
Ease of Implementation: Community Acceptance	To be determined following public comment period	To be determined following public comment period
COST	No Capital, Monitoring, or Post-Removal Costs	Range of costs does not include post removal restoration, based on volume of material.
Cost Estimate	$0	$44,562
Low End Cost Estimate (-30%)	$0	$31,193
High End Cost Estimate (+50%)	$0	$66,842

7. RECOMMENDED REMOVAL ACTION ALTERNATIVE

Based on the findings presented in the SI and comparative analysis of RAAs, excavation and disposal of contaminated soils exceeding the human health and ecological ESVs for site COCs is the recommended alternative. The excavation and offsite disposal is easy to implement, is the most efficient, provides maximum protection to human health and the environment, complies with ARARs, and is the most cost effective. Since the selected alternative is estimated to require 6 to 9 months to implement, calculation of present worth and post-removal Site control costs are not presented.

The following table presents a breakdown of the estimated costs for excavation, disposal and restoration. Appendix F provides the detailed backup costs associated with the below table.

Table 20 - Estimated Costs for Excavation, Disposal and Restoration

Task	Description	Low End (-30%)	High End (+50%)
Management	Project Management	$8,050	$17,250
Plans & Report	Work Plan, HAZSP, Removal Action Report	$3,850	$8,250
Removal Action	Clear and Stockpile, Confirmation sampling and analysis, Loading, Engineering Oversight	$11,343	$24,306
Transportation	Licensed Hazardous Waste Transport to a Class II Landfill	$2,520	$5,400
Disposal	Disposal Fees	$4,730	$10,136
Restoration	Restore Site	$700	$1,500
	Totals	**$31,193**	**$66,842**
Task	**Description**	**Low End (-30%)**	**High End (+50%)**
Optional Task	Remove lead-impacted soil from partial DU-1	$40,722	$87,261

As described in Section 3, there is the potential for the SI findings to have included dilution of lead concentrations identified in DU1. Supplemental site investigation may be warranted to prevent potentially elevated concentrations of lead to remain in shallow soil in portions of DU1. Supplemental investigation could comprise the extension of DU2 confirmation sampling into the southern DU1 area, and spot cleanup as required to meet ARARs. The prospective additional cost to remove potentially lead-impacted soil from the southern half of DU1 is $58,174, with a range of $40,722 to $87,261.

8. REFERENCES

Beyer, W. N., Connor, E. E., & Gerould, S. (1994). Estimates of soil ingestion by wildlife. Journal of Wildlife Management, 52(2), 375-382.

CalEPA, 2009. Revised California Human Health Screening Levels for Lead. September 2009.

CalEPA, 2010. California Environmental Protection Agency Office of Environmental Health Hazard Assessment Residential and Industrial Human Health Screening Levels. September 2010.

DTSC, 2011. User's Guide to LEADSPREAD 8 and Recommendations for Evaluation of Lead Exposures in Adults. September 2011.

California Department of Fish and Wildlife. 2016. Two Gray Wolves Confirmed in Lassen County. CDFW News. November 2.

California Regional Water Quality Control Board, Central Valley Region. Water Quality Control Plan (Basin Plan) for the Central Valley Region, The Sacramento River Basin and the San Joaquin River Basin. Fourth Edition, Revised July 2016 (with Approved Amendments).

DTSC, 2011. User's Guide to LEADSPREAD 8 and Recommendations for Evaluation of Lead Exposures in Adults. September 2011.

DTSC, 2016. *A7615* California Department of Toxic Substances Control Human and Ecological Risk Office (HERO) Residential and Industrial Screening Levels. October 2016.

ENPLAN, 2013. Preliminary Assessment, Firing Range Lassen Volcanic National Park. December 2013.

Los Alamos National Laboratory [LANL], 2015. ECORISK (version 3.3, Sept. 2015) database. Accessed 12/12/2016.

Maughan, J.T. 1993. *Ecological Assessments of Hazardous Waste Sites*. New York: Van Nostrand Reinhold.

NatureServe. 2017. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: June 9, 2017).

Norton, S.B., D.J. Rodier, J.H. Gentile, and et al. (1992). *A framework for ecological risk assessment at the EPA*. Environmental Toxicology and Chemistry 11:1663-1672.

NPS, 2016. NPS Protocol for the Selection and Use of Ecological Screening Values for Non-Radiological Analytes, Rev. 2. February 18, 2016.

NPS, 2017a https://www.nps.gov/lavo/learn/nature/index.htm. Accessed February 2017.

NPS, 2017b https://www.nps.gov/lavo/planyourvisit/weather.htm Accessed February 2017.

NPS, 2017c https://irma.nps.gov/NPSpecies/Search/SpeciesList Accessed February 2017.

NPS. No date. "The Public Lands Flora - Lassen Volcanic National Park." http://symbiota.org/nps/checklists/checklist.php?cl=3997&pid=104 Accessed June 2017.

Resource Environmental Management Consultants, Inc. (REMC), 2016. Site Inspection Report, Lassen Volcanic National Park Former Firing Range. January, 2016.

Sample, B. E., II, S. G. W., Beauchamp, J. J., & Efroymson, R. (1999). Literature-derived bioaccumulation models for earthworms: development and validation. Environmental Toxicology and Chemistry, 18(9), 2110-2120.

Sample, B. E., & Suter II, G. W. (1994). Estimated Exposure of Terrestrial Wildlife to Contaminants. Oak Ridge, TN: Oak Ridge National Laboratory, Environmental Sciences Division.

Shacklette, H.,1984. Element Concentrations in Soils and Other Surficial Materials of Conterminous United States. U.S. Geologic Survey Professional Paper, 1270.

Sheehan, P.J., and O.L. Loucks. "Issue Paper on Effects Characterization." In U.S. Environmental Protection Agency. Ecological Risk Assessment Issue Papers. Washington, DC: U.S. Environmental Protection Agency, 1994.

USEPA. 1992. *Framework for Ecological Risk Assessment*. U.S. Environmental Protection Agency, Risk Assessment Forum. EPA/630/R-92/001.

USEPA, 1993a. *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA*. Office of Solid Waste and Emergency Response (OSWER) EPA540-R-93-057. August 1993.

USEPA. 1993b. *Wildlife Exposure Factors Handbook Volume I and II.* U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-93/187a and EPA/600/R-93/187b.

USEPA, 1994a. *National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule*. Office of Solid Waste and Emergency Response (OSWER). Section 300.415(b)(4)(i). October 1994.

USEPA, 1994b. Memorandum: OSWER Directive: Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER #9355.4-12. Office of Emergency and Remedial Response, Washington, D.C. February.

USEPA, 1994c. *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*. OSWER #9285.7-15-1. Office of Emergency and Remedial

Response, Washington, D.C. February. http://www.epa.gov/superfund/health/contaminants/lead/products/toc.pdf.

USEPA. 1994d. *Peer Review Workshop Report On Ecological Risk Assessment Issue Papers*. U.S. Environmental Protection Agency, Risk Assessment Forum.

USEPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final*. EPA 540-R-97-006.

USEPA. 1998. *Guidelines for Ecological Risk Assessment*. U.S. Environmental Protection Agency, Risk Assessment Forum. EPA/630/R-95/002F.

USEPA, 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. EPA 530-D-99-001A.

USEPA, 2001. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*. EPA 540/F-01/014.

USEPA, 2003. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. EPA. Washington, DC. EPA-540-R-03-001. January 2003.

USEPA, 2007. *Estimating the Soil Lead Concentration Term for the Integrated Exposure Uptake Biokinetic (IEUBK) Model*. OSWER #9200.1-78, September 2007.

USEPA, 2009. *Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters, and Transmittal Memo. Office of Solid Waste and Emergency Response.* OSWER 9200.2-82, June 2009.

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120, February 2014.

USEPA, 2016. Regional Screening Levels Table. May 2016.

Figures

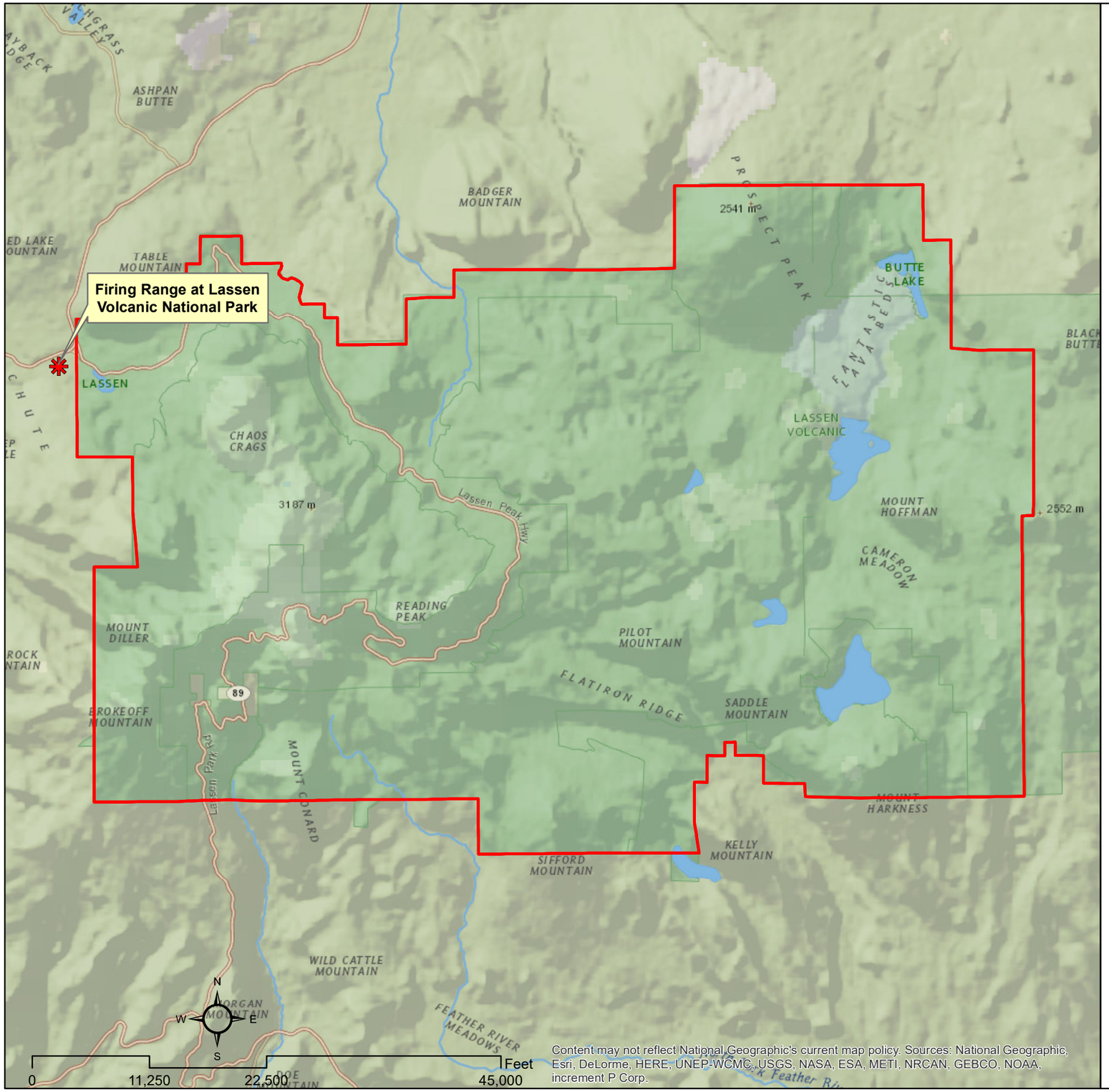


FIGURE 1

SITE LOCATION MAP
SPECIAL USE FIRING RANGE

U.S. DEPARTMENT OF THE INTERIOR,
NATIONAL PARK SERVICE
LASSEN VOLCANIC NATIONAL PARK
SHASTA COUNTY, CALIFORNIA

AVATAR ENVIRONMENTAL

Legend

Special Use Pistol Range Boundary

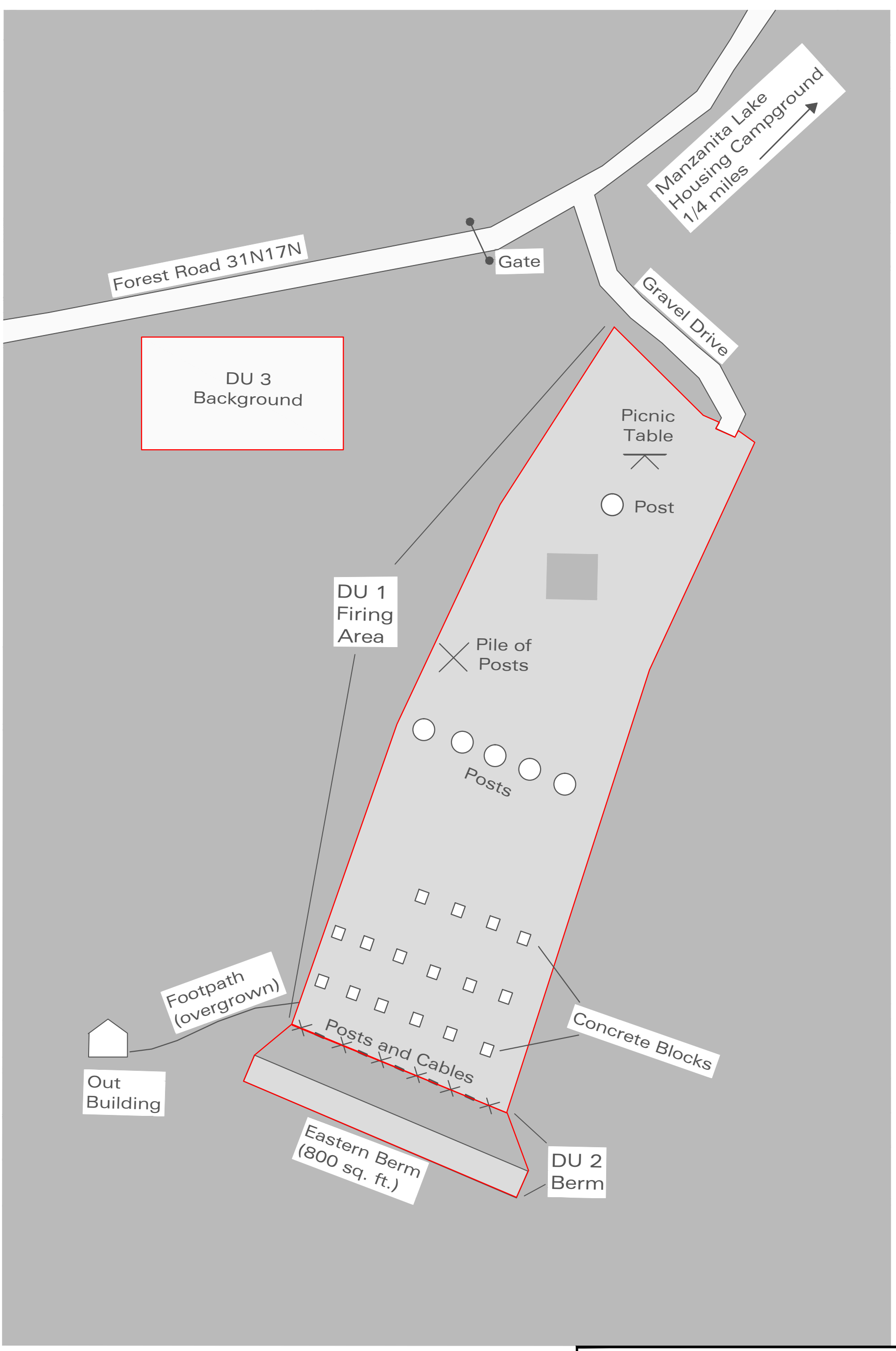
N
W E
S

80 40 0 80 160
Feet

FIGURE 2

SITE DETAIL
SPECIAL USE FIRING RANGE
LASSEN VOLCANIC NATIONAL PARK
SHASTA COUNTY, CALIFORNIA

AVATAR ENVIRONMENTAL



NOTES:
LOCATIONS NOT SURVEYED

N
W E
S

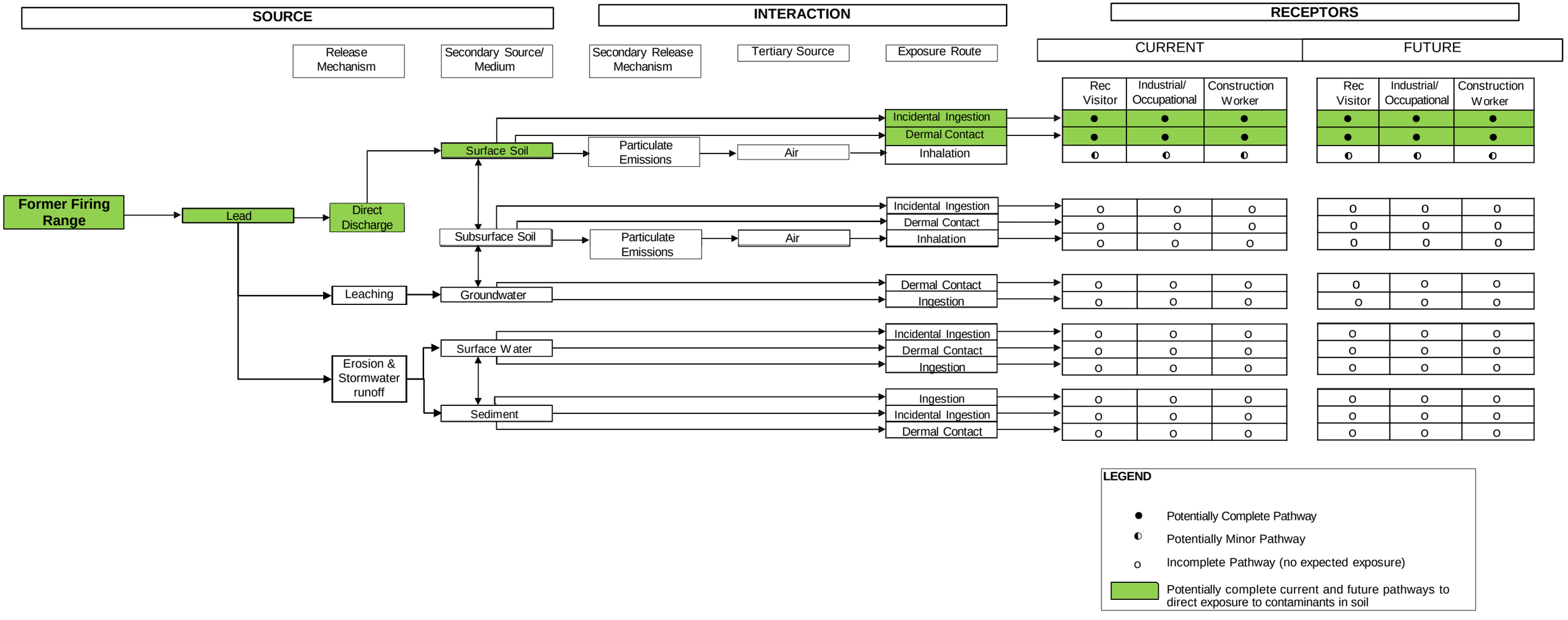
0 25 50
Feet

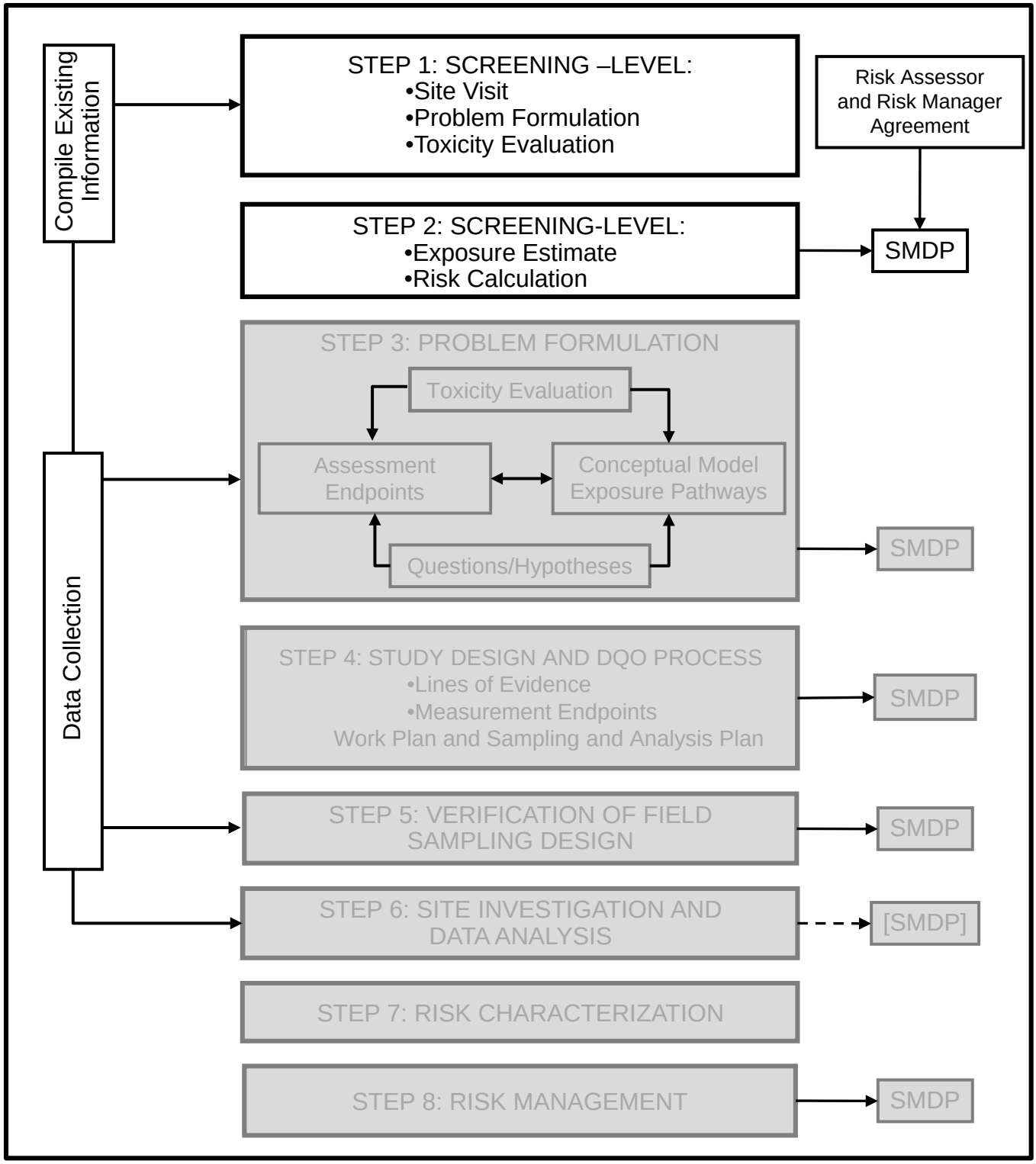
FIGURE 3

SAMPLE LOCATION MAP
SPECIAL USE FIRING RANGE
LASSEN VOLCANIC NATIONAL PARK
SHASTA COUNTY, CALIFORNIA

AVATAR ENVIRONMENTAL

Figure 4
Conceptual Site Model – Human Health Risk Assessment
Former Firing Range
Lassen Volcanic National Park, Shasta County, California





Legend:
SMDP - Scientific/management decision point
[SMDP] - only if change to the sampling and analysis plan is necessary

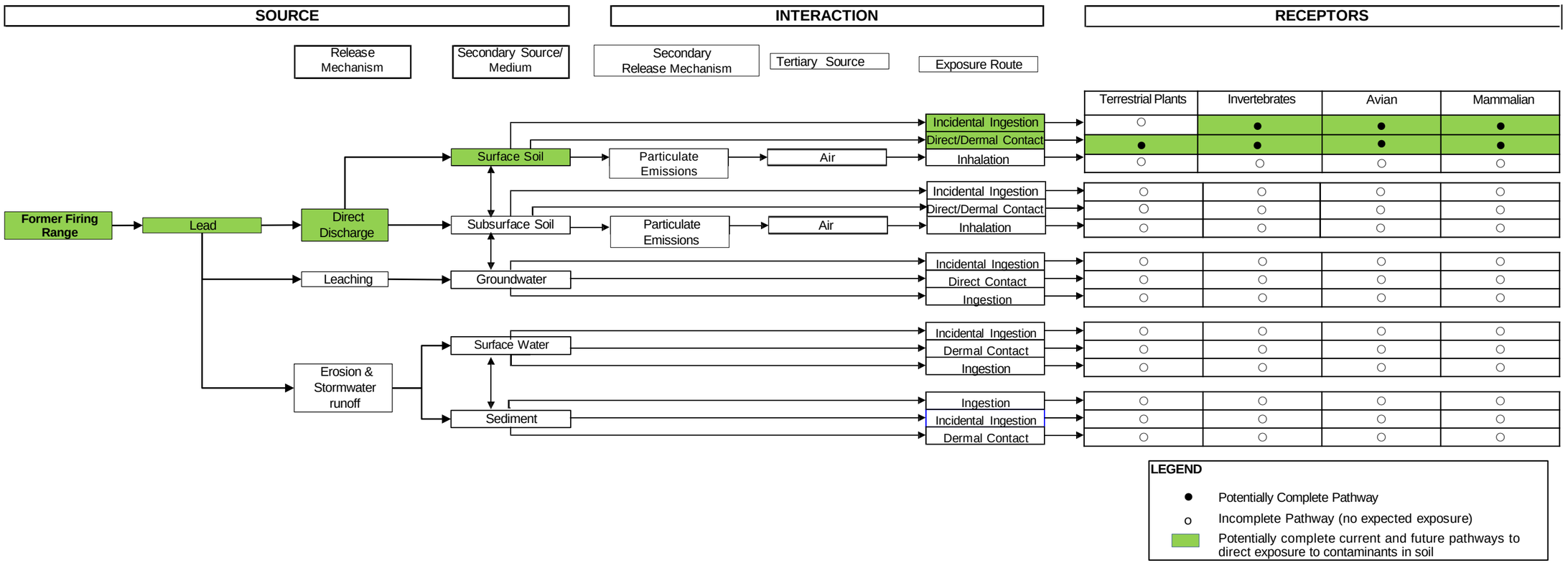
Source: EPA (U.S. Environmental Protection Agency), Environmental Response Team. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final. EPA 540-R-97-006.

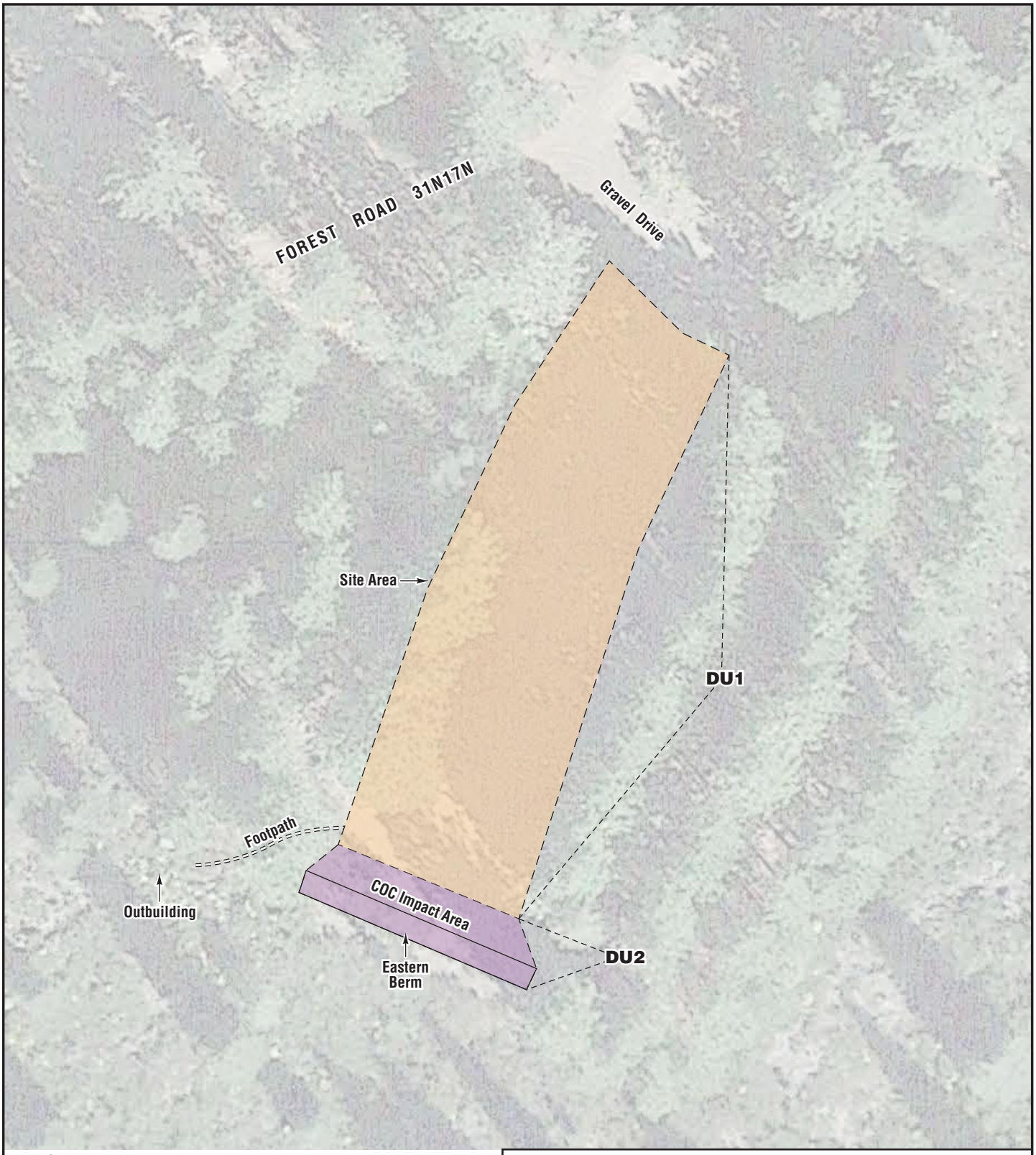
Former Firing Range
Lassen Volcanic National Park
Shasta County, California

FIGURE 5

GENERIC EIGHT-STEP ECOLOGICAL RISK ASSESSMENT PROCESS FOR SUPERFUND

Figure 6
Conceptual Site Model – Ecological
Former Firing Range
Lassen Volcanic National Park, Shasta County, California





Ref: *Site Inspection Report, Lassen Volcanic National Park, Former Firing Range,* Resource Environmental Management Consultants, Inc., 1/20/2016

N
W E
S

0 40

Approx. Scale in Feet

FIGURE 7

AREA OF COC IMPACT
SPECIAL USE FIRING RANGE
LASSEN VOLCANIC, NATIONAL PARK
SHASTA COUNTY, CALIFORNIA

AVATAR ENVIRONMENTAL