Draft RCRA Facility Investigation
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Ventura County, California

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Prepared by

CH2M HILL
4121 Carmichael Road, Suite 400
Montgomery, Alabama 36106

I certify that the information contained in or accompanying this submittal is true, accurate, and complete. As to those portions of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared at my direction in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted.

Signature: _____ 11/26/2008

Joohi R. Sood, P.E
Senior Project Engineer

Date

REGISTERED PROFESSIONAL ENGINEER
JOOHI RASIKA SOOD
NO. C 54918
EXP 6/10
CIVIL
STATE OF CALIFORNIA

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6.1-1 Offsite Seep/Spring and Monitoring Well Locations

Acronyms

ABS	dermal absorption fraction
ACM	Asbestos-containing material
ADD	Average daily dose
AI	Atomics International
AOC	Area of concern
AST	Aboveground storage tank
atm-m^3/M	Atmosphere-cubic-meter per mole
ATL	American Technologies Laboratory
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area use factor
AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
BAA	Benzo(a)anthracene
BaP	Benzo(a)pyrene
BBI	Brandeis-Bardin Institute
BCF	Bioconcentration factor
BEHP	Bis(2-ethylhexyl)phthalate
bgs	Below ground surface
BTAG	Biological Technical Assistance Group
BTEX	Benzene, toluene, ethylbenzene, and xylene
Cal/EPA	California Environmental Protection Agency
CCR	Current Conditions Report
CDD	Chlorinated dibenzo-p-dioxin
CDF	Chlorinated dibenzofuran
CDFG	California Department of Fish and Game
CFOU	Chatsworth Formation Operable Unit
cm^2	square centimeter
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COC	Contaminant of concern
COEC	Contaminant of ecological concern
COPC	Contaminant of potential concern
CPEC	Chemical of potential ecological concern
CSF	Cancer slope factor
CSM	Conceptual site model
CTC	Carbon tetrachloride
CTE	Central tendency exposure
CTL	Component Test Laboratory
DCE	Dichloroethene
DDE	Dichlorodiphenyldichloroethylene
DG	Data gap
DHS-RHB	Department of Health Services-Radiologic Health Branch

DOE	U.S. Department of Energy
DQE	Data quality evaluation
DQO	Data quality objective
DRO	Diesel range organic
DTSC	Department of Toxic Substances Control
EC_{20}s	20-percent effective concentration
ECAO	Environmental Criteria and Assessment Office
Eco-SSL	Ecological soil screening level
ECL	Engineering Chemistry Lab
EFA	Engineering Field Activity
EFH	Extractable fuel hydrocarbons
EIR	Environmental Impact Report
ELCR	Excess lifetime cancer risk
ELV	Expendable Launch Vehicle
ENTS	Engineered Natural Treatment System
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
EPH	Extractable petroleum hydrocarbon
ERA	Ecological risk assessment
ESL	Ecological screening level
ETEC	Energy Technology and Engineering Center
^{o}F	Degrees Fahrenheit
f_{oc}	Fraction of organic carbon
ft	Feet
ft/ft	Feet per foot
ft^2	Square foot
gpd	Gallons per day
gpm	Gallons per minute
GRC	Groundwater Resources Consultants, Inc.
GWCC	Groundwater comparison concentration
H	Henry's Law Constant
H_2O_2	Hydrogen peroxide
HCPC	High-carbon petroleum constituents
HDMS	Historical Document Management System
HEAST	Health Effects Assessment Summary Table
HERD	Human and Ecological Risk Division
HHRA	Human health risk assessment
HI	Hazard index
HMW	High-molecular-weight
HQ	Hazard quotient
ID	Identification
IFC	ICF Kaiser Engineers
IFRNA	Inhibited red fuming nitric acid
IRIS	Integrated Risk Information System
J-E	Johnson and Ettinger
JP	Jet propellant
K_d	Soil-water distribution coefficient

K_{oc}	partition coefficient
K_{ow}	Octanol-water partition coefficient
kg	Kilogram
KUCS	Sage Member of the Upper Chatsworth formation
L	Liter
LADD	Lifetime average daily dose
LCPC	Low-carbon petroleum constituents
LCS	Laboratory control sample
LD50	Lethal dose to 50 percent of test organism
LEOS	Laser and Electro-Optical System
LH2	Liquid hydrogen
LMW	Low-molecular-weight
LOAEL	Lowest observed adverse effect level
LOEC	Lowest observed effect concentration
LOX	Liquid oxygen
µg/dL	Micrograms per deciliter
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
$\mu g/m^3$	Micrograms per cubic meter
MAK	Methyl n-amyl ketone
MDL	Method detection limit
mg/kg	Milligrams per kilogram
mg/kg-day	Milligrams per kilogram per day
mg/L	Milligrams per liter
mg/m^3	Milligrams per cubic mete
mL/g	Milliliter per gram
MMH	Monomethyl hydrazine
MRCA	Mountains Recreation Conservancy Authority
MS/MSD	Matrix spike/matrix spike duplicate
msl	Mean sea level
MWH	MWH Americas, Inc.
NAA	North American Aviation
NASA	National Aeronautics and Space Administration
NFA	No further action
ng/kg	Nanograms per kilogram
NOAEL	No observed adverse effect level
NOEC	No observed effect concentration
NPDES	National Pollutant Discharge Elimination System
NRWQC	National recommended ambient water quality criteria
NSGW	Near-surface groundwater
NTO	Nitrogen tetroxide
OEHHA	Office of Environmental Health Hazard Assessment
Ogden	Ogden Environmental and Energy Services Company, Inc.
ORP	Oxidation-reduction potential
OU	Operable unit
pCi/L	Picocuries per liter
PAH	Polycyclic aromatic hydrocarbon

PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofuran
PCE	Tetrachloroethene
PEC	Probable effect concentration
PEF	Particulate emission factor
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
R&D	Research and development
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfD	Reference dose
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RL	Reporting limit
RME	Reasonable maximum exposure
RMHF	Radioactive Materials Handling Facility
RP	Rocket propellant
RQD	Rock quality designation
RWQCB	Regional Water Quality Control Board
SA	Source area
SAIC	Science Applications International Corporation
SMOU	Surficial media operable unit
SOP	Standard operating procedure
SQL	Sample quantitation limit
SRAM	Standardized Risk Assessment Methodology
SSFL	Santa Susana Field Laboratory
STI	Sonoma Technology, Inc.
STL	Systems Test Laboratory
STP	Sewage Treatment Plant
SVOC	Semivolatile organic compound
SWMU	Solid waste management units
TAL	Target analyte list
TCA	Trichloroethane
TCE	Trichloroethene
TCDD	Tetrachlorodibenzo-p-dioxin
TEC	Threshold effect concentration
TEF	Toxic equivalency factor
TEQ	Toxicity equivalent
TF	Freon trichlorofluoroethene
TPH	Total petroleum hydrocarbon
TRPH	Total recoverable petroleum hydrocarbon
TRV	Toxicity reference value
UCL	Upper confidence limit
UF	Uncertainty factor
USAF	U.S. Air Force

USEFF	Universal Space Engine Flow Facility
USFWS	U.S. Fish and Wildlife Service
UST	Underground storage tank
UV	Ultraviolet
VC	Vinyl chloride
VCAPCD	Ventura County Air Pollution Control District
VCEHD	Ventura County Environmental Health Division
VF	Volatilization factor
VOC	Volatile organic compound
VSI	Visual site inspection
WDP	Waste discharge permit
WHO	World Health Organization
WoE	Weight of evidence
WPA	Work Plan Addendum
WRS	Wilcoxon Rank Sum
yd^3	Cubic yard

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Executive Summary

…Between 1993 and 2008, thousands of samples have been collected from areas within Group 2 at the Santa Susana Field Laboratory (SSFL). After an extensive evaluation of the data and an assessment of the risk to humans and ecological receptors, the findings show that elevated risks occur only in localized areas in Group 2. After the Group 2 Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report is reviewed and approved by the California Department of Toxic Substances Control (DTSC), the Corrective Measures Study (that addresses the possible cleanup actions to be taken) will be developed.

SSFL is located approximately 29 miles northwest of downtown Los Angeles, California, in the southeastern corner of Ventura County. SSFL occupies approximately 2,850 acres of hilly terrain and is owned in part by The Boeing Company (Boeing) and in part by the National Aeronautics and Space Administration (NASA). The land ownership is designated by Administrative Areas–Area II and part of Area I are owned by NASA. The remaining part of Area I, along with Areas III and IV and the Undeveloped Land, are owned by Boeing.

Cleanup of the site is governed by DTSC pursuant to the corrective action provisions of RCRA. For RCRA investigation and reporting purposes, the SSFL sites are considered by geographic locale and similar historical use rather than by ownership. These are referred to as Groups. A Group may have sites that are owned and operated by NASA and Boeing. This RFI Report presents the results and recommendations for the investigation conducted within Group 2. Group 2 contains five distinct sites, all owned by NASA: the former Liquid Oxygen (LOX) Plant, the Area II Landfill, the Expendable Launch Vehicle (ELV) area, the former Area II Incinerator Ash Pile, and the Building 515 Sewage Treatment Plant (STP). The former LOX Plant is located in the NASA part of Area I; the other four Group 2 sites are located in Area II. After the Group 2 RFI Report is reviewed and approved by DTSC, the Corrective Measures Study (which will address the possible cleanup actions to be taken) will be developed.

Initially, the land at SSFL was used for ranching. Most of SSFL was acquired with the purchase of the Silvernale property in 1954. Area II (where most of the Group 2 sites in this report are located) was inactive before 1954, when the land was purchased by North American Aviation (NAA). NAA owned the land from 1954 to 1958; it was then deeded to the U.S. Air Force (USAF). In the 1970s, the property transferred ownership from the USAF to NASA, which currently owns the property.

Primary NASA activities at SSFL since 1948 have included research, development, and testing of liquid-fueled rocket engines and associated components (pumps, valves, etc.). Rocket engine testing frequency decreased during the 1980s and 1990s and ceased in 2005. Engine testing at SSFL primarily used petroleum-based compounds as the fuel and LOX as the oxidizer. Trichloroethene (also known as trichloroethylene) (TCE) was the primary solvent used for cleaning rocket engine components and other cleaning purposes.

Extensive sampling of the soil, soil gas, and groundwater at the five Group 2 sites (former LOX Plant, Area II Landfill, ELV area, former Area II Incinerator Ash Pile, and Building 515 STP) has been conducted and is described in this report, along with an assessment of the risks posed to both human and ecological receptors. On the basis of the results of this sampling effort, some additional sampling is recommended for all five Group 2 sites to further evaluate the extent of the contamination. The chemicals at the sites are known, and for the most part, the extents of these chemicals have been defined. There are a few areas where additional sampling to identify the bounds of the chemical locations is still needed. Most of this sampling is recommended for the subsurface soils, although some sampling of surface soil and soil gas also is recommended.

At DTSC's request, additional sampling of the interior building features and subsurface sewer within Group 2 is being completed. A gridded walkover for debris areas (and subsequent sampling, if warranted) also is being completed. These sampling events are either ongoing or have been scheduled and will be conducted to complete the findings presented in this report. The RFI results are summarized below.

LOX Plant. Of the soil constituents that were evaluated, none was found to pose a high risk to the ecological receptors evaluated at the LOX Plant. Elevated human health risk estimates at the LOX Plant generally were due to elevated concentrations of arsenic, benzo(a)pyrene (BaP), polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs) in specific localized areas. After additional sampling to confirm the extent of contamination, removal of soils that have elevated concentrations is recommended at this location to reduce risks.

Area II Landfill. Elevated ecological and human health risks within the Area II Landfill were identified in a localized area. This localized area has elevated concentrations of di-n-butylphthalate, bis(2-ethylhexyl)phthalate (BEHP), dioxins/furans, and coplanar polychlorinated biphenyls (PCBs) for ecological risks; and BaP, coplanar PCBs, benzene, and PAHs for human health risks. After additional sampling to confirm the extent of contamination, the removal of soils that have elevated concentrations is recommended to reduce human health risks.

ELV. Of the chemicals present, only mercury and dioxin/furans (including coplanar PCBs) were identified as presenting unacceptable ecological risks. Elevated human health risks were identified for dioxins/furans in a localized area that has elevated concentrations. After additional sampling to confirm the extent of contamination, removal of soils that have elevated concentrations and extraction of soil vapors in areas that have elevated VOC concentrations are recommended to reduce risks.

Ash Pile and STP. Because these two sites are geographically contiguous, the data for these sites were combined and evaluated together. Elevated ecological risks were identified for barium in one localized spot within the Ash Pile site boundary. Elevated human health risk estimates from chemicals generally are in a localized area that has elevated concentrations (dioxins/furans, barium, and tetrachloroethene [PCE] in soil vapor). After additional sampling to confirm the extent of contamination, removal of soils that have elevated concentrations and extraction of soil vapors in areas that have elevated VOC concentrations are recommended to reduce risks.

Seeeps and Springs. No contamination has been detected as part of the springs and seeps characterization efforts in the hill slopes north of the Group 2 area.

Surficial Media Operable Unit (SMOU) Groundwater. Cross media transfer of contaminants from the soils to the groundwater in Group 2 probably occurs at the STP. At that location, contaminated groundwater in the Chatsworth Formation is connected hydraulically to the SMOU groundwater, which is present mainly in the weathered bedrock interval. There is a shallow 100-foot-depth interval where nearly all of the TCE mass resides and that is near the affected groundwater present in the weathered bedrock interval near the STP.

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1. Introduction and Methodology

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report presents the results and recommendations for the investigation conducted within the Group 2 Reporting Area in the northern portion of Area II at the Santa Susana Field Laboratory (SSFL). The RCRA Corrective Action Program is being conducted at SSFL under the oversight of the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC). As discussed in Section 1.1.3, the RFI is being conducted at former operational areas called "RFI Sites." The Group 2 Reporting Area includes five RFI sites: the former Liquid Oxygen Plant (LOX), the Area II Landfill, the Expendable Launch Vehicle (ELV) area, the former Area II Incinerator Ash Pile, and the Building 515 Sewage Treatment Plant (STP).

For consistency of presentation, general information concerning SSFL and the RFI program has been taken directly from the Group 4 RFI report prepared by MWH, Americas, Inc. (MWH, 2007).

This report is organized as follows:

Section 1 presents an overview of the SSFL site as a whole, the methodology for the Group 2 RFI, and the organization of this report.

Sections 2 through 6 present the RFI results for the LOX Plant, Area II Landfill, ELV Area, Former Area II Incinerator Ash Pile, the Building 515 STP, and Seeps and Springs, respectively. Each section presents the following information:

- Background and history
- RFI characterization activities
- RFI characterization results
- Nature and extent of contamination
- Conceptual site exposure model
- Fate and transport analysis for chemicals detected in surface media
- Human Health Risk Assessment (HHRA)
- Environmental Risk Assessment (ERA)
- Summary of findings and recommendations

Section 7 presents recommendations for consideration during the Corrective Measures Study (CMS), including a summary of findings for Group 2, a summary of human health and ecological risks, a discussion of cross-media transfer of contaminants of concern (COCs), and recommendations for areas to be carried forward into the CMS.

Section 8 provides the references used in preparing this report.

The appendixes are as follows:

- **Appendix A**–Ecological Surveys Conducted in April 2008, Santa Susana Field Laboratory, Ventura County, California
- **Appendix B**–Liquid Oxygen Plant
- **Appendix C**–Area II Landfill, SWMU 5.1
- **Appendix D**–Expendable Launch Vehicle, SWMUs 5.2, 5.3
- **Appendix E**–Former Area II Incinerator Ash Pile, SWMU 5.6, and Building 515 Sewage Treatment Plant
- **Appendix F**–Springs and Seeps
- **Appendix G**–Laboratory Data

1.1 SSFL Description and Background

1.1.1 SSFL Facility Information

SSFL is located approximately 29 miles northwest of downtown Los Angeles, California, in the southeastern corner of Ventura County. SSFL occupies approximately 2,850 acres of hilly terrain, with approximately 1,100 feet (ft) of topographic relief near the crest of the Simi Hills. Figure 1.1.1-1 shows the geographic location and property boundaries of the site, as well as the surrounding communities. The following subsections describe the site use, history, land ownership, surrounding land use, and environmental programs at SSFL. Additional SSFL facility information is provided in the RFI Program Report (MWH, 2004).

1.1.1.1 SSFL Ownership and History

SSFL is owned jointly by The Boeing Company (Boeing) and the National Aeronautics and Space Administration (NASA), and is operated by Boeing. The site is divided into four administrative areas (Areas I, II, III, and IV) and undeveloped land areas to both the north and south (Figure 1.1.1.1-1). Areas I, III, and IV are owned by Boeing. Area II is owned by NASA. Ninety acres of Area IV were leased to the U.S. Department of Energy (DOE). The northern and southern undeveloped lands of SSFL, which are owned by Boeing, were not used for industrial activities. The Group 4 Reporting Area primarily is located in the southern portion of administrative Area II.

Before development, the land at SSFL was used for ranching. In 1948, North American Aviation (NAA), a predecessor company to Boeing, began using (by lease) what is now known as the northeastern portion, or administrative Area I of SSFL. Most of SSFL was acquired with the purchase of the Silvernale property in 1954, and development of the western portion of SSFL began soon after. Area II was inactive before 1954, when the land was purchased by NAA. NAA owned the land from 1954 to 1958. In December 1958, the property was deeded from Rocketdyne to the U.S. Air Force (USAF) and was operated as USAF Plant 57. In 1973, the property's ownership was transferred from the USAF to NASA, which currently owns the property. Undeveloped land parcels to the south of SSFL were

acquired by Boeing during 1968 and 1976 and to the north during 1998. No site-related operations were conducted in these undeveloped portions of SSFL.

The primary site activities at SSFL since 1948 have included research, development, and testing of liquid-fueled rocket engines and associated components (pumps, valves, etc.) (Science Applications International Corporation [SAIC], 1994). Since 1996, operations at SSFL have been conducted by Boeing. Predecessor companies to Boeing have included the Rocketdyne Propulsion and Power Division (Rocketdyne) of NAA and of the Rockwell Corporation. The vast majority of rocket engine testing and ancillary support operations occurred from the 1950s through the early 1970s and was conducted by Rocketdyne in Areas I and III in support of various government space programs and in Area II on behalf of NASA. Rocket engine testing frequency decreased during the 1980s and 1990s and ceased in 2005. Currently, no rocket engine test areas are in operation. Engine testing at SSFL primarily used petroleum-based compounds as the "fuel" and LOX as the "oxidizer." Trichloroethene (TCE) was the primary solvent used for cleaning rocket engine components and other cleaning purposes. Solid propellant testing was not conducted at the large rocket engine test stands, but was used in small rocket motor testing and various research and development (R&D) programs. Primarily solid propellants, including perchlorate compounds, were used, stored, and tested within Area I.

In addition to the primary facility operation of rocket engine testing, SSFL was used for research, development, and testing of water jet pumps, lasers, liquid metal heat exchanger components, nuclear energy research, and related technologies. Nuclear energy research, testing, and support facilities were located within the 90-acre portion of Area IV that was leased to the DOE and designated as the Energy Technology and Engineering Center (ETEC). Operations were conducted by Atomics International (AI), a division of NAA, and Rocketdyne on behalf of the DOE, with operations primarily from the 1950s through the early 1980s.

1.1.1.2 Surrounding Land Use

Land surrounding SSFL generally is open space or rural residential, although other uses are present. The current land uses of each of the offsite adjacent properties are described briefly in the following text (MWH, 2004). Adjacent land uses are shown in Figure 1.1.1-1.

Northern Adjacent Properties–The adjacent property to the northwest is occupied by the Brandeis-Bardin Institute (BBI) and the adjacent property to the northeast is occupied by the Mountains Recreation Conservancy Authority (MRCA). The BBI is zoned as rural agricultural on Ventura County zoning maps. This designation permits a wide range of agricultural uses. The specific land use permit conditions for the BBI indicate that this property contains religious, teaching, and camping facilities. The MCRA property is zoned as open space and currently operates as Sage Ranch Park, which is a Ventura County Park, and has a house where the park ranger resides.

Eastern Adjacent Properties–The properties situated immediately adjacent to the east of SSFL are zoned light agricultural, with variances that permit higher-density use (such as mobile home parks). There is a residential community approximately ¼-mile east of SSFL's boundary in Woolsey Canyon. A new residential community is under development ½-mile southeast of SSFL's boundary near Dayton Canyon.

Southern Adjacent Properties–The properties situated adjacent to the south of SSFL are used for residential purposes (Bell Canyon). Dense residential development begins in the San Fernando Valley about 5 miles southeast of SSFL.

Western Adjacent Properties–Most of the properties situated adjacent to the west of SSFL are designated by Ventura County as open space. This land has been and currently is used for cattle grazing. Recently, a portion of Runkle Canyon in this area has been proposed for development.

1.1.1.3 SSFL Environmental Programs

Five environmental programs at SSFL are being conducted under the authority of RCRA. The RCRA Program is described further in Section 1.1.2. In addition to RCRA, other federal, state, and county environmental programs are being conducted at SSFL, including permitting for air emissions, surface water discharges, and other site investigation and closure activities. Information regarding the environmental programs conducted at SSFL is provided in the RFI Program Report (MWH, 2004). Because these other environmental programs overlap and occur within some of the RCRA RFI sites, they are described briefly below:

- Waste discharge permits (WDPs) have been issued to SSFL by the Regional Water Quality Control Board (RWQCB) since 1958. Currently, surface water discharges from SSFL are regulated under a National Pollutant Discharge Elimination System (NPDES) permit issued by the RWQCB, beginning in 1984. Surface water discharges are monitored regularly at 18 NPDES locations, shown in Figure 1.1.1.1-1.
- Fuel storage tanks at the site are now included in the RCRA Program under oversight by DTSC. Historically, underground storage tanks (USTs) were regulated by the Ventura County Environmental Health Division (VCEHD). Aboveground storage tanks (ASTs) were regulated by the RWQCB.
- Closure of nuclear testing and research facilities in Area IV is being performed under the DOE's jurisdiction. The California Department of Health Services–Radiologic Health Branch (DHS-RHB) oversees the Boeing-owned Radioactive Materials License, conducts facility verification surveys, evaluates the radioactive facility cleanup, and conducts environmental monitoring.

1.1.2 RCRA Corrective Action Program

The RCRA-related activities at SSFL include four major environmental programs, all under the oversight and jurisdiction of the DTSC. These programs include: 1) RCRA Corrective Action; 2) closure of inactive RCRA units; 3) compliance and permitting of RCRA units; and 4) interim measures. In some instances, these programs overlap (for example, closed RCRA units within RFI sites that are investigated as part of a corrective action). Although related under RCRA, each program has separate process requirements and guidelines. Collectively, these programs represent a comprehensive program for the handling and cleanup of hazardous chemicals. The RCRA Corrective Action process is described below; the RFI Program Report (MWH, 2004) describes the other RCRA Programs.

1.1.2.1 Corrective Action Process

The RCRA Corrective Action process includes four phases to achieve site cleanup and closure. These include the RCRA Facility Assessment (RFA), RFI, CMS, and Corrective Measures Implementation (CMI) phases. The first phase of the process, the RFA, is performed to identify solid waste management units (SWMUs) and areas of concern (AOCs), which are units that have used, stored, or handled various hazardous materials. The RFA for SSFL was completed in 1994 (SAIC, 1994).

The SSFL RCRA Corrective Action program is currently in the RFI phase. During the RFI, additional AOCs (beyond those listed in the RFA) have been identified and investigated at SSFL (MWH, 2004). A total of 135 SWMUs and AOCs have been identified at SSFL, and those undergoing closure as part of the RFI Program have been grouped by location for purposes of investigation and are called "RFI sites." RFI sites have been grouped for reporting as described in Section 1.1.2.3. The RFI Program Report (MWH, 2004) listed 51 RFI sites. Further evaluation of the RCRA Program has resulted in a new total of 57 RFI sites. Four sites were added to include land surrounding the permitted facilities (Area I Burn Pit, Radioactive Materials Handling Facility [RMHF], Building 133, and Building 029). Two sites were added when the leach fields were regrouped to allow for planned reporting. The 57 RFI sites identified for investigation at SSFL are shown in Figure 1.1.2.1-1. For ease of presentation in Figure 1.1.2.1-1, and as reported in previous documents (MWH, 2004), the Boeing and DOE leach fields not associated with an existing RFI site have been grouped together (a DOE group and a Boeing group) and listed as additional RFI sites.

The RFI includes characterization of all relevant environmental media present at SSFL. Investigations of environmental media have been conducted following DTSC-approved work plans (ICF Kaiser Engineers [ICF], 1993; Groundwater Resources Consultants, Inc. [GRC], 1995a, 1995b; Ogden Environmental and Energy Services Company, Inc. [Ogden], 1996, 2000a, 2000b; Montgomery Watson, 2000b; MWH, 2001, 2003e, 2003f, 2005c). The scope and extent of sampling at SSFL during the RFI is described in the RFI Program Report (MWH, 2004).

The objectives of the RFI are to characterize the nature and extent of chemical contamination in environmental media, to evaluate risks to potential receptors, to gather data for the CMS, and to identify areas for additional work (DTSC, 1995). Site action recommendations resulting from the RFI are categorized into: 1) further evaluation in the CMS; 2) no further action (NFA); 3) interim source area stabilization measures to control contaminant migration (Stabilization Areas) while cleanup plans are prepared; and 4) data gap (DG) areas for further evaluation. Stabilization Areas may be included within CMS Areas.

The CMS phase of the RCRA Corrective Action Program is an evaluation of remedial alternatives for areas identified for further evaluation during the RFI. The CMS also may include further evaluation of uncertainties identified in the RFI related to risk assessment, delineation of chemicals requiring cleanup, or characterization of new chemical source areas identified during the preparation of the Group 2 RFI Report. CMS plans are prepared for DTSC review and the findings are published in a final CMS report for DTSC approval. During the CMI, the Corrective Action Program moves from cleanup planning to cleanup implementation and confirmation and monitoring sampling. The complete SSFL cleanup plan will be evaluated in an environmental impact report (EIR) before implementation.

Public review and comment will be included during several steps in this process before the selection and implementation of cleanup activities.

1.1.2.2 Operable Units at SSFL

Since the early 1980s, SSFL site characterization has proceeded along two parallel paths: one for groundwater and the other for soil and related surficial media. In 1999, DTSC formalized this approach by identifying two operable units (OUs) (DTSC, 1999). As defined by the U.S. Environmental Protection Agency (EPA), an OU is a discrete entity that may comprise various attributes, including the characteristics of the affected media, geographical location, vertical and aerial considerations, specific site problems, and potential exposure pathways. The OUs identified at SSFL are consistent with this definition and incorporate different geographic portions of the site, project phases, and exposure pathways. Two OUs have been identified at SSFL through discussion with the DTSC based on an understanding of where chemicals are present today, where they may migrate in the future, and how either human or ecological receptors may be exposed to those chemicals (DTSC, 1999). The OUs at SSFL are as follows:

- The Surficial Media OU (Surficial OU), comprised of saturated and unsaturated soil, sediment, surface water, near-surface groundwater (NSGW), air, biota, and weathered bedrock. NSGW occurs within alluvium or weathered bedrock
- The Chatsworth Formation OU (CFOU), comprised of the Chatsworth formation groundwater, and both saturated and unsaturated unweathered (competent) bedrock

The Surficial OU consists primarily of soil, sediment, and surface water, which potentially are affected by spills. Also included in this OU are NSGW, air, biota, and the upper weathered portion of the bedrock. These additional media have been included in the Surficial OU because chemicals released into soil, sediment, or surface water could directly contact, or potentially be transferred to, NSGW, surface seeps or springs, air, biota, and weathered bedrock. Direct exposure to surficial media by receptors is possible, although the type of exposure may vary based on location (steep drainage terrain versus flat upland terrain). These potential surficial media exposures in Group 2 are evaluated in the risk assessments completed for the RFI sites within this group.

The CFOU consists of groundwater and associated unweathered, competent bedrock of the Chatsworth formation, which is comprised of thickly bedded sandstone with interbeds of siltstone and shale. This unit has been affected by downward migration of chlorinated solvents (primarily TCE) from surficial spills and/or by dissolved phase contaminants transported to and within Chatsworth formation groundwater. In contrast to surficial media, because of its nature and depth (typically more than 70 ft below ground surface [bgs]), it is unlikely that human or ecological receptors would be exposed directly to chemicals in the unweathered, deeper bedrock. Direct exposures to Chatsworth formation groundwater only could occur through the installation of a drinking water well, or at a surface seep or spring supplied by Chatsworth formation groundwater. Indirect exposures to chemicals in Chatsworth formation media (bedrock or groundwater) also are considered as part of the RFI site risk assessments. These potential direct and indirect groundwater exposures in Group 2 are evaluated in the risk assessments completed for the RFI sites within this group. As stated above, a goal of the RFI Program is to characterize chemical

impacts in all relevant environmental media at SSFL. This goal is achieved by combining and integrating site data from the characterization programs for both OUs. Similarly, the goal of the RFI risk assessment is to evaluate risks from all relevant environmental media. This goal is accomplished by combining the estimated risk associated with exposure pathways for both OUs. Several possible pathways of chemical migration across or between OUs have been identified. Each of these potential pathways is included in the risk evaluations of the Surficial OU and the CFOU, as described further in Section 1.5.

1.1.2.3 RFI Program and Reporting Approach

As described in the RFI Program Report (MWH, 2004), the data quality objective (DQO) process (EPA, 1994, 2000) was used to guide the SSFL RFI. The problem statement developed for the Surficial OU RFI is as follows:

> *Comply with regulatory requirements by characterizing the nature and extent of contamination in surficial media (soil matrix, soil vapor, sediment, surface water, near surface groundwater, air, biota, and weathered bedrock).*

Five decision questions were identified during the DQO development and have been used to guide the data collection and evaluation process for the Surficial OU RFI. These five questions are listed below:

1. Has historical information regarding chemical use areas and chemical releases been used to identify potential source areas?
2. Have source area sampling and analysis plans been developed to characterize the nature and extent of contamination?
3. Is the nature and extent of contamination at potential source areas in RFI sites characterized sufficiently for risk assessment?
4. Have potential human health and ecological impacts been assessed?
5. Have characterization and risk assessment results been used to make site action recommendations for the CMS?

Although developed for the Surficial OU, these five questions are relevant for the overall RFI Program at SSFL. The RFI reporting approach has been designed to answer these questions in a comprehensive, integrated manner for large areas of the site. On the basis of input from the DTSC, SSFL has been divided into 10 Group Reporting Areas, as shown in Figure 1.1.2.3-1. The Group Reporting Areas have been established to accomplish the goal of providing a comprehensive, integrated description of site data from all media across large, interrelated areas of the site. As such, the Group RFI Reports include evaluation of data from both OUs to determine characterization completeness, transport and fate of contaminants, and assessment of potential risks to receptors. As necessary, offsite areas will be included in the RFI evaluation of SSFL-related impacts. Group Reporting Areas were identified generally based on natural topographic constraints at SSFL, but groundwater plume extents, RFI site responsibility, and operational boundaries also were considered. The Group Reporting Areas shown in Figure 1.1.2.3-1 serve to facilitate the evaluation of all migration pathways, and therefore, capture all appropriate site data for risk assessment.

The focus and objective of the Group RFI Reports is to provide DTSC with sufficient information so that site action decisions regarding Surficial Media can be made and CMS evaluation areas determined. Because the CFOU investigation is ongoing while the Group Reports are being prepared, CMS recommendations regarding groundwater will be provided in a final Sitewide Groundwater Report, which will be submitted at the completion of the CFOU investigation. However, groundwater-related risks are presented in the risk assessments and considered with the Surficial OU risks in making CMS recommendations.

Two aspects of the Surficial Media RFI will be addressed after all Group RFI Reports are prepared. In both of these cases, additional Surficial Media recommendations will be in addition to those presented in the Group Reports. The first involves completion of the CFOU investigation described above. Because all media are being assessed for potential risks to receptors in the current Group RFI Reports, new data resulting from the ongoing CFOU investigation must be reassessed for contribution to Surficial Media risks and, if necessary, additional areas recommended for CMS evaluation. This assessment of subsequent CFOU data will be included in the Sitewide Groundwater Report.

The second aspect that affects the Surficial Media site action recommendations for the CMS is a sitewide evaluation for large-home-range receptors (mule deer and hawk). An assessment of potential risks to these receptors will be performed once sufficiently large areas of SSFL have been evaluated and presented in the Group RFI Reports. Estimated large-home-range receptor risks will be reported in a Sitewide Large-Home-Range Risk Assessment Report, which also will identify any additional areas that should be considered for CMS evaluation resulting from that assessment.

These two additional aspects of RFI reporting will serve to confirm and finalize the areas to be evaluated in the CMS as described in this (and other) Group RFI Reports. The areas recommended for further evaluation in this report can be confidently carried forward into the CMS, because it is believed that additional, not fewer, areas will be identified by subsequent sitewide RFI evaluations.

Previous RFI reports submitted to the DTSC for review include Groups 4, 6, and 8.

1.1.3 Scope and Objectives of the Group 2 RFI Report

The Group 2 RFI Report presents RFI findings and CMS recommendations for the northern portion of Area II. The scope and objectives of the Group 2 Report are described below, as along with the content and format of this report.

1.1.3.1 Scope

The Group 2 Reporting Area consists of approximately 285 acres within the northern portion of Area II, and 42 acres in Area I (the former LOX Plant site) (Figure 1.1.2.3-1). Adjacent areas to the Group 2 Reporting Area include the RFI Groups 3 and 6 to the west, Groups 3 and 1b to the south, Group 1a and offsite areas to the east, and Boeing-owned undeveloped land and offsite areas to the north. Reporting Group 3 consists of NASA RFI sites; other areas belong to Boeing.

The following five RFI sites are included in the Group 2 Reporting Area:

- **LOX Plant** includes the LOX Plant Waste Oil Sump and Clarifier (SWMU 4.5) and the LOX Asbestos and Drum Disposal Site (SWMU 4.6).
- **Area II Landfill** (SWMU 5.1)
- **ELV Area** includes the ELV Final Assembly Building 2206 (SWMU 5.2) (also includes Buildings 2201, 2202, 2203, 2211, 2231, and 2232); SWMU 5.3, Building 231 Polychlorinated Biphenyl (PCB) Storage Facility (SWMU 5.3); Building 2206 Diesel UST (UT-51) AOC; and the Building 2207 UST (UT-53) AOC. Building 207 also is included because of the building's proximity to the ELV.
- **Incinerator Ash Pile** (SWMU 5.6); RD-9 Area Ultraviolet Light/Hydrogen Peroxide (UV/H_2O_2) Treatment System (SWMU 5.4) also is included because of its proximity to the former ash pile site.
- **Building 515 STP** AOC; includes the UT-52 AOC and the Area II Service Area Building 211 Leach Field AOC. The Universal Space Engine Flow Facility (USEFF) also is included because of its proximity to the STP.

It should be noted that the RFI Site boundaries shown in maps and figures depicted in this report are not meant as administrative boundaries, but rather serve as outlines that encompass the primary operational activities at a site. As described in Sections 2 through 6, the RFI sampling extended outside of these boundaries, as necessary, to evaluate the nature and extent of potential contamination and to assess potential migration pathways.

1.1.3.2 Objectives

This report has the following objectives:

- To present characterization results in the Group 2 Reporting Area and to identify the nature and extent of chemical contamination in environmental media.
- To present HHRA and ERA results based on chemicals present in the Group 2 Reporting Area.
- To present risk-based recommendations for site actions, including NFA areas, areas recommended for further evaluation in the CMS, and areas recommended for source stabilization.

As stated above, the Surficial Media areas recommended for further CMS evaluation are considered to have been defined sufficiently for CMS planning, although supplemental areas or volumes may be added following the completion of the Sitewide Groundwater Report and/or the Sitewide Large-Home-Range Risk Assessment Report.

1.2 Physical Setting of the Reporting Area

1.2.1 Climate and Meteorology

For consistency of presentation, general information concerning climate and meteorology at SSFL has been taken directly from the Group 4 RFI report prepared by MWH (2007).

Climate and meteorological data have been collected for SSFL since the 1960s. The climate falls within the Mediterranean sub-classification, and monthly mean temperatures range from 50 degrees Fahrenheit (ºF) during the winter months to 70ºF during the summer months (SAIC, 1994). During the summer months (April through October), an onshore wind pattern occurs because of the proximity of the adjacent Pacific Ocean; during the winter months this is interrupted by weather fronts (SAIC, 1994). Wind measurements have been collected at SSFL in Area IV west of the Group 4 Reporting Area. A wind rose diagram from January to December 2001, presented in Figure 1.2.1-1, indicates that the prevailing wind pattern is northwest-southeast (Sonoma Technology, Inc. [STI], 2003). This wind rose pattern is consistent with the historical data collected both in the 1960s and 1990s.

Precipitation at SSFL is normally in the form of rain, although snow occasionally has fallen during the winter months. Precipitation at the site has averaged approximately 18 inches per year between 1960 and 2006, as shown in Figure 1.2.1-2. The annual precipitation has ranged from a low of 5.7 inches in 2002 to a maximum of 41.2 inches in 1998. Precipitation has been measured at SSFL daily during rainstorms at two onsite stations. The monthly precipitation for the 6-year period from October 2000 through June 2006 is presented in Figure 1.2.1-3. Most of the annual precipitation at SSFL occurs between November and March, consistent with the regional precipitation pattern of southern California.

1.2.2 Physiography

SSFL is located within the Pacific Mountain System, Pacific Border Province, Los Angeles Ranges (also know as the Transverse Ranges) physiographic region. Generally, the Transverse Ranges represent a complex of tectonic forces resulting from the interaction of the Pacific and the North American plates along the San Andreas fault. The Transverse ranges are oriented predominantly east-west. The Transverse Ranges include the Santa Ynez Mountains, the San Rafael Mountains, the Sierra Madre Mountains, the Topatopa Mountains, the Santa Susana Mountains, the Simi Hills, the Santa Monica Mountains, the San Gabriel Mountains, the Puente Hills, the Chino Hills, and the San Bernardino Mountains.

The Transverse Ranges are characterized by extreme differences in geologic age and composition, varying from sedimentary rocks in the western Santa Ynez and Santa Monica mountains to primarily granitic and metamorphic rock in the eastern regions, where they terminate abruptly in the San Gabriel and San Bernardino mountains.

Located in the Simi Hills, SSFL occupies approximately 2,850 acres of hilly terrain that expresses approximately 1,100 ft of topographic relief (Figure 1.2.2-1). The highest surface elevation at SSFL occurs near the center of the site at an approximate elevation of 2,245 ft above mean sea level (msl). The highest surface elevations at SSFL occur in two general bands that strike along a northeast-southwest trend, consistent with the geology of the area. The lowest elevation occurs at the eastern property boundary and has an elevation of approximately 1,1,75 ft above msl. The lower elevations at SSFL occur primarily along the eastern, southern, and north-central to northwestern perimeters of the property. A broad, relatively flat area of topography exists in the northwestern portion of SSFL that is referred to as the Burro Flats area (MWH, 2003).

Group 2 RFI sites range in elevation from approximately 1,700 ft above msl at the eastern boundary of the group to approximately 1,900 ft above msl at the western boundary. The area is dissected by several perennial drainages.

1.2.3 General Geology and Hydrogeology at the Santa Susana Field Laboratory

The regional geology and hydrogeology have been reported extensively in previous documents submitted to the DTSC. Brief summaries are provided below. Detailed information regarding the geology and hydrogeology are provided in the site-specific sections (Sections 2 through 5) and the seeps and springs (Section 6).

1.2.3.1 Summary of Geology

SSFL is located in the Transverse Ranges of southern California, characterized by north-south compression that has produced geologic structures such as faults, synclines, and anticlines that are elongated in an east-west direction. Primary geologic units present at SSFL are the Quaternary Alluvium and the Cretaceous Chatsworth formation. The Chatsworth is overlain by the Simi Conglomerate Member of the Paleocene Santa Susana formation in the northern part of the site, and is faulted against the Santa Susana formation in the western part of the site. To the south, the Chatsworth is overlain by southward dipping late Tertiary formations. Structurally, SSFL is located on the southern flank of an east-west striking and westward plunging syncline that passes through the central part of the Simi Valley (MWH, 2003). The regional geology is depicted in Figure 1.2.3.1-1. A geologic map of the SSFL area is presented in Figure 1.2.3.1-2. These geologic formations are described below:

- Quaternary Alluvium–Alluvial soils are generally thin and typically 5 to 15 ft thick at SSFL. Alluvial soils usually occur in topographic lows and along stream drainages. A thin alluvial veneer covers a broad expanse in the Burro Flats area. Disturbed soils also have been used as fill material in developed portions of SSFL. Thick fill soils (up to 35 to 40 ft) have been identified in the northeast and north-central sections of SSFL. The alluvium generally consists of weathered Chatsworth formation sediments and is usually a fine-grained silty sand (MHW, 2003).
- Chatsworth Formation–Most of SSFL is underlain by the Cretaceous Chatsworth formation, which consists of interbedded sandstone and shale. These sediments have been interpreted as deep-sea turbidite deposits. The Chatsworth formation has been divided into the lower Chatsworth Formation and the upper Chatsworth Formation. The upper Chatsworth formation has been further subdivided into the Sandstone 1 and Sandstone 2 units (Figure 1.2.3.1-3). Further subdivision of these sandstone units has resulted in the naming of multiple members. A series of thin shale, siltstone, and sandstone beds, known collectively as Shale 2, separate the older Sandstone 1 deposits from the overlying Sandstone 2 deposits.

SSFL Group 2 RFI units are underlain by members of the Sandstone 2 unit. These deposits consist primarily of fine- to medium-grained sandstone with varying thicknesses of siltstone and shale. The eastern section of the Group 2 RFI sites is bounded by rocks of the Shale 2 unit. The western boundary of the Group 2 RFI sites is bounded by the Upper Burro Flats Member. An east-west trending, laterally extensive fault known as the North Fault traverses the northern boundary of the Group 2 RFI units. Faults at SSFL are believed to dip

vertically. The southern boundary of the Group 2 RFI units is bounded by the southwest-northeast trending rocks of the Shale 2 unit.

1.2.3.2 Summary of Hydrogeology

Groundwater occurrence at SSFL is classified into two categories. Groundwater that occurs in the alluvium and in weathered bedrock of the Chatsworth formation is categorized as NSGW. Groundwater that occurs in the unweathered Chatsworth formation is categorized as Chatsworth formation groundwater. NSGW occurs as perched and vertically continuous with Chatsworth formation water. First encountered groundwater typically exists under water table conditions and may be encountered in any of these media. First-encountered groundwater can be found at depths as shallow as approximately 4 ft bgs to depths greater than 500 ft. Groundwater springs and/or seeps have been found both in ephemeral drainages in the southern section of SSFL and offsite to the north and east of SSFL (MWH, 2003).

The occurrence of NSGW is ephemeral. Groundwater monitoring wells completed in alluvial and weathered bedrock will, on occasion, be dry. Groundwater flow is influenced by topography, with flow generally being parallel to the long axis of valleys.

The fractured Chatsworth formation is the principal water bearing system at SSFL. Chatsworth formation groundwater occurs regionally, rather than being localized in extent, as with NSGW. Depths to water measured in Chatsworth formation wells (where groundwater is not vertically continuous with NSGW) range between 60 and 300 ft bgs and can vary over short distances (MWH, 2004). Chatsworth groundwater occurs in secondary porosity features (fractures, bedding planes, and joints), where most groundwater movement occurs. Groundwater also occurs within the matrix of the sandstone (in between fractures and bedding planes), but little to no movement of this water occurs within the rock matrix. The matrix hydraulic conductivity is approximately an order-of-magnitude lower than the bulk hydraulic conductivity of the Chatsworth formation, indicating that the hydraulic conductivity of the formation is dominated by the fractures within the bedrock (Montgomery Watson, 2000).

On the basis of an analysis of hydrogeologic data, five groundwater units have been established at SSFL (Montgomery Watson, 2000). Group 2 SWMUs are contained within Groundwater Unit 3. Groundwater flow in this unit is generally north and northwest. The estimated rate of groundwater discharge along the northern boundary of the unit ranges from 5 to 10 gallons per minute (gpm), based on gradient and bulk hydraulic conductivity observations (Montgomery Watson, 2000).

1.2.4 SSFL Surface Water Features

The occurrence of surface water at SSFL is intermittent. That which does not seep into the ground is collected in one of four major drainages and conveyed offsite (Figure 1.2.4-1). Most of the surface water from SSFL runs off the southern property boundary through Bell Canyon and into Bell Creek, which subsequently discharges into the Los Angeles River. The eastern portion of the facility drains through Dayton Canyon into Dayton Creek and joins with Bell Creek to form the Los Angeles River. The northwestern perimeter drains northward into Meier Canyon, which discharges into Arroyo Simi. The northeastern and north-central portions of SSFL drain into the Northern Drainage, which connects to the

Meier Canyon drainage offsite to the north of SSFL on property owned by the BBI. NPDES outfalls monitor discharge from these drainages. Other drainages where no operations occur include the Runkle Canyon, Woolsey Canyon, and Eastern drainages (MWH, 2003).

The Group 2 RFI sites are located in the northern drainage, which consists of 355 acres. Several ephemeral streams drain this area. Flow direction varies with the orientation of valleys, but generally is east to west in the eastern section of the Group to northerly in the central section of the Group.

There are four perennial ponds or surface water bodies in SSFL. The ponds have been used to collect storm water runoff, treated groundwater, and operational water. No perennial ponds or surface water bodies exist in the Group 2 RFI boundary.

Numerous ephemeral and perennial springs and seeps, most of which occur in the area surrounding SSFL, have been identified (Figure 1.2.4-2). Seeps are defined as any location where water is observed discharging from the subsurface; this includes locations that have flowing water, ponded water, and wetness, but no observed ponding or active flow. The definition includes features normally referred to as "springs." No springs or seeps have been identified within the boundaries of the Group 2 RFI sites; however, several have been identified in the drainage basin north of the Group 2 RFI sites. These seeps and springs are discussed in detail in Section 6.

Three seeps or springs have been identified within the northern drainage on BBI property (MWH, 2003a). One spring has been reported as a "perennial seep along canyon bottom" and a second spring has been reported as "beginning of flow in creek." These springs are located along the prominent drainage feature in the northern drainage leading from Area II.

1.2.5 Habitat

A broad-scale evaluation of habitats present at SSFL was conducted, as reported in the Biological Conditions Report (MWH, Appendix I, 2005e). This survey documented the occurrence of 16 different habitat types within SSFL: freshwater marsh, open water, unvegetated drainage channels, coast live oak woodland, southern coast live oak riparian forest, southern willow scrub, mulefat scrub, baccharis scrub, Venturan coastal sage scrub, chaparral, native grassland, nonnative grassland, ruderal, rock outcrop, eucalyptus woodland, and developed. Habitat surveys specific to Group 2 were not reported in MWH (2005e).

To characterize the presence and condition of the habitats in Group 2, site-specific field surveys were conducted at each of the five Group 2 RFI sites in early April 2008. These surveys identified the nature and spatial extent of the habitat and land cover types present at each site, and reported whether there was evidence of stress among resident plants[1]. Incidental observations of animals or animal signs also were recorded. Habitat and land cover types in each of the RFI sites are summarized in Table 1.2.5-1 and shown in Figure 1.2.5-1. Habitats at each RFI site are described briefly below. The complete details of

[1] Observations of stressed vegetation are a critical component of the qualitative assessment of risks to the plant community and a prerequisite for a quantitative risk evaluation for plants [Section 1.5.4].

the field surveys, including a checklist, photographs, and site-specific habitat maps for each RFI site, are presented in Appendix A. The habitats are summarized below:

- LOX Area–Habitat at the LOX area, approximately 6 acres[2], is predominantly open, ruderal vegetation, less than 10 inches in height. Shrub/scrub habitat and pavement and former buildings cover approximately 25 and 15 percent of the site, respectively. Woodland cover at this site is less than 1 percent. Approximately 40 percent of the vegetated area at the LOX was observed to be stressed. Standing dead woody vegetation provides evidence that this site burned in the 2005 Topanga Fire. Multiple bird and mammal species (song sparrow, California towhee, lark sparrow, western scrub-jay, house finch, spotted towhee, mourning dove, California quail, woodrat [dens and scat], kangaroo rat [burrows], coyote [scat], and cottontail rabbit) were observed to use the site.

- Area II Landfill–The Area II Landfill is approximately 5.5 acres. Ruderal and shrub/scrub habitat cover approximately 69 and 23 percent of the site, respectively. No woodland habitat is present. A small area of stressed vegetation (approximately 0.1 acre or almost 2 percent of the site) was observed. The Area II Landfill burned in the 2005 Topanga Fire. Multiple bird and mammal species (spotted towhee, song sparrow, western scrub-jay, California towhee, kangaroo rat [burrows], gopher [burrows], mule deer [tracks], coyote [scat], and cottontail rabbit) were observed to use the site.

- ELV/Building 206 Area–Land cover at the 8.6-acre ELV area is predominantly (66 percent) pavement or buildings. The dominant vegetation types, ruderal and shrub/scrub habitat, cover approximately 12 and 15 percent of the site, respectively. Approximately 5 percent of the site (0.4 acre) was identified as stressed vegetation. Woodland cover at this site is trivial (less than 1 percent). This site was burned in the 2005 Topanga Fire. Multiple bird, mammal, and reptile species (spotted towhee, American crow, mourning dove, house finch, red-tailed hawk, white-throated swift, gopher [burrows], cottontail rabbit, and western fence lizard) were observed to use the site.

- B515/STP (RD-09 Area)–The B515 STP is a small area (approximately 1.4 acres) covered predominantly (approximately 76 percent) by shrub/scrub habitat. Ruderal vegetation is the next most common cover type (approximately 15 percent). Approximately 2.7 percent of the site (0.04 acre) is coast live oak woodland. Just less than 2 percent of the site (0.03 acre) was observed to have stressed vegetation. This site was burned in the 2005 Topanga Fire. Multiple bird, mammal, and reptile species (dark-eyed junco, black phoebe, Anna's hummingbird, spotted towhee, western scrub-jay, yellow-rumped warbler, orange-crowned warbler, cottontail rabbit, kangaroo rat [burrows], gopher [burrows], and coyote [scat], and western fence lizard) were observed to use the site.

- Former Area II Incinerator Ash Pile–The ash pile is the smallest RFI site in Group 2 (0.4 acre). The dominant land cover is coast live oak woodland (approximately 50 percent or 0.18 acre), followed by ruderal vegetation (approximately 33 percent or

[2] Spatial areas for RFI sites represent the area within the defined boundaries of the site. The actual spatial extent evaluated as part of the ecological risk evaluation was determined by the spatial distribution of analytical chemistry samples associated with the activities at the site. Consequently, the spatial area evaluated for each RFI site exceeded the actual spatial area within the defined boundary.

0.12 acre). No stressed vegetation was observed. This site was burned in the 2005 Topanga Fire. Multiple bird and mammal species (dark-eyed junco, Anna's hummingbird, Nuttall's woodpecker, woodrat [scat and dens], cottontail rabbit, kangaroo rat [burrows and tracks], and gopher [burrows]) were observed to use the site.

1.3 Previous Investigations, Interim Actions, and Monitoring

The primary investigations and actions referenced for the Group 2 RFI are summarized below. These investigations and actions were driven by RCRA and state standards and regulations, and were approved and overseen by various agencies.

Interim measures for groundwater contamination were initiated in the late 1980s under RWQCB oversight. The ongoing groundwater pump and treatment systems, now under a DTSC permit, are a continuation of this interim measure (MWH, 2004).

An RFA was conducted for EPA in 1989 by SAIC, which identified 122 SWMUs and AOCs at SSFL. These include units that have used, stored, or handled various hazardous materials. When finalized in 1994, the RFA included 3 additional sites for a total of 125 SWMUs and AOCs at SSFL. During the subsequent RFI phase of Corrective Action, 10 additional AOCs were identified at SSFL (MWH, 2004).

Asbestos cleanup at the LOX Plant was conducted in 1990 under the oversight of VCEHD and Ventura County Air Pollution Control District (VCAPCD). As a result, VCEHD issued an NFA.

A Current Conditions Report (CCR) was completed by ICF in 1993, describing the existing site conditions, history, operation, and previous sampling results for SWMUs and AOCs identified in the RFA. As part of the CCR sampling event, accelerated cleanup actions were conducted at three sites following approval by DTSC. The CCR included the original RFI Work Plan, which proposed to investigate 21 SWMUs and AOCs that were grouped into 13 RFI sites (MWH, 2004).

As part of the accelerated cleanup program in 1993, the LOX Plant sump, clarifier, and leach pit were excavated and removed.

In 1988, two 1,500-gallon diesel USTs (UT-51 and UT-53) were removed from the northeastern corner of Building 2206 and northern side of Building 2207, respectively. Assessments were completed in 1996 by Groundwater Technology for these tanks to confirm clean closure (Groundwater Technology, 1996a; 1996b).

An RFI Work Plan Addendum (WPA) was completed by Ogden in 1996 based on DTSC's comments on the CCR RFI Work Plan. The report included the history, operations, and previous sampling of all SWMUs and AOCs not included in other environmental programs at SSFL. As a preliminary sampling event to support the WPA development, a metals sampling program was implemented for the RFI. The metals sampling and analysis results were summarized in the RCRA RFI WPA, Volume I (Ogden, 1996b). In 1996, the WPA was approved by DTSC and included the evaluation of 64 SWMUs and AOCs grouped into 34 RFI sites. During RFI activities between 1996 and 1998, 3 additional AOCs were identified, and the total number of RFI sites was expanded to 37 sites (MWH, 2004).

A 1998 investigation at the Building 2231 PCB Storage Facility (SWMU 5.2) identified no contamination. The facility received closure by the DTSC in 1998 (MWH, 2004).

The Area II Landfill investigation was initiated in 2003, after the work plan was approved by DTSC (MWH, 2003). A geophysical survey was completed in 2003 that identified several mass anomalies near the eastern and western ends. An investigation followed that included 13 trench locations, 15 hand auger sample locations, and 33 test pits. This work was completed in 2004 (MWH, 2004).

An interim measure was conducted at the ELV (SWMU 5.2), north of Building 203, in 2004 (MWH, 2005). Approximately 3,000 cubic yards (yd^3) of soil contaminated with mercury were excavated and removed. Further investigation was conducted in this area, as documented in this RFI report (DTSC, 2005).

A 2004 RCRA Program Report for the Surficial OU indicated that soil vapor sampling was performed at Building 2206 and the former Paint Booth. Additional soil samples were collected at the Building 2202 Clarifier, the 2206 Catchment Pond, and northwest of Building 2203 (MWH, 2004).

Following the demolition of the incinerator (Buildings 2758 and 2758A) in 2006, a soil investigation was performed. Additional investigation was performed in this area and is documented in this report.

In 2007, an asbestos abatement was performed in the area of the former LOX Plant. This debris removal action included asbestos-containing material (ACM) that was removed from an ephemeral drainage area east of the former LOX Plant (Zenco, 2007).

As part of an ongoing RFI sampling program, soil and soil vapor samples were collected at the STP in 2006 and 2007 (MWH, 2006).

1.4 Group 2 Data Evaluation Process

In this Group 2 RFI Report, analytical data were evaluated by comparison against the screening criteria developed for SSFL, as outlined in the Standardized Risk Assessment Methodology (SRAM) Work Plan (MWH, 2003b). The SRAM was developed with input from DTSC to provide a standardized regulatory-accepted approach to assess human health and ecological risks related to assessments of chemicals present in various media. Provisions of the SRAM allow the work to be "evergreen" through time, such that the methods and assumptions presented in the document may be modified in the future based on scientific advancements or changes in regulatory guidance or policies.

The data requirements and selection criteria addressed in the SRAM were implemented as part of the Group 2 RFI data evaluation process, as discussed in Section 1.5. Methods for selecting representative data sets for groundwater, PCBs, and total petroleum hydrocarbon (TPH) constituent concentrations also are provided in the SRAM and were incorporated into the data selection and evaluation process. The data selection criteria and methodologies described in the SRAM are common to all risk assessments for SSFL, and have been developed in conjunction with DTSC. Figure 1.4.1-1 is a flow chart showing the data evaluation process for the nature and extent evaluation.

1.4.1 Screening Candidate Compounds

The data requirements and selection criteria addressed in the SRAM were implemented as part of the Group 2 RFI data evaluation process. The details of the RFI screening process are discussed in Section 1.5. Methods for selecting representative data sets for groundwater, PCBs, and TPH constituent concentrations also are provided in the SRAM and were incorporated in the data selection and evaluation process. The data selection criteria and methodologies described in the SRAM are common to all risk assessments for SSFL, and have been developed in conjunction with DTSC.

Samples were collected at each site where releases may have occurred from each medium that was present. Samples were located in biased locations (selected based on a knowledge of site conditions) and analyzed for the contaminants of potential concern (COPCs) identified for that site on the basis of the site-specific CSM. Samples were collected from the Group 2 sites in various phases, with the most recent round of sampling conducted in 2008.

Other indicators were evaluated as part of the data screening process that might indicate a release to the environment has occurred. The frequency of detection of a parameter was evaluated by reviewing the parameters that were detected in more than 5 percent of the samples when 20 or more data points were collected. This frequency of detection (in this example, 25 percent) could indicate that a release has occurred, and further sampling would then be conducted. In addition, tentatively identified compounds were evaluated in the data quality evaluation (DQE) (Section 1.7) and screened to assess the likelihood they were identified and whether they should be carried forward in the data evaluation process.

1.4.2 Data Presentation

The parameters detected at each site in Group 2 are listed in tables introduced in the appropriate subsections of this report in a media-specific manner. The parameters that exceeded the screening criteria are shown in figures, along with the major features of a particular site. Parameters such as volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals are shown in the same figures in groups of two or three. The parameters were grouped in this fashion to facilitate the evaluation of the extent of contamination in the sampled media.

1.4.3 Risk Assessment

The data evaluation process culminated in risk assessments performed in a systematic manner following guidelines set forth in the SRAM. The selection of COPCs followed a sequential, multi-step process of screening data from each investigational unit. Chemicals of potential ecological concern (CPECs) and exposure point concentrations (EPCs) were then identified in the problem formulation stage in accordance with methodology established in the SRAM. These values were incorporated in the exposure assessment and risk characterization process, following a consistent technical approach described in detail in Section 1.5.

1.5 RCRA Facility Investigation Approach

1.5.1 Presentation of Site Background and History

The site background and history for RFI Group 2 was developed based on historical SSFL documents; interviews; information provided by SSFL personnel; and site reconnaissance of the buildings, features, and other areas.

During 2007 and 2008, Boeing compiled historical documents and records, and depositions from previous legal actions, related to SSFL operations. These documents were reviewed for relevance to the various RFI site groups, scanned, and placed into a searchable electronic database called the Historical Document Management System (HDMS). For the historical document review, approximately 4,347 historical documents applicable to RFI Group 2 were reviewed using the HDMS.

The process used to review these documents included the following:

- A review of the historical documents for new processes, operations, or areas not yet investigated
- A review of the historical documents for potential new COPCs or chemical releases or use areas

Of the 4,347 historical Group 2-related documents, 367 documents were identified as potentially having new information pertaining to Group 2. These 367 documents were reviewed in more detail to summarize the following:

- The number of documents with new information identified
- Potential new COPCs identified
- Potential new release areas

After reviewing the above sources, any new data gaps that were identified relating to chemical use areas, potential release areas, or COPCs were identified and further investigated. The new historical information (data gaps) has been incorporated into the RFI data gap evaluation and sampling program. The results of the RFI data gap evaluation are presented in the Site Background and History section for each RFI site. The historical document review process is described in the Group 2 summary of findings report (CH2M HILL, August 2008).

1.5.2 Source, Nature, and Extent of Contamination

This subsection discusses the nature and extent of contamination at each site in Group 2. The CSM portion includes two subsections–the first subsection includes a comprehensive evaluation of historical operations at each of the sites, buildings, and its vicinity. The second subsection includes, on the basis of the site history, the existing analytical data for the environmental media, potential sources, migration pathways, exposure routes, and receptors, as a conceptual site exposure model for each site.

In addition, this subsection examines the contamination migration potential through an environmental contaminant fate and transport evaluation. The factors that influence the fate and transport, including the site's physical features, source characteristics, and extent of

contamination in site media, were combined to form the basis of the contaminant fate and transport evaluation. The site-specific subsections describe the results of these evaluations.

1.5.3 Human Health Risk Assessment Overview and Methods

The objective of an HHRA is to assess whether the environmental media at these sites could pose unacceptable risks to human health and might require remedial action, or if the media are eligible for an NFA designation. Potential health risks to humans are estimated by identifying the COCs present at a site, the toxicity of those contaminants, and the potential human exposure to those contaminants. Sampling and analysis provide information regarding the presence of chemicals at a site. The evaluation of health risks is conducted in the risk assessment by incorporating chemical toxicity and exposure estimates for each COC. The risks associated with exposure to surficial media (soil and sediment), indirect groundwater (vapor migration), and direct groundwater (drinking water) are estimated, as well as the total risks from these media. The HHRAs include an evaluation of the potential health risks to human receptors associated with the current site conditions and proposed future uses of the site.

The HHRA results for each site are summarized in Sections 2.7, 3.7, 4.7, 5.7, and 6.7 of this report.

The HHRA was performed following the guidelines in the SRAM [MWH, 2005b]. The approaches outlined in the SRAM were derived, in part, following the HHRA guidance in the following documents:

- *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (Cal/EPA, 1996)
- *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (Cal/EPA, 2004)
- *Risk Assessment Guidance for Superfund (RAGS)–Volume I: Human Health Evaluation Manual, Part A* (Interim Final) (EPA, 1989)
- *RAGS, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (EPA, 2004)
- Software for Calculating UCLs, ProUCL Version 4.0 (EPA, 2008 [Online])
- *Exposure Factors Handbook, Volume I: General Factors* (EPA, 1997a)

Finally, risk assessment guidance from the California Office of Environmental Health Hazard Assessment (OEHHA) was used, where appropriate.

The objective of the SRAM (MWH, 2005b) is to provide a consistent approach for risk assessment at the investigational units at SSFL. Although each investigational unit is unique, many have similar potential contaminants, exposure pathways, and receptors.

Therefore, a consistent technical approach for all investigational units at SSFL has been proposed. The SRAM provides the following HHRA methods:

- **Data Evaluation.** The requirements and selection criteria for data collected in each media to be used for the risk assessment.
- **Identification of COPCs.** The criteria for the selection of COPCs in soil, groundwater, soil vapor, sediment, and surface water that will be quantitatively evaluated in the HHRA.
- **Exposure Assessment.** The human health receptors, exposure pathways, exposure points, derivation of EPCs, and intake estimates.
- **Toxicity Assessment.** A description of the toxicity criteria used in the HHRA.
- **Risk Characterization.** The procedures for calculating cancer risk estimates and non-cancer hazard indexes (HIs), as well as a summary of the risk estimates for each Group 2 RFI site.
- **Uncertainty Assessment.** A general description of the uncertainties, limitations, and assumptions associated with each step of the HHRA process.

Each of these methods is described in more detail in the following subsections.

1.5.3.1 Data Evaluation

Sample analytical results were evaluated to determine their suitability for use in the risk assessment. The data quality assessment performed on the sampling results followed the criteria provided by EPA in the *Guidance for Data Usability in Risk Assessment (Part A), Final* (EPA, 1992d). The data assessment was based on five criteria–data source review, documentation, analytical methods and detection limits, data review and validation, and data quality indicators (representativeness and completeness). In addition to these data requirements, specific methods for selecting representative data sets for groundwater, PCBs, and TPH constituent concentrations were followed for each risk assessment.

The five criteria of the data assessment are discussed in detail in the following subsections.

Data Source Review. The objective of the data source review was to ensure that appropriate analytical and non-analytical data are used in the HHRA. Data collected during the Group 2 RFI are considered current, while data collected before the Group 2 RFI activities are considered historical. Historical data sources were used to identify sampling locations and analytical approaches for the RFI. Historical data were used to indicate industry-specific analytes and general levels of contamination and trends, to identify exposure pathways of concern, to develop sampling design, and to select appropriate analytical methods. The quality of the historical data, including the sampling and analytical techniques, detection limits, and data quality, was reviewed before the data were used in the HHRA. The use of historical data in the quantitative risk assessments is discussed in the presentation of the site-specific risk assessment results in Sections 2.7, 3.7, 4.7, 5.7, and 6.7.

Documentation. The purpose of the documentation review was to ensure that each analytical result could be associated with a sampling location and that the sample was collected according to the appropriate procedures. This objective was achieved by

evaluating the manner in which samples were managed by the field sampling teams and laboratories. Three types of documentation were used to track samples and analytical methods: 1) chain-of-custody forms; 2) standard operating procedures (SOPs); and 3) field sampling and analytical records.

In addition to documentation from the current sampling activities, historical data obtained from previous reports were reviewed, as appropriate. The criteria used to evaluate information contained in the previous reports included the following:

- Map(s) of sampling locations
- Rationales for sampling design and procedures
- Identification of sample collection and preparation methods
- Identification of analytical methods
- Analytical results
- Sample-specific detection limits
- Sample-specific qualification of the analytical results
- Description of the data review
- Description of the field conditions and physical parameters

Analytical Methods and Detection Limits. For an analytical result to be usable for the risk assessment process, the sample collection, preparation, and analytical methods should appropriately identify the chemical form or species, and the specified sample detection limit should be at or below a concentration that is associated with toxicologically relevant levels (benchmarks). The significance of detection limits greater than benchmark levels were evaluated on a case-by-case basis in the uncertainty section for each investigational unit. Data reduction includes resolving multiple results for a single constituent reported using different analytical methods (for example, naphthalene reported using both SW8260 and SW8270) to produce a single value for each constituent per sample.

Data Review and Validation. All sample data collected and used in the HHRA were reviewed and validated. The data were validated following the guidelines outlined in EPA's *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (1994e), and EPA's *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (1994f).

Soil, soil vapor, and water sample data were validated based on the following criteria: sample management (appropriate containers, preservatives, documented chain-of-custody, and holding times), method blank sample results, blank spikes and laboratory control sample (LCS) results, surrogate recoveries, matrix spike/matrix spike duplicate (MS/MSD) recoveries and precision, reporting limits (RLs), and field quality control (QC) sample results (equipment blanks, field blanks, and field duplicates).

Data that were collocated duplicates, laboratory confirmation samples, or agency split samples were only used for DQE and were not quantitatively included in the HHRA.

The data validation procedures met the overall project DQOs. Data qualifiers were assigned to data with associated qualification codes, which denote the specific reason for the qualification.

Laboratory confirmation or agency split sample data were used to assess data quality, but were not used quantitatively in the risk assessment. Estimated values flagged with a "J"

qualifier were treated as detected concentrations. Data qualified as rejected (flagged "R") were not used in the risk assessment.

Data Quality Indicators–Representativeness and Completeness. Data representativeness was determined by evaluating how well the samples described the investigation unit conditions (that is, were samples appropriately placed to reveal potential releases and were all compounds potentially related to activities at the investigational unit being analyzed). To determine data completeness, sample results were evaluated to verify whether enough sample results were retained after validation to adequately characterize the investigational unit. Additionally, data were reviewed to determine if the variability of chemical concentrations in time and space were adequately characterized.

Soil Data Selection Criteria. For the purposes of this HHRA, soil samples were grouped into two data groups for evaluation of the specific exposure scenarios associated with each soil depth interval, as follows:

- Surface Soil : 0 to 2 ft bgs
- Subsurface Soil: 0 to 10 ft bgs

Soil data were used to quantify both indirect exposures (inhalation of ambient and indoor air and ingestion of edible plants) and direct exposures (dermal contact and ingestion) for potential human receptors.

Soil Vapor Data Selection Criteria. Soil vapor data were used to estimate indirect exposures, including the inhalation of indoor air and ambient air. In accordance with Cal/EPA vapor intrusion guidance (DTSC, 2004), soil vapor data collected from 5 ft bgs or deeper are preferred for use in risk assessments.

Groundwater Data Selection Criteria. Groundwater that occurs within the alluvium or weathered bedrock is defined as NSGW, while groundwater in unweathered, competent bedrock of the Chatsworth formation is defined as Chatsworth formation groundwater. At SSFL, NSGW primarily is monitored by wells and piezometers constructed with open intervals within the alluvium and/or weathered bedrock. However, some NSGW at the site also is monitored by deeper wells constructed with screened or open intervals within both the overlying weathered bedrock and deeper unweathered (competent) bedrock.

Because of the complexity of the data available for the SSFL HHRA, selection criteria were used to select the groundwater data used. These criteria include the definition of and identification of CFOU and NSGW monitoring wells, and the selection of the water quality data set, as described below:

1. Definition of NSGW Monitoring Wells:

    a) Monitoring wells completed within the alluvium and/or weathered bedrock; or

    b) Monitoring wells completed within the deeper, competent bedrock that have a screened or open interval exposed to the alluvium/weathered bedrock, and historical water levels that have risen to that alluvium/weathered bedrock interface.

2. Definition of CFOU Groundwater Monitoring Wells:

   a) Monitoring wells completed within the deeper unweathered, competent bedrock of the Chatsworth formation.

3. Selection of Water Quality Data Set:

   a) Groundwater monitoring data from the most recent 3-year period were evaluated to determine whether the data adequately reflected the water concentrations to which potential receptors would be exposed. All historical groundwater data were evaluated to ensure representativeness for the 3-year period used. In addition, groundwater data from upgradient monitoring wells were evaluated to determine what chemicals might migrate and result in future exposures.

   b) If a compound previously was detected in groundwater and not represented in the analytical suite for the most recent consecutive 3-year period, then the most recent data over a consecutive 3-year period when that compound was analyzed were used.

   c) The analytes represented in the CFOU or NSGW data set were compared with those mobile compounds (VOCs and perchlorate) selected as COPCs in soil and soil vapor, and the need for the inclusion of certain mobile soil or soil vapor COPCs as CFOU or NSGW COPCs was determined.

If discrete depth water quality monitoring data within the alluvium or weathered bedrock were available for a well, those data were used instead of standard water quality data collected from deep, open boreholes.

PCB Extrapolation Methodology. As described in Section 2.7 of the SRAM (MWH, 2005b), potential risks associated with PCBs were assessed using two different methods: 1) risks associated with the 12 "dioxin-like" PCB congeners using the toxicity equivalency approach (Van den Berg et al., 2006); and 2) risks associated with a total aroclor mixture (EPA, 1996a). Potential risks associated with the 12 PCB congeners and potential risks associated with aroclor mixtures are presented separately in the HHRA. The PCB extrapolation methods described in Section 2.7 of the SRAM (MWH, 2005b) were used to estimate the concentrations of each of the 12 PCB congeners in samples for which only aroclors historically have been detected.

The extrapolation factors used in the HHRA at SSFL are summarized in Table 2-5 of the SRAM (MWH, 2005b). Aroclor-to-PCB extrapolation factors were developed to predict PCB congener concentrations, as described in the following equation.

$$C_{congener} = EF \times C_{Aroclor}$$

Where,

$C_{congener}$ = Predicted PCB congener concentration in soil (nanograms per kilogram [ng/kg])

$C_{Aroclor}$ = Measured aroclor concentration in soil (micrograms per kilogram [µg/kg])

EF = Aroclor-to-PCB congener extrapolation factor ([ng/kg]/[µg/kg])

Total Petroleum Hydrocarbon Extrapolation Methodology. The risks associated with TPH impacts commonly are included in risk assessments based on the petroleum constituent concentrations rather than the TPH results, because toxicity criteria for TPHs are not well established or approved within the regulatory community. For the purposes of evaluation in this HHRA, petroleum chemical constituents include low-carbon petroleum constituents (LCPCs) [benzene, toluene, ethylbenzene, and xylenes (BTEX)] and high-carbon petroleum constituents (HCPCs) [polycyclic aromatic hydrocarbons (PAHs), 2-methylnaphthalene, and naphthalene]. The TPH extrapolation methods described in Section 2.8 of the SRAM (MWH, 2005b) were used to estimate the concentrations of the petroleum chemical constituents. The TPH extrapolation factors used in the HHRA at SSFL are summarized in Table 2-8 of the SRAM (MWH, 2005b).

TPH extrapolation factors were used to predict LCPC and HCPC concentrations, as described in the following equations, respectively:

$$C_{LCPC} = EF \times C_{C08-C11}$$

Where,

C_{LCPC} = Predicted BTEX, naphthalene, or 2-methylnaphthalene concentration in soil (milligrams per kilogram [mg/kg])

$C_{C08-C11}$ = Measured C08-C11 TPH fraction concentration in soil (mg/kg)

EF = TPH-to-LCPC extrapolation factor ([mg/kg]/[mg/kg])

$$C_{HCPC} = EF \times C_{C11-C30}$$

Where,

C_{HCPC} = Predicted PAH concentration in soil (mg/kg)

$C_{C11-C30}$ = Sum of measured C11-C14, C14-C20, and C20-C30 TPH fraction concentrations in soil (mg/kg)

EF = TPH-to-HCPC extrapolation factor ([mg/kg]/[mg/kg])

1.5.3.2 Identification of Contaminants of Potential Concern

To ensure that the focus of the HHRA was on site-related chemicals, COPCs were selected using several criteria. COPCs are those constituents that are carried through the human health risk quantification process. During the course of the HHRA, the COPCs are

evaluated to identify and prioritize which constituents, if any, are estimated to pose unacceptable risks. COPCs are identified separately for each exposure medium (soil, soil vapor, and groundwater), based on the exposure scenarios described in Section 1.5.3.3.

The criteria used to select COPCs ensured that site-related chemicals that might pose a human health risk were included in the evaluation and, if risks were above the acceptable levels, subsequently would be included in remedial response actions. The selection of COPCs relies on a sequential, multi-step process of screening data from each investigational unit, as described in the following text.

Screening Criteria. The criteria used to select COPCs ensured that site-related chemicals that might pose a human health risk were included in the evaluation and, if risks were above the acceptable levels, subsequently would be addressed in remedial response actions. The following criteria were used to select COPCs for the HHRA:

1. Chemicals were detected at an investigational unit using validated laboratory analyses.
2. Chemicals occurred above a 5-percent detection frequency and/or historical use at the investigational unit.
3. Chemicals were present in excess of the concentrations observed in laboratory or field blanks.
4. For metals and for chlorinated dibenzo-p-dioxins and dibenzofurans (collectively referred to as dioxins), the measured concentrations were in excess of soil background or groundwater comparison concentrations.

Further details regarding the COPC selection process are provided in Section 3.1 of the SRAM (MWH, 2005b).

Excluded data are documented in the HHRA, including the rationale for the removal.

Comparison of Site Data to Soil Background and Groundwater Comparison Concentration Data. DTSC's risk assessment policy indicates that metals and dioxins should be included as COPCs if the site-specific analytical data indicate conditions are in excess of "background" (DTSC, 1997). This subsection discusses two screening approaches–a simple comparison of investigational unit data with comparison data (comparison method) and the use of the Wilcoxon Rank Sum (WRS) test.

For groundwater, the maximum concentration in the groundwater comparison data set was the groundwater comparison concentration. If the maximum unit concentration did not exceed the groundwater comparison concentration, then the chemical was excluded as a COPC. If the maximum unit concentration exceeded the groundwater comparison concentration, then the data sets were evaluated further by performing the WRS test.

As discussed in Appendix D of the SRAM (MWH, 2005b), the comparison method was not used for selecting COPCs in soil.

Further details about the WRS test are provided in Section 3.3 of the SRAM (MWH, 2005b).

Background Comparison Methods for Dioxins. Only the seventeen 2,3,7,8-dioxin congeners were evaluated in the HHRA (EPA, 1989c). An extensive database of background

concentrations in various environmental media has been compiled by EPA for use in risk assessment and other scientific applications (EPA, 1994c). Therefore, the HHRA applies a soil background delineation similar to the procedures described for metals to dioxin data, except that a modification was required to account for the fact that dioxins often occur as mixtures.

Consistent with a Human and Ecological Risk Division (HERD) memorandum (DTSC, 1998a) on establishing dioxin background, a graphical representation of relative chlorinated dibenzo-p-dioxin (CDD) and chlorinated dibenzofuran (CDF) concentrations in samples (a "radar" plot) was compared to similar presentations for background to determine qualitatively if the site samples are similar to background. This analysis was done for five congener groups: tetra-CDD/CDFs, penta-CDD/CDFs, hexa-CDD/CDFs, hepta-CDD/CDFs, and octa-CDD/CDFs. Because only the 2,3,7,8-substituted CDDs and CDFs are of toxicological interest, the five group concentrations were calculated as the sum of the concentrations of each 2,3,7,8-substituted congener within the chlorination group, on a per-sample basis. In cases where a congener was detected a least once in a given media at an investigational unit, it was assumed to be present in other samples of the same media at that unit. When a congener was thus assumed to be present at an investigational unit, but was not detected in a sample, then the concentration in that sample was estimated as one-half the sample quantitation limit (SQL). In cases where a specific congener was never detected in a given media at an investigational unit, then that congener was assumed to not be present in that media at that unit, and was not included in the summation of congeners within its respective congener group at that unit.

Following the graphical evaluation, the same approach used to evaluate metals was used to evaluate investigational unit and soil background CDD/CDF data sets. The data sets were evaluated by application of the WRS test (or as applicable, the Gehan Test) to determine consistency with soil background concentrations. In the case of CDD/CDFs, the WRS test (or as applicable, the Gehan Test) evaluation was performed on the five congener groups, as described in the SRAM (MWH, 2005b). If the WRS test (or as applicable, the Gehan Test) was implemented, a Bonferroni correction to the statistical significance threshold, α , was applied. Because the critical significance level applied to single inorganic compounds is 0.05, the corrected term for comparison of the five CDD and CDF groups was 0.01 (0.05/5).

Because CDD and CDF compounds frequently appear as mixtures, an additional requirement for the evaluation of investigational unit data was that all "groups" of CDD and CDF classes must be shown to be consistent with soil background concentrations. If such a demonstration could not be made, all CDD and CDF compounds must have been considered in the risk assessment. Because a groundwater comparison concentration data set was not developed for the potential presence of dioxins in groundwater, the approach described above for soil also was applied for groundwater.

1.5.3.3 Exposure Assessment

The exposure assessment component of the HHRA identifies the means by which individuals at or near the investigational unit may come into contact with constituents in exposure media. It addresses exposures that may result in the future under reasonably anticipated potential uses of the site and the surrounding areas. The exposure assessment

also identifies the populations that may be exposed, the routes by which individuals may become exposed, and the magnitude, frequency, and duration of potential exposures.

Conceptual Site Model. A generalized CSM for SSFL has been developed based on field observations, current and future site use scenarios, and data collected to date during environmental programs at SSFL (Figure 1.5.3-1).

Potential Human Receptors. Potential human receptors are populations potentially exposed to chemicals, either onsite or as a result of chemical migration to offsite areas. The current potential human receptors are current site workers and trespassers. Onsite workers, residents, and visitors (for example, recreationists who might occupy the site in the future in the event of a change in property use) are future potential human receptors. The exposure scenarios listed in the SRAM (MWH, 2005b) for evaluation in the HHRA are current site workers and trespassers, as well as future onsite residents and visitors. A more likely future use of SSFL is for recreational purposes, and recreationists are the most plausible future human receptors. California Senate Bill 990 states that response actions at SSFL also should consider hypothetical future agricultural and residential land uses.

Given the potential future land use, the following receptors will be addressed in the HHRA for each site:

- Future onsite adult industrial workers
- Hypothetical future onsite adult and child recreationists
- Hypothetical future onsite adult and child residents

Potentially Complete Exposure Pathways. Potential exposure pathways were considered to assess whether they might be "complete" (receptors can come into contact with compounds from the site), "incomplete" (no exposure is possible), or "potentially complete" (exposure may occur if site conditions change). The generalized CSM includes complete or potentially complete exposure pathways for receptors that may occur, either at certain locations or throughout SSFL. Complete or potentially complete exposure pathways include direct contact with soil, sediment, weathered bedrock, surface water, air, and groundwater (including seeps and springs), as well as indirect exposure to chemicals in soil via uptake into plants.

Also, in accordance with California Senate Bill 990, a hypothetical future agricultural exposure scenario will be evaluated. This scenario will include the consumption of beef, eggs, milk, swine, fruits, and vegetables. However, pending final agreement of the input assumptions considered in the scenario, an assessment of the subsistence agricultural exposure scenario will be included in a supplemental risk assessment report separate from this RFI Report.

Additional information about the selection of exposure pathways is discussed in the SRAM (MWH, 2005b).

Human Exposure Models. Human exposure models provide the basis for quantifying potential exposure to COPCs. The exposure models are based on the calculation of an internal dosage for each COPC. For noncarcinogenic effects, the dosage is averaged over the period of exposure and is referred to as the average daily dosage (ADD). For carcinogenic

effects, the dosage is averaged over a lifetime and is referred to as the lifetime average daily dosage (LADD).

Consistent with current DTSC (1992) and EPA (1989a) guidance, the following general equation was applied to assess the chemical dosage for each complete or potentially complete exposure pathway considered in the HHRA:

$$Dosage = \frac{C \times IR \times EF \times ED \times B}{BW \times AT}$$

where:

Dosage = ADD (milligrams per kilogram per day [mg/kg-day]) for noncarcinogens;

LADD (mg/kg-day) for carcinogens

C = chemical concentration in environmental medium (mg/kg soil; milligrams per liter [mg/L] water; or, milligrams per cubic meter [mg/m^3] air)

IR = intake rate (mg soil/day; L water/day; or, m^3 air/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

B = bioavailability (fraction)

BW = body weight (kilogram [kg])

AT = averaging time (days)

Additional details regarding each specific exposure pathway are discussed in Section 5 of the SRAM (MWH, 2005b).

Estimation of Exposure Point Concentrations. EPCs are estimated constituent concentrations with which a receptor may come into contact, and are specific to each exposure medium. For direct contact routes of exposure to soil and groundwater (incidental ingestion and dermal contact), EPCs are represented by concentrations directly measured in soil or groundwater samples collected from the Group 2 sites. EPCs also can be estimated through prediction (modeling). In the HHRAs for the Group 2 sites, measured concentrations were used whenever available and appropriate.

EPCs were estimated for several chemical classes (inorganics, volatiles, and high and low molecular weight SVOCs, as defined in DTSC [1994]) for the following media: soil, air, sediment, surface water, groundwater, and produce.

Data collected from the 0- to 2-foot-bgs and 0- to 10-foot-bgs depth intervals during field investigations at the site formed the basis for soil/surface sediment (hereafter collectively referred to as soil) EPCs used to estimate chemical-specific dosages for the ingestion of and dermal absorption from soil pathways. Deterministic estimates of soil EPCs were calculated for all investigations.

Groundwater EPCs for the Surficial OU were developed on an investigational unit basis. EPCs were the maximum concentrations measured from NSGW wells from within a particular investigational unit and from areas that were upgradient from the investigational unit. For the CFOU, EPCs were the maximum concentrations measured from the Chatsworth formation groundwater at an investigational unit, in a Reporting Area, or upgradient from these areas. Groundwater monitoring data from the most recent 3-year period were evaluated to determine whether this process adequately reflects water concentrations to which potential receptors will be exposed. All historical groundwater data from this 3-year period were used. If adequate groundwater data for metals were not available, the potential groundwater concentration was estimated by using a soil-to-groundwater leachate model.

For the inhalation route, EPCs were estimated using modeling approaches consistent with the risk assessment guidance. Soil-derived vapor and dust concentrations in ambient air were estimated using volatilization factors (VFs) and particulate emission factors (PEFs), derived as described in Section 1.5.3.3. Data, including soil vapor measurements, collected during the field investigations of areas overlying groundwater were the basis for modeling the volatilization of COPCs from groundwater to indoor and ambient air. In cases where soil vapor data were not available, groundwater and bulk soil concentrations were used. Indoor air concentrations were estimated for each VOC detected in soil vapor using the *Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings, Updated 2003* (SG-ADV Version 3.1; 02/04) (EPA, 2003). This model was adjusted to use DTSC-specific values in lieu of EPA default values for the toxicity factors, building ventilation rates, crack-to-total-area ratios, and soil-building pressure differential. Additional details regarding the Johnson and Ettinger (J-E) input parameters and equations are described in Section 6.4 of the SRAM (MWH, 2005b).

In cases where it was determined that existing groundwater data, either near-surface or Chatsworth formation groundwater (depending on the groundwater source), were representative of specific seeps or springs, then existing groundwater data were used as EPCs for seeps and springs. If the groundwater source was not representative of specific seeps, then those seeps and springs were sampled and those data were used as EPCs.

Surface water sampling and analysis were used for EPCs for surface water pathways.

EPCs in home-grown produce were estimated in accordance with Section 5.5 of the SRAM (MWH, 2005b), using bio uptake models to estimate the transfer of COPCs from the top 2 ft of soil to both root-zone and aboveground (leaf and fruit) portions of edible plants.

EPC Calculation Approach. The EPCs for exposure pathways associated with soil, soil vapor, and groundwater at the Group 2 sites were estimated by aggregating concentration data from samples collected for each medium (and in the case of soil, for each depth interval of 0 to 2 ft bgs or 0 to 10 ft bgs).

For the reasonable maximum exposure (RME) case, the EPCs for risk estimation were calculated by using the best statistical estimate of an upper bound on the average exposure concentrations, in accordance with EPA guidance for statistical analysis of monitoring data (EPA, 1989, 1992, 2002). The 95% upper confidence limit (UCL) on the mean concentration is considered by these guidance documents as a conservative upper bound estimate that is

not likely to underestimate the mean concentration and probably overestimates that concentration. EPCs were calculated for each analyte using EPA's statistical program ProUCL, Version 4.0 (EPA, 2008). This procedure identifies the statistical distribution type (that is, normal, lognormal, or non-parametric) for each constituent within the defined exposure area and computes the corresponding 95% UCL for the identified distribution type. The maximum detected concentration is used in place of the 95% UCL when the calculated 95% UCL is greater than the maximum detected value.

For the central tendency exposure (CTE) case, the EPCs for risk estimation were calculated as the arithmetic mean concentration of the sample data for each medium and data group, in accordance with Section 6 of the SRAM (MWH, 2005b).

EPCs for COPCs in soil, soil vapor, and groundwater are summarized in Appendixes B through F for both the RME and CTE cases. As indicated, the EPCs for some constituents are based on the maximum detected value rather than the 95% UCL. Factors affecting the distribution of the data (resulting in the selection of the maximum detected value rather than the 95% UCL) include small sample size, low frequency of detection, and/or wide variability. Using maximum detected values for EPCs may contribute to overestimation of risk (this and other uncertainties are discussed in Section 1.5.3.6).

EPC Approach for Dioxins/Furans. EPCs for "dioxin-like" congeners of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were adjusted in accordance with the 2005 World Health Organization (WHO) toxic equivalency factor (TEF) approach (Van den Berg et al., 2006). The purpose of using the WHO TEF adjustment is to account for the relative carcinogenic potency of dioxin-like PCDDs and PCDFs relative to 2,3,7,8-tetrach-lorodibenzo-p-dioxin (TCDD).

Human Exposure Assumptions. The estimation of exposure requires numerous assumptions to describe potential exposure situations. Upper-bound exposure assumptions are used to estimate RME conditions to provide a bounding estimate on exposure. The RME case is defined as the highest exposure that is reasonably expected to occur at a site. The intent of the RME scenario is to estimate a conservative exposure case that is still within the range of possibilities. In addition to RME assumptions, average exposure assumptions are used to estimate CTE conditions to represent the typical case. The exposure assumptions used are specific to a hypothetical residential exposure scenario, consistent with assumed unrestricted future land use. The range of risk estimates bounded by the CTE and RME cases provides an indication of the most plausible range over which residential risks may occur under most conditions at the site.

Calculation of Chemical Intake. Exposure that is normalized over time and body weight is termed intake (expressed as milligrams of chemical per kilogram of body weight per day [mg/kg-day]). The method for the computation of intake for the Group 2 site exposure scenarios is described in the following subsections; the intake results are provided in the risk calculation tables in Appendixes B through F.

The exposure assumptions for estimating chemical intake from the ingestion of constituents in soil are listed in Table 1.5.3-1 for the adult resident, Table 1.5.3-2 for the child resident, Table 1.5.3-3 for the adult recreational user, Table 1.5.3-4 for the child recreational user, and Table 1.5.3-5 for the industrial worker. The exposure assumptions for ingestion, dermal

contact, and inhalation are in accordance with Tables 5-2 and 5-3 of the SRAM (MWH, 2005b) and generally are based on values provided in Cal/EPA and EPA guidance documents.

Incidental Ingestion of Soil. The following equation is used to calculate the intake associated with the incidental ingestion of constituents in soil for the hypothetical adult and child resident, adult and child recreational user, and industrial worker scenarios:

$$Intake = \frac{C_s \times IRS \times EF \times ED \times 10^{-6} kg/mg}{BW \times AT}$$

where:

CS	=	Constituent concentration in soil (mg/kg)
IRS	=	Soil ingestion rate (mg/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

Dermal Contact with Soil. Chemical intake from dermal contact with soil for the hypothetical adult and child resident, adult and child recreational user, and industrial worker scenarios is estimated using the following equation:

$$Intake = \frac{C_S \times SA \times ABS \times AF \times EF \times ED \times 10^{-6} kg/mg}{BW \times AT}$$

where:

C_S	=	Constituent concentration in soil (mg/kg)
SA	=	Exposed skin surface area (square centimeter [cm^2])
ABS	=	Fraction of constituent absorbed from soil to skin (unitless)
AF	=	Soil to skin adherence factor (mg/cm^2)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

Dermal absorption fraction (ABS) values are derived from the EPA's *Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004) and are listed in Table 1.5.3-6.

Inhalation of Ambient Dust and Vapors from Soil. Chemical intake from the inhalation of dust and vapors from ambient air for the hypothetical adult and child resident, adult and child recreational user, and industrial worker scenarios is estimated using the following equation:

$$Intake = \frac{C_s \times INH \times \left(\frac{1}{PEF} + \frac{1}{VF}\right) \times EF \times ED}{BW \times AT}$$

where:

C_S	=	Constituent concentration in soil (mg/kg)
INH	=	Inhalation rate (m^3/day)
PEF	=	Particulate emissions factor (m^3/kg)
VF	=	Volatilization factor (m^3/kg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Adult body weight (kg)
AT	=	Averaging time (days)

The VFs for the VOCs identified as COPCs in soil were calculated using the Jury Model described in EPA's *Soil Screening Guidance: Users Guide* (EPA, 1996) and are provided in Table 1.5.3-7. The PEF used was the default value recommended by EPA Region 9 (2004b).

Ingestion of Groundwater. The following equation is used to calculate the intake associated with ingestion of constituents in groundwater for the hypothetical adult and child resident, adult and child recreational user, and industrial worker scenarios:

$$Intake = \frac{C_w \times IRW \times EF \times ED}{BW \times AT}$$

where:

C_w	=	Constituent concentration in groundwater (mg/L)
IRS	=	Water ingestion rate (L/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

In accordance with the SRAM (MWH, 2005b), the intake of VOCs from the dermal and inhalation routes of exposure is assumed to be equivalent to the intake from the ingestion route.

Ingestion of Homegrown Produce. The following equation is used to calculate the intake associated with the ingestion of constituents in homegrown produce for the hypothetical adult and child resident scenarios: $Intake = \frac{C_p \times IRP \times EF \times ED}{BW \times AT}$

where:

C_p	=	Constituent concentration in produce (mg/kg, wet weight basis)
IRS	=	Produce ingestion rate (kg/day, wet weight basis)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The concentration term C_p reflects COPC uptake from soil (0 to 2 ft bgs) to both aboveground (leaf and fruit) produce concentrations and to belowground (root) produce. The consumption rate data listed in Tables 1.5.3-1 and 1.5.3-2 for fruits and vegetables are not specific to aboveground and belowground produce. Therefore, it is conservatively assumed that one-half an individual's total produce consumption is associated with aboveground produce and one-half is associated with belowground plants. This assumption is considered conservative because it is highly unlikely that most individuals consume a higher amount of belowground produce than aboveground produce, yet the biotransfer factors (used to estimate EPCs) for belowground produce are 35 times greater than those for aboveground produce. The biotransfer factors used to estimate uptake into produce are listed in Table 1.5.3-8.

1.5.3.4 Toxicity Assessment

The relationship between the dosage of a chemical and the probability of an adverse health effect in the exposed population is characterized in the toxicity assessment portion of the HHRA. The dosage-response assessment for the COPCs identified for each investigational unit is discussed in this subsection. Chemicals were identified as having carcinogenic and/or noncarcinogenic toxicity criteria, and were evaluated in accordance with OEHHA and DTSC guidelines (DTSC, 1992, 1994; OEHHA, 2003). The hierarchy of sources for toxicological criteria is as follows:

1. OEHHA (http://www.oehha.ca.gov/risk/chemicalDB/index.asp)
2. Integrated Risk Information System (IRIS) (EPA, 2005a)
3. Health Effects Assessment Summary Table (HEAST))EPA, 1997)
4. EPA criteria documents
5. Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles
6. Environmental Criteria and Assessment Office (ECAO)
7. Other sources

The toxicity criteria used in the HHRA are provided in Table 1.5.3-9.

The toxicity criteria used to assess dioxin and coplanar PCB congeners are based on TEFs developed by WHO and published by Van den Berg et al. (2006). TEFs are measures of the relative toxicity of a dioxin or coplanar PCB congener to the toxicity of 2,3,7,8-TCDD. For risk assessments conducted at SSFL, dioxin and PCB congener-specific TEFs were applied to toxicity criteria (that is, the cancer slope factor [CSF] for 2,3,7,8-TCDD) to generate congener-specific toxicity values that were then applied to congener-specific exposure levels to estimate risk.

1.5.3.5 Risk Characterization

In the risk characterization component of the HHRA process, quantification of risk is accomplished by combining the results of the exposure assessment (estimated chemical intakes) with the results of the dose-response assessment (toxicity values identified in the toxicity assessment) to provide numerical estimates of potential health risks. The quantification approach differs for potential non-cancer and cancer effects, as described in the subsections below.

Although this HHRA produces numerical estimates of risk, it should be recognized that these numbers might not predict actual health outcomes because they are based largely on hypothetical assumptions. Their purpose is to provide a frame of reference for risk management decision making. Any actual risks are likely to be lower than these estimates. Interpretation of the risk estimates provided should consider the nature and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding them, as described in Section 1.5.3.6.

Estimation of Carcinogenic Risks. The potential for cancer effects is evaluated by estimating the excess lifetime cancer risk (ELCR). This risk is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer (that is, if no exposure to site constituents occurs). For example, a 2×10^{-6} ELCR means that, for every 1 million people exposed to the carcinogen throughout their lifetimes, the average incidence of cancer may increase by two cases of cancer. In the United States, the background probability of developing cancer for men is a little less than one in two, and for women a little more than one in three (American Cancer Society, 2003).

Potential carcinogenic health risks were characterized for each COPC identified as a potential human carcinogen. Potential carcinogenic health risks were characterized as the upper-bound probability of an individual developing cancer over a lifetime as a result of exposure to a site-related chemical under specific exposure scenarios. The incremental probability of developing cancer (the theoretical excess [above background] carcinogenic risk) is the risk attributed to exposure to the COPCs at the site (EPA, 1989) and is independent of chemical exposures in our daily lives that are not related to SSFL.

For each COPC identified as a potential human carcinogen, the theoretical upper-bound excess cancer risk was based on the LADD and a factor relating dosage to cancer risk (the CSF). CSFs were used to characterize carcinogenic risk. These values are, in general, upper-bound estimates on the slope of the cancer-response and exposure relationship rather than accurate representations of true cancer risk. The true cancer risk is likely to be less than that predicted (EPA, 1989). The following equation (EPA, 1989a; DTSC, 1992) was applied to estimate the cancer risk for each relevant exposure pathway:

$$Risk = Intake \times CSF$$

where:

Risk = Excess lifetime cancer risk (unitless probability)
Intake = Chronic daily intake averaged over a lifetime (mg/kg-day)
CSF = Cancer slope factor $(mg/kg\text{-}day)^{-1}$

Although synergistic or antagonistic interactions might occur between cancer-causing constituents and other constituents, information generally is lacking in the toxicological literature to predict quantitatively the effects of these potential interactions. Therefore, cancer risks are treated as additive within an exposure route in this assessment. This is consistent with the EPA guidance regarding risk assessment of chemical mixtures (EPA, 1986). For estimating the cancer risks from exposure to multiple carcinogens from a single exposure route, the following equation is used:

$$Risk_T = \sum_1^N Risk_i$$

where:

$Risk_T$ = Total cancer risk from route of exposure
$Risk_i$ = Cancer risk for the ith constituent
N = Number of constituent

Additional details regarding the estimation of carcinogenic health effects are discussed in Section 8.1 of the SRAM (MWH, 2005b).

Estimation of Noncarcinogenic Health Effects. For non-cancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular constituent with the highest level of exposure that is considered protective (that is, its reference dose [RfD]). Potential noncarcinogenic adverse health effects were characterized for each COPC exhibiting noncarcinogenic health effects. The ratio of the intake divided by the RfD is termed the hazard quotient (HQ):

$$HQ = Intake / RfD$$

where:

HQ = Non-cancer hazard quotient from route of exposure
Intake = Chronic daily intake averaged over the exposure duration (mg/kg-day)
RfD = Non-cancer reference dose (mg/kg-day)

When the HQ for a constituent exceeds 1 (that is, exposure exceeds the RfD), there is a concern for potential non-cancer health effects. To assess the potential for non-cancer effects posed by exposure to multiple constituents, an HI approach was used according to EPA guidance (EPA, 1989). This approach assumes that the non-cancer hazard associated with exposure to more than one constituent is additive; therefore, synergistic or antagonistic interactions between constituents are not accounted for. The HI may exceed 1 even if all of the individual HQs are less than 1. In this case, the constituents may be segregated by similar mechanisms of toxicity and toxicological effects. Separate HIs may then be derived based on mechanism and effect. The HI is calculated as follows:

$$HI = \sum_1^N Intake_i \Big/ RfD_i$$

where:

HI = Non-cancer hazard index
$Intake_i$ = Chronic daily intake of the ith constituent (mg/kg-day)
RfD_i = Reference dose of the ith constituent (mg/kg-day)
N = Number of constituents

Additional details regarding the estimation of noncarcinogenic health effects are discussed in Section 8.2 of the SRAM (MWH, 2005b).

Characterizing Risks from Lead, Dioxins, PCBs, and PAHs. If lead was selected as a COPC, potential risks from lead concentrations were evaluated using methods different from those

conventionally used for other carcinogens and noncarcinogens. The risks resulting from the uptake of lead were evaluated using the DTSC LeadSpread 7 calculation spreadsheet from the Cal/EPA Web site (Cal/EPA, 2006b). The model calculates blood lead levels from exposure to soil lead concentrations, in addition to other routes. A default blood lead level of 10 micrograms per deciliter (10 µg/dL) of blood is considered a level of concern that triggers intervention to reduce exposure. As recommended by DTSC, the 90th, 95th, 98th, and 99th percentile blood lead concentrations predicted by the model were evaluated for both children and adults. If the lead concentrations in site media resulted in a calculated blood lead level below 10 µg/dL in 95 to 99 percent of the potentially exposed population, no unacceptable risk exists. Additional details regarding characterizing risks from lead are discussed in Section 8.5.1 of the SRAM (MWH, 2005b).

The specific dioxin and coplanar PCB congeners that were considered in the HHRAs at SSFL are the 17 2,3,7,8-substituted dioxin congeners and 12 non-ortho- and mono-orthosubstituted coplanar congeners for which TEFs were developed by WHO and published by Van den Berg et al. (2006). The congeners and TEFs are summarized in Table 1.5.3-10.

Risk estimates for dioxins and coplanar PCBs were based on the assumption that all 17 of the 2,3,7,8-substituted dioxin congeners and 12 coplanar PCB congeners are present in all samples at some level when at least one congener is detected in a single sample in a given media at an investigational unit. The concentrations for those congeners not detected in sample media were estimated at one-half the SQL. In cases where a congener was never detected in a given media at an investigational unit, that congener was assumed not present.

For each of the 12 PCB congeners and 17 dioxin congeners, one of two approaches was taken for estimating risks. PCB congener and dioxin TEFs were applied to the CSF for 2,3,7,8-TCDD, and risks were estimated by multiplying the estimated congener-specific CSFs (based on 2,3,7,8-TCDD) by the respective congener-specific LADDs.

It is not appropriate to include both estimated aroclor risks and PCB congener risks in the cumulative risk estimate, because this would essentially be "double-counting." Therefore, DTSC has requested that only aroclor risks be included in the cumulative risk estimates, and that PCB congeners risks be presented with the risk estimates for other chemicals but not included in the cumulative risk estimate. Additional details regarding characterizing risks from PCBs and dioxins are discussed in Section 8.5.2 of the SRAM (MWH, 2005b).

For the purpose of evaluation in SSFL RFI HHRAs, petroleum chemical constituents include BTEX and PAHs. To adequately assess the potential risks associated with TPH in environmental media, a site-specific extrapolation methodology has been developed to allow correlation between the TPH fraction concentration and petroleum constituent concentrations (Section 1.5.3.1). When TPH was detected in the gasoline range, then BTEX compounds were added as COPCs. When TPH was detected in the diesel range, then PAHs were added as COPCs. Concentrations of BTEX or PAHs were determined by using the site-specific extrapolation factors. Additional details regarding the characterization of risks from PAHs are discussed in Section 8.5.3 of the SRAM (MWH, 2005b).

Risk estimates related to the soil vapor pathway are presented separately in the HHRA and discussed in the uncertainty section (Section 1.5.3.6), as requested by DTSC.

The risk estimates for the plant uptake exposure pathway are presented separately from other estimated risks to facilitate evaluation by risk managers.

Summary and Conclusions. The HHRA results will be used to help identify areas within Group 2 that require further action (additional site characterization or remediation). The results of the risk assessment are presented in a format that allows the risk manager to integrate and weigh decision factors appropriately and optimally (MWH, 2005). An important risk management consideration is that new data may become available subsequent to the completion of the risk assessment. Risk managers should consider newly published information (site-specific or chemical-specific) as it becomes available to ensure that the final site decisions are protective of human health.

1.5.3.6 Uncertainty Discussion

The risk assessment results are based on conservative risk assessment methods and assumptions (MWH, 2005). Therefore, it is important that uncertainties associated with the risk assessment process be addressed to place the numerical risk estimates in proper perspective. The discussions of uncertainties are largely qualitative and are presented for each of the investigational units within Group 2. The uncertainty discussion focuses on those COPCs with the greatest contribution to the cumulative risk.

Uncertainties associated with the results of the HHRA are a function of both the "state of the practice" of risk assessment in general and uncertainty factors specific to the investigational unit. The HHRA is subject to uncertainty with regard to a variety of factors, including the following:

- Environmental sampling and analysis
- Fate and transport estimation
- Exposure assessment
- Toxicity assessment
- Risk characterization

Environmental Sampling and Analysis. Uncertainties associated with sampling and analysis include the inherent variability (standard error) in the analysis, the representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. The quality assurance (QA)/QC program used in the investigation serves to reduce these errors, but it cannot eliminate all errors associated with sampling and analysis. The degree to which sample collection and analyses reflect real EPCs partly determines the reliability of the risk estimates.

Fate and Transport Estimation. This HHRA makes simplifying assumptions about the environmental fate and transport of COPCs. Specifically, it is assumed that no constituent loss or transformation occurs in the future, and that the constituent concentrations detected in soil and shallow groundwater remain constant during the assessed exposure duration. In cases where natural attenuation or other degradation processes are significant, the analytical data chosen to represent EPCs may overstate actual long-term exposure levels.

Exposure Assessment. The estimation of exposure requires many assumptions to describe potential exposure situations. There are uncertainties regarding the likelihood of exposure, the frequency of contact with contaminated media, the concentrations of constituents at

exposure points, and the time period of exposure. The assumptions used tend to simplify and approximate actual site conditions and may overestimate or underestimate the actual risks. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard. This HHRA evaluates an assumed unrestricted residential land use. To the extent that future uses are actually more limited than assumed here for residential use (for example, a more plausible recreational use), exposures and risks would be proportionately lower than reported here.

Toxicity Assessment. Uncertainties in toxicological data can influence the reliability of risk management decisions. The toxicity values used for quantifying risk in this assessment have varying levels of confidence that affect the usefulness of the resulting risk estimates.

Sources of uncertainty associated with the toxicity values used in the toxicity assessment include the following:

- Extrapolation of dose-response data derived from high dose exposures to adverse health effects that may occur at the low levels seen in the environment
- Extrapolation of dose-response data derived from short-term tests to predict effects of chronic exposures
- Extrapolation of dose-response data derived from animal studies to predict effects on humans
- Extrapolation of dose-response data from homogeneous populations to predict effects on the general population

The levels of uncertainty associated with the RfDs for the COPCs (as judged by EPA) are expressed as uncertainty factors and modifying factors and are provided in IRIS or HEAST. For those chemicals suspected of resulting in cancer effects, uncertainty is in part expressed in terms of EPA's weight of evidence (WoE) classification system, as listed in Table 1.5.3-9.

Dermal exposures are different from oral exposures because not all of a constituent that comes into contact with a person's skin travels across the various layers of epidermal tissue, as indicated by a skin permeability factor, and because the toxic effects produced from this route of exposure may not be the same as when the constituent is ingested. In lieu of available toxicity values for the dermal route, this HHRA uses oral toxicity values to estimate the effects of dermally available constituents. This approach may result in an underestimate or an overestimate of risks, depending on whether a constituent is more or less toxic by the dermal route versus by ingestion.

Risk Characterization. In the risk characterization phase, the assumption is made that the total risk of developing an adverse effect from aggregate exposure to site constituents is the sum of the HQs or cancer risks estimated for exposure to each individual constituent. This approach does not account for the possibility that chemicals act synergistically or antagonistically.

1.5.3.7 Use of Risk Assessment Results in the RFI and CMS Process

The HHRA results will be used to help identify areas in Group 2 that require further action (additional site characterization or remediation). Generally, estimated cancer risks within

the range 10^{-6} to 10^{-4}, and HIs less than 1, are considered to be acceptable for the purpose of making remedial decisions (EPA, 1989). Although this HHRA produces numerical estimates of risk, it should be recognized that these numbers might not predict actual health outcomes because they are based largely on hypothetical assumptions. Their purpose is to provide a frame of reference for risk management decision making. Actual risks are likely to be lower than these estimates. Interpretation of the risk estimates provided should consider the nature and WoE supporting these estimates, as well as the magnitude of uncertainty surrounding them, as described in Section 1.5.3.6.

The results of the risk assessment will be presented in a format that allows the risk manager to integrate and weigh decision factors appropriately and optimally (MWH, 2005). An important risk management consideration is that new data may become available subsequent to the completion of the risk assessment. Risk managers will consider newly published information (site-specific or chemical-specific) as it becomes available to ensure that the final site decisions are protective of human health.

The use of the risk assessment results in the RFI and CMS process is discussed in Section 8.

1.5.4 Ecological Risk Assessment

This subsection presents the general approach used for conducting ERAs at RFI sites within Group 2 at SSFL. ERAs specific for each of the five sites in Group 2 (the LOX Plant, Area II Landfill, ELV Site, Former Area II Incinerator Ash Pile, and Building 515 STP) are presented as part of the RFI discussions specific to each site (Sections 2 through 5) and to the seeps and springs (Section 6). These ERAs, prepared to support the Group 2 RFI, describe the potential exposures and effects to resident biota from chemical stressors associated with past activities within each site. The results of these ERAs are intended to assist risk managers in determining whether remedial actions are needed and, if so, the scale required.

Because the ERAs for all five areas will be conducted in the same manner, using many of the same assumptions and supporting data, the approach for and information common to all of these ERAs is presented in this initial section to reduce repetition. The common data and supporting information will be referenced in each of the RFI site-specific risk assessments as appropriate.

1.5.4.1 Approach

ERAs for Group 2 are conducted in phases, as recommended by the SRAM (MWH, 2005b; DTSC, 1996; EPA, 1997). Each phase is more detailed and focused than the one preceding it, and data from one phase are used to determine whether further studies are needed to meet the objectives of the assessment. It includes both a scoping and a predictive assessment, as defined by DTSC (1996).

The scoping assessment uses the most conservative exposure assumptions. The results of the scoping assessment are used to determine the chemicals, receptors, and exposure pathways to be carried forward to the predictive assessment.

The predictive assessment uses more realistic assumptions for the estimation of exposure and effects. In some instances, procedures outlined in the SRAM (MWH, 2005b) have been updated to reflect current state-of-the-practice for ERAs that have been agreed to by

representatives of NASA, Boeing, and DOE. These changes result in a more robust risk assessment and provide more information for risk managers to use in making remedial decisions. Deviations and/or updated methods from the SRAM (MWH, 2005b) are identified and explained in Section 1.5.5.2 with respect to the nature of the deviation and the overall impacts to the ERA.

The results of the ERA will be used to make recommendations, as follows:

- "NFA with respect to ecological risk" will be recommended for sites where *de minimus* risk (most conservative HQs or HIs are less than 1) to ecological receptors is identified for small-home-range species (representative species that spend most of their life span within the investigational unit). This NFA finding is tentative pending the completion of the risk assessment for species with large home ranges (representative species that spend most of their life span outside of the site or forage across multiple sites[3]). Sites will not be recommended definitively for NFA until cumulative risks to large-home-range representative species are evaluated across multiple sites.
- Further evaluation by risk managers will be recommended as part of the CMS process for individual sites or site combinations where the WoE indicates potential adverse effects to ecological receptors. This evaluation will include the selection of an appropriate remedial alternative (including no action). As appropriate, natural resource trustees, including the California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service (USFWS), must be consulted in the selection of a remedial alternative.
- A Phase III Impact Assessment may be recommended as part of the CMS process for sites where significant uncertainties exist in the WoE risk estimate or where it is determined that remediation may cause adverse effects to ecological receptors or their habitats.

1.5.4.2 Guidance

The ERAs for Group 2 were performed in general accordance with the following guidance:

- SRAM Work Plan (MWH, 2005b)
- *Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities* (DTSC, 1996)
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment, Interim Final* (EPA, 1997)
- ECO Updates, Volume 1, Numbers 1 through 5 (EPA, 1991a, 1991b, 1992a, 1992b, 1992c)
- ECO Updates, Volume 2, Numbers 1 through 4 (EPA, 1994a, 1994b, 1994c, 1994d)
- ECO Updates, Volume 3, Numbers 1 and 2 (EPA, 1996a, 1996b)
- *Final Guidelines for Ecological Risk Assessment* (EPA, 1998)
- *Ecological Risk Assessment and Risk Management Principles for Superfund Sites* (EPA, 1999)
- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (EPA, 2001)

[3] Note that the evaluation of cumulative risks to receptors with large home ranges will be the focus of a subsequent risk assessment report and is beyond the scope of this report.

1.5.4.3 Organization

Each of the ERAs is organized following the framework recommended by EPA (1998), which consists of three main components: Problem Formulation, Analysis, and Risk Characterization (shown conceptually in Figure 1.5.4-1). The evaluations conducted as part of this ERA are described and discussed in the following sections:

- **Problem Formulation**. Contains the information necessary to focus the remainder of the ERA. It describes the location and ecological setting of the site; discusses selection of assessment endpoints and measures; identifies sources of contaminants, CPECs, potential ecological receptors, and exposure pathways; and develops the ecological conceptual site model (CSM). The general components of the Problem Formulation are included in this subsection. Information specific to each RFI site is located in the site-specific Problem Formulation.

- **Analysis**. Presents the technical evaluation of potential exposures and adverse effects through the Exposure Characterization and the Ecological Effects Characterization:

  – Exposure Characterization–Describes exposure assumptions and models and presents the exposure estimates for selected representative species.

  – Ecological Effects Characterization–Presents an overview of the toxicity information available for each representative species.

  The approach to exposure characterization, which is consistent across all sites, is described later in this section. EPCs and modeled exposure results specific for each RFI site are presented in each site-specific ERA. The ecological effects characterization, which is consistent across all sites, is presented later in this section and referenced in each site-specific ERA.

- **Risk Characterization**. Integrates the Problem Formulation and the Analysis to estimate the likelihood of impacts to ecological receptors from exposure to CPECs. It also presents uncertainties and limitations associated with the risk assessment data and methodology. The approach to risk characterization and many uncertainties are consistent across all sites and are described later in this section. Risk characterization results and uncertainties specific for each RFI site are presented in each site-specific ERA.

- **Conclusions and Recommendations**. Summarizes the overall conclusions and recommendations that can be drawn about potential ecological risks associated with CPECs.

1.5.4.4 Problem Formulation

The Problem Formulation integrates available information (sources, contaminants, effects, and environmental setting) and serves to provide focus to the ERA. It includes a description of the site setting, identification of the ecological management goals and the important aspects of the site to be protected (referred to as "assessment endpoints"), the means by which the assessment endpoints will be evaluated (measures of exposure and effects), and the identification of CPECs. The end product of the problem formulation is a CSM that describes the contaminant sources and transport mechanisms, evaluates potential exposure

pathways, and identifies the representative species that were used to assess potential ecological risk to those and other similar species. Whereas the general components of the Problem Formulation are presented and described here, site-specific variations to the Problem Formulation are presented in the section for each RFI site.

Site Background. This section briefly describes the physical location and ecological setting of the RFI site and the historical activities that may have resulted in releases of hazardous substances. This is a site-specific component of the Problem Formulation and is presented separately for each RFI site.

Ecological Management Goals, Assessment Endpoints, and Measures. The identification of ecological management goals, assessment endpoints, and measures provides the focus of the ERA, links the ERA with the site characterization and the nature and extent portions of the RFI Report, and ensures that the methodologies and results of the ERA are technically sound.

Ecological Management Goals are statements of the desired ecological conditions for the site. They must be established according to a realistic assessment of the current status of the ecological community and potential current and future land uses at the site. The ecological management goal for all Group 2 RFI sites is stated as follows:

- Maintenance of soil, sediment, water quality, food source, and habitat conditions capable of supporting ecological receptors, including special-status species, likely to be found in the area.

Assessment Endpoints are an expression of the important ecological values that should be protected at a site (Suter, 1990, 1993; Suter et al., 2000; EPA, 1998). The assessment endpoints are developed according to known information concerning the contaminants present, the ecological setting of the site (current and potential future conditions), and the ecological management goals.

The assessment endpoints for SSFL are listed in Table 1.5.4-1 and are applicable to all terrestrial and aquatic and wetlands habitats. Assessment endpoints specific to each RFI site in Group 2 are identified in the section for each RFI site.

Measures used in this ERA are predictive of the assessment endpoints (EPA, 1998). The three categories of measures include the following:

- Measures of Exposure–Used to evaluate how exposures could be occurring
- Measures of Effects–Used to evaluate the response of the assessment endpoints when exposed to contaminants
- Measures of Ecosystem and Receptor Characteristics–Used to evaluate the ecosystem characteristics that could affect exposure or response to contaminants

Measures identified for an ERA can be from one or more of the above categories, depending on the complexity of the ERA. Criteria considered in the selection of measures are as follows:

- Corresponds to or is predictive of an assessment endpoint
- Readily measured or evaluated

- Appropriate to the scale of the site
- Appropriate to the temporal dynamics
- Appropriate to the exposure pathway
- Associated with low natural variability
- Disruptive (minimally) to ecological community and species variability

Measures of exposure and effects associated with assessment endpoints for SSFL are listed in Table 1.5.4-1. These measures are applicable to all terrestrial and aquatic and wetlands habitats. Measures specific to each RFI site in Group 2 are identified in the section for each RFI site.

Ecological Conceptual Site Model. The CSM is a written and visual presentation of predicted relationships among stressors, exposure pathways, and assessment endpoints. It includes a description of the complete exposure pathways and outlines the potential routes of exposure for each assessment endpoint. A CSM diagram for ecological exposures was developed for SSFL in general (Figure 1.5.4-2). CSMs specific to the receptors and pathways unique to each RFI site within Group 2 are presented in each appropriate section.

The primary contaminant sources at SSFL include chemical use and storage, accidental spills and releases, ASTs and USTs, drainage channels and impoundments associated with rocket testing, and waste disposal areas. Primary release mechanisms include spills, leakage, and prior waste disposal practices. Secondary sources of potential contaminants are soils, sediment, and surface water. Secondary release mechanisms include volatilization and wind erosion, bioaccumulation from soil, soil and sediment erosion, leaching from soil and surface water into groundwater, and surface discharge from groundwater.

Complete or potentially complete exposure pathways from contaminated soil, sediment, surface water, groundwater, and biota to ecological receptors exist at the sites. Burrowing mammals (deer mice) may be exposed to soil vapors via inhalation. Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, and small mammals resident in or associated with site soils. Additionally, terrestrial plants potentially may be exposed to contaminated groundwater via uptake. Although benthic invertebrates, fish, and amphibians may be exposed to contaminants via surface water or sediment, benthic invertebrates primarily are exposed through sediment, and fish and amphibians primarily are exposed through surface water. Terrestrial and aquatic wildlife (herbivores, omnivores, invertivores, and carnivores), including reptiles, may be exposed directly to contaminants in surface water through ingestion and to contaminants in soil or sediment by incidental soil or sediment ingestion, by dermal contact, or by the inhalation of wind-borne particles. Terrestrial and aquatic invertebrates, fish, and wildlife (amphibians, reptiles, birds, and mammals) also may receive contaminant exposure through the food-web transfer of chemicals from lower trophic levels (plants to herbivores, plants and prey animals to omnivores, etc.). The potential exposure pathways for ecological receptors at SSFL are summarized in Table 1.5.4-2, along with the rationale for inclusion or exclusion in the quantitative and qualitative evaluations.

Identification of Representative Species. Representative species are selected from those species that are either known to occur or may occur at the site. They are chosen to reflect the assessment endpoints for the ERA because their exposures are expected to be

"representative" of other species in their functional group or trophic level. In general, representative species are selected using the following criteria:

- Receptor is considered essential to, or indicative of healthy functioning ecosystems.
- Receptor is vital to the structure and function of the food web.
- Receptor is representative of an ecological guild or niche.
- Receptor has a small home range.
- Receptor is susceptible to bioaccumulation or biomagnification of CPECs (higher trophic-level predators).
- Receptor is likely to be exposed to CPECs or to serve as a link between viable exposure pathways and CPECs.
- Receptor occurs at the site, or habitat is available to support the selected receptor.
- Toxicological data are readily available in the literature for the receptor.
- Receptor is known or suspected to be sensitive to contaminants providing a protective estimate of exposure and risk to other members of the guild.

Representative species were identified in the SRAM (MWH, 2005b) from each trophic level to fulfill as many of the criteria listed above as possible. Species assessed at the population[4] level include all other birds and mammals for which protection of populations is important. Receptors assessed at the community level consist of terrestrial and/or aquatic plants and invertebrates that provide forage or prey for higher trophic levels or support habitat quality and require protection at a community[5] level. The representative species that are evaluated in the ERAs at SSFL are listed in Table 1.5.4-3. Representative species specific to each RFI site are identified in each appropriate section of this report.

A brief profile for each selected receptor is presented below.

Terrestrial Habitats. The following representative species are evaluated for terrestrial habitats at SSFL.

Terrestrial Plants. Terrestrial plants are a primary producer and are evaluated at the community level. They include a wide variety of grasses and forbs. Terrestrial plants are a vital part of the food chain, serving as a main food source for both herbivorous and omnivorous species. Terrestrial plants also are directly exposed to CPECs in the soil, may bioaccumulate CPECs, and can be used to assess the status of the habitat.

Soil Invertebrates. Soil invertebrates are primary consumers and are assessed at the community level. They comprise a wide range of species, including earthworms, ground and flying insects, and spiders. Soil invertebrates primarily serve as food sources for omnivorous and insectivorous birds and mammals and may bioaccumulate CPECs.

[4] A population is defined as a group if inter-breeding individuals of the same species occupy a given area.
[5] A community is a collection of individuals of different species that occupy a given area.

Hermit Thrush. The hermit thrush is considered representative of primary and secondary consumers and is evaluated at the population level. The hermit thrush is found in mixed woods, forests, parks, and thickets. Its breeding range extends from Alaska east across Canada and south to California, and it winters mainly in the United States. The hermit thrush has been observed frequently at SSFL. It is primarily insectivorous during the breeding season and becomes more omnivorous during the winter. The hermit thrush builds a cup nest of moss, twigs, or grasses on or near the ground (Jones and Donovan, 1996; Ransom, 1981).

Red-tailed Hawk. The red-tailed hawk is a tertiary consumer and is evaluated at the population level. The red-tailed hawk is found in a variety of habitats including woodlands, farm country, prairies, marshes, mountains, and deserts. Its range extends from Alaska to south Central America; wintering is primarily south of British Columbia. Red-tailed hawks are primarily carnivorous, feeding on rodents and other small mammals, but will prey on other birds, lizards, snakes, and large insects, depending on availability. Platform nests are built close to the tops of trees or other tall structures where trees are scarce (EPA, 1993; Ransom, 1981).

Deer Mouse. The deer mouse represents primary and secondary consumers and is evaluated at the population level. It also was selected to represent burrowing mammals and because it serves as prey for other representative species (red-tailed hawk and bobcat). It has the widest distribution of any *Peromyscus* species and resides in dry-land habitat including alpine tundra, coniferous and deciduous forests, grasslands, and deserts. Deer mice are omnivorous and opportunistic, feeding mainly on seeds, arthropods, some green vegetation, roots, fruits, and fungi. The deer mouse gets a high proportion of its water requirements from the nonseed plant materials in its diet (EPA, 1993).

Mule Deer. The mule deer is a primary consumer and is evaluated at the population level. These herbivores are found in coastal forests, brushy areas, rocky uplands, desert shrubs, and chaparral habitats. Their range extends from southern Alaska to Mexico and throughout the western United States. The Pacific coast black-tailed deer are considered a subspecies of the mule deer. They feed on grass heads, grass leaves, stems and roots, and forb leaves (Ransom, 1981).

Bobcat. The bobcat is representative of secondary and tertiary consumers and is evaluated at the population level. Bobcats are found in forests, swamps, deserts, and mountains, although they prefer scrub, thickets, and broken country. Their range extends from southern Canada to Mexico and throughout most of the continental United States. The bobcat preys primarily on rabbits and hares, but will hunt anything from insects and small rodents to deer, depending on location and habitat, season, and abundance. The bobcat is territorial and largely solitary, although there is some overlap in home ranges.

Aquatic and Wetland Habitats. Aquatic and wetland habitats as defined for SSFL include seasonal wetlands and ephemeral ponds. Seasonal drainage ditches are evaluated as terrestrial exposures rather than aquatic. The representative aquatic organisms discussed below are evaluated in one or more of the aquatic habitats.

Aquatic Plants. Aquatic plants represent primary producers and are evaluated only as a food source for other representative receptors. Aquatic plants serve as major food items for

several species in the food chain and provide refuge and nesting habitats for various species.

Aquatic Invertebrates and Benthic Macroinvertebrates. For the purposes of this ERA, the term "aquatic invertebrates" refers to water-column organisms and "benthic macroinvertebrates" refers to sediment-associated organisms. They both represent primary consumers and are evaluated at the community level. Aquatic invertebrates and benthic macroinvertebrates may bioaccumulate CPECs through the food chain.

Fish. Fish represent primary and secondary consumers and are evaluated at the population level. Fish primarily serve as prey for piscivorous birds and can bioaccumulate CPECs.

Great Blue Heron. Great blue herons were assessed at the population level. They feed primarily on fish, but also feed on amphibians, crustaceans, aquatic insects, and plants. They are widespread throughout the United States and are found in ponds, marshes, and lakes wherever fish are plentiful. Great blue herons nest in or near wetlands where tall trees provide safe sites for heronries. They lay three to seven bluish-green eggs in a stick nest, and several nests may be in the same tree (Udvardy, 1993).

Selection of Chemicals of Potential Ecological Concern. The CPECs for all Group 2 sites were identified through several data evaluation procedures and selection criteria. These criteria generally were as outlined in the SRAM (MWH, 2005b), with some additional discussion in Section 1.4; however, some deviations and modifications were made. The CPECs were selected as follows:

1. A chemical is detected at the site using validated laboratory analyses. Data validation was completed for all aspects of the RFI and validated data are reported in the RFI Characterization Results section of each RFI site section.

2. A chemical is present in excess of concentrations observed in laboratory field blanks. This step was completed as part of the data evaluation and reduction steps completed for all aspects of the RFI and the results are reported in Section 1.4 of the main text.

3. A chemical occurs above a 5-percent detection frequency. This step was applied only when there were at least 20 data points for the chemical.

4. A chemical historically was used at the site. This step was not followed, so this is a deviation from the SRAM (MWH, 2005b). All chemicals meeting other criteria were retained for risk assessment regardless of potential historical use.

5. Metals and dioxins and furans are present in excess of soil and groundwater comparison concentrations. Soils were compared to the background data set using the WRS Test, as described in the SRAM (MWH, 2005b). Groundwater data were compared to a background comparison concentration and then evaluated using the WRS Test, as described in the SRAM. A chemical determined to be consistent with background concentrations using the WRS Test may still be retained as a CPEC if the maximum detected concentration is significantly greater than the maximum background concentration, the sample was located in an area that potentially might have been affected by metals, and the SQLs were elevated above the ecological screening levels (ESLs).

6. The SQL for a chemical exceeds the ESL. ESLs will be used in the CPEC selection process to ensure that SQLs for chemicals in soil, sediment, and water samples are sufficiently low to identify chemicals that may present risks. For the purpose of CPEC selection, if there are a sufficient number of the SQLs in a data set below the ESL to conclude that the chemical is not present at concentrations that could pose an ecological risk, and all other criteria are met, then the chemical will be excluded as a CPEC. Justification (sample size, frequency of detection, and number of SQLs below the ESL) will be presented in the risk assessment in cases where a chemical with one or more SQLs at levels exceeding the ESL is excluded as a CPEC.

7. Extrapolation of TPH and PCB data. Data for TPH or PCBs will be extrapolated to estimate TPH- or PCB-constituent concentrations (PAHs, BTEX, and arolors) at sites where these data are not already available. If constituent data are available at a given site, this extrapolation will not be conducted. This is a deviation of the SRAM (MWH, 2005b) that states that all TPH and PCB results will be extrapolated, regardless of the availability of constituent data.

8. If a VOC analyte was detected in soil and also was analyzed for in soil gas, the inhalation exposure for the VOC was based on the soil gas measurement, regardless of whether the VOC was detected in soil gas or not. If a VOC was detected in soil but not analyzed for in soil vapor, it was retained and a concentration in soil vapor was modeled from the soil concentration. This modeled concentration was then evaluated in the soil vapor screening.

Chemical data meeting the CPEC selection criteria were identified separately for each RFI site in Group 2 and are presented in the analyses for each RFI site.

1.5.4.5 Analysis

The analysis phase links the problem formulation (Section 1.5.4.4) with the risk characterization (Section 1.5.4.6) and consists of the technical evaluation of ecological and chemical data to determine the potential for ecological exposures and effects, as shown in Figure 1.5.4-1. The analysis phase includes the exposure characterization and the ecological effects characterization. These two components are used to evaluate the relationships among receptors, potential exposures, and potential effects. The results provide the information necessary to estimate the potential risks to the representative species under the conditions defined for Group 2.

Exposure Characterization. The exposure characterization is used to evaluate the relationship between receptors at the site and potential stressors (CPECs). Exposure is defined as the co-occurrence of a stressor (chemical) and a receptor in both space and time. For risk to be present, there must be exposure. The methods used to estimate exposure, including receptor-specific exposure models, exposure factors, and assumptions; exposure areas; and calculation of EPCs, are described in this subsection.

Exposure Models. The exposure model describes the relationships and equations used to estimate how much of a given chemical in a given medium is being taken up by the receptor via a given exposure route. These relationships may be simple or complex depending on the receptor involved and the number of exposure routes being evaluated. Two exposure models are used in this ERA: the concentration-based model and a dosage-based model.

Concentration-based Exposure Models

The exposure model for several of the groups of ecological receptors is simple, and is expressed as the concentration of each chemical in the medium to which the receptor is most likely to be exposed. The ecological groups for which this exposure model is used are as follows:

- Terrestrial plants (soil; only when qualitative evaluation indicates potential stress)
- Soil invertebrates (soil)
- Aquatic plants (sediment and surface water)
- Aquatic invertebrates (surface water)
- Benthic macroinvertebrates (sediment)
- Burrowing mammals (soil vapor inhalation only)

Dosage-based Exposure Models

The exposure model for birds and mammals is much more complex. Birds and mammals experience exposure through multiple pathways, including the ingestion of abiotic media (soil and surface water), biotic media (food), and inhalation of or dermal contact with abiotic media. To address these multiple pathways, modeling is required. Exposure via ingestion pathways is described below. Inhalation exposure is evaluated using the concentration-based model. Dermal exposure was not quantitatively evaluated in this ERA.

Ingestion exposure estimates for birds and mammals are generated according to the following:

- Receptor-specific exposure factors (or life-history parameters)
- Estimated exposure concentrations in food sources and bioaccumulation potential
- Area use factors (AUFs)
- EPCs for abiotic media

The end product of the exposure estimate is a dosage (amount of chemicals per kilogram receptor body weight per day [mg/kg-day]) rather than a medium concentration, as is the case for terrestrial and aquatic plants and invertebrates. This is a function of both the multiple pathway approach and the typical methods used in toxicity testing for birds and mammals. Exposure estimates for birds and mammals followed one of the generalized food chain uptake exposure models described below (modified from Suter et al. [2000] and cited in the SRAM [MWH, 2005b]):

Hermit thrush and deer mouse:

$$Ej = [Soil_j \bullet Ps \bullet FIR] + [\sum_{i=1}^{N} Bij \bullet Pi \bullet FIR] + [Water_j \bullet WIR]$$

Red-tailed hawk, bobcat, and mule deer:

$$Ej = [\sum_{i=1}^{N} Bij \bullet Pi \bullet FIR] + [Water_j \bullet WIR]$$

Great blue heron:

$$Ej = [Sediment_j \bullet Ps \bullet FIR] + [\sum_{i=1}^{N} Bij \bullet Pi \bullet FIR] + [Water_j \bullet WIR]$$

Where:

E_j	=	Total exposure (mg/kg-day)
$Soil_j$	=	Concentration of chemical in soil (mg/kg)
$Sediment_j$	=	Concentration of chemical in sediment (mg/kg)
$Water_j$	=	Concentration of chemical in water (mg/L)
P_s	=	Soil/sediment ingestion rate as a proportion of diet
FIR	=	Total food ingestion rate for the representative species (kg_{diet}/kg BW/day)
WIR	=	Total water ingestion rate for the representative species (L/kg BW/day)
B_{ij}	=	Concentration of chemical (j) in biota type (i) (mg/kg)
P_i	=	Proportion of biota type (i) in diet

Exposure Factors. Species-specific life history factors are needed to estimate exposure to CPECs for each representative species. These include body weight; food, water, and media ingestion rates; diet composition; and respective proportion of each diet component. These parameters were used as cited in the SRAM (MWH, 2005b) and are summarized in Table 1.5.4-4.

Bioaccumulation Potential. The measurement and/or estimation of concentrations of CPECs in wildlife food is necessary to evaluate how much of a receptor's exposure is via food versus direct uptake of contaminated media. Although the preferred data are direct measurements of concentrations in samples collected from the site, such data were not available for any RFI site in Group 2. Site-specific bioaccumulation factors (BAFs) were developed in the SRAM (MWH, 2005b). These values were used if available; if not, other literature-reported values or regression models were used. If literature values or reliable models were not available for a given chemical, then a conservative default bioaccumulation value of 1 was used. The AUFs for the Group 2 sites are listed in Table 1.5.4-5. Bioaccumulation factors and uptake models for terrestrial receptors are summarized in Tables 1.5.4-6 and 1.5.4-7. Biota and sediment accumulation factors and uptake models for aquatic receptors are summarized in Tables 1.5.4-8 and 1.5.4-9.

Area Use Factors. The AUF is used to modify the risk estimates based on how much time the receptor may actually spend onsite. The AUF is a ratio of the size of the site relative to an animal's foraging range. For animals with a small home range, the AUF defaults to 1. The AUFs are estimated using the following equation:

$$AUF = \frac{EA}{FRx}$$

Where:

AUF = Area use factor
EA = Exposure area (hectares)
FRx = Foraging range for target species x (hectares)

An AUF is not used for estimating exposures in the scoping assessment (receptors were assumed to spend 100 percent of their time at the site). Receptor-specific AUFs are used in the predictive assessment. The AUFs for each receptor are defined in each Group 2 RFI site section.

Exposure Point Concentrations. The concentration of a CPEC in a given medium to which potential ecological receptors and representative species would most likely be exposed is referred to as the EPC. This ERA used three different EPCs, including the maximum detected concentration, the RME, and the CTE. The maximum detected concentration was taken from all samples collected at a given RFI site that met the data quality requirements for the CPEC. The maximum represents a "worst case" exposure. The CTE concentration was the arithmetic mean as specified by the SRAM (MWH, 2005b) and represents an "average" exposure. The RME concentration (generally the 95% UCL) was calculated using the most recent version of ProUCL, as specified by the SRAM. The RME concentration represents a conservative estimate of average exposure. Taken together, these three EPCs describe the range of expected exposure, from average to most extreme, for a given CPEC and will help inform subsequent risk management decision-making.

The RME EPC was calculated following the most recent parametric (distributional) and nonparametric EPA recommendations as offered in ProUCL (EPA, 2006; 2007). EPA released Version 4.0 of ProUCL in 2007 for general usage; it offers new approaches for calculating UCLs of the mean, particularly when non-detects are present. These new approaches consider a large variety of inputs including the perceived distribution of the detected results (if no perceived distribution is acceptable, nonparametric alternatives are offered), sample size, variability, and skewness.

The ProUCL decision tree for UCLs of the mean is large, with parametric approaches for left-censored data sets (those with nondetects) centering on maximum likelihood estimates for use as proxy substitutions. These estimates attempt to complete the censored left tail of the data using information available from the available detected data. The distributions available in ProUCL include normal, lognormal, and gamma distributions.

Nonparametric approaches are available when a discernable distribution cannot be identified. When non-detects are present, the primary nonparametric approach involves the Kaplan-Meier approach. Depending on the data, the Kaplan-Meier approach may be applied with aspects of a student *t* approach or one of various "bootstrap" approaches. When all results are detected, other nonparametric approaches (such as the Chebyshev approach) are used.

Calculations using the Chebyshev approach adhere to EPA's recommendation of sometimes using a 97.5% or 99% Chebyshev UCL when sample size, variability, and skewness suggest unusually high uncertainty. These elevated-confidence UCLs are not offered in an attempt to alter the overall confidence that the true mean falls below the calculated UCL (95%), but to recognize the results of EPA's Monte Carlo studies, which indicate that under such

conditions, a 95% Chebyshev UCL tends not to offer sufficient coverage of the true mean. Thus, these special Chebyshev UCLs remain attempts to offer the best 95% UCL despite the nomenclature describing higher confidence (97.5% or 99%).

The most appropriate method for calculating the UCL for each CPEC is based on sample size, goodness of fit to distributions, variability, and skewness. [Note: if there are more than four data points, but only one is a detected value, ProUCL does not calculate a UCL. In these cases, the UCL was calculated using the Chebyshev method with ½ the reported value for non-detects.]

The RME EPC for each CPEC at each RFI site was determined based on the following decision rules:

- If there are fewer than four data points (samples), then the EPC defaults to the maximum detected concentration.
- If there are four or more data points, then the UCL recommended by ProUCL is used as the EPC.
- If the UCL is greater than the maximum detected concentration, then the EPC defaults to the maximum detected concentration.

Site-specific EPCs are reported in each RFI site section.

Ecological Effects Characterization. The ecological effects characterization consists of an evaluation of available toxicity or other effects information that can be used to relate the exposure estimates to a level of adverse effects. Stressor-response (effects) data that may be used to evaluate ecological risks resulting from chemical exposures comprise three general categories: literature-derived or site-specific single-chemical toxicity data, site-specific ambient media toxicity tests, and site-specific field surveys (Suter et al., 2000). Site-specific toxicity studies and quantitative field surveys were not conducted for this ERA. Therefore, single-chemical toxicity data found in the literature were the basis for determining toxicity reference values (TRVs).

TRVs were classified into three categories: ESLs, Low TRVs, and High TRVs. ESLs are screening values that integrate conservative exposure assumptions and no observed adverse effect levels (NOAELs) into a value expressed as a media-based chemical concentration. Low TRVs include NOAELs, no observed effect concentrations (NOECs), low Biological Technical Assistance Group (BTAG) values, threshold effect concentrations (TECs), and chronic national recommended ambient water quality criteria (NRWQC). High TRVs reflect a mid-range exposure at which adverse effects might occur based on a chronic or sub-chronic exposure. High TRVs include the lowest observed adverse effect levels (LOAELs), lowest observed effect concentrations (LOECs), 20-percent effective concentrations (EC_{20}s), high BTAG values, and probable effect concentrations (PECs). Toxicity results with other endpoints were used in the absence of preferred effect levels and were modified with uncertainty factors.

Tables 1.5.4-10 and 1.5.4-11 provide the soil vapor modeling parameters and the chemical properties for VOCs, respectively. The ESLs are summarized in Table 1.5.4-12; the lowest soil ESL is listed in Table 1.5.4-13. The ESLs for most chemicals are those listed in the SRAM

(MWH, 2005b); however, some values were revised based on a review of the calculations and literature used to derive the values, in agreement with MWH (conference calls between MWH and CH2M HILL staff, April 2008).

The TRVs for soil invertebrates were obtained primarily from sources listed in the SRAM (MWH, 2005b), followed by EPA ecological soil screening levels (Eco-SSLs), Efroymson et al. (1997), and literature searches. The TRVs for terrestrial plants are listed in Table 1.5.4-14; the TRVs for soil invertebrates are summarized in Table 1.5.4-15.

The Low TRVs for birds and mammals were obtained from the studies used to develop the ESLs in the SRAM (MWH, 2005b), where available. High TRVs were obtained from the same study and source as the Low TRVs when possible. TRVs for analytes that were not listed in the SRAM, or for which no TRV was identified in the SRAM, were obtained first through searches of the SRAM-recommended sources listed below, followed by searches of the open literature:

- EPA IRIS-http://cfpub.epa.gov/ncea/iris/index.cfm
- ATSDR-http://www.atsdr.cdc.gov/
- *Toxicological Benchmarks for Wildlife: 1996* (Sample et al., 1996)
- EPA Region 9 BTAG TRVs developed for the U.S. Navy (Engineering Field Activity [EFA] West [EFA West], 1998)

For this assessment, the Low TRV is considered to be within the range of a NOAEL; the High TRV is considered to be within the range of a LOAEL. Using both a Low TRV and a High TRV provides a range of HQs that reflect the range of estimated risk between a no effect and a possible effect level. The TRVs for birds based on ingestion are listed in Table 1.5.4-16. The TRVs for mammals based on ingestion are listed in Table 1.5.4-17, and the TRVs for mammals based on inhalation are listed in Table 1.5.4-18.

The TRVs for benthic macroinvertebrates exposed to sediment were obtained primarily from sources listed in the SRAM (MWH, 2005b), but values selected from those sources reflected the consensus-based values as opposed to strictly the lowest values. In addition, marine values were used only when freshwater values were not available, as opposed to the use of either marine or freshwater (depending on which was lower) in the SRAM. TRVs for sediment are listed in Table 1.5.4-19.

The TRVs for fish and other aquatic organisms exposed to surface water were obtained primarily from the sources listed in the SRAM (MWH, 2005b) and included chronic NRWQC, secondary chronic values (Tier II values), and TRVs obtained from other literature searches. TRVs for surface water are listed in Table 1.5.4-20.

The toxicological studies compiled in the TRV tables were evaluated for endpoints and assigned uncertainty factors (UFs), if necessary, to normalize the endpoints to a Low or High TRV equivalent. Per the SRAM (MWH, 2005b), the UFs applied were as follows:

- Lethal Dose to 50 percent of test organisms (LD50) to NOAEL: UF = 100
- LD50 to LOAEL: UF = 10

- LOAEL to NOAEL: UF = 5
- Subchronic to chronic: UF = 2

The determination of whether a toxicity study was subchronic or chronic was made using the following guidelines:

- A chronic exposure in mammals is equivalent to at least 50 percent of a species' lifespan, based on technical support information for the Great Lakes Water Initiative Wildlife Criteria (EPA, 1995a, b; Sample et al., 1996). For example, exposures of 1 year or greater would be considered chronic exposures for studies on laboratory rodents (with life spans of about 2 years).
- Little information is available concerning the life spans of birds used in toxicity tests. Consistent with Sample et al. (1996), avian studies where the exposure duration was greater than 10 weeks are considered chronic studies.
- In addition to duration, the time when contaminant exposure occurs is critical. Reproduction and development periods (mating, gestation, and lactation) are particularly sensitive life stages because of the stressed condition of the adults and the rapid growth and differentiation occurring within the embryo (Sample et al., 1996). Because benchmarks are intended to evaluate the potential for adverse effects on wildlife populations consistent with SSFL assessment endpoints and consistent with Sample et al. (1996), exposures that occur during most of a species' reproduction and development period (critical life stage) are considered to represent chronic exposures.
- Sources of TRVs such as IRIS, HEAST, ATSDR, EFA West (1998, BTAG values), and Sample et al. (1996) occasionally apply different UFs than those used in the SRAM (MWH, 2005b) to adjust a study to what they label a "Chronic NOAEL." For IRIS, HEAST, and ATSDR, the details of the study were reviewed and the criteria in the first bullet above are used. If the details of the study are not presented or are not sufficiently complete to make a determination, then the interpretation made by the source document are used. In the case of EFA West (1998) and Sample et al. (1996), the final derived chronic NOAEL (or Low TRV) values will be used.

1.5.4.6 Risk Characterization

The risk characterization evaluates the evidence linking exposures to CPECs with their potential ecological effects on the representative species identified for Group 2. This evaluation is completed through the integration of information gathered in the problem formulation, the results of the analysis, and other lines of evidence. For the Group 2 ERAs, the evidence to be evaluated consisted of measured chemical concentrations in abiotic media (soil, sediment, surface water, and/or soil vapor, as appropriate), modeled concentrations in biota (food-chain uptake), exposure estimates for representative species, toxicity information obtained from the literature, and quantitative and/or qualitative risk evaluations. Three main components comprise the risk characterization: the risk estimation, risk description, and uncertainty analysis. These three components are used together to identify the final contaminants of ecological concern (COECs) and recommendations for Group 2.

Risk Characterization Process. A sequential process was used to integrate the three components of the risk characterization. The process includes the elements required by the SRAM (MWH, 2005b), as well as additional refinements that result in a more robust ERA and provide risk managers with more information for making risk management decisions for the site. The risk characterization process includes the risk estimation through the calculation of HQs and HIs, and the risk description and uncertainty analysis through the interpretation of HQs and HIs via WoE.

The risk characterization process for each medium is described below. The procedures for calculating HQs and HIs are described in the risk estimation subsection, the interpretation of results is presented in the risk description, and the description of uncertainties is presented in the uncertainty analysis subsection.

Soil. The generalized risk characterization process for soil is presented in Figure 1.5.4-3 and includes an evaluation of direct exposures for soil invertebrates and modeled dietary exposure risk estimates using two EPCs (CTE and RME) and two TRVs (Low TRV and High TRV). The process for the burrowing small mammal (the deer mouse) accounts for the potential for exposures during burrowing at greater depths than other wildlife, as shown in Figure 1.5.4-4. Calculations include HQs and HIs, which are described in Section 1.5.4.

For soil invertebrates the maximum detected concentration of a CPEC is compared to the LOAEL or High TRV for soil invertebrates (Figure 1.5.4-3). If the maximum detected concentration does not exceed the High TRV, that individual chemical can be concluded to present no unacceptable risk to soil invertebrates. If the maximum detected concentration exceeds the High TRV, sample locations that exceed are identified. When High TRV-based HQs exceed 1, those chemicals are retained for potential remedial decisions (hot spot removal) as part of the CMS. The decision to perform a CMS will depend on the number of chemicals that exceed High TRVs, clustering of samples with contaminants in excess of High TRVs, and the magnitude of High TRV exceedances.

Risks to terrestrial plants initially are evaluated qualitatively using field observations to determine if resident vegetation displays visible signs of impaired health. If the field observations suggest effects to resident plants, soil concentration data are evaluated using literature-derived effects' data in a manner comparable to that described above for soil invertebrates.

Birds and mammals experience multi-media exposure, which requires modeling of the dietary dose for comparison to TRVs. Dietary exposure (described in Sections 1.5.4.4 and 1.5.4.5) is estimated for all bird and mammal receptors based on both RME and CTE surface (0 to 2 ft) soil, sediment, and surface water concentrations (where available) (Figure 1.5.4-3). The process for evaluating the deer mouse is slightly different, as described below. Both the RME and CTE exposure estimates are compared to Low and High TRVs. HQs for each chemical and HIs for groups of like chemicals are calculated. The WoE will be used to identify chemical and chemical groups for potential remedial decisions in the CMS. The decision to perform a CMS will depend on the threshold (Low or High TRV) exceeded and magnitude of exceedance, the bioavailability of the chemical, and the availability and quality of habitat for the receptor at the site.

Because some small mammals burrow, they may experience exposure over depths ranging from the surface to 6 ft bgs. The general soil risk characterization process (Figure 1.5.4-3) was modified to accommodate the soil depth (Figure 1.5.4-4). To identify the soil depth range representing the greatest exposure, maximum detected soil concentrations in the 0- to 2, 0- to 4-, and 0- to 6-foot-depth ranges are compared to the small mammal ESLs. HIs over all chemicals are calculated for each depth range. The depth with the greatest total HI is selected for more detailed RME and CTE exposure modeling, which is conducted and evaluated as described above for other wildlife receptors.

Because inorganics are naturally occurring, they are expected to occur in soil samples from any given site. In an effort to determine the incremental risk associated with each inorganic (that is, the risk in excess of that attributable exclusively to background concentrations), background risks were calculated for inorganics that failed the screen for one or more receptors by dividing the background RME soil concentration by the TRV for the appropriate receptor. Background HQs were then subtracted from site HQs to determine the incremental risk HQ.

Soil Vapor. The process for evaluating the potential risk that soil vapor may present to small mammals is outlined in Figure 1.5.4-5. The maximum detected soil vapor concentration is compared to the mammalian inhalation ESL. If the maximum detected soil vapor concentration is less than the inhalation ESL, that individual chemical can be concluded to present no unacceptable risk to burrowing mammals. The maximum detected soil vapor concentration also is compared to the alternative NOAEL-based inhalation TRVs presented by Gallegos et al. (2007). Samples that exceed the inhalation ESL or alternate TRVs are identified. The WoE is used to identify chemicals for potential remedial decisions in the CMS. The decision to perform a CMS will depend on the number of chemicals that exceed the TRVs, the clustering of samples with contaminants in excess of Low or High TRVs, and the magnitude of exceedances.

Sediment. The screening process for sediment (Figure 1.5.4-6) is conceptually similar to that for soil invertebrates. The maximum detected concentrations of chemicals are compared to the sediment ESLs (which are equivalent to Low TRVs or TECs). Chemicals that fail this screen are carried forward and the maximum detected concentration is the compared to the High TRV (or PEC) for sediment. If the maximum detected concentration does not exceed the High TRV, that individual chemical can be concluded to present no unacceptable risk to benthic macroinvertebrates. If the maximum detected concentration exceeds the High TRV, the sample locations that exceed are identified. When High TRV-based HQs exceed 1, those chemicals are retained for potential remedial decisions (hot spot removal) as part of the CMS. The decision to perform a CMS will depend on the number of chemicals that exceed the High TRVs, the clustering of samples with contaminants in excess of the High TRVs, and the magnitude of the High TRV exceedances.

Surface Water. The screening process for surface water (Figure 1.5.4-7) is conceptually similar to that for sediment. The maximum detected concentrations of chemicals are compared to the Low TRVs (which in this case are chronic ambient water quality criteria [AWQCs]). If the maximum detected concentration does not exceed the Low TRV, that individual chemical can be concluded to present no unacceptable risk to aquatic organisms. If the maximum detected concentration exceeds the Low TRV, the sample locations that

exceed are identified. When the Low TRV-based HQs exceed 1, those chemicals are retained for potential remedial decisions (hot spot removal) as part of the CMS. The decision to perform a CMS will depend on the number of chemicals that exceed the High TRVs, the clustering of samples with contaminants in excess of the High TRVs, and the magnitude of the High TRV exceedances.

Risk Estimation. The risk estimation focuses primarily on quantitative methods to evaluate the potential for risk. The results of the quantitative risk estimation are presented as HQs and HIs.

HQs were developed for two types of comparisons using the indicated equations:

1. Direct comparisons of measured concentrations in soil, soil vapor, sediment, or surface water to the respective TRVs for each CPEC. These comparisons were conducted for soil invertebrates and terrestrial plants exposed to soil, burrowing mammals' exposure to soil vapor, benthic macroinvertebrates exposed to sediment, and aquatic plants and other aquatic organisms exposed to surface water, according to the following equation:

$$HQ = \left(\frac{EPC\ (mg/kg\ or\ mg/m^3\ or\ \mu g/L)}{TRV\ (mg/kg\ or\ mg/m^3\ or\ \mu g/L)} \right)$$

2. Comparisons of estimated total exposure dosages via the food-chain uptake model to effects dosage TRVs. These comparisons were conducted for birds and mammals exposed to soil or sediment, surface water, and food, according to the following equation:

$$HQ = \left(\frac{Exposure\ dosage\ (mg/kgbw/d)}{receptor-specific\ TRV\ (mg/kgbw/d)} \right)$$

HIs, calculated only for dietary exposures to birds and mammals, were developed for specific classes of chemicals assuming similar modes of action for chemicals within those classes. HIs were calculated for the following classes, when available:

- Dioxins and furans (and dioxin-like PCBs)
- PAHs
- Aroclors
- PCBs
- Phthalates
- Organochlorine Pesticides
- Organophosphorous Pesticides
- Volatile Organics
- TPHs

The HI was calculated as follows:

$$HI = \sum HQs\left(chemicals\ in\ class\right)$$

Risk estimates were derived from the combinations of EPCs and TRVs for each representative receptor, as described in Section 1.5.4.6. Chemicals or chemical classes with HQs or HIs greater than 1 were retained for further evaluation in the risk description; all other CPECs (HQs and HIs less than 1) were not considered to pose an unacceptable risk to ecological receptors and were removed from further consideration.

Risk Description. The risk description incorporates the results of the risk estimates, along with any other available and appropriate lines of evidence to evaluate potential chemical impacts on ecological receptors in Group 2. Chemicals that had HQs exceeding 1 were further evaluated to determine the COECs. Information considered in the determination of COECs includes receptor groups potentially affected, exceedance of Low and/or High TRVs, magnitude of exceedance, bioavailability, and habitat quality at the site.

To facilitate the interpretation of TRV exceedances, chemicals that exceeded one of the TRVs (ESL, Low TRV, or High TRV) were assigned into seven general risk groups (1 through 7, described below). These groups were created specifically for this report as an additional tool to assist risk managers in making remedial decisions. The groupings are subjective, based on professional judgment, and the placement of a chemical within a given group is not an absolute indicator of the potential risk:

1. High Risk–HQs>5 for High TRV (RME), or HQs>100 for any EPC/TRV combination. Chemical classes with HIs>10 at High TRV (RME). Four or more receptors showing estimated risks.
2. Medium-High Risk–2<HQs<5 for the High TRV (RME). Chemical classes with 2<HIs<10 at the High TRV (RME) or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.
3. Medium Risk–1<HQs<2 for High TRV (RME), but HQ>10 for Low TRV (RME). Chemical classes with 1<HIs<2 at the High TRV or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.
4. Medium-Low Risk–HQs<1 for the High TRV (RME), but 1<HQs<10 for the Low TRV (RME). Chemical classes with HIs<1 at the High TRV or 2<HIs<10 at the Low TRV. No more than two of six receptors showing estimated risks.
5. Low Risk–HQs<1 for the Low TRV (RME). Chemical classes with HIs<1 at the Low TRV.
6. No Risk–All HQs and associated HIs<1.
7. Uncertain–TRVs unavailable to calculate either HQs or HIs.

Uncertainty Analysis. Uncertainties are inherent in all aspects of an ERA. The nature and magnitude of uncertainties depend on the amount and quality of the data available, the degree of knowledge concerning site conditions, and the assumptions made to perform the risk assessment. A qualitative evaluation of the major uncertainties associated with ERAs for all RFI sites in Group 2 is outlined below. Uncertainties that are specific to any RFI site are presented in the each site-specific section, as appropriate.

Problem Formulation.

- Representative species were selected to reduce uncertainty and to focus on species that are both maximally exposed and representative of the wildlife using the site. However, differences among species, including physiology, reproductive biology, or foraging habits, can result in different exposures and sensitivities to different chemicals.

- No site-specific data regarding CPEC concentrations in wildlife foods at Group 2 sites were available for avian and mammalian exposure estimate calculations. Therefore, concentrations in food items were estimated using SSFL site-specific BAFs or literature-derived bioaccumulation models. The suitability of the literature-derived bioaccumulation models to conditions at the site is unknown. Therefore, concentrations of CPECs in biota present at the site and, consequently, the dietary exposures of birds and mammals, may be either higher or lower than values estimated in this ERA that were based on literature-derived bioaccumulation models.

Exposure Characterization.

- No avian and mammalian life history data specific to Group 2 were available; therefore, exposure parameters either were modeled according to allometric relationships (food ingestion rates) or data from the same species in other portions of its range. Because diet composition, including food, water, and soil, may not accurately reflect individuals present at the site, potential risks may either be overestimated or underestimated.

- Several exposure routes were considered minor and were not included in the exposure analysis. Although exposure via these other routes still contributes to the total risk to each receptor, potential risks could have been underestimated because these routes were not quantified.

- Dermal contact with soil, sediment, or surface water is considered to be a minor secondary route of exposure for birds and mammals. Dermal contact is of concern primarily for organic chemicals that are lipophilic (have an affinity for fats) and can cross the epidermis of the exposed organism. Although some CPECs are highly lipophilic (for example, dichlorodiphenyldichloroethane [DDE]) and can bioaccumulate, they are of greater concern in the food-chain pathway as opposed to direct contact.

Ecological Effects Characterization.

- Literature-derived toxicity data from laboratory studies were the only toxicity data used to evaluate risks to all receptor groups. Effects observed in laboratory species were assumed to be indicative of effects that would occur in wild species. The suitability of this assumption is unknown. Therefore, potential risks may either be overestimated or underestimated.

- Toxicity data were not available for all CPECs or media considered in this ERA. CPECs for which toxicity data were unavailable were not evaluated, or surrogate toxicity data were used. The potential risks may be overestimated or underestimated.

- Bioavailability of CPECs was assumed to be 100 percent. This is a conservative estimate and may overestimate risks to receptors at the site.

Risk Characterization.

- Potential ecological risks were quantified using the HQ approach. The magnitude of the HQ indicates the potential for ecological risk, but is not an exact estimation of risk. For example, the actual risk from a chemical with an HQ of 70 could be less than that for a chemical with an HQ of 20 because of uncertainties involved in estimating exposure, selection of effects criteria (TRVs), or other field conditions.

- Data necessary to estimate potential risks from all pathways for all chemicals in the food-chain uptake model were not always available. For these chemicals and/or areas, the food-chain uptake model was completed using the available data.

Conclusions and Recommendations. The overall ERA conclusions and recommendations specific to each RFI site in Group 2 are presented in each site-specific section. The conclusions will identify chemicals that present risks, the estimated magnitude of that risk, the receptors to which they present risk, and if possible, the sample locations (or other attributes) that drive risk. Chemicals that present no risks also will be identified. Recommendations for additional data collection and further evaluation or consideration of remediation (CMS) will be made depending on the nature and magnitude of the risk conclusions.

1.5.5 Deviations from SRAM

The SRAM (MWH, 2005b) provides the primary guidance for conducting and reporting HHRAs and ERAs at SSFL. Although all reasonable efforts have been made to perform risk evaluations in accordance with the SRAM, because of progress in the development of risk assessment methodologies and tools since the SRAM was prepared, and subsequent identification of areas where enhancements were appropriate, deviations from the SRAM-dictated approaches were necessary in some cases. Deviations from the SRAM for both the HHRAs and ERAs are summarized below.

1.5.5.1 Human Health Risk Assessment Deviations

As described in Section 1.5.3, the HHRA was performed following the guidelines in the SRAM (MWH, 2005b).

Because risk assessment science and regulatory policy change with time, provisions are included in the SRAM (MWH, 2005b) that allow the proposed approach to be modified to reflect scientific advancement or changes in regulatory guidance or policies. The deviations in risk assessment methods from those provided in the SRAM (MWH, 2005b) are listed below:

- This HHRA addresses residential exposure scenarios, in addition to adult and child recreational user and industrial worker scenarios. A more likely future use of SSFL is for recreational purposes, and recreationists are the most plausible future human receptors. However, in accordance with California Senate Bill 990, response actions at SSFL also should consider a hypothetical future agricultural residential land use. This is a deviation from the SRAM (MWH, 2005b). The exposure scenarios listed in the SRAM are current site workers and trespassers, as well as future onsite residents and visitors. This agricultural residential scenario will include the consumption of beef, eggs, milk, swine, fruits, and vegetables. However, pending final agreement of the input

assumptions considered in the scenario, the assessment of the subsistence agricultural exposure scenario will be included in a supplemental risk assessment report separate from this RFI Report.

- The toxicity criteria used to assess dioxin and coplanar PCB congeners were the 2005 WHO TEFs published by Van den Berg et al. (2006), as opposed to the WHO TEFs published by Van den Berg et al. (1998), as stated in the SRAM (MWH, 2005b). In addition, the chemical-specific toxicity criteria that were used in the HHRA have been updated since their inclusion in the SRAM.

1.5.5.2 Ecological Risk Assessment Deviations

Deviations from the SRAM (MWH, 2005b) guidance for performing ERAs are summarized below:

- The TRVs for benthic macroinvertebrates exposed to sediment were obtained primarily from sources listed in the SRAM (MWH, 2005b), but values selected from those sources reflected the consensus-based values (McDonald et al., 2000) as opposed to strictly the lowest values. In addition, marine values were used only when freshwater values were not available, as opposed to the use of either marine or freshwater (depending on which was lower) in the SRAM (MWH, 2005b).
- ESLs–Several opportunities to enhance the process used to develop the ESLs reported in the SRAM (MWH, 2005b) were found. Several discussions were held between MWH and CH2M HILL to address the underlying interpretive issues, as well as to review the ESLs for chemicals that were identified as risk drivers. Items that were agreed to between MWH and CH2M HILL include the following:
  - Establishing the criteria for the interpretation of mammalian and avian toxicity studies as required for correct application of UFs
  - Hierarchy for the selection of ESLs for sediment and surface water
  - Review and/or correction of mammalian soil ESLs (approximately 100 chemicals), bird ESLs (4 chemicals), soil invertebrate ESLs (7 chemicals), surface water ESLs (approximately 38 chemicals), and sediment (approximately 37 chemicals). Corrected mammalian ESLs and toxicity values are summarized in Table 1.5.5-1.
- Selection process for CPECs. The selection criteria were generally as outlined in the SRAM (MWH, 2005b); however, some deviations were made, as noted below:
  - Chemical is present in excess of the concentrations observed in laboratory field blanks. This step was completed as part of the data evaluation and reduction steps completed for all aspects of the RFI.
  - Chemical historically was used at the site. This step was not followed, because it is too subjective. All chemicals meeting the other criteria were retained for risk assessment regardless of the potential historical use.
- Site-specific BAFs were developed in the SRAM (MWH, 2005b) for many chemicals and were used if available (with the exception of perchlorate). If a site-specific BAF was not available, other literature-reported values or regression models were used. If literature

values or reliable models were not available for a given chemical, then a conservative default bioaccumulation value of 1 was used. Perchlorate was discussed with MWH and DTSC and a revised BAF for plants was proposed and accepted.

- Selection of TRVs. The SRAM (MWH, 2005b) uses only one set of TRVs to evaluate potential risks (Low TRVs). Three levels (ESLs, Low TRVs, and High TRVs) were used in preparing this RFI Report to provide a risk range for the WoE regarding COECs.
- Use of allometric scaling. The SRAM specifies using allometric scaling when receptor and test animal body weight differs by more than 100 times. Per recent discussions with DTSC and MWH, it is recognized that allometric scaling is no longer in favor with DTSC because it is not scientifically supported. Allometric scaling of toxicity data, therefore, has been removed from all analyses.
- EPCs. The SRAM (MWH, 2005b) uses the CTE and an RME (which is the 95% UCL) for estimating risk. This risk assessment uses the maximum concentration, in addition to the CTE and RME. This approach assists in the WoE for COECs.
- Determination of the RME exposure level. The SRAM (MWH, 2005b) forces the RME to be a 95% UCL even when ProUCL recommends a different value, which can be a 97% UCL or even a 99% UCL. This risk assessment proposes to use the recommended ProUCL output for the RME (unless the UCL exceeds the maximum detected value, in which case a default occurs to the maximum detected value). Unlike the SRAM, it is proposed that this risk assessment follow EPA's recommendations, which sometimes result in a 97.5% or 99% Chebyshev UCL when sample size, variability, and skewness suggest unusually high uncertainty. These elevated-confidence UCLs are not offered in an attempt to alter the overall confidence that the true mean falls below the calculated UCL (95%), but to recognize the results of EPA's Monte Carlo studies, which indicate that under such conditions a 95% Chebyshev UCL tends not to offer sufficient coverage of the true mean. Thus, these special Chebyshev UCLs remain attempts to offer the best 95% UCL despite the nomenclature describing higher confidence (97.5% or 99%).
- Risk characterization processes. The risk estimation processes include the basic comparisons specified in the SRAM (MWH, 2005b), but also include the additional calculations using more TRVs and EPCs.
- HIs. The SRAM (MWH, 2005b) specified that certain HIs be developed for specific classes of chemicals assuming similar modes of action for chemicals within those classes. HIs were calculated for these, as well as some additional classes (as requested by DTSC), as follows:
  - Dioxins and furans (and dioxin-like PCBs)–specified in the SRAM (MWH, 2005b)
  - PAHs–specified in the SRAM
  - Aroclors–specified in the SRAM
  - PCBs–specified in the SRAM
  - Phthalates-additional
  - Organochlorine pesticides-additional

- Organophosphorous pesticides-additional
- Volatile organics-additional
- TPHs–specified in the SRAM

1.6 Fate and Transport Evaluation Approach Overview for Group 2

This subsection examines the contamination migration potentials through an environmental contaminant fate and transport evaluation. The site physical characteristics, source characteristics, and extent of contamination are combined to form the basis of the contaminant fate and transport.

1.6.1 CSM: Contaminant Sources, Release Mechanisms, and Migration Pathways

The various CSMs of the contaminant sources, release mechanisms, and migration pathways are shown in Sections 2 through 6 for each site. Waste on the surface or buried in the ground may contaminate surface and subsurface soil. Runoff and erosion may move contaminants to surface water and sediment. Contaminants buried in subsurface soil may leach to groundwater. For areas that have high levels of VOCs, air is also a medium of interest for exposure evaluations.

1.6.2 Potential Routes of Migration

The primary mechanism for contaminant transport from the source areas at a site is evaluated in this subsection. Typically, the migration pathways are likely to be surface runoff, particularly when a site is located on an incline. Other media affected by surface runoff include the sediments and surface water if a surface water body is present in the vicinity. Other potential migration pathways include contaminants in soil and buried waste materials and contaminated surface water migrating vertically downward, which may leach through the vadose zone and be transported into the groundwater system. Surface soil also may be released to the air by wind erosion.

Another potential contaminant pathway is the migration of contaminants from surface soil into the subsurface. Infiltration of rainfall may leach some contaminants into subsurface soil and subsequently into the groundwater system.

1.6.3 Contaminant Persistence

The mobility and persistence of the potential contaminants at the site are determined by their physical, chemical, and biological interaction with the environment. Mobility is the potential for a chemical to migrate from a site, and persistence is a measure of how long a chemical will remain in the environment.

Various basic physical and chemical properties affect the transport of chemicals in the environment at the site. The fate and transport evaluation of the COCs that are identified for each site will be conducted using their respective physical and chemical properties to assess the most probable fate at the individual sites. In general, chemicals that are soluble, volatile, or leachable tend to be mobile. Mobile chemicals are likely to be released and transported from the source and are not persistent, whereas persistent chemicals tend to

remain localized in the source area (SA) and are resistant to chemical and biological degradation reactions. The following are considered to be the most important properties:

- Sorption
- Volatilization
- Degradation
- Transformation
- Bioaccumulation

Sorption is the tendency for chemicals to adsorb to and desorb from materials in the media through which the contaminants are being transported. The subsurface materials likely to sorb chemicals typically are clays and organic material. In addition, inorganic chemicals adsorb onto iron, manganese, and aluminum oxyhydroxide or oxide coatings on soil and sediment grains. The conventional measure of sorption for a chemical is the soil-water distribution coefficient (K_d). The K_d for organic chemicals is the product of a partition coefficient (K_{oc}) and the fraction of organic carbon (f_{oc}). In general, chemicals with a K_{oc} greater than 10,000 milliliters per gram (mL/g) (which includes many SVOCs) have high degrees of adsorption and consequentially low mobility, whereas chemicals with a K_{oc} lower than 1,000 mL/g (which includes many VOCs) have lower degrees of adsorption and consequentially higher mobility.

Volatilization is the tendency for some chemicals, particularly VOCs, to change from a liquid or adsorbed state to a gas. A conventional measure of volatility is Henry's Law Constant (H). Compounds with H values higher than 10^{-3} atmosphere-cubic-meter per mole (atm-m^3/M) are expected to volatilize readily from water to air, whereas those with H values lower than 10^{-5} atm-m^3/M are relatively non-volatile. Most inorganic chemicals are not volatile under normal temperature and pressure conditions.

Degradation is the transformation of one chemical to another by such processes as hydrolysis, photolysis, and biodegradation. Hydrolysis is the reaction of a chemical with water and photolysis is the result of exposing the chemical to light. Degradation commonly is expressed as a half-life that composites the degradation by whatever processes may be operating.

Transformation occurs when metals are increased or reduced in a valence state by oxidation or reduction, respectively. Transformation may have a significant effect on the mobility of a metal, either increasing or decreasing it. Transformation can be caused by oxidation-reduction potential (ORP) and pH changes and by microbial or non-microbial (abiotic) processes.

Bioaccumulation is the extent to which a chemical will partition from water into the lipophilic parts (fat) of an organism. Bioaccumulation commonly is estimated by the octanol-water partition coefficient (K_{ow}). Chemicals with high values of K_{ow} tend to avoid the aqueous phase and to remain in soil longer or bioaccumulate in the lipid tissue of exposed organisms. The accumulation of a chemical in the tissue of the organism can be quantified by a bioconcentration factor (BCF), which is the ratio of the concentration of the chemical in the tissue to the concentration in the water. BCFs are both contaminant-specific and species-specific. Inorganic chemicals and SVOCs tend to have higher K_{ow} values, so they bioaccumulate more extensively than VOCs.

1.7 Data Quality Evaluation Summary

Analytical data from the SSFL RFI sampling for Group 2 were assessed in accordance with the procedures and specifications contained in the *Surficial Media Operable Unit Quality Assurance Project Plan (RFI QAPP)* (MEC^{x}, June 2008). This subsection and Table 1.7-1 briefly summarize the overall results and quality of the data used in the evaluation and risk assessments for the Group 2 site (Sections 2 through 6). Data flags were assigned according to the QC acceptance limits defined in the QAPP, as follows:

- J = Analyte concentration was considered an estimated value because one or more QC specifications were not met, or concentration was greater than the method detection limit (MDL) but less than the project quantitation limit (low-level detects).
- R = Rejected result; identification and/or quantitation could not be verified because critical QC specifications were not met.
- U = Analyte was not detected.
- UJ = Analyte was not detected. The SQL was estimated.

Overall, the data collected from Group 2 during this investigation were of acceptable quality. Out of approximately 29,740 reported results, 566 data points were qualified as not detected because of low-level blank contamination (1.9 percent), 937 data points were qualified as estimated concentrations due to QC exceedances (3.2 percent), and 1,263 data points were qualified as estimated concentrations because of low-level detects (4.2 percent). There were 36 data points rejected for poor correlation between total and dissolved metal results (0.1 percent), 13 data points rejected due to low MS/MSD recovery (0.04 percent), 9 data points rejected due to low blank spike recovery (0.03 percent), and 1 data point rejected due to low surrogate recovery (less than 0.01 percent). The overall data were 99.8 percent complete, and with the exception of the rejected results, the data can be used in the project decision-making process as qualified.

2. Liquid Oxygen (LOX) Plant

On the basis of the historical sampling and the 2008 RFI investigation, additional sampling is warranted to further evaluate the extent of contamination in the subsurface to support risk assessment decisions. One metal (silver), 2 SVOCs (benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene), one TPH (total recoverable petroleum hydrocarbon [TRPH]), and one VOC (TCE) require additional sampling in the subsurface soil to complete a vertical extent assessment for the LOX Plant.

Of the soil analytes that were evaluated, no analytes were found to pose a high risk to the ecological receptors evaluated at the LOX Plant. Barium was found to pose a medium risk to birds and mammals, so additional characterization is recommended. Of the remaining soil analytes, 30 posed no risk and 28 lacked TRVs. Ten analytes in soil vapor were considered to pose inhalation risks to burrowing mammals and are recommended for further evaluation, based on the elevated concentrations detected in the shallow soil vapor.

Potentially significant human health risks were identified for three COCs in soil–benzidine, benzo(a)pyrene (BaP), and arsenic–along with a number of VOCs (in soil vapor) and PAHs (in surface soil). Human health risk estimates from arsenic, BaP, PAHs, and VOCs generally were driven by a localized area with elevated concentrations. However, it is recommended that the nature and extent of benzidine, and to a limited extent, PAHs, be confirmed, based on the detection limits above the risk levels of concern and the fact that benzidine was not analyzed in many samples. After confirmation of the extent of contamination, the removal of soils with elevated concentrations is recommended at this location to reduce human health risks.

2.1 LOX Site Background and History

The LOX Plant was located on 42 acres in the northern part of Area I at SSFL. LOX was produced using a cryogenic process in which air is liquefied and the oxygen is separated from the nitrogen (ICF, 1993). The LOX Plant buildings and tanks were removed in the early 1970s.

2.1.1 SWMUs and AOCs

The LOX Plant area contains two SWMUs. The LOX Plant Waste Oil Sump and Clarifier has been designated as SWMU 4.5 and the LOX Asbestos and Drum Disposal Site has been designated as SWMU 4.6.

2.1.2 Site History

The LOX Plant was deeded to the USAF in 1958 by NAA. The LOX Plant was operated from the 1950s through the 1960s by Air Products and Chemicals, Inc., for the USAF (TechLaw, 1990). LOX was produced using a cryogenic process in which air is liquefied and the oxygen is separated from the nitrogen (ICF, 1993). The 42-acre property, which currently is owned by NASA, had been known as Air Force Plant #64 under USAF

ownership (TechLaw, 1990). The LOX Plant buildings and tanks were removed by Rockwell in the early 1970s. NASA acquired ownership of the LOX Plant area in 1976.

A former waste oil sump and clarifier (SWMU 4.5) were located north of the driveway leading to the LOX Plant. A suspected leach pit was identified while the sump and clarifier were being excavated during the LOX Plant removal. Boeing personnel described the leach pit as being constructed of brick. As part of an accelerated cleanup program in 1993, the sump, clarifier, and leach pit were excavated and removed. The plant's concrete foundations were removed in 1996. None of the primary buildings remain at the former LOX Plant location.

A former asbestos and drum SWMU (SWMU 4.6) is located on a hillside to the west of the former LOX Plant, where ACMs were placed following the LOX Plant site demolition activities. Asbestos and soil were removed from a 54,000-square-foot (ft^2) area of the hillside for offsite disposal during the late 1980s. Approximately 12 to 14 empty, rusted drums were found in this area before the removal effort and also were removed from the site (MWH, 2005d).

Additional asbestos abatement was conducted in 2007, during which debris, including ACM, was removed from an ephemeral drainage east of the former LOX Plant, along the Northern Drainage (Zenco, 2007).

A geotechnical investigation was conducted in 2008 for the conceptual design of the proposed Engineered Natural Treatment System (ENTS) to improve the drainage areas (Boeing, 2008).

A truck scale and affiliated controls building are the only remaining structures at the LOX Plant. The truck scale was refurbished for use by Rockwell in 1992 (Rockwell, 1992).

2.1.2.1 Site Inventories

A site inventory of the buildings, tanks, transformers, and chemicals used at the former LOX Plant was completed during the preparation of this RFI report. This information was obtained from historical document reviews, facility drawings, and visual site inspections (VSIs). These features are shown in Figure 2.1-1, as applicable. Chemical use inventories for features where information was available are included in Table 2.1-1.

Inventories for these features are not included in this RFI for the LOX Plant, because the buildings, tanks, and transformers are no longer present.

2.1.3 Site Chemical Use Areas

The LOX process reportedly did not require the use of solvents, although it remains unclear whether Freon was used as a refrigerant (TechLaw, 1990). Small quantities of solvents reportedly were used at the site for equipment cleaning (SAIC, 1994).

The former sump and clarifier were used for the disposal of liquid wastes containing solvents, fuel, waste oil, and wastewater containing oil from the LOX Plant operations. There were no reported releases from this SWMU, but soil staining around the sump and clarifier was observed during the RFA (SAIC, 1994).

Asbestos and rusted drums were removed from the hillside west of the LOX Plant, and ACM was removed from the drainage area east of the LOX Plant (MWH, 2005d; Zenco, 2007).

2.1.4 Site Conditions

The only structure that remains at the LOX Plant area is a full-size truck scale and the small structure that houses the scale controls. The area was graded after the foundations and aboveground concrete supports were removed in 1996, and the site has been re-graded to conform to natural topography (MWH, 2005d).

2.1.5 Site Habitats/Land Cover

The former LOX Plant area is primarily a ruderal habitat with chaparral, coast live oak woodland, mulefat scrub, and developed area with venturan coastal sage scrub in the western and northern portions of the site. There is additional ruderal habitat to the south ,east, and west of the LOX Plant. Chaparral can be found on all sides of the LOX Plant, and coast live oak woodland is found to the west and south of the site. Developed area with venturan coastal sage scrub is on the northern and southern sides of the former plant, and mulefat scrub can be found to the north. Developed area with chaparral is to the east, and non-native grassland is to the north. A seasonal stream runs near the southern and eastern borders of the site. Mule deer and bobcat habitat runs along the southern portion of the site, south of the former LOX Plant (Figure 2.1-2).

2.1.6 Historical Document Reviews

As described in Section 1.5.1, a historical document review was completed of documents applicable to the RFI Group 2. As a result of this historical document review, two new potential features at the former LOX Plant were identified–a leach pit associated with the sump and clarifier (SWMU 4.5) and a septic leach field located on the western side of where the former LOX Plant was located. Exactly where this septic leach field was located is not known. However, it was in an area where extensive soil and soil vapor investigations already have been completed, which would have identified any contamination that might have been associated with the septic leach field.

2.2 RFI Characterization Activities

This subsection describes the sampling objectives, sampling scope, and key decision points associated with defining the nature and extent of chemical effects for the surface soil, subsurface soil, and groundwater at the LOX Plant.

2.2.1 Sampling Objectives

To characterize the extent of potential chemical effects at the LOX Plant, soil and groundwater samples were collected. The objectives of the investigation were as follows:

- Define the lateral and vertical extent of chemical impacts.
- Define the potential gradients of chemicals.
- Develop a sufficient data set for performing a risk assessment.

These objectives contributed to the selection of sampling locations, analytical methods, and depths, while incorporating site-specific information such as the following:

- Site conditions observed at the location of proposed sampling
- Historical sampling results and/or previous remediation activities
- Fate and transport characteristics of chemicals
- SSFL background concentrations of chemicals
- SSFL SRAM-based screening concentrations for human health and ecological receptors

2.2.2 Sampling Scope

Provided in this report are all of the characterization results for soil matrix, soil vapor, and groundwater investigations. The total numbers of historical and 2008 RFI samples collected as part of this report for soil matrix, soil vapor, and groundwater are summarized below.

- Soil matrix: 251 samples
- Soil vapor: 262 samples
- Groundwater: 1 sample

These samples were collected between 1993 and 2008 to identify the potential chemical impacts associated with the activities at the LOX Plant. These sample result are described further in Section 2.4.

Note that four wells installed in the LOX Plant area were not sampled because of the seasonally dry conditions. Sampling will be completed during the next wet season.

2.2.3 Key Decision Points

The site-specific decision points identified for the LOX Plant represent the assumptions and/or decisions made during the sampling phase component of this RFI, as follows:

- For historical sample points where the sample depth had not been recorded, it was assumed that these sample points were taken between the 0- to 2-foot-bgs range.

2.3 RFI Characterization Results

The characterization results from previous soil matrix, soil vapor, and groundwater investigations at the LOX Plant are summarized below.

2.3.1 Soil Matrix and Soil Vapor Findings

In 1992, sludge samples from the sump and clarifier were collected during two events and analyzed for VOCs, oil and grease, TPH, PCBs, and metals. The analytical results included low concentrations of VOCs, including TCE (3.1 micrograms per liter [µg/L]); ethylbenzene (310 µg/L); total xylenes (180 µg/L); a relatively high concentration of TPH (9,000 mg/L); and low levels of oil and grease (maximum concentration of 14 mg/L). PCBs were not detected. Copper and lead were detected at concentrations of 330 mg/L and 280 mg/L, respectively (Ogden, 1996c).

As part of an accelerated cleanup program in 1993, the sump and clarifier were excavated and removed (MWH, 2005d). As noted previously, a suspected leach pit was identified

during the sump and clarifier removal. Boeing personnel described the leach pit as being constructed of brick. This leach pit also was removed, along with the sump and clarifier. Sludge and soil samples were collected during the removal action. The sludge was analyzed for SVOCs and TRPHs. The analytical results indicate that TRPH was detected at a maximum concentration of 1, 600 mg/kg. Several phenols were detected in the sludge collected from the sump; a maximum concentration of 83 mg/kg of 2,4-dimethylphenol was reported (Ogden, 1996c).

Nature and extent characterization soil sampling at this site was intensive during 2001 and 2006 through 2008. Some soil sampling was conducted before these years, dating back to 1993, but it primarily was tied with previous cleanup and removal activities. Each additional sampling effort was in response to comments from the DTSC requesting additional extent information. From 2001 to 2003, nine RFI reports were submitted to DTSC for review outlining sampling efforts deemed sufficient to evaluate risk and to support site action recommendations.

Investigations into soil vapor present in the soil at the LOX Plant began in 1993. Intensive investigative work to characterize soil vapors was conducted in 2001, 2003, and 2005 through 2008, primarily to address DTSC-requested additional sampling requirements. A grid of sampling stations was defined across the area, with an emphasis being centralized from the northwest tank farm to a northwesterly direction. Samples were analyzed for VOCs; the nature and extent of the potential soil gas contamination is detailed in Section 2.4.

2.3.2 Groundwater Findings

2.3.2.1 Background

The former LOX Plant and Former Asbestos and Drum Area, SWMUs 4.5 and 4.6, make up an approximately 2–acre area located in the northern portion of Area I. The elevation varies from approximately 1,720 ft above msl to 1,760 ft msl.

NSGW conditions initially were investigated through the installation of two piezometers (PZ-062 and PZ-095) installed on January 3, 2001, and February 14, 2001, respectively. The piezometers were installed in weathered sandstone and siltstone of the Chatsworth formation. Since their installation, these piezometers have been dry. Chatsworth wells also have been installed, including RD-52A, RD-52B, RD-52C, RD-69, and RD-80. Wells RD-81 and WS-12, although associated with the Area II Landfill, have been included to provide additional information regarding the geologic and hydrogeologic characteristics of the area.

As part of this RFI, five piezometers (PZ-128, PZ-129, PZ-130, PZ-131, and PZ-132) were installed at the LOX Plant. The piezometers were installed near the base of the weathered bedrock interval to characterize groundwater occurrence and water quality in the surficial media operable unit (SMOU). A well construction data summary of the newly installed piezometers and existing wells is provided in Table 2.3.2-1. Construction logs and boring logs for the newly installed piezometers are provided in Appendix B. All well locations are shown in Figure 2.3.2-1. One location, CB-2, was advanced to a depth of 45 ft bgs; however, this location subsequently was abandoned, with no piezometers being installed after unweathered bedrock was encountered approximately 4 ft bgs. Well and piezometer locations are shown in Figure 2.3.2-1.

2.3.2.2 Local Geology

The LOX Plant area is underlain by deposits of the Shale 2–Sage Member of the Upper Chatsworth formation (KUCS)-2 unit and the Silvernale member of the Chatsworth formation (Figure 1.2.3.1-2). The Shale 2–KUCS-2 unit is a prominent stratigraphic marker that separates the older, underlying Sandstone 1 unit from the Sandstone 2 unit, occurs across the central section of SSFL, and strikes northeast to the southwest and dips to the northwest. The Shale 2–KUCS-2 consists of thin bedded shale, siltstone, and sandstone. The Silvernale member consists primarily of medium-grained sandstone with minor siltstone units.

A prominent structural feature in the LOX Plant area is the north fault that transects the LOX area east to west. Detailed mapping conducted by GeoSyntec (2008) has identified two traces associated with the north fault that cut through the LOX Plant area. The north fault primary strand transects the LOX Plant area through the central section of the site. A secondary shear zone associated with the north fault has been mapped approximately 120 ft to 150 ft south of the primary strand of the north fault. Dip measurements on the north fault indicate a south-southwest dip at 60 degrees. The dip on the north fault secondary shear zone has been measured at 80 degrees to the south-southwest. The planes of the north fault and the shear zone possibly change angle with depth (becoming less inclined), based on observations of the physical character of Chatsworth formation rock observed in groundwater monitoring well RD-80, located to the south of the LOX Plant and the secondary shear zone. Figures 2.3.2-2, 2.3.2-3, 2.3.2-4, and 2.3.2-5 are geologic and hydrogeologic profiles across the LOX Plant area.

During rock-coring activities at PZ-128, PZ-129, PZ-130, PZ-131, and PZ-132, materials encountered include fill and alluvium, weathered bedrock, and fresh, unweathered bedrock of the Chatsworth formation. Alluvial material consisted of dark brown to yellowish-brown sandy silt with some organic matter. Alluvial materials ranged in thickness from approximately 1 foot at most locations to 20 ft at PZ-132. Approximately 0.5 ft to 2 ft of fill material was encountered at PZ-128, PZ-130, and PZ-132, consisting of dark to yellowish-brown sandy silt with organics to light brown silty sand.

Weathered bedrock, largely characterized by decomposed and oxidized rock, was encountered at all locations and ranged in color from various hues of brown to yellow and gray, and in texture from fine- to medium-grained sandstone with some siltstone. Weathering graded in degree from light to heavy; rock quality designations were generally low (as compared with fresh bedrock) and the rock was typically weak. The thickness of the weathered sandstone varied from 5.5 ft at CB-2 to approximately 26 ft at PZ-129.

Fresh bedrock ranged in color from various shades of gray and brown and texturally from fine to medium grained. Some siltstone also was encountered. Core samples of fresh bedrock typically were described as strong rock, with fractures (both healed and open, and some clay-lined), and usually with high rock quality designations (RQDs). The depth to fresh bedrock ranged from approximately 6 ft at CB-2 to 45 ft at PZ-132.

The configuration of the unweathered bedrock surface is an important component of the NSGW system hydrogeologic setting. A depression or trough present on this surface may be related to a damage zone near a fault or an area of high fracture density, resulting in localized areas or zones that exhibit relatively high transmissivity and fracture connection

compared to surrounding rock in a groundwater system. Within this framework, erosion may develop topographic lows that dictate surface water drainage and deposition of alluvium. This geologic setting could form areas where recharge probably is greater than for the surrounding terrain, creating conditions, in turn, that facilitate NSGW occurrence. In summary, low bedrock surface trends form geologic discontinuities that may be preferential pathways that dictate the occurrence of NSGW in the SMOU.

2.3.2.3 Local Hydrogeologic Setting

NSGW at the LOX Plant area probably is not present during the dry months. Only one water-level measurement to date was obtained at PZ-131 on July 16, 2008, below the weathered bedrock interval. The water detected in PZ-131 may have been residual development water or condensate and will require re-measurement in future planned sampling events for confirmation. Residual or condensate water at the bottom of many shallow wells in Area I has been reported to the DTSC in the past (The Boeing Company, Rocketdyne Propulsion and Power, 2002).

Previously installed piezometers (PZ-062 and PZ-095) historically have been dry. The newly installed piezometers (PZ-128, PZ-129, PZ-130, and PZ-132) were dry during a sampling event in July 2008. The depth to NSGW at PZ-131 on July 16, 2008, was approximately 29 ft bgs. Additional water level measurements will be taken over the course of several seasons to determine the nature of NSGW occurrence at the LOX Plant.

Figure 2.3.2-2 illustrates the geologic and hydrogeologic setting at the LOX Plant. The presence of the North Fault and its splay fault may compartmentalize the groundwater system in both the SMOU and CFOU. The water level offset shown in the CFOU provides a line of evidence suggesting that there is no hydraulic connection across the fault and a low hydraulic conductivity associated with the fault itself.

As shown in Figure 2.3.2-3, the possible occurrence of groundwater in PZ-131 is offset compared to the water level shown in RD-52C. PZ-131 is located in a fault block bounded by the north fault shear zone to the south and the primary strand of the north fault to the north. PZ-130, located to the east of PZ-131, is thought to be located to the south of the north fault shear zone because no NSGW was measured at PZ-130, which is screened topographically lower in elevation than PZ-131. Figure 2.3.2-4 confirms no occurrence of NSGW and the offset of water levels across fault blocks suggests that structural, and perhaps stratigraphic, controls influence the distribution of NSGW at the LOX Plant; however, additional water level soundings during the wet season are necessary before such a conclusion can be definitive.

Figure 2.3.2-6 shows that PZ-132 is located in a depression on the unweathered Chatsworth formation surface. On the basis of this geologic setting and the historical water levels measured in RD-69, NSGW is most likely to occur during the wet season. Because this location corresponds to the solvent release area, further characterization is warranted in this area to confirm site conditions in a possible source area.

2.3.2.4 Characterization Results

Because PZ-062 and PZ-095 have been dry since their installation in 2001, there have been no prior NSGW characterization results. New piezometers have been installed and

sampling has been conducted to evaluate whether NSGW is present within the weathered sandstones of the Chatsworth formation. Except for PZ-131, which contained less than 0.2 foot of water, all other newly installed piezometers were dry during a sampling event conducted in July 2008. Section 2.4 summarizes the July 2008 sampling event at the LOX Plant. Additional sampling events are planned to ascertain the effect of seasonal variations in precipitation on NSGW occurrence. The results of future sampling events will be provided as an addendum to this RFI report.

2.3.2.5 Chatsworth Formation Groundwater

VOCs, which resulted from historical operations at the site, have affected the Chatsworth formation groundwater at the LOX Plant. An overview of the most frequently detected VOCs in the Chatsworth formation groundwater is provided herein to relate possible NSGW impacts (based on an assumption that NSGW will be present in piezometers for sampling in future events) with those in the Chatsworth formation groundwater.

Figure 2.3.2-7 presents the concentration trends of the most commonly detected halogenated ethene and ethane concentrations over time in groundwater samples collected from Chatsworth formation groundwater monitoring wells. The highest concentrations historically have been detected in groundwater samples collected from RD-52A. Groundwater samples from monitoring wells RD-52B and RD-52C, which are open hole completions that monitor deeper groundwater conditions in the Chatsworth formation than RD-52A, have had typically lower concentration of similar compounds. Detections of VOCs in RD-52C, RD-69, and RD-80 have been rare.

2.3.3 Surface Water Findings

Surface water features at the LOX Plant consist of a single small ephemeral drainage ditch located to the south of the LOX Plant. Flow in this drainage is directed westward and exits the operational boundary of SSFL north of the ELV area. NPDES monitoring of surface water discharge is conducted at this point.

Surface water samples were not collected during this RFI investigation because of seasonal dry conditions.

2.3.4 Completeness of Characterization

As described in Section 2.3.1, areas of known exceedances, areas downgradient from the former LOX Plant, and locations in the ephemeral stream located to the south were investigated using soil and soil vapor samples. The predominantly detected contaminants from previous investigations at the former LOX Plant were metals, PCBs, VOCs, and TPHs.

Although there is only limited information available regarding the types of chemicals that would have been used at this facility, the detections that were identified probably are attributable to the former activities at the LOX Plant. Presumably, there were would have been oils, lubricants, solvents, and cleaners used at the facility, as well as transformers to support the large machinery associated with the LOX Plant production process.

Detections of SVOC (BaP) in the ephemeral stream south of the former LOX Plant may be attributable to activities upstream. It has been reported that clay target debris from a former

Rocketdyne employee shooting range located on the Sage Ranch property have been carried downstream toward the LOX Plant.

2.3.4.1 Near-surface Groundwater Characterization

The possible occurrence of NSGW at the SSFL, including the LOX Plant, is ephemeral and believed to be related to seasonal variations in precipitation. Newly installed piezometers (PZ-128, PZ-129, PZ-130, PZ-131, and PZ-132) have been sounded for the presence of groundwater, and groundwater was sampled in PZ-131. Except for PZ-131, all newly installed piezometers were dry, along with previously existing piezometers PZ-062 and PZ-095. Additional synoptic gauging of piezometers for the occurrence of NSGW and sampling of NSGW, when present, is planned across several seasons to include late-winter and early-spring events when precipitation is anticipated to increase.

2.3.4.2 Surface Water

NPDES monitoring of surface water discharges at the designated point north of the ELV area will continue. Drainages that exist at the LOX Plant are directed to this point.

2.4 Former LOX Plant Nature and Extent

Surface and subsurface soil samples were collected at the former LOX Plant, per the protocol described in Section 2.2 and the data provided in Appendix B. Figure 2.4-1 shows the historical sample locations and the most recent soil samples collected as part of this RFI investigation. Table 2.4-1 lists the parameters analyzed for in the sample media at the former LOX Plant. The nature and extent of contamination that exceeded the comparison criteria values in the media sampled are described below.

2.4.1 Surface Soil Nature and Extent

To evaluate the nature and extent of potential contaminants in the Former LOX Plant Area, 114 surface soil samples were collected at this site and analyzed for 1 or more of the following: dioxins, 1,2-diphenylhydrazine, target analyte list (TAL) metals (including hexavalent chromium), PCBs (aroclors and congeners), SVOCs, TPHs, and VOCs. Table 2.4-2 lists the parameters detected in the surface soil samples at the Former LOX Plant Area. A historical investigation revealed an effort to remove an unknown quantity of ACM, soil, and empty, rusted drums from a 54,000-ft^2 area of the nearby hillside for offsite disposal during the late 1980s, which may have relieved the area of a potential source of surface soil contamination.

The compound 1,2-diphenylhydrazine, analyzed for in eight surface soil samples located at the sampling test pits, was not detected at this site.

2.4.1.1 Parameters above Comparison Criteria

The nature and horizontal extent of the parameters encountered at concentrations exceeding their respective comparison criteria are detailed below.

Dioxins. Eight surface soil samples were analyzed for dioxins at this site, including both CDDs and CDFs. Five of those samples reported a combined 15 dioxin parameters at

concentrations exceeding their respective human health comparison criteria. The current approach to assessing the toxicity of these mixtures is to use information about the toxic potency of the different congeners to convert the congener concentrations to a toxicologically equivalent concentration of the most potent congener, 2,3,7,8-TCDD. The 2,3,7,8-TCDD toxicity equivalents (TEQs) also were reported by the laboratory for the LOX Plant surface soil dioxin samples, if there was an exceedance of individual congener. The samples were evaluated for nature and extent by comparing the frequency of the different CDDs and the CDFs that exceeded the screening criteria at each location. The CDD and CDF exceedances were added together according to the chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-) and the 2,3,7,8-TCDD TEQ values were compared to the ecological screening criteria (0.0043 µg/kg) and the more conservative human health screening criteria (0.0013 µg/kg). Table 2.4-3 summarizes the samples; the nature and extent of the 2,3,7,8-TCDD TEQ values are discussed below.

Four of the five samples with dioxin congener exceedances also exceeded the 2,3,7,8-TCDD TEQ human health screening criteria (0.0013 µg/kg), and three of those also exceed the ecological (0.0043 µg/kg) screening criteria. The exceedances ranged from 0.0019 µg/kg at LXBSC05 to 0.0081 µg/kg at LXSTP04. These sampling locations are concentrated in the central portion of the LOX Plant area and are bound geographically to the north and south by the hill slopes, and to the west and east by sampling locations that did not have 2,3,7,8-TCDD TEQ exceedances. The horizontal extent of the 2,3,7,8-TCDD TEQ concentrations has been characterized adequately at this site, as shown in Figure 2.4-2. The vertical extent of these parameters is addressed in Section 2.4.2.

Metals. Of the 74 samples analyzed for metals, 26 reported a combined 16 TAL metals parameters that were detected at levels exceeding the applicable comparison criteria. Most of those parameters were encountered at concentrations mostly similar to their respective background values, and probably are indicative of natural occurrence. The nature and extent of the metals exceedances in the LOX Plant area are detailed below.

Six parameters–aluminum, arsenic, chromium, lead, silver, and zinc–were detected at concentrations the exceeding comparison criteria at this site at one location each; however, the reported concentrations were mostly similar to their respective background values. The highest aluminum exceedance reported was 30,400 mg/kg (LXSS04) compared to its background value of 20,000 mg/kg. Arsenic was detected at 20 mg/kg (LXTC0001S06) compared to its background value of 15 mg/kg. Chromium was reported at 72 mg/kg (LXBS1013) compared to its background value of 37 mg/kg, while lead was reported at 71.6 mg/kg (LXTSTP04) compared to its background value of 34 mg/kg. Silver was reported at a concentration of 1.40 mg/kg (LXBS0063) compared to its background value of 0.79 mg/kg, and zinc was reported at 148 mg/kg (LXTSTP04) compared to its background value of 110 mg/kg. Each of these parameters had reported concentrations exceeding its respective human health criteria. Five of the six (all except chromium) also surpassed their respective ecological comparison criteria. However, as noted, the elevated concentrations encountered were more similar to their respective background values, suggesting that these metals may be naturally occurring at this site at the reported concentrations. The horizontal extents of aluminum, arsenic, chromium, lead, silver, and zinc have been addressed sufficiently.

Sole exceedances of antimony, manganese, nickel, sodium, and selenium also were encountered at this site. Antimony was detected at a concentration of 465 mg/kg (NDBS0076), exceeding its common human health and ecological comparison criteria of 0.09 mg/kg. Manganese was encountered at a concentration of 2,700 mg/kg (LXSS04), exceeding its ecological (59 mg/kg) and human health (29 mg/kg) comparison criteria. Nickel was detected at a concentration of 92.3 mg/kg (LXBS1013), exceeding its common ecological and human health criteria of 0.1 mg/kg. Sodium was encountered at 1,900 mg/kg (LXSS04), exceeding its human health criterion of 110 mg/kg. Selenium was reported at a concentration of 2.6 mg/kg (LXSS04), which exceeds its common ecological and human health criteria of 0.17 mg/kg. Four of these five parameters, including antimony, manganese, nickel, and sodium, exhibited background values significantly higher than their respective comparison criteria; thus, the exceedances are most similar to their respective background values. Additionally, each of these stations is surrounded by surface soil samples that did not have reported exceedances of these four parameters. The extents of antimony, manganese, nickel, sodium, and selenium also are bound physically to the north by the hillside. The horizontal extents of antimony, manganese, nickel, sodium, and selenium in the LOX Plant area have been characterized adequately.

There were four exceedances of barium and boron, and three cadmium exceedances, reported at this site, spanning a combined seven sampling stations. Each of these parameters was encountered at concentrations exceeding both its human health and ecological comparison criteria. Elevated concentrations of barium ranged from an estimated 160 J mg/kg (LXTC0001S20) to 540 mg/kg (LXSS04), compared to its higher valued ecological criterion of 15 mg/kg. Boron was encountered at concentrations ranging from an estimated 14 J mg/kg (LXBS0064) to 118 mg/kg (LXSS04), compared to its common human health and ecological criteria of 6.76 mg/kg. Elevated concentrations of cadmium ranged from 1.1 mg/kg (1662) to an estimated 20 J mg/kg (LXBS0040), compared to its higher valued human health criteria of 0.02 mg/kg. Stations that had barium, boron, and cadmium exceedances reported are bound to the north and south physically by hillsides, and to the east and west by additional samples that did not have reported metals exceedances. In some situations, there are also sampling stations without elevated metals concentrations between the exceedance and the hillsides, thus minimizing the horizontal extent of these parameters further. The extents of barium, boron, and cadmium in the surface soil have been evaluated adequately at the LOX Plant area, as shown in Figure 2.4-3.

Beryllium and copper each were encountered 3 and 10 times, respectively, at concentrations exceeding their respective comparison criteria. Elevated concentrations of beryllium ranged from 1.2 mg/kg (LXTC0001S20) to 3.6 mg/kg (LXSS04), exceeding its human health criterion of 0.9 mg/kg. Copper exceedances ranged from an estimated 36.8 J mg/kg (LXBSCB01) to 140 mg/kg (LXBS0061), exceeding its ecological (1.10 mg/kg) and human health (1.09 mg/kg) comparison criteria. Eight of the 10 copper exceedances were within twice the background value of 29 mg/kg, and copper was detected in each of the surface soil samples analyzed, suggesting that the exceedances may be related to natural occurrence and not to LOX Plant processes. The beryllium and copper exceedances are bound to the east and west by additional sampling, and physically to the north and south by the nearby hillsides. The horizontal extents of beryllium and copper have been evaluated sufficiently, as shown in Figure 2.4-4.

Ten of the 16 TAL metals parameters also were encountered in subsurface soil samples at elevated concentrations. These exceedances, along with the additional parameters encountered, are addressed in Section 2.4.2.

PCB Aroclors/Congeners. One PCB aroclor and two PCB congeners were encountered at concentrations exceeding their comparison criteria at four sampling stations in the central portion of the LOX Plant area. Two Aroclor-1254 exceedances were reported at concentrations of 40 µg/kg (1662) and 51.9 µg/kg (LXBS1024), exceeding its human health criterion of 20 µg/kg. These stations are bound by nearby sampling stations that did not have PCB aroclor exceedances reported. PCB-126 and PCB-77, the PCB congeners, each had single exceedances of 0.0185 µg/kg (LXBS1025) and 0.322 J µg/kg (LXBS1023), respectively, each solely exceeding its human health comparison criterion (PCB-126, 0.0131 µg/kg; PCB-77, 0.276 µg/kg). Neither PCB congener was encountered at elevated concentrations in the other three samples analyzed, which were close to each respective exceedance. The horizontal extent of PCBs in the surface soil has been addressed sufficiently, as illustrated in Figure 2.4-5.

There were no PCB congener exceedances reported in the subsurface soil samples collected at this site. Two PCB aroclors, including Aroclor-1254, were encountered at elevated concentrations in the subsurface soil, which is addressed in Section 2.4.2.

SVOCs. Of the 74 surface soil samples analyzed for SVOCs, 22 had reported exceedances of a combined 10 SVOC parameters. Seven of the parameters detected at elevated concentrations are classified as PAHs. The extent of the SVOC exceedances in the LOX Plant area is discussed below.

2,4-Dimethylphenol and phenol each were encountered once at concentrations exceeding their respective comparison criteria. 2,4-Dimethylphenol was detected at a concentration of 15,000 µg/kg (1662), exceeding its human health criterion of 4,000 µg/kg; phenol was encountered at 6,400 µg/kg (080993MH01), exceeding its ecological (5,000 µg/kg) and human health (5,020 µg/kg) criteria. Each sampling station is situated near other stations that did not have exceedances of either parameter reported. The horizontal extents of 2,4-dimethylphenol and phenol have been characterized sufficiently.

Benzidine and chrysene were encountered at elevated concentrations in 2 and 3 samples, respectively, spanning 5 separate sampling stations. Reported exceedances of benzidine were estimated values of 340 J µg/kg (LXBSCB03) and 345 J µg/kg (LXTSTP08), compared to its human health criterion of 0.0016 µg/kg. Elevated concentrations of chrysene ranged from 980 µg/kg (LXBS0035) to 2,500 µg/kg (LXBS0054), each exceeding its human health (870 µg/kg) criterion, and the latter also exceeding its ecological (2,400 µg/kg) comparison criterion. Seven of the 9 samples analyzed for benzidine, and 48 of the 51 samples analyzed for chrysene, did not report exceedances. The horizontal extents of these parameters are bound by additional sampling to the east and west, and physically by the elevated surface to the north and ravine to the south. Additionally, specific to benzidine, there is sampling to the north and northeast that also did not report any exceedances. The horizontal extents of benzidine and chrysene have been evaluated adequately, as illustrated in Figure 2.4-6.

There were several reported exceedances of benzo(a)anthracene (BAA), BaP, benzo(b)fluoranthene, and benzo(k)fluoranthene in the LOX Plant area. Elevated

concentrations of BAA were reported in 9 surface soil samples, with concentrations ranging from 108 µg/kg (LXBS1001) to 2,200 µg/kg (LXBS0054), exceeding its human health (80 µg/kg) comparison criterion. BaP was encountered in 20 samples ranging from an estimated 110 J µg/kg (LXBS0044) to 4,200 µg/kg (LXBS0037), exceeding its human health criterion of 100 µg/kg. Benzo(b)fluoranthene was encountered in 13 samples, with concentrations ranging from 130 µg/kg (LXBS0055) to 4,100 µg/kg (LXBS0037), each exceeding its human health criterion of 100 µg/kg. Benzo(k)fluoranthene was encountered in 5 samples, with concentrations ranging from 160 µg/kg (NDBS74) to 1,500 µg/kg (LXBS0054), exceeding its human health criterion of 100 µg/kg. The horizontal extents of BAA, BaP, benzo(b)fluoranthene, and benzo(k)fluoranthene are illustrated in Figure 2.4-7.

Six exceedances of dibenz(a,h)anthracene, and 10 exceedances of indeno(1,2,3-cd)pyrene were reported in this area, each surpassing its respective human health comparison criteria. Elevated concentrations of dibenz(a,h)anthracene ranged from 33 µg/kg (LXBS0026) to 250 µg/kg (LXBS0037), exceeding its human health criterion of 30 µg/kg. Elevated concentrations of indeno(1,2,3-cd)pyrene ranged from 112 µg/kg (LXBSCB05) to 1,800 µg/kg (LXBS0054), exceeding its human health criterion of 100 µg/kg. The horizontal extents of dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene are shown in Figure 2.4-8.

Nine SVOC parameters were encountered in subsurface soil at levels exceeding their respective comparison criteria, 7 of which also were encountered in the surface soil at concentrations exceeding the screening criteria, as described above. The vertical extent of these SVOCs will be addressed in Section 2.4.2.

TPHs. Two TPHs, extractable fuel hydrocarbons (EFH) (C15-C20) and EFH (C21-C30), were detected at concentrations that exceeded their common ecological and human health comparison criteria of 100,000 µg/kg. EFH (C15-C20) was encountered once at a concentration of 160,000 µg/kg (LXBS0040), while 9 exceedances of EFH (C21-C30) were reported, ranging from 240,000 µg/kg (LXBS0040) to an estimated 670,000 J µg/kg (NDBS73). Each TPH parameter was analyzed for in 46 surface soil samples. There is not a clear pattern for the sampling stations that exhibited TPH exceedances; however, there are multiple sampling stations near each exceedance that did not report elevated concentrations of TPHs, specifically in the eastern and western portions of the site. Additionally, the hillsides to the north and south provide horizontal boundaries for the exceedances encountered. The horizontal extents of EFH (C15-C20) and EFH (C21-C30) have been evaluated sufficiently, as shown in Figure 2.4-9.

The vertical extent of TPHs in subsurface soils at this site is addressed in Section 2.4.2.

VOCs. Of the 44 samples analyzed for VOCs at the LOX Plant area, only 4 exhibited concentrations of TCE at levels exceeding their human health criteria of 30 µg/kg. Elevated concentrations of TCE ranged from 41 µg/kg (LXBS0058) to an estimated 130 J µg/kg (LXBS17). TCE exceedances are relatively grouped on the northwestern side of the tank storage area in the central portion of this area. The extent is bound through additional sampling in which elevated concentrations of VOCs were not reported. The horizontal extent of TCE has been evaluated adequately, as shown in Figure 2.4-10.

2.4.2 Subsurface Soil Nature and Extent

A total of 137 subsurface soil samples were collected at this site from 79 sampling stations to a maximum depth of 21 ft bgs. The subsurface soil at the site was analyzed for 1 or more of the following: dioxins, 1,2-diphenylhydrazine, metals, PCBs (aroclors and congeners), SVOCs, TPHs, and VOCs. Table 2.4-4 lists the parameters detected in the subsurface soil samples at the LOX Plant area.

The compound 1,2-diphenylhydrazine was analyzed for in subsurface soil at the same locations it was analyzed for in the surface soil media. Similar to the surface soil results, 1,2-diphenylhydrazine was not detected in any of the samples analyzed; hence, its vertical extent has been addressed sufficiently.

2.4.2.1 Parameters above Comparison Criteria

The nature and vertical extent of the parameters encountered at concentrations exceeding their respective comparison criteria are described below.

Dioxins. The eight surface soil sampling stations analyzed for dioxins also were analyzed for dioxins in the subsurface to a maximum depth of 20 ft bgs. No dioxin exceedances were reported in the subsurface soil media at the LOX Plant area; therefore, the vertical extent of dioxins has been evaluated adequately.

Metals. A total of 83 subsurface soil samples, collected from 51 sampling stations, were analyzed for metals to a maximum depth of 20.5 ft bgs. Of those, 23 samples from 19 stations exhibited elevated concentrations of 13 metals parameters. Most of the parameters were detected at exceeding concentrations mostly similar to their respective background values, as detailed below.

One exceedance each for cobalt, lead, and molybdenum was reported, and 2 exceedances each of aluminum and arsenic were reported in the subsurface soil, each being mostly similar to its respective background value. Cobalt was detected at a concentration of 21.5 mg/kg (LXBS1015, 12 to 14 ft bgs) compared to its background value of 21 mg/kg. Lead was detected at 56 mg/kg (LXBS0062, 3.5 to 4 ft bgs), compared to its background value of 36 mg/kg. Molybdenum was detected at 6.2 mg/kg (LXBSCB03, 15 to 15.5 ft bgs), compared to its background value of 5.3 mg/kg. Aluminum was encountered at concentrations of 21,000 mg/kg (LXBS0058, 7 to 7.5 ft bgs) and 21,300 mg/kg (LXBS1005, 15 to 16 ft bgs), compared to its background value of 20,000 mg/kg, and arsenic was detected at 23 mg/kg (LXBS1015, 12 to 14 ft bgs) and 24.7 mg/kg (LXBS1019, 7 to 8.5 ft bgs), compared to its background value of 15 mg/kg. As noted above, these exceedances are mostly similar to their respective background values and likely are the result of natural occurrence. The vertical extents of aluminum, arsenic, cobalt, lead, and molybdenum have been evaluated adequately.

Beryllium, chromium, nickel, vanadium, and zinc exceedances were encountered in the subsurface soil, also at concentrations mostly similar to their respective background values. Five beryllium exceedances were reported at concentrations ranging from 1.2 mg/kg (LXBS1015, 12 to 14 ft bgs) to 2.4 mg/kg (LXBSCB05, 15 to 15.5 ft bgs), compared to its background value of 1.1 mg/kg. Seven chromium exceedances were reported, ranging from 37.1 mg/kg (LXBS1018, 5 to 6.5 ft bgs) to 57.4 mg/kg (LXBS1005, 15 to 16 ft bgs), compared

to its background value of 36.8 mg/kg. Six nickel exceedances were reported, ranging from an estimated 31.4 J mg/kg (LXBS1018, 5 to 6.5 ft bgs) to 44.8 mg/kg (LXBSCB05, 5 to 5.5 ft bgs), compared to its background value of 29 mg/kg. Three vanadium exceedances were encountered, ranging from 69.4 mg/kg (LSBSCB05, 15 to 15.5 ft bgs) to 75.7 mg/kg (LSBS1005, 15 to 16 ft bgs), compared to its background value of 62 mg/kg. Finally, elevated concentrations of zinc were detected in 5 samples, ranging from 116 mg/kg (LXBS1019, 4.5 to 6 ft bgs) to 146 mg/kg (LSBSCB05, 15 to 15.5 ft bgs), compared to its background value of 110 mg/kg. Because these 5 parameters were encountered at exceeding concentrations mostly similar to their respective background values, it is likely that these parameters are occurring naturally at this site, at these concentrations. The vertical extents of beryllium, chromium, nickel, vanadium, and zinc have been evaluated adequately.

Five exceedances of silver were encountered out of the 69 samples analyzed, each surpassing both the ecological (0.54 mg/kg) and human health (0.53 mg/kg) comparison criteria. Elevated concentrations of silver ranged from 1.2 mg/kg (LXTC0001S17, 9.5 to 10 ft bgs) to 6.5 mg/kg (LXTC0001S13, 9.5 to 10 ft bgs). One exceedance was detected at LXBS02, 5 ft bgs, and an additional sample was collected at a deeper interval, thus providing a vertical extent boundary. The remaining 4 silver exceedances are localized in the far southeastern portion of the site, along the ravine, and were detected in the deepest intervals sampled. Additional sampling is warranted to further evaluate the vertical extent in this particular area of the LOX Plant. The vertical extent of silver in the subsurface soil is illustrated in Figure 2.4-11.

Barium was detected in all 69 subsurface soil samples analyzed, exceeding the comparison criteria in 9 samples. Elevated concentrations of barium ranged from 141 mg/kg (LXBS1019, 7 to 8.6 ft bgs) to 949 mg/kg (LXBSCB03, 15 to 15.5 ft bgs), each exceeding its ecological (15 mg/kg) and human health (14.6 mg/kg) comparison criteria. Eight of the 9 exceedances were mostly similar to its background value of 140 mg/kg, suggesting that most of the barium exceedances may be a result of natural occurrence. The highest barium concentration detected (949 mg/kg) was encountered at a station (LXBSCB03) that was sampled at a deeper interval, 20 to 20.5 ft bgs, that did not have an elevated concentration of barium reported. Therefore, the vertical extent of barium has been evaluated adequately, as illustrated in Figure 2.4-12.

Copper, detected in 77 of 81 samples analyzed, had reported exceedances in 11 subsurface soil samples. Elevated concentrations of copper ranged from an estimated 31.9 mg/kg (LXBS1020, 4-5 to 6 ft bgs) to 3,500 mg/kg (LXBS02, 5 ft bgs), exceeding its ecological (1.10 mg/kg) and human health (1.09 mg/kg) comparison criteria. The 4 highest concentrations reported (400 mg/kg to 3,500 mg/kg) were encountered in a localized area in the southwestern portion of the AOC. These particular locations each were sampled at intervals deeper than the exceedance; the deeper samples did not have reported elevated copper concentrations. Four of the 11 exceedances were encountered at the deepest sample interval at a given location; however, the deepest interval analyzed (20 to 20.5 ft bgs) for copper across the LOX Plant area did not exhibit elevated concentrations. Combined with the data that bind the four greatest concentrations vertically, it is inferred that the vertical extent of copper has been evaluated adequately at this site, as shown in Figure 2.4-13.

Six parameters (antimony, boron, cadmium, manganese, selenium, and sodium) detected at exceeding concentrations in the surface soil were not encountered at elevated concentrations in subsurface soil media; thus, the vertical extents of these constituents have been addressed sufficiently. With the exception of a portion of the silver exceedances reported, the extent of metals has been evaluated adequately at the LOX Plant area.

PCBs Aroclors/Congeners. No PCB congeners were detected in the subsurface soil at concentrations that exceeded the comparison criteria. The vertical extent of PCBs encountered at elevated concentrations in the surface soil has been evaluated adequately.

Two PCB aroclors, Aroclor-1254 and Aroclor-1260, were detected at estimated concentrations that exceeded their common human health criteria of 20 µg/kg. Aroclor-1260 exceedances were reported twice at concentrations of 23 J µg/kg (LXBS0062, 3.5 to 4 ft bgs) and 24 J µg/kg (LXTSTP04, 5 to 5.5 ft bgs), and the Aroclor-1254 exceedance was reported at a concentration of 21.5 J µg/kg (LXTSTP04, 5 to 5.5 ft bgs). Neither location was sampled at deeper intervals than reported here; however, there are multiple locations in the vicinity of stations LXBS0062 and LXTSTP04 that were analyzed for PCBs in similar or deeper sampling intervals. Neither location discussed here had a PCB aroclor exceedance reported in the surface soil. The vertical extent of PCB aroclors in the LOX Plant area has been evaluated adequately.

SVOCs. Eighty-one samples were collected from 43 stations and analyzed for SVOCs in the LOX Plant area. Of those, 14 samples exhibited elevated concentrations of a combined 9 SVOC parameters. Three parameters, benzo(k)fluoranthene, chrysene, and dibenz(a,h)anthracene, were encountered in the surface soil, but not in the subsurface soil, at elevated concentrations; hence, their vertical extents have been evaluated adequately. Exceedances detected in the subsurface soil are detailed below.

1,4-Dichlorobenzene and 2-methylphenol were not encountered in the surface soil, but each was detected once at an elevated concentration in the subsurface soil. 1,4-Dichlorobenzene was reported at a concentration of 1,800 µg/kg (LXBS02, 5 ft bgs), exceeding its human health criterion of 1,000 µg/kg. 2-Methylphenol was encountered at a concentration of 9,300 µg/kg (1661, 11.5 to 12 ft bgs), exceeding its human health criterion of 8,000 µg/kg. Sampling station LXBS02 was sampled below the interval exhibiting the 1,4-dichlorobenzene exceedance; however that sample did not yield an elevated concentration of this parameter. The vertical extent of 1,4-dichlorobenzene has been evaluated adequately. The 2-methylphenol exceedance was encountered in the deepest interval analyzed at sampling location 1661; however, another close by station, LXBSCB03, did not have reported exceedances down to the 20- to 20.5-foot-bgs sampling interval. It is inferred, therefore, that the vertical extent of 2-methylphenol has been addressed sufficiently at this site.

Sole exceedances of benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and phenol were reported at this site in the subsurface soil. Benzo(b)fluoranthene was encountered at a concentration of 799 µg/kg (NDBS0124, 2 to 2.5 ft bgs), exceeding its human health criterion (100 µg/kg). Indeno(1,2,3-cd)pyrene was encountered at a concentration of 322 µg/kg (NDBS0124, 2 to 2.5 ft bgs), exceeding its human health criterion (110 µg/kg). Phenol was encountered at a concentration of 7,000 µg/kg (1661, 11.5 to 12 ft bgs), exceeding its ecological (5,000 µg/kg) and human health (5,020 µg/kg) comparison criteria. Sampling

station NDBS0124 is the most upgradient sampling station along the ravine running east to west on the southern side of the site. It is likely that the exceedances detected here have been brought in from other portions of the site during rain events. There are no upgradient subsurface analytical data, and the location was not sampled at intervals deeper than the exceedances; however, some subsurface soil samples, downgradient and from a similar interval, did not have reported SVOC exceedances. Concentrations of both benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene did, however, increase in the subsurface, suggesting that a data gap exists in this area. Additional sampling at sampling station 1661 provides a vertical extent boundary for the sole phenol exceedance. The vertical extent of phenol has been evaluated adequately. The vertical extents of benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene require additional investigation.

Two exceedances of 2,4-methylphenol were detected at concentrations of 29,000 µg/kg (LXBS01, 9.5 ft bgs) and 83,000 µg/kg (1661, 11.5 to 12 ft bgs), surpassing its human health criterion of 400 µg/kg. These exceedances were encountered at the deepest sampled intervals at the given locations, at concentrations greater than what were reported in surface soil samples. Nearby, however, is a sampling station, LXBSCB03, that was sampled to the 20- to 20.5-foot-bgs interval, and that did not report SVOC exceedances at the deepest intervals. It is inferred that the vertical extent of 2,4-methylphenol has been evaluated adequately. The extent of 2,4-methylphenol in the subsurface soil at this site is shown in Figure 2.4-14.

Six exceedances of benzidine, each reported as an estimated concentration, were encountered at this site, at concentrations ranging from 354 J µg/kg (LXBSCB03, 10 to 10.5 ft bgs) to 378 J µg/kg (LXBSCB03, 15 to 15.5 ft bgs), each exceeding its human health criterion of 0.0016 µg/kg. Benzidine exceedances were encountered in three locations congregated in the southwestern corner of the AOC. These exceedances were detected at the deepest interval sampled at these three locations, and show an increasing trend from the samples collected from the surface soil media. The vertical extent of benzidine, along with 2,4-methylphenol, is shown in Figure 2.4-14.

Two exceedances of BAA were encountered in subsurface soil at concentrations of an estimated 94.5 J µg/kg (LXBS1026, 7 to 7.5 ft bgs) and 339 µg/kg (NDBS0124, 2 to 2.5 ft bgs), exceeding its human health criterion of 80 µg/kg. Each exceedance was detected at the deepest interval sampled at its given station. The exceedance at sampling station LXBS1026 has been vertically profiled, because bedrock refusal was encountered at approximately 8.5 ft bgs; additionally, a nearby sampling station was profiled to deeper intervals and did not have reported elevated concentrations of BAA. Station NDBS0124 is located at the most upgradient point of the southern ravine at this site; exceedances encountered in this area are likely to have washed in during rain events and to be unrelated to the processes associated with the LOX Plant area. The vertical extent of BAA has been evaluated sufficiently, as shown in Figure 2.4-15.

Four exceedances of BaP were reported in the subsurface soil at this site, at concentrations ranging from an estimated 12 J µg/kg (LXBS0038, 5 to 6 ft bgs) to 536 µg/kg (NDBS0124, 2 to 2.5 ft bgs), exceeding its human health criterion of 10 µg/kg. Elevated concentrations in the subsurface soil were either similar to or less than the exceedances encountered in the surface soil of this SVOC constituent. These particular sampling stations were not sampled at deeper intervals; however, other close-by stations did not have reported elevated SVOC

concentrations at similar or deeper intervals. The vertical extent of BaP, along with BAA, has been addressed sufficiently, as illustrated in Figure 2.4-15.

TPHs. Fifty-one subsurface soil samples were collected from 31 sampling stations and analyzed for TPHs. Of those, 6 samples had reported elevated concentrations of a combined 6 TPH parameters, each exceeding its common ecological and human health criteria of 100,000 µg/kg. EFH (C15-C20), encountered in the surface soil at this site, was not detected at exceeding concentrations in the subsurface; therefore, the vertical extent of EFH (C15-C20) has been evaluated adequately.

TPH groups C11-C14 (kerosene range), diesel range organics (DROs) (C14-C20), EFH (C8-C11), and TRPH each was encountered once at concentrations exceeding the respective comparison criteria. Group C11-C14 (kerosene range) was reported at a concentration of 420,000 J µg/kg (LXBS02, 5 ft bgs), DROs (C14-C20) at 640,000 J µg/kg (LXBS02, 5 ft bgs), EFH (C8-C11) at 320,000 J µg/kg (LXBS04, 5 ft bgs), and TRPH at 1,600,000 µg/kg (1661, 11.5 to 12 ft bgs). Exceedances encountered at station LXBS02 are bound vertically by an additional sample collected at this location, and TRPH was only analyzed for in the sample discussed here. The vertical extents of C11-C14 (kerosene range), DROs (C14-C20), and EFH (C8-C11) have been evaluated sufficiently. Although there were no available comparison criteria for the TRPH detections in the surface soil, the concentrations did increase from the surface soil to the subsurface soil sample at station 1661, suggesting that a data gap exists for this parameter.

DROs (C20-C30) were encountered 3 times at estimated concentrations that exceeded the comparison criteria, ranging from 110,000 J µg/kg (LXBS01, 5 ft bgs) to 990,000 J µg/kg (LXBS02, 5 ft bgs). Two of the (C20-C30) exceedances are bound vertically through additional sampling at their respective locations. The third, collected at LXBS06 at 10 ft bgs, was encountered in the deepest sample collected from that location. However, nearby samples collected from LXBS01 and LXBS02 in a similar interval did not exhibit exceeding concentrations, suggesting that the extent of (C20-C30) is limited to the immediate vicinity of LXBS06. The vertical extent of DROs (C20-C30) has been addressed sufficiently, as illustrated in Figure 2.4-16.

Elevated concentrations of EFH (C21-C30) were encountered twice at estimated concentrations of 157,000 J µg/kg (LXBS1012, 5.5 to 6 ft bgs) and 3,180,000 µg/kg (LXBS1026, 7 to 7.5 ft bgs). Sampling station LXBS1012 also was sampled at a deeper interval and analyzed for EFH (C21-C30); however, the deeper sample did not have a reported exceedance, thus providing a vertical extent boundary. On the other hand, the exceedance at LXBS1026 was reported in the deepest interval sample at that location. However, nearby sampling station LXBS1027 was sampled at a deeper interval, 10.5 to 11 ft bgs, and did not have a reported exceedance of this parameter. Additionally, surface soil exceedances of EFH (C21-C30) were not detected at either of these sampling stations. It is inferred that the vertical extent of EFH (C21-C30) has been evaluated adequately, when considering the results from nearby sampling stations. EFH (C21-C30) is illustrated in Figure 2.4-16 along with the diesel range organics (C20-C30) results from the subsurface soil sampling.

VOCs. A total of 81 subsurface soil samples were collected from 42 sampling stations and analyzed for VOCs. Of those, 26 samples from 11 stations exhibited elevated concentrations

of a combined 9 VOC parameters, including TCE, the sole VOC parameter encountered at elevated concentrations in the surface soil. The elevated VOC concentrations probably are due to the historical use of solvents at the LOX Plant.

1,1-Dichloroethene (DCE), methylene chloride, tetrachloroethene (PCE), and trans-1,2-DCE each was encountered once at estimated concentrations exceeding the respective human health comparison criteria. 1,1-DCE and trans-1,2-DCE were encountered at LXBS13, 12 to 12.5 ft bgs, at concentrations of 62 J µg/kg and 2,500 J µg/kg, respectively, exceeding their human health criteria of 10 µg/kg and 150 µg/kg, respectively. Methylene chloride also was encountered at LXBS13 at the 9- to 9.5-foot-bgs interval at a concentration of 410 J µg/kg, exceeding its human health criterion of 10 µg/kg. PCE was detected at a concentration of 2,130 J µg/kg (LXBS1005, 5 to 6 ft bgs), exceeding its human health criterion of 30 µg/kg. These two sampling stations are relatively close to one another in the north-central portion of the site, where they are bound in the southerly directions by additional sampling and to the north by a hillside. Each sampling station also was sampled at deeper intervals that did not have reported elevated concentrations of any of the parameters described here. Therefore, the vertical extents of these four VOC parameters have been evaluated adequately.

There were 10 exceedances of cis-1,2-DCE reported in the subsurface soil at this site, at concentrations ranging from an estimated 86.5 J µg/kg (LXBS1005, 15 to 16 ft bgs) to an estimated 15,000 µg/kg (LXBS13, 12 to 12.5 ft bgs), each solely exceeding its human health criterion of 50 µg/kg. Cis-1,2-DCE exceedances were detected at four sampling stations, consolidated in the north-central portion of the site. Although cis-1,2-DCE was encountered in the deepest sampling intervals at these stations, concentrations generally decrease as the sampling progressed from the surface, suggesting that vertical migration is confined to this general area, because vertical migration apparently is stifled at deeper intervals. The vertical extent of cis-1,2-DCE is shown in Figure 2.4-17.

TCE was encountered in 25 subsurface soil samples, spanning 12 sampling stations, at elevated concentrations. Detections of TCE ranged from an estimated 36 J µg/kg (LXBS14, 4.5 to 5 ft bgs) to an estimated 140,000 J µg/kg (LXBS1005, 5 to 6 ft bgs), each exceeding its human health criterion (30 µg/kg); 9 detections also exceeded its ecological screening criterion of 3,000 µg/kg. Similar to other VOC exceedances, the reported TCE exceedances mostly are concentrated in the north-central portion of the site. Elevated concentrations mostly decrease in the deeper interval sample at a given sampling station. Currently, points of refusal during the subsurface sampling events are unavailable for the legacy data at this site. It is likely that many of the deepest interval samples were collected just above bedrock, suggesting that the vertical migration has been evaluated adequately at this site. However, because of the lack of data, additional investigation is required. The vertical extent of TCE in the subsurface soil at the LOX Plant is shown in Figure 2.4-18.

Seven exceedances, spanning four sampling stations, of vinyl chloride (VC) were reported at this site, each solely exceeding its human health criterion of 1.10 µg/kg. Elevated concentrations ranged from an estimated 3 J µg/kg (LXBS13, 17 to 17.5 ft bgs) to an estimated 280 J µg/kg (LXBS13, 12 to 12.5 ft bgs). Similar to other VOC exceedances, VC exceedances were confined to the north-central portion of the site. Two of the stations exhibiting elevated concentrations show either a dramatic decrease in concentration or non-detectable concentrations in the deepest interval analyzed. Additional sampling in the

southerly directions, in similar intervals, had non-exceeding or non-detectable concentrations of VC, suggesting that the extent of this parameter is bound to the area where the exceedances were detected. The vertical extent of VC has been addressed sufficiently, as shown in Figure 2.4-19.

2.4.3 Soil Gas Nature and Extent

A total of 262 soil gas samples were collected at this site from 123 sampling stations to a maximum depth of 29 ft bgs. The soil gas samples were analyzed for VOCs at the LOX Plant and 8 VOC parameters were encountered at exceeding concentrations. Table 2.4-5 lists the parameters detected in the soil gas samples at the LOX Plant. The elevated VOC concentrations probably are due to historic solvent use associated with the cleaning of the LOX tanks. The extent of VOCs encountered via soil gas sampling at this site is described below.

One exceedances of benzene was reported at this site. Benzene was reported at LXSV33, 2 ft bgs, at 1,200 µg/kg, exceeding both its human health (36.2 micrograms per cubic meter [µg/m^3]) and ecological (570 µg/m^3) comparison criteria. Soil gas samples surrounding station LXSV33 did not have reported benzene exceedances, suggesting that the extent of benzene has been addressed sufficiently.

Nine exceedances of 1,1-DCE were reported in soil gas samples collected at this site. Elevated concentrations ranged from 607 micrograms per cubic meter (µg/m^3) (LXSA22, 10 ft bgs) to 1,500,000 µg/m^3 (LXSV77, 12 ft bgs), each exceeding its ecological comparison criteria of 600 µg/m^3. Most of the stations exhibiting exceedances of 1,1-DCE were sampled at intervals deeper and/or shallower than the exceedance, but did not have reported elevated concentrations of this parameter. Additionally, there are multiple soil gas sampling points surrounding the exceedances that also did not have reported elevated concentrations. The extent of 1,1-DCE has been evaluated adequately, as shown in Figure 2.4-20.

A total of 53 soil vapor samples exhibited elevated concentrations of cis-1,2-DCE. The reported exceedances ranged in concentration from 2,000 µg/m^3 (LXSV29, 1 ft bgs) to 21,000,000 µg/m^3 (LXSV76, 5 ft bgs), each surpassing the ecological comparison criterion of 1,900 µg/m^3, 29 of the 53 also exceeding the human health criterion of 15,900 µg/m^3. Exceedances are localized in the north-central portion of the site and are horizontally bound by additional soil gas samples in which elevated concentrations were not reported. The deepest soil gas exceedance for cis-1,2-DCE was reported in the 18-foot-bgs interval. An additional 11 samples from 7 sampling stations were sampled in the north-central portion of the site below 18 ft bgs; none of these samples had reported exceedances of cis-1,2-DCE. Thus, it is likely that the nature and extent of cis-1,2-DCE soil vapors in the LOX Plant area have been evaluated adequately, as shown in Figure 2.4-21.

Sixteen soil vapor samples exhibited elevated concentrations of PCE. The reported concentrations ranged from an estimated 700 J µg/m^3 (LXSV1003, 5 to 5.5 ft bgs) to an estimated 264,000 J µg/m^3 (LXSA24, 17 ft bgs), each exceeding its human health criterion of 180 µg/m^3 and two also exceeding its ecological screening criterion of 24,000 µg/m^3. A total of 249 of the 265 soil gas samples did not have reported exceedances of PCE, and most of those were reported as non-detectable concentrations. Additionally, the deepest interval

exhibiting an exceedance was 17 ft bgs, while the site was analyzed down to 29 ft bgs, where allowed. Generally, samples that exhibited non-detect concentrations of PCE surround the reported exceedances, most of which bind the elevated concentrations horizontally and vertically. The extent of PCE, soil vapor, has been evaluated sufficiently, as shown in Figure 2.4-22.

Forty-five soil gas samples, spanning 25 sampling stations, exhibited elevated trans-1,2-DCE concentrations. Exceedances ranged in concentration from 2,000 $\mu g/m^3$ (LXSA12, 10 ft bgs) to an estimated 14,000,000 J $\mu g/m^3$ (LXSV76, 5 ft bgs), each exceeding its ecological comparison criterion (1,900 $\mu g/m^3$), with 21 detections also exceeding its human health criterion of 31,900 $\mu g/m^3$. Generally, exceedances of trans-1,2-DCE were encountered in samples exhibiting cis-1,2-DCE exceedances. As noted earlier, these samples are bound horizontally through additional soil gas sampling. Similarly, this parameter has been bound vertically by the 11 soil gas samples collected below 18 ft bgs. The nature and extent of trans-1,2-DCE in soil gas has been addressed sufficiently, as illustrated in Figure 2.4-23.

A total of 110 of the 262 soil gas samples exhibited elevated concentrations of TCE at the LOX Plant area. Exceedances ranged in concentration from 1,000 $\mu g/m^3$ (LXSV61, 4 ft bgs) to 7,000,000 $\mu g/m^3$ (LXSV77, 12 ft bgs), each exceeding its human health criterion (528 $\mu g/m^3$) and 88 of the 110 exceedances also surpassing its ecological comparison criterion of 6,400 $\mu g/m^3$. Exceedances of TCE were encountered to a maximum depth of 27 ft bgs; only 1 sample of soil gas was collected at a depth greater than the reported exceedances, at LXSV40, which is to the southwest of the primary localization of soil gas exceedances. Additional sampling is required at this site to effectively evaluate the vertical extent of TCE. Horizontally, TCE exceedances are bound by additional soil gas samples. To the northeast and northwest, sampling coverage is not quite as extensive as in other portions of the site; however, the increasing elevation of the ground level provides additional support for horizontal extent. The extent of TCE soil gas is illustrated in Figure 2.4-24.

Seventeen soil vapor samples, spanning 10 sampling stations, exhibited elevated concentrations of VC. Elevated concentrations ranged from an estimated 93.4 $\mu g/m^3$ (LXSA24, 0 to 1 ft bgs) to an estimated 23,000,000 $\mu g/m^3$ (LXSV76, 5 ft bgs). Soil vapor VC exceedances are localized to the north-central area of the site, near and around the grouping of horizontal tanks. The nature of the reported exceedances depicts a localized area of higher concentrations, with, in general, progressively lower concentrations expanding outward. Additional soil vapor samples were collected around the area that had the reported exceedances; these additional samples did not have reported elevated concentrations of VC. The extent of VC as soil vapor at the LOX Plant has been evaluated adequately, as shown in Figure 2.4-25.

2.5 Conceptual Site Exposure Model

A generalized CSM for the human health exposure pathways is presented in Section 1.5.3.3. Given the potential future land use, the following receptors will be addressed in the LOX Plant HHRA:

- Future onsite adult industrial workers potentially exposed to chemicals in soil, indoor air, outdoor air, and seeps and springs (where applicable).
- Hypothetical future onsite adult and child recreationists potentially exposed to chemicals in soil, outdoor air, and seeps and springs (where applicable).
- Hypothetical future onsite adult and child residents potentially exposed to chemicals in soil, indoor air, outdoor air, homegrown produce, groundwater (where applicable), and seeps and springs (where applicable).

In addition, in accordance with California Senate Bill 990, a hypothetical future subsistence agricultural exposure scenario must be included to assess the risks associated with the potential consumption of beef, eggs, milk, swine, fruits, and vegetables. However, pending final agreement of the input assumptions considered in the scenario, the assessment of the subsistence agricultural exposure scenario will be included in a supplemental risk assessment report separate from this RFI Report.

Any deviations from this generalized CSM for the LOX Plant are presented in Section 2.7.2.

2.6 Fate and Transport Analysis for Chemicals Detected in Groundwater in Surficial Media at the LOX Plant

No groundwater is present in the SMOU at the LOX Plant, based on the Group 2 RFI characterization efforts to date. Therefore, no fate and transport analysis for this medium currently is warranted. Sampling during the rainy season in 2009 may yield groundwater analytical results that will evaluated in an addendum to the Group 2 RFI.

2.6.1 Contaminant Sources and Release Mechanisms

The primary release mechanism for contamination at the LOX Plant area is attributed to the oils, lubricants, solvents, and cleaners used at the facility, as well as transformers used to support the large machinery associated with the LOX production process. In addition, potential leaks and spills from chemicals stored in the drum storage area could have introduced contaminants to the surface media.

2.6.2 Potential Routes of Migration

The primary pathway for contaminant transport from the source areas at the LOX Plant is the vertical migration of contaminants into subsurface soils. A secondary transport mechanism for this site includes the release of surface soil to the air by wind erosion or volatilization.

2.6.3 Contaminant Persistence

Dioxins, inorganics, PCBs, SVOCs, TPHs, and VOCs were detected in the soil at the LOX Plant at levels above their screening criteria.

2.6.3.1 Chemicals Applicable to the LOX Plant

This subsection describes the chemicals applicable to the LOX Plant.

Dioxins. Dioxins are characterized by extremely low vapor pressures, high log K_{ow}, high K_{oc}, and extremely low water solubilities. Their strong adsorption to soil, low water solubilities, and high K_{oc} values indicate that the rate of transport from unsaturated zone soils to the water table via rain infiltration would be extremely low.

Dioxins were detected at levels above the screening criteria in both the surface and subsurface soils. Because dioxins have low vapor pressure, they are not very volatile and tend to stay bound to particles. Dioxins also have low solubility; thus, any aerially deposited dioxins tend to stay adsorbed to soils in the top few millimeters in surface soil. This theory is consistent with the collected LOX Plant area data, which did not have dioxins detected at levels above the screening criteria in the subsurface soils.

Inorganics. Several metals were detected at the LOX Plant at levels above the screening criteria. Many metals are naturally occurring and their reported presence may or may not indicate a contaminant release. The mobility of metals is complex and depends on several factors such as the overall groundwater composition, pH, metal complex formation, valence state of the metal, and cation-ion exchange capacity. Metals typically are not volatile. In the water phase, the total metal concentration includes the dissolved metal concentration and the suspended metal concentration, which is sorbed to colloidal particles.

SVOCs. PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances. High-molecular-weight (HMW) PAHs are more likely to be transported via particulate emissions, while low-molecular-weight (LMW) PAHs have a greater tendency to volatilize (ATSDR, 1995). In general, PAHs are more likely to sorb to soil or organic matter than to partition significantly to water. Photolysis and biodegradation are two common attenuation mechanisms for PAH compounds (Howard, 1991). Animals and microorganisms can metabolize PAHs to products that ultimately reach complete degradation.

PCBs. PCBs are persistent in the environment. Aroclor-1254 and Aroclor-1260 are characterized by low water solubility, moderate volatility, high affinity for organic matter, and high resistance to chemical or biological degradation. They will strongly sorb to soil and do not tend to leach to groundwater. In surface water, they will partition to sediment and sorb to organic matter. PCBs will bioaccumulate in aquatic organisms.

TPHs. TPHs are defined as the measurable amount of petroleum-based hydrocarbon in an environmental media. The lighter petroleum products such as gasoline contain constituents with higher water solubility and volatility and lower sorption potential than heavier petroleum products such as fuel oil. Data compiled from gasoline spills and laboratory studies indicate that these light-fraction hydrocarbons tend to migrate readily through soil, potentially threatening or affecting groundwater supplies. In contrast, petroleum products

with heavier molecular weight constituents, such as fuel oil, generally are more persistent in soils, because of their relatively low water solubility and volatility and high sorption capacity (Stelljes and Watkin, 1991).

VOCs. VOCs are characterized by relatively high vapor pressures, Henry's Law constants, and generally high solubility in water. VOCs have a tendency to partition to the vapor phase from either soil or surface water and could be released through volatilization from contaminated soil. The sorption potential of VOCs is variable; some may persist in soil or sediment, while some are highly mobile in soil. VOCs will leach to groundwater and may persist, depending on their ability to degrade or transform in the environment.

TCE was the most prevalent VOC in the soil gas samples collected. Although TCE does not have a high K_{oc}, it may sorb to soil, sediment, or organic matter and persist in the environment for a long time. It also may persist in groundwater. TCE does not accumulate in plants or animal tissue and undergoes biotic and abiotic degradation via natural attenuation processes.

2.6.4 Contaminant Migration

The primary source for contaminant migration is from historical spills and leaks associated with the LOX Plant operations and possibly from the drum storage activities.

2.6.5 Surface Soil Contaminants

Dioxins and organic and inorganic compounds have been identified in surface soil at levels above the background and/or health-based risk criteria. The following observations were made for contaminants in surface soil:

- Dioxins were only detected in the surface soil.
- The metals antimony, boron, manganese, selenium, and sodium were detected at levels above their respective screening criteria in the surface soil, but did not exceed their screening criteria in subsurface soil samples.
- The metals aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, silver, and zinc were detected in both the surface and subsurface soils. Most of these parameters were encountered at concentrations mostly similar to their respective background values, and probably are indicative of natural occurrence.

2.6.6 Subsurface Soil Migration

The following observations were made for the contaminants in subsurface soil:

- Dioxins were not detected at levels above the screening criteria in the subsurface soil samples.
- Cobalt, molybdenum, and vanadium were detected at levels above the screening criteria in the subsurface soil, but exceedances were not detected in the surface soil for these parameters.
- The highest TCE concentrations were typically in the top 10 ft bgs, and concentrations decreased with depth.

2.6.7 Soil-to-Groundwater Migration

Chemical impacts to groundwater at the LOX Plant are similar to site conditions throughout SSFL and generally are characterized by TCE and its daughter products in the CFOU. The occurrence of NSGW at the LOX Plant has not yet been confirmed and may coincide with the winter rainy season. Elevated concentrations of TCE, its daughter products, and other VOCs in surface soil, subsurface soils, and soil vapor are mostly found in the north-central portion of the site near the solvent release area by the clarifier and sump.

The area of chemical impacts and likely groundwater source area can be delineated by the TCE distribution in soil and soil vapor as the benchmark for site conditions in the north-central portion of the site, as shown in Figures 2.4-10, 2.4-18, and 2.4-24. Other than the localized elevated DRO (C20-C30) and extractable petroleum hydrocarbon (EPH) (C21-C30) concentrations found in soil in the southwestern portion of the site (Figures 2.4-9 and 2.4-16), the distribution of other VOCs in soil and soil vapor is generally within the footprint of TCE.

The release of TCE from SSFL operations probably resulted in the entry of immiscible-phase liquid into and below the water table by the interconnected fracture network within the Chatsworth formation. This area of affected soil within the documented release area coincides with a localized depression at the top of the unweathered Chatsworth formation surface (Figure 2.3.2-6). This interpreted geologic feature might be an area of relatively high fracture density along the North Fault that could provide a pathway for contaminant migration in the subsurface. Well RD-52A, immediately west of this feature, has displayed the most elevated TCE concentrations at the LOX Plant, with levels ranging from 1,000 to 10,000 µg/L. The elevated concentrations of TCE and other VOCs in this area could still provide a source of groundwater contamination and soil vapor.

2.7 Human Health Risk Assessment for LOX Plant

The objective of this HHRA is to assess whether the environmental media at the LOX Plant could pose risks to human health that might require remedial action, or are eligible for an NFA designation. This HHRA assesses the potential current and future exposures to chemicals in soil, soil vapor, and groundwater at the LOX Plant. The methods and guidance documents used in the preparation of this HHRA are discussed in Section 1.5.3 of this report. A discussion of the HHRA results for the LOX Plant is presented below. The results are summarized in Section 2.9.2.

The concentration data, input parameters, and results of the HHRA for the LOX Plant are presented in Appendix B. An index of the tables (Appendix B human health RA Tables Index) is provided and can be used to locate tables that contain information regarding the HHRA data set, EPCs, exposure parameters, toxicity factors, estimated chemical intakes, estimated ELCRs, and estimated non-cancer HIs.

2.7.1 Identification of Chemicals of Potential Concern

Chemicals were selected as COPCs at the LOX Plant, based on the protocol presented in Sections 1.5.3.1 and 1.5.3.2.

2.7.1.1 Data Evaluation

The soil, soil vapor, and groundwater sampling analytical data at the LOX Plant were evaluated to assess their suitability for use in the risk assessment following the procedures presented in Section 1.5.3.1. Sediment and surface water data were not collected as part of the RFI site characterization activities. The locations of the soil, soil vapor, and groundwater samples used in this HHRA are shown in Figure 2.4-1. The samples used in this HHRA re listed in Table B.7.1-1 by medium, sample identification (ID), sampling depth interval, and date of collection. Table B.7.1-2 lists the target receptor populations by medium. Descriptive summary statistics of this data are provided in Table B.7.1-3.

2.7.1.2 Identification of COPCs in Soil

The results of the COPC screening process for soil at 0 to 2 ft bgs and 0 to 10 ft bgs are listed in Table B.7.1-3. Detected analytes in soil at the LOX Plant were compared to background levels. COPCs identified in soil (0 to 2 ft bgs) included 1 inorganic (barium) and 78 organics. COPCs identified in soil (0 to 10 ft bgs) included 2 inorganics (arsenic and barium) and 55 organics.

2.7.1.3 Identification of COPCs in Groundwater

NSGW data are not available for the LOX Plant; therefore, COPCs are not identified for groundwater.

2.7.1.4 Identification of COPCs in Soil Vapor

The results of the COPC screening process for soil vapor at 3 to 10 ft bgs are presented in Table B.7.1-3. The COPCs identified in soil vapor included 1,1-DCE, isopropanol, PCE, TCE, VC, xylenes total, cis-1,2-DCE, and trans-1,2-DCE.

2.7.2 Exposure Assessment

The exposure assessment component of the HHRA identifies the means by which individuals at or near the LOX Plant may come into contact with constituents in exposure media. It addresses current exposures and those that may result in the future under reasonably anticipated potential uses of the site and the surrounding areas. The exposure assessment also identifies the populations that may be exposed; the routes by which individuals may become exposed; and the magnitude, frequency, and duration of potential exposures. Figure 1.5.3-1 depicts the conceptual exposure model for the LOX Plant. Table B.7.1-2 summarizes the exposure scenarios. The methods and assumptions used in the exposure assessment are discussed in Section 1.5.3.3.

2.7.2.1 Identification of Receptors

The LOX Plant area recently was used for industrial purposes and is most likely to have a future industrial or recreational land use; however, a hypothetical future residential scenario also was included in the exposure assessment. Future residents are expected to have the greatest level of exposure. Therefore, the hypothetical future residential scenario, assuming adult and child receptors, was the most conservative scenario in the HHRA. In addition to the residential scenario, the industrial worker and recreationist exposure scenarios were evaluated.

As stated in Section 1.5.3.3, an agricultural-based residential exposure scenario will be evaluated to meet the requirements of Senate Bill 990.

2.7.2.2 Identification of Exposure Pathways

Future residents and industrial workers were assumed to be exposed to groundwater, seeps and springs (future residents only), soil vapor (modeled for migration to indoor air and ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Future recreationists were assumed to be exposed to groundwater, soil vapor (modeled for migration to ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Exposure pathways for groundwater, seeps and springs, and soil included direct exposures (ingestion and dermal) and indirect exposures. Inhalation exposures were quantified for the migration of groundwater and soil vapor to ambient air and indoor air. Additionally, exposures were quantified for residential receptors for inhalation of VOCs in bathroom air while showering or bathing for groundwater and seeps and springs. Residential receptors also were assumed to ingest edible plants and homegrown produce. The exposure pathways and exposure assumptions included in the HHRA for the LOX Plant are provided in Table B.7.1-6.

2.7.2.3 Exposure Point Concentrations

EPCs for soil at 0 to 2 ft bgs, soil at 0 to 10 ft bgs, soil vapor, seeps and springs, and groundwater at the LOX Plant are listed in Table B.7.1-3. EPCs were estimated for indirect exposures for the following media: airborne fugitive dusts, ambient air, indoor air, and edible plants (homegrown consumption). Airborne particulate COPC concentrations were estimated for non-volatile COPCs. The derivation of the PEF for soil is listed in Table B.7.1-7.

Ambient air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs to ambient air and migration from groundwater to ambient air. Parameter values used for soil vapor-to-air migration and for estimating the ambient air EPCs related to soils are listed in Table B.7.1-9. Parameter values used for estimating ambient air EPCs related to groundwater also are listed in Table B.7.1-9. The estimated ambient air concentrations from the migration of volatile COPCs in soil and groundwater are listed in Tables B.7.1-10, B.7.1-11, and B.7.1-12, respectively.

Indoor air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs and from NSGW using the J-E Model (EPA, 2004). The parameter values used in the J-E Model (EPA, 2004e) are presented in Table B.7.1-9. Soil vapor data, where available, were preferentially used for indoor air modeling. The estimation of indoor air concentrations from soil vapor and groundwater migration are presented in Tables B.7.1-13 through B.7.1-18.

The derivation of edible plant concentrations is calculated using soil-to-plant uptake factors, as described in the SRAM (MWH, 2005b). COPC concentrations in edible plant tissues from soil at 0 to 2 ft bgs are presented in Table B.7.1-19.

2.7.2.4 Intake Estimates

EPCs were applied to human intake equations, as presented in the SRAM (MWH, 2005b), to calculate chemical intakes for potential adult and child residential, adult and child

recreationist, and industrial worker receptors at the LOX Plant. The chemical-specific intakes were estimated based on an RME scenario and a CTE scenario. The exposure assumptions and the chemical intakes for soil are presented in Appendix B. See the Appendix B human health RA Tables Index for the exposure parameters and chemical intakes for each exposure scenario.

2.7.3 Risk Characterization

In the risk characterization component of the HHRA process, quantification of risk is accomplished by combining the results of the exposure assessment (estimated chemical intakes) with the results of the dose-response assessment (toxicity values identified in the toxicity assessment, see Section 1.5.3.4) to provide numerical estimates of potential health risks. The quantification approach differs for potential noncancer and cancer effects. The methods used in the risk characterization are discussed in Section 1.5.3.5.

The exposure assumptions, EPCs, toxicity factors, and risk characterization results tables for this HHRA are presented in Appendix B (Appendix B human health RA Tables Index**)**. The risk calculation tables present the estimated ELCRs and non-cancer HIs for potentially exposed receptors and individual exposure routes for soil, indoor air, and groundwater at the LOX Plant, as well as the cumulative risks and HIs across all exposure routes for the RME and CTE scenarios.

2.7.3.1 Hypothetical Future Adult Residential Exposure Scenario

Potential residential adult exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of homegrown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-5} for the CTE case to 1×10^{-4} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.002 for the CTE case to 0.01 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogencic COPCs for exposure to 0- to 2-foot-bgs soil from the plant consumption exposure route ranges from 6×10^{-1} for the CTE case to $1 \times 10^{+1}$ for the RME case. The RME and CTE ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 23 for the CTE case to 132 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-5} for the CTE case to 1×10^{-4} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.02 for the CTE case to 0.1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated inside a future residence. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-2} for the CTE case to 8×10^{-1} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 78 for the CTE case to 884 for the RME case. The CTE and RME HI estimate exceed the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-4} for the CTE case to 1×10^{-2} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 1 for the CTE case to 11 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

2.7.3.2 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Residential Exposure Scenario

Potential residential child exposure to COPCs in soil, soil vapor, seeps and springs, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of homegrown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-5} for the CTE case to 1×10^{-4} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range

from 0.02 for the CTE case to 0.06 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogencic COPCs for exposure to 0- to 2-foot-bgs soil from the plant consumption exposure route ranges from 6×10^{-1} for the CTE case to $3 \times 10^{+0}$ for the RME case. The RME and CTE ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 35 for the CTE case to 146 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-4} for the CTE case to 3×10^{-4} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.2 for the CTE case to 1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas is inhalation of vapors that have migrated inside a future residence. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 9 x 10-2 for the CTE case to 6 x 10-1 for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1 x 10-6 to 1 x 10-4. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 433 for the CTE case to 2624 for the RME case. The CTE and RME HI estimates exceed the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-3} for the CTE case to 9×10^{-3} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 5 for the CTE case to 33 for the RME case. The CTE and RME HI estimates exceed the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

2.7.3.3 Hypothetical Future Adult Recreational Exposure Scenario

Potential adult recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below.

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 8×10^{-7} for the CTE case to 7×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.0001 for the CTE case to 0.003 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-5} for the CTE case to 1×10^{-3} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.1 for the CTE case to 1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

2.7.3.4 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Recreational Exposure Scenario

Potential child recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. A hypothetical future recreationist child (15-kg body weight) was assumed to be exposed for 350 days per year over 6 years for the RME case and 6 years for the CTE case. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-5} for the CTE case to 7×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.002 for the CTE case to 0.02 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-4} for the CTE case to 3×10^{-3} for the RME case. The RME ELCR estimate exceeds the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.4 for the CTE case to 10 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

2.7.3.5 Hypothetical Future Industrial Worker Exposure Scenario

Potential industrial worker exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-6} for the CTE case to 1×10^{-4} for the RME case. The CTE and RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.001 for the CTE case to 0.01 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 9x 10-6 for the CTE case to 2 x 10-4 for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1 x 10-6 to 1 x 10-4. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.01 for the CTE case to 0.1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated inside a future industrial building. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 8×10^{-3} for the CTE case to 2×10^{-1} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 23 for the CTE case to 250 for the RME case. The CTE and RME HI estimates exceed the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-4} for the CTE case to 1×10^{-2} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.9 for the CTE case to 10 for the RME case. The RME HI estimates exceed the regulatory threshold value of 1. These ELCR and HI estimates are driven by a handful of samples with elevated VOC concentrations that skew the overall site EPC.

2.7.4 Uncertainty Discussion

Uncertainties associated with the results of this HHRA are a function of both the "state of the practice" of human health risk assessment in general and UFs specific to the LOX Plant. A discussion of the general HHRA uncertainty is presented in Section 1.5.3.

2.8 Ecological Risk Assessment for the LOX Plant

2.8.1 Problem Formulation

The problem formulation describes the site to be assessed, specifies the assumptions and data to be employed, and is generally the foundation of the ERA. Generalized components of the problem formulation, applicable to all RFI sites in Group 2, are described in Section 1.5.4.1. Problem formulation components specific to the LOX Plant are described below.

2.8.1.1 Site Background

LOX was produced at the LOX Plant using a cryogenic process in which air is liquefied and the oxygen is separated from the nitrogen (ICF, 1993). The LOX process did not appear to require the use of solvents, although it remains unclear whether Freon was used as a refrigerant (TechLaw, 1990). Solvents reportedly were used at the site for equipment cleaning, but only small quantities were used (SAIC, 1994). The former waste oil sump and clarifier were located north of the driveway leading to the LOX Plant. As part of an accelerated cleanup program in 1993, the sump and clarifier were excavated and removed (MWH, 2005d). The former sump and clarifier were used for disposing liquid wastes containing solvents, fuel, waste oil, and wastewater containing oil from the LOX Plant. There have been no reported releases from these units, but soil staining around the sump and clarifier was observed during the RFA (SAIC, 1994). A more detailed discussion of the site conditions and history is presented in Sections 2.1.2, 2.1.3, and 2.1.4.

The LOX Plant area contains a dirt road running east-west and north-south; the road is considered developed. The road and associated developed areas constitute about 15 percent of the land cover at this site. Habitat at the site was determined based on a site survey conducted by CH2M HILL staff in April 2008. This survey indicated that the LOX Plant area is made up of three habitat types, including scrub-shrub, ruderal, and woodland

habitat (Figure 2.8-1). Most of the site (about 25 percent) is made up of scrub-shrub habitat consisting mainly of coyote brush, Mexican elderberry, poison oak, and yerba santa. The scrub-shrub habitat is located in the north and northwestern portions of the site. Ruderal habitat makes up about 59 percent of the site and is located in the middle of the site. It is dominated by mulefat, coyote brush, short-pod mustard, red brome, and red-stemmed filaree. Less than 1 percent of the site is made up of woodland habitat, which is located along the southwestern edge of the site. Evidence or actual observation of the following species was noted during the site visit: song sparrow, California towhee, lark sparrow, western scrub-jay, house finch, spotted towhee, mourning dove, California quail, woodrat (dens and scat), kangaroo rat (burrows), coyote (scat), and cottontail rabbit. It also was noted that this area was burned in 2005, and standing burned woody vegetation is present. Stressed ruderal vegetation accounts for approximately 41 percent of the habitat at the site.

2.8.1.2 Ecological Management Goals, Assessment Endpoints, and Measures

The ecological management goal for the LOX Plant is the same as that for all Group 2 RFI sites, as follows:

- Maintenance of soil, sediment, water quality, food source, and habitat conditions capable of supporting ecological receptors, including special-status species, likely to be found in the area.
- Habitats present at the LOX Plant are exclusively terrestrial. Consequently, only terrestrial assessment endpoints and measures were identified for this site (Table 2.8-1).
- Representative species and receptor groups considered for the LOX Plant include the terrestrial plant community (primary producers), soil invertebrate community (primary consumers), hermit thrush (primary and secondary consumer), red-tailed hawk (tertiary consumer), deer mouse (primary and secondary consumer), mule deer (primary consumer), and bobcat (secondary and tertiary consumer).

2.8.1.3 Ecological Conceptual Site Model

The generalized ecological CSM for Group 2 is presented in Section 1.5.4.4. Because the LOX Plant is strictly a terrestrial location, only the terrestrial pathways are relevant. The CSM specific to the LOX Plant is described below and presented in Figure 2.8-2.

The primary contaminant sources at the LOX Plant include minor equipment cleaning activities and disposal of liquid wastes in the sump and clarifier. Primary release mechanisms include spills and leakage to the ground surface or leaks to subsurface soils from the sump. Secondary sources of potential contaminants are soils and soil vapor. Secondary release mechanisms include volatilization and wind erosion and bioaccumulation from soil.

Complete or potentially complete exposure pathways from contaminated soil and biota to ecological receptors exist at the sites. Burrowing mammals (deer mice) may be exposed to soil vapors via inhalation. Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, and small mammals resident in and associated with the site soils. Terrestrial wildlife (herbivores, omnivores, invertivores, and carnivores), including reptiles, may be exposed directly to contaminants in soil by incidental ingestion, by dermal contact, or by the inhalation of wind-borne particles. Terrestrial invertebrates

and wildlife (reptiles, birds, and mammals) also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (plants to herbivores, plants and prey animals to omnivores, etc.). Table 2.8-2 provides additional descriptions of potential exposure pathways for the ecological receptors at the LOX Plant, along with the rationale for inclusion or exclusion in the quantitative and qualitative evaluations.

2.8.1.4 Selection of Chemicals of Potential Ecological Concern

The process for the selection of CPECs is described in Section 1.5.4.4. Detected analytes in soil and soil vapor are listed in Table 2.8-3. Summary statistics for those detected analytes are listed in Table 2.8-4. TEQ values for dioxin and furans (including coplanar PCBs) were calculated as detailed in Table 2.8-5. A central tendency background comparison for metals and dioxins/furans in soils was conducted to assess whether the analytes were consistent with background (Table 2.8-6). The volatile organics in soil and soil vapor are compared in Table 2.8-7. Non-detect analytes were evaluated by comparing the maximum SQLs against the minimum ESL and determining the exceedance frequency of the SQLs (Table 2.8-8). The CPECs identified for the LOX Plant are summarized in Table 2.8-9. EPCs for each depth interval (0 to 2 ft, 0 to 4 ft, and 0 to 6 ft bgs) are provided in Tables 2.8-10, 2.8-11, and 2.8-12, respectively. EPCs for soil vapor from 0 to 6 ft bgs are listed in Table 2.8-13. Calculations for extrapolating soil vapor concentrations from soil concentrations are listed in Table 2.8-14.

2.8.2 Analysis

The analysis phase, which consists of the exposure characterization and the ecological effects characterization, links the problem formulation (Section 2.8.1) with the risk characterization (Section 2.8.3) and consists of the technical evaluation of ecological and chemical data to determine the potential for ecological exposure and effects. Generalized components of the exposure and ecological effects characterizations are presented in Section 1.5.4. Exposure and effects information specific to the LOX Plant is presented below.

2.8.2.1 Exposure Characterization

The exposure characterization is used to evaluate the relationship between receptors at the site and potential stressors (CPECs). The methods used to estimate exposure, including receptor-specific exposure models, exposure factors, and assumptions; exposure areas; and calculation of EPCs, are described in this section.

The receptor-specific exposure models, exposure factors, and assumptions presented in Section 1.5.4.4 are used for receptors at the LOX Plant. Because the LOX Plant is strictly terrestrial, exposure is based on soil and soil vapor and was evaluated only for terrestrial receptors (plants, soil invertebrates, birds, and mammals).

Although the LOX Plant is 4.2 acres, the spatial extent of samples associated with the site is 11.5 acres. Land cover consists primarily of ruderal habitat, with no buildings present at the site. Consequently, most of the site represents habitat of moderate or better quality, although almost half the site was noted as having stressed vegetation.

Summary statistics and EPCs for CPECs in soil at various depths (up to 6 ft bgs) and soil vapor were calculated for the LOX Plant, according to the approach outlined in

Section 1.5.4.4. These values are presented in Tables 2.8-10 through 2.8-13. Modeled exposure estimates for bird and mammal receptors are presented as part of the risk characterization (Section 2.8.3).

2.8.2.2 Ecological Effects Characterization

The ecological effects characterization consists of an evaluation of available toxicity or other effects information that can be used to relate the exposure estimates to a level of adverse effects. Generalized effects data for all receptors at the SSFL are summarized in Section 1.5.4.4. No effects data specific to the LOX Plant are available. Consequently, the ESLs, Low TRVs, and High TRVs for terrestrial receptors described in Section 1.5.4.5 were used to evaluate the effects associated with the estimated exposures.

2.8.3 Risk Characterization

The risk characterization integrates estimated CPEC exposures with their potential ecological effects on the assessment endpoints for the LOX Plant. The sequential processes for performing the risk characterization, described in Section 1.5.4.4, were applied to the LOX Plant. The results of these comparisons are presented below.

2.8.3.1 Risk Estimation

The Risk Estimation focuses primarily on quantitative methods to evaluate the potential for risk. The results of the quantitative risk estimation are presented as HQs and HIs. HQs and HIs for evaluated receptors are provided in Tables 2.8-15 through 2.8-22. Table 2.8-18 presents an analysis of the depth intervals for evaluation of burrowing animals (deer mouse). The 0- to 6-foot-bgs depth interval had the greatest HI; therefore, the data from this depth were used to evaluate the deer mouse.

2.8.3.2 Risk Description

The risk description incorporates the results of the risk estimates, along with any other available and appropriate lines of evidence to evaluate potential chemical impacts on ecological receptors in SSFL's Group 2. Chemicals that had HQs exceeding 1 were further evaluated to determine the COECs. Information considered in the determination of COECs includes receptor groups potentially affected, exceedance of Low and/or High TRVs, magnitude of exceedance, bioavailability, and habitat quality at the site.

To facilitate the interpretation of TRV exceedances, chemicals that exceeded one of the TRVs (ESL, Low TRV, or High TRV) were assigned into seven general risk groups (1 through 7, described below). These groups were created as an additional tool to assist risk managers in making remedial decisions. The groupings are subjective, based on professional judgment,

and the placement of a chemical within a given group is not an absolute indicator of the potential risk:

1. High Risk–HQs>5 for High TRV (RME), or HQs>100 for any EPC/TRV combination. Chemical classes with HIs>10 at High TRV (RME). Four or more receptors showing estimated risks.
2. Medium-High Risk–2<HQs<5 for the High TRV (RME). Chemical classes with 2<HIs<10 at the High TRV (RME) or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.
3. Medium Risk–1<HQs<2 for High TRV (RME), but HQ>10 for Low TRV (RME). Chemical classes with 1<HIs<2 at the High TRV or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.
4. Medium-Low Risk–HQs<1 for the High TRV (RME), but 1<HQs<10 for the Low TRV (RME). Chemical classes with HIs<1 at the High TRV or 2<HIs<10 at the Low TRV. No more than two of six receptors showing estimated risks.
5. Low Risk–HQs<1 for the Low TRV (RME). Chemical classes with HIs<1 at the Low TRV.
6. No Risk–all HQs and associated HIs<1.
7. Uncertain–TRVs unavailable to calculate either HQs or HIs.

Nine soil analytes (barium, PCB TEQ [PCB congeners], and seven PAHs) were found to have one or more HQs greater than 1 under any scenario (Table 2.8-23). All other soil analytes and/or analyte groups were found to pose no risk (all HQs and HIs were less than 1) to any receptor under any scenario (maximum concentration for plants, invertebrates, and soil vapor exposures; CTE and RME concentrations for birds and mammals) at the LOX Plant.

Two inorganics, barium and sodium, were identified as elevated relative to background, based on the non-parametric central tendency background comparisons for soil (Table 2.8-6). Barium had one or more HQs above 1 for at least one receptor in the refined screen. TRVs generally were not available for sodium. On the basis of the risk ranking discussed above, barium was found to pose a medium risk (1<HQs<2 for High TRV [RME], but HQ>10 for Low TRV [RME]).

Risks from barium are predicted for terrestrial plants (HQ = 1.9) and soil invertebrates (HQ = 2.9). It should be noted, however, that only 2 sample locations (LXSS04 and LXBSCB03S04) exceeded the plant ESL for barium and only 3 sample locations (LXSS04, LXTC0001S01, and LXBSCB03S04) exceeded the invertebrate ESL. This result represents less than 5 percent of the available samples. Additionally, two of these three locations (LXSS04 and LXBSCB03S04) were based on legacy data, for which depth information is not available. Consequently, there is uncertainty as to whether the samples truly represent soil depths in which terrestrial plants and soil invertebrates would occur and therefore be exposed. Risks to terrestrial plants and soil invertebrates, therefore, are highly localized to areas around these two and three samples, respectively.

Risks from barium are predicted for the hermit thrush, based on the high TRV and RME in the refined screen (HQs of 1.7), and for the deer mouse, with a high TRV-based HQ of 2.3. High TRV-based HQs for the hermit thrush and deer mouse, based on the CTE, also exceeded 1 (1.1 and 1.6, respectively). Because the maximum concentration for barium is based on legacy data that have unknown depth intervals, risks associated with this analyte are uncertain, but clearly are localized to a few hot spot areas. The magnitude of exceedance was low and barium was significantly elevated (only five samples were greater than two times background) at only a few locations. The areas with locations that contained the highest barium concentrations include LXSS04, LXTC0001S01, LXBS0052, LXBSCB05S02, and LXBSCB03S04.

In addition to the highly localized nature of elevated barium, some of the risk associated with barium is attributable to background concentrations. When accounting for background, the risk from barium is low and incremental risk HQs (difference between HQs from onsite barium data and HQs based on RME background barium concentrations, as detailed in Section 1.5.4) were all less than 5, with background making up about half the refined HQ values for the hermit thrush and deer mouse (Table 2.8-24). This result suggests that the some of the predicted exposure is associated with naturally occurring barium concentrations. Consequently, the risk from barium is considered low.

In addition to barium, seven PAHs and PCB congeners (based on the evaluation of 2,3,7,8-TCDD TEQs), were found to fail one or more screens for one or more receptors (Table 2.8-23). PAHs failed only the plant screen and the magnitudes of exceedance were all low (HQs less than 5), suggesting that PAHs pose a low risk. The PCB TEQ exceeded the low TRV for the hermit thrush based on the CTE and RME exposures, but the high TRV was less than 1 under all scenarios, indicating that the risk from PCB congeners also is low.

Soil vapor CPECs were identified and evaluated as part of this ERA. Nine analytes were detected in soil vapor, 5 non-detects were carried forward based on a comparison of SQLs to ESLs, and concentrations of 13 analytes were modeled based on detections in soil (Table 2.8-13). Of these, 11 analytes had HQs greater than 1 (Table 2.8-17). PCE was the only analyte considered to pose a low risk, based on the low magnitude of exceedance (HQ = 4) and low detection frequency (12 percent). All other soil vapor analytes (including one modeled concentration from soil) were considered to potentially pose risks and are recommended for additional evaluation. Soil gas concentrations were elevated significantly at several sampling locations, including LXSV70 through LXSV73, LXSV75 through LXSV77, and LXSV48. The highest concentrations were found at LXSV73 at 6 ft bgs. VC (1,200,000 mg/m^3) and cis-1,2-DCE (560,000 mg/m^3) were detected at the highest concentrations. Additional investigation of soil vapors is recommended at this site. Tables 2.8-25 and 2.8-26 list the soil chemicals of ecological concern and the soil vapor chemicals of ecological concern, respectively.

2.8.3.3 Uncertainty Analysis

Uncertainty is an implicit component in all risk assessments. Generalized uncertainties for ERAs in SSFL's Group 2 are summarized in Section 1.5.4.5. Additional uncertainties include the following:

- Samples were collected outside of the site boundary in an effort to define and fully characterize potential releases from the LOX Plant. If sample concentrations decreased with distance from the site, the inclusion of this additional data may underestimate risk in the core portion of the site when these data are integrated into the RME and CTE calculations.
- Depths were unavailable for several historical soil and soil vapor sample locations included in the LOX Plant dataset. The maximum concentration of barium was associated with these "legacy" data. In an effort to be conservative and to ensure completeness, these data were included in the 0- to 2-foot-depth interval for the purposes of risk assessment. There is some uncertainty associated with including these data in this depth interval (especially for soil vapor), and risks may be overestimated. However, it is likely that maximum soil concentrations would be detected at shallower depths, so inclusion with the shallowest depth interval for soil is deemed appropriate.
- Aroclor data were not evaluated in this assessment because PCB congener data were available and were used to calculate a TCDD TEQ. PCBs and dioxin/furans were evaluated based on the 2,3,7,8-TCDD TEQs. Concentrations of aroclors were low, and these are not expected to be significant contaminants of concern.
- No screening levels were available to evaluate the TPH data; however, PAH data were available and no risk from these constituents was predicted.
- Non-detect soil vapor analytes were included in the soil vapor screening, per the procedure dictated by the SRAM (MWH, 2005b). Because these analytes were not detected in any of the 187 collected samples, basing risk off the maximum SQL is conservative; this approach probably overestimates risk from exposure to soil vapor. However, soil vapor contamination is present at the site and may support the presence of some of the non-detect analytes with high SQLs.

2.8.4 Conclusions and Recommendations

Of the soil analytes that were evaluated, no analytes were found to pose high risks to the receptors evaluated at the LOX Plant. Barium was found to pose a medium risk, but because the magnitude of exceedance and incremental risk relative to background were low (background accounted for half of the predicted risk), the risk was considered low. Of the remaining soil analytes, 30 posed no risk and 28 lacked TRVs. Ten analytes in soil vapor were considered to pose risks and are recommended for further evaluation, based on the elevated concentrations detected in shallow soil vapor.

Although sitewide risks from barium probably are low, hot spot removal would reduce this risk, and barium is recommended for evaluation in the CMS.

2.9 Summary of Findings and Recommendations for Former LOX Plant

2.9.1 Nature and Extent of Contamination Summary

To evaluate the nature and extent of potential contaminants at the LOX Plant, 114 surface soil, 137 subsurface soil, and 262 soil gas samples were collected and analyzed for targeted potential contaminants. Of the surface soil samples collected, 14 dioxins, 16 metals, 3 PCBs (1 aroclor and 2 congeners), 10 SVOCs, 2 TPH groups, and 1 VOC (TCE) exceeded 1 or more of the screening criteria. Of the subsurface soil samples collected, 13 metals, 2 PCB aroclors, 9 SVOCs, 6 TPH groups, and 9 VOCs were reported at concentrations that exceeded 1 or more of the screening criteria. Seven VOCs were detected in soil gas samples at levels exceeding their respective screening criteria. Table 2.9-1 lists the parameters that exceeded the applicable comparison criteria. The extents of the parameters that exceeded the screening criteria at the LOX Plant have been evaluated sufficiently, for the most part. The horizontal extents of exceedances have been sufficiently assessed, although some data gaps remain while evaluating the vertical extents of potential contaminants in this area.

One metal (silver), 2 SVOCs (benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene), 1 TPH (TRPH), and one VOC (TCE) require additional sampling in subsurface soil to complete a vertical extent assessment in the LOX Plant. Most of the analytical data are legacy data from the site, and depths of refusal during subsurface soil investigative sampling efforts at this time are unavailable. There is a potential that these parameters have been evaluated to the points of refusal, but the lack of data prevents that analysis from being made. The TPH group TRPH-reported concentrations increased at the deeper sampling intervals, suggesting a potential for vertical migration. TCE was the sole parameter encountered in soil gas samples that requires additional sampling to complete the vertical extent evaluation. However, additional subsurface soil sampling for this parameter should be completed to provide an inferred boundary for VOC soil vapors.

2.9.2 Risk Assessment Summary

This subsection summarizes the HHRA performed for the LOX Plant. The HHRA assesses the potential current and future exposures to chemicals in surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater. The methods used to prepare the HHRA are described in Section 1.5.3. The results of the HHRA for the LOX Plant are presented in Section 2.7.

The surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater samples collected during the RFI sampling activities were evaluated for use in the HHRA. Surface water and sediment samples are not evaluated in this HHRA, because they were not present during the RFI site characterization activities. The HHRA data set is listed in Table B.7.1-3 in Appendix B. The COPCs identified from the LOX Plant HHRA data set for each exposure area are listed in Table B.7.1-5.

The potential future receptors at the LOX Plant include recreationists, workers, and residents. The LOX Plant and surrounding area is likely to have a future recreational or industrial land use; however, a hypothetical future residential scenario was assessed in the

HHRA, along with recreational and industrial exposure scenarios. The residential scenario consists of conservative exposure assumptions, and residents are expected to have the greatest level of exposure. The residential exposure scenario evaluated in this report assumes that exposure can occur through consuming fruits and vegetables from a garden. The agricultural residential exposure scenario evaluation will be included in a separate report. The assumed exposure pathways for future residents, workers, and recreationists are shown in Figure 1.5.3-1.

Generally, estimated cumulative cancer risks (ELCRs) less the regulatory risk range (range of 1 in a million [1 x 10-6] to 1 in 10,000 [1 x 10-4]) and estimated noncancer hazards (HIs) less than the regulatory threshold value of 1 are considered acceptable (EPA, 1993). Estimated ELCRs within the 1 x 10-6 to 1 x 10-4 range are managed on a site-specific basis. Table B.7.5-1 summarizes the ELCRs and HIs.

The following exposure scenarios for the LOX Plant exceed the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult and child residents exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult and child residents exposed to soil (0 to 2 ft bgs) from plant consumption
- Hypothetical future adult and child residents exposed to soil (0 to 10 ft bgs)
- Hypothetical future adult industrial worker exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult industrial worker exposed to soil (0 to 10 ft bgs)
- Hypothetical future residents, industrial workers, and recreationists exposed to indoor and ambient air (migration of soil vapor COPCs)

The following exposure scenarios for the LOX Plant are within the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult and child recreationist exposed to soil (0 to 2 ft bgs)

The following exposure scenarios for the LOX Plant exceed the regulatory threshold values for noncarcinogenic COPCs:

- Hypothetical future residents, industrial workers, and recreationists exposed to indoor and ambient air (migration of soil vapor COPCs)
- Hypothetical future adult and child residents exposed to soil (0 to 2 ft bgs) from plant consumption
- Hypothetical future child resident exposed to soil (0 to 10 ft bgs)

As described in Sections 1.5.3.6 and 2.7.4, there is a degree of uncertainty associated with these risk estimates that should be considered before risk management decisions are made.

2.9.3 Recommendations for Former Area II LOX Plant

On the basis of the historical sampling and the 2008 RFI investigation, additional sampling is warranted to further evaluate the extent of contamination in the subsurface to support risk assessment decisions. One metal (silver), 2 SVOCs (benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene), 1 TPH (TRPH), and one VOC (TCE) require additional sampling in the subsurface soil to complete a vertical extent assessment in the LOX Plant.

Of the soil analytes that were evaluated, no analytes were found to pose a high risk to the ecological receptors evaluated at the LOX Plant. Barium was found to pose a medium risk to birds and mammals; additional characterization is recommended. Of the remaining soil analytes, 30 posed no risk and 28 lacked TRVs. Ten analytes in soil vapor were considered to pose inhalation risks to burrowing mammals and are recommended for further evaluation, based on the elevated concentrations detected in the shallow soil vapor.

Potentially significant human health risks were identified for three COCs in soil–benzidine, BaP, and arsenic–along with a number of VOCs (in soil vapor) and PAHs (in surface soil). Human health risk estimates from arsenic, BaP, PAHs, and VOCs generally were driven by a localized area with elevated concentrations. However, it is recommended that the nature and extent of benzidine and, to a limited extent PAHs, be confirmed, based on the detection limits above the risk levels of concern and the fact that benzidine was not analyzed in many samples. After confirmation of the extent of contamination, removal of soils with elevated concentrations is recommended at this location to reduce human health risks.

3. Area II Landfill, SWMU 5.1

On the basis of the historical sampling and the 2008 RFI investigation, additional soil samples are warranted to more definitely evaluate the extent of metals, specifically copper, in the subsurface soils. Additional PCB congener surface soil samples also would provide a better understanding of the horizontal extent of contamination in the surface soil.

Of the 50 analytes (dioxins/furans and coplanar PCBs were counted as one analyte) in soil for which ecological risks were evaluated, significant risks were identified for three analytes: di-n-butylphthalate, bis(2-ethylhexyl)phthalate (BEHP), and dioxins/furans and coplanar PCBs. Ecological risk estimates from these analytes were driven by a localized area with elevated concentrations. As a consequence, additional investigation is not considered necessary. The removal of soils that have elevated concentrations, therefore, is recommended at this location, because it would reduce ecological risks.

Potentially significant human health risks were identified for three COCs in soil–BaP and coplanar PCBs–along with a number of benzene (in soil vapor) and PAHs (in surface soil). Human health risk estimates from chemical generally were driven by a localized area with elevated concentrations. However, it is recommended that the localized extent of benzene in soil gas and PAHs in soil be confirmed to address the risk-based assessment. After confirmation of the extent of contamination, the removal of soils with elevated concentrations is recommended to reduce human health risks.

3.1 Area II Landfill, SWMU 5.1 Site Background and History

The Area II Landfill is located in the northern portions of Areas I and II. It was active from approximately 1955 to 1980, but the years of primary use were between 1965 and 1978 (MWH, 2005d). The Area II Landfill received unused fill materials, vegetation, some drums of unknown content, and construction debris.

3.1.1 SWMUs and AOCs

The Area II Landfill has been identified as SWMU 5.1 and is the only SWMU or AOC associated with the site. As part of the VCEHD landfill program, the Area II Landfill has been designated a "closed landfill" (MWH, 2003e). The location of this SWMU is shown in Figure 3.1-1.

3.1.2 Site History

The Area II Landfill was acquired by NASA in 1973, along with the remaining Area II property (known as USAF Plant 57 under USAF ownership). The 3.6-acre landfill, which measured 500 ft wide by 150 ft deep by 50 ft across, is located in the northern portions of Areas I and II (SAIC, 1994). The landfill was active from approximately 1955 to 1980, but the years of primary use were between 1965 and 1978 (MWH, 2005d).

As noted in an MWH report: "There was no visible disturbance at the site in 1953. Use of the landfill is visible in the 1957 photograph, which shows an area disturbed north of the Area II Road along an east-west landfill access road that parallels the southern edge of the landfill area. The 1965 photograph shows some natural re-growth of the area with visible disturbance along the westernmost portion of the access road, northward into the canyon. The photographs appear to indicate primary activity between 1965 and 1978 based on what appears to be landfill-type activities. The greatest extent of the landfill boundary for these time periods is during 1978. Later aerial photographs from 1988 and 1995 show near-total re-vegetation of the disturbed areas" (MWH, 2003e).

The Area II Landfill received unused fill materials, vegetation, some drums of unknown content, and construction debris. Previous VSIs at the landfill reported that the visible waste appeared to consist of construction debris such as asphalt pieces, timber, vegetation, piping, cement, glass, and steel. The original content of the rusted drums is unknown. Drums and other receptacles containing kerosene also were identified on the landfill face during a VSI (SAIC, 1994). The drums were not found to be leaking upon removal; soil samples taken from the area beneath where the drums were located confirmed that they had not leaked.

A geophysical survey completed in 2003 by Utility Locating Services, Inc., identified several mass anomalies near the eastern and western ends (MWH, 2003e). An investigation by MWH followed and included 13 trench locations, 15 hand auger sample locations, and 33 test pits. The results were not published, but in 2004, the Area II Landfill was approved by the County of Ventura Environmental Health Division for trench backfilling following the investigation.

3.1.3 Site Inventories

An inventory of the buildings, tanks, transformers, and chemicals used at the Area II Landfill was completed as part of the preparation of this RFI. This information was obtained from historical document reviews, facility drawings, and VSIs. Because the above listed features historically have not been present at the landfill, inventories for these features are not included in this RFI.

3.1.4 Site Chemical Use Areas

There have been no documented releases from the Area II Landfill (ICF, 1993). There is no evidence of release controls at the Landfill.

Operations in Area II during the period of the Landfill use were petroleum-based liquid fuel rocket testing, component testing, maintenance facilities, and peace-keeper missile loading. The chemicals associated with these operations include the following:

- Liquid rocket test fuels such as kerosene (RP-1), jet fuel (JP-4), monomethyl hydrazine (MMH), hydrazine derivatives, and liquid hydrogen (LH2)
- Oxidizers such as LOX and nitrogen tetroxide (NTO)
- Fluoride compounds and inhibited red fuming nitric acid (IRFNA)
- Solvents such as TCE, 1,1,1-trichloroethane (TCA), and Freon 113

- Energetic materials such as perchlorate (this perchlorate is completely combusted during testing and is not exposed to the environment)
- Various chemicals associated with laboratory operations, waste oils, incinerator ash, and construction debris

3.1.5 Site Conditions

The Area II Landfill is relatively level in the southern portion, near the Area II Road, and has a steep north-facing slope. Two valleys extend from the southern portion of the landfill toward an ephemeral drainage to the north of the landfill. Up gradient of the northern ephemeral drainage ravine is underdeveloped Boeing land, Boeing Area I, and the NASA LOX Plant of Area II. The landfill is heavily vegetated (MWH, 2003e).

3.1.6 Site Habitats/Land Cover

The northern portions of the Area II Landfill are covered with chaparral and rock outcrops. The southern portion of the landfill is covered mainly with chaparral, but has some areas covered with venturan coastal sage scrub and contains access roads that are considered developed (Figure 3.1-2).

The Area II Landfill is habitat for mule deer. In addition, before the geophysical investigation at the landfill in 2003, the Coast horned lizard was observed at the site (MWH, 2003e).

3.1.7 Historical Document Reviews

As described in Section 1.5.1, a historical document review was completed of documents applicable to RFI Group 2. As a result of this historical document review, there were no new features identified at the landfill.

3.2 RFI Characterization Activities

This subsection describes the sampling objectives, sampling scope, and key decision points associated with defining the nature and extent of chemical effects for the surface soil, subsurface soil, and groundwater at the landfill.

3.2.1 Sampling Objectives

To characterize the extent of potential chemical impacts at the landfill, soil and groundwater samples were collected. The objectives of the investigation were as follows:

- Define the lateral and vertical extent of chemical impacts
- Define the potential gradients of chemicals
- Develop a sufficient data set for performing a risk assessment

These objectives contributed to the selection of sampling locations, analytical methods, and depths, while incorporating site-specific information such as the following:

- Site conditions observed at the location of proposed sampling
- Historical sampling results and/or previous remediation activities

- Fate and transport characteristics of chemicals
- SSFL background concentrations of chemicals
- SSFL SRAM-based screening concentrations for human health and ecological receptors

3.2.2 Sampling Scope

Provided in this report are all of the characterization results for soil matrix, soil vapor, and groundwater sampling. The total numbers of historical samples and samples collected as part of this RFI for soil matrix, soil vapor, and groundwater are summarized below.

- Soil matrix: 154
- Soil vapor: 83
- Groundwater: 1

These samples were collected between 1993 and 2008 to identify the potential chemical impacts associated with the activities at the landfill. Detailed summaries for all of these samples are described further in Section 3.4.

Note that four wells installed at the Area II Landfill were not sampled because of the seasonally dry conditions. Sampling will be completed during the next wet season.

3.2.3 Key Decision Points

The site-specific decision points identified for the landfill represent the assumptions and/or decisions made during the sampling phase component of this RFI.

For historical sample points where the sample depth had not been recorded, it was assumed that these sample points were taken between 0 and 2 ft bgs.

3.3 RFI Characterization Results

The characterization results from previous soil matrix, soil vapor, groundwater, and surface water investigations at the Area II Landfill are summarized below.

3.3.1 Soil Matrix and Soil Vapor Findings

Surface soil samples have been collected at the landfill beginning in 1993, with subsequent RFI sampling from 2003 through 2007. Soil sampling has been performed on the top of the landfill, the landfill face (to the north), the foot of the landfill, and in the ephemeral drainage ravine north of the landfill. Concentrations of dioxins, metals, PCBs, SVOCs, and TPHs were detected at levels above the ecological and human health screening criteria at 24 sample locations.

The ephemeral drainage ravine to the north of the landfill could potentially be affected by other areas. To the north lies undeveloped property of Boeing, to the northeast is Boeing Area I, where investigations have been and are being conducted in lieu of the inactive skeet range, and to the west is the LOX Plant of Area II outlined in Section 2 of this report. Samples collected in the drainage ravine itself yielded elevated concentrations of PAHs.

In the surface soil, concentrations at levels above the screening criteria were detected for dioxins, metals, PCBs, SVOCs, and TPHs. The subsurface soil samples also had the same parameter groups detected at levels above the screening criteria as did the surface soil.

In the soil gas sampling performed at the landfill for VOCs, only one location was identified with a VOC (benzene) detected at a level above the ecological and human health screening criteria.

The analytes detected at levels above the screening criteria at the landfill from the previous investigations and the 2008 RFI sampling are discussed in detail in Section 3.4.

3.3.2 Groundwater Findings

3.3.2.1 Background

The Area II Landfill is an approximately 3.6-acre site located in the northern section of Areas I and II. The landfill is relatively level in the southern upper portion near the Area II Road and has a steep north-facing slope. The elevation at the Area II Landfill varies from approximately 1,700 ft above msl at the northern boundary of the landfill to 1,820 ft above msl toward the southern boundary.

Before this RFI, no near-surface monitoring wells or piezometers existed at the Area II Landfill. As part of this RFI, 5 piezometers (PZ-133, PZ-134, PZ-135, PZ-136, and PZ-137) were installed at the Area II Landfill. The piezometers were installed within weathered bedrock of the Chatsworth formation at the top of fresh bedrock. Construction logs and boring logs for the newly installed piezometers are provided in Appendix C. Six Chatsworth formation groundwater monitoring wells surround the Area II Landfill and include RD-81, RD-82, RD-83, WS-09B, WS-12, and WS-13. Table 3.3.2-1 summarizes the well construction data for the newly installed piezometers and existing wells. All well locations are shown in Figure 3.3.2-1.

3.3.2.2 Local Geology

The Landfill II area is underlain by deposits of the Lower Burro Flats member of the Chatsworth formation, which consists primarily of medium-grained sandstone and also may contain significant siltstone and shale interbeds. The north fault transects the Landfill II area at the northern boundary. Recent geologic mapping at the former LOX Plant to the east has indicated that the north fault dips to the south at approximately 60 degrees (Geosyntec, May 2008). Figures 3.3.2-2 and 3.3.2-3 are geologic and hydrogeologic profiles across the Landfill II area.

During the rock-coring activities at PZ-133, PZ-134, PZ-135, PZ-136, and PZ-137, the materials encountered include fill and alluvium, weathered sandstone, and fresh, unweathered bedrock of the Chatsworth formation. Fill and alluvial material consisted of yellowish-brown to olive-brown silty to clayey sands. Some asphaltic materials were encountered, particularly at PZ-137. The thickness of the fill and alluvial material ranged from 1 foot at PZ-133 to approximately 26 ft thick at PZ-135. Materials that typically would be associated with landfill-deposited debris were not observed in cuttings, except for some asphaltic material at PZ-137.

Weathered sandstone and siltstone of the Chatsworth formation was encountered at all locations and ranged in color from various shades of brown to yellow and gray. Weathered sandstone ranged in texture from fine to coarse grained. Weathering graded in degree from light to heavy, RQDs were generally low (as compared with fresh bedrock), and the rock was typically weak. The depth to weathered bedrock ranged from approximately 1 foot at PZ-133 to 26 ft at PZ-135. The thickness of weathered bedrock ranged from 59 ft at PZ-133 to approximately 79 ft at PZ-134.

Fresh bedrock was encountered at depths ranging from 60 ft at PZ-133 to 88 ft at PZ-134. Fresh bedrock ranged in color from various shades of gray and brown and texturally from fine to medium grained. Some siltstone was also encountered. Core samples of fresh bedrock were typically described as strong rock, with fractures (both healed and open and some clay-lined), and with usually high RQDs.

The top of the Chatsworth formation elevation is presented in Figure 3.3.2-4. The contours shown reflect the sloping surface topography at the SWMU. There are no depressions or other discontinuities illustrated on the unweathered bedrock surface that would be interpreted as preferential pathways.

3.3.2.3 Local Hydrogeology

The occurrence of NSGW at the Landfill II area is not likely. A thin (less than 1 foot thick), potentially saturated interval of weathered sandstone at PZ-135 was measured on July 17, 2008. The water detected in PZ-135 may have been residual development water or condensate and will require sampling in future, planned sampling events for confirmation. Residual or condensate water at the bottom of many shallow wells in Area I has been reported to the DTSC in the past (The Boeing Company, Rocketdyne Propulsion and Power, 2002).

3.3.2.4 Characterization Results

There has been no prior NSGW characterization sampling at the Landfill II area. New piezometers have been installed and sampling has been conducted to evaluate whether NSGW is present within the weathered sandstones of the Chatsworth formation. Except for one location (PZ-135) that contained less than 1 foot of water, all other newly installed piezometers were dry during a sampling event conducted in July 2008. Section 3.4 summarizes the July 2008 sampling event at the Area II Landfill. Additional sampling events are planned to determine the effect of seasonal variations in precipitation and to confirm the NSGW conditions at the SWMU. The results of future sampling events will be provided as an addendum to this RFI report.

3.3.2.5 Chatsworth Formation Groundwater

VOCs have had a limited effect on the Chatsworth formation groundwater at the Landfill II area. An overview of VOCs in Chatsworth formation groundwater is provided herein to relate possible NSGW impacts (based on an assumption that NSGW will be present in piezometers for sampling in future events) with those in the Chatsworth formation groundwater. Chatsworth formation groundwater analytical results for the Area II Landfill are provided in Appendix C.

Figure 3.3.2-5 presents the concentration trends of the most commonly detected halogenated ethene and ethane concentrations over time in the groundwater samples collected from the Chatsworth formation groundwater monitoring wells. The highest VOC concentrations historically have been detected in groundwater samples collected from WS-12, to the northwest of the Landfill II area, and on the northern side of the north fault. The VOCs detected in WS-12 are considered to be the western boundary of the VOC distribution in the CFOU at the Area II Landfill. Elsewhere, halogenated ethene and ethane VOC concentrations have been at non-detect levels or below 10 µg/L.

3.3.3 Surface Water Findings

Surface water features at the Landfill II area consist of a single small ephemeral drainage ditch south of the landfill. The flow in this drainage is directed westward and exits the operational boundary of the SSFL north of the ELV area. NPDES monitoring of the surface water discharge is conducted at this point.

Surface water samples were not collected during this RFI investigation because of seasonally dry conditions.

3.3.4 Completeness of Characterization

Areas of known exceedances and areas downgradient from the Area II Landfill were further investigated through soil samples. The predominantly detected contaminants at the Area II Landfill are dioxins, metals, PCB (aroclors and congeners), SVOCs, and TPHs. The detections of these constituents primarily are attributed to the landfill activities.

3.3.4.1 NSGW Characterization

The occurrence of NSGW at the SSFL, including the Area II Landfill, if present, probably is ephemeral and is believed to be related to seasonal variations in precipitation. Newly installed piezometers (PZ-133, PZ-134, PZ-135, PZ-136, and PZ-137) have been sounded for the presence of groundwater, and where groundwater has been present, sampling of the groundwater has occurred. Except for a small amount of water in PZ-135, all newly installed piezometers were dry. No preexisting NSGW piezometers or wells were present. Additional synoptic gauging of piezometers for the occurrence of NSGW and sampling of NSGW, when present, is planned across several seasons to include late-winter and early-spring events, when precipitation is anticipated to increase. The NSGW monitoring network now in place is adequate to characterize the site conditions under optimum conditions.

3.3.4.2 Surface Water

NPDES monitoring of surface water discharges at the designated point north of the Area II landfill will continue. Drainages that exist at the Area II Landfill are directed to this point.

3.4 Area II Landfill, SWMU 5.1 Nature and Extent

Surface and subsurface soil samples were collected at the Area II Landfill, per the protocol described in Section 3.2 and the data provided in Appendix C. Figure 3-4.1 shows the sample locations at the site, and Table 3.4-1 lists the parameters analyzed for in the sample

media at the Area II Landfill. The nature and extent of contamination that exceeded the comparison criteria values in the media sampled are described below.

3.4.1 Surface Soil Nature and Extent

A total of 90 surface soil samples were collected at this site from 87 sampling locations and analyzed for dioxins, metals, PCBs (aroclors and congeners), SVOCs, TPH, and VOCs. Table 3.4-2 lists the parameters detected in the surface soil samples at the Area II Landfill.

3.4.1.1 Parameters Detected in Surface Soil

Dioxins. Seven surface soil samples were analyzed for dioxins at this site, which included both CDDs and CDFs. Dioxins were detected in all 7 of the surface soil samples collected. The current approach for assessing the toxicity of these mixtures is to use information regarding the toxic potency of the different congeners to convert the congener concentrations to a toxicologically equivalent concentration of the most potent congener, 2,3,7,8-TCDD. The 2,3,7,8-TCDD TEQs were reported by the laboratory for the historical surface soil dioxin samples, but not for the most recent two samples, A2BS1069 and A2BS1070. Neither of these samples, however, had reported concentrations of any dioxin at levels exceeding the screening criteria. The samples were evaluated for nature and extent by comparing the frequency of the different CDDs and the CDFs that exceeded the screening criteria at each location. The CDD and CDF exceedances, where added together according to the chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-) and the 2,3,7,8-TCDD TEQ values, were compared to the ecological screening criteria (0.0043 µg/kg) and the more conservative human health screening criteria (0.0013 µg/kg). These data are shown in Figure 3.4-2 and summarized in Table 3.4-2.

Only one sample, at A2BS0035, reported 2,3,7,8-TCDD TEQ at a concentration (0.007 µg/kg) that exceeded the screening criteria. Samples from the recent RFI sampling, at locations A2SB1069 and A2SB1070, did not exceed the screening criteria for 2,3,7,8-TCDD TEQ because none of the dioxin congeners at these locations exceeded the screening criteria. Downgradient from the exceedance location, additional samples were collected and analyzed for dioxins; none exceeded the screening criteria. The horizontal extent of dioxins in the surface soil at the Area II Landfill has been evaluated sufficiently. The vertical extent of these parameters is addressed in Section 3.4.2.

Metals. A total of 47 surface soils were analyzed for metals at the Area II Landfill. Of the metals detected, only 8 exceeded the screening criteria. The sample locations with metals exceedances are primarily in the west-central portion of the Area II Landfill and are bounded by locations in which the metals concentrations did not exceed the screening criteria. The horizontal extent of metals in the surface soil at the Area II Landfill has been evaluated sufficiently; the vertical extent of these parameters is addressed in Section 3.4.2. The details of the metals exceedances are summarized below.

Mercury, with 4 detections above the human health criterion of 0.09 mg/kg, was the most prevalent metal in the Area II Landfill. The mercury exceedances ranged from 0.097 mg/kg at A2B233 to 1.2 mg/kg at A2BS18. The mercury exceedances are bounded by locations at which the metals concentrations did not exceed the screening criteria, as shown in Figure 3.4-3.

Aluminum, arsenic, boron, cobalt, and selenium each had only one detection at levels above the screening criteria, with the exceedances being concentrated in the west-central portion of the Area II Landfill. Aluminum was detected in all of the samples collected, exceeding the screening criteria at A2BS1050 at 24,600 mg/kg, similar to the background concentration of 20,000 mg/kg. Arsenic was detected in all of the samples collected, but only exceeded the screening criteria at A2BS1044, with a concentration of 39.1 mg/kg. Boron was detected in 6 samples, but only exceeded the human health and ecological screening criteria of 6.76 mg/kg at A2BS33 with a concentration of 23 mg/kg. Cobalt also was detected in all of the samples collected, but only exceeded the screening criteria at A2BS32, with an estimated detection of 23 J mg/kg. Selenium was detected in the majority of the samples collected, exceeding the screening once at A2BS1044 at a concentration of 1.80 mg/kg.

Lead was detected above the screening criteria at two locations, A2BS33 (110 mg/kg) and A2BS039 (89 mg/kg), which were both bounded by locations in which the metals concentrations did not exceed the screening criteria. A2BS039 is located in the drainageway to the north of the Area II Landfill and is bound to the north and south by topography. Silver was detected at levels above the human health (0.53 mg/kg) and ecological (0.54 mg/kg) screening criteria at two locations in the drainageway. The silver detection at ASBS0040 (1.3 mg/kg) was downgradient and at a lower concentration than the silver exceedance at A2BS0035 of 1.7 mg/kg.

PCB Aroclors/Congeners. A total of 46 surface soil samples were collected and analyzed for PCB aroclors at the Area II landfill. PCB aroclors were detected in 6 of the samples, exceeding 1 or more of the screening criteria in 4 of the samples. Three of the sample locations had reported exceedances of 1 PCB aroclor each. At A2BS25, only Aroclor-1260 (93 µg/kg) exceeded the ecological (70 µg/kg) and human health (20 µg/kg) screening criteria. At A2BS1045, only Aroclor-1248 exceeded both the ecological and human health screening criteria (10 µg/kg each), at an estimated 304 J µg/kg. At A2BS1046, PCB-1254 exceeded only the human health screening criterion of 20 µg/kg, with an estimated concentration of 42.9 J µg/kg. Three PCB aroclors exceeded their respective screening criteria at A2BS27, PCB-1016 at 1,900 µg/kg compared to the ecological (1,600 µg/kg) and human health (20 µg/kg) screening criteria, PCB-1248 at 160 µg/kg, and PCB-1254 at 210 µg/kg. The exceedance samples are located in a tight grouping along the northern slope of the landfill. Several downgradient samples were collected that did not exceed any screening criteria. The horizontal extent of the PCB aroclors in surface soil at the Area II Landfill has been evaluated sufficiently. The vertical extent of these parameters is addressed in Section 3.4.2.

PCB congeners were analyzed for at four locations in the surface soil at the Area II Landfill. Four PCB congeners (PCB-77, PCB-81, PCB-118, and PCB-126) were detected at concentrations that exceeded both the human health and ecological screening criteria. PCB-77, PCB-81, and PCB-118 exceeded the criteria at one location, A2BS1045, at an estimated 3.6 J µg/kg, 0.2 J µg/kg, and 8.5 J µg/kg, respectively. This location, on the northern slope, is the furthest downhill of the four samples collected. PCB-126 exceeded the screening criteria at A2BS1045 at an estimated 0.06 J µg/kg, and at A2BS1048 at an estimated 0.05 J µg/kg, compared to the common ecological and human health screening criteria of 0.01 µg/kg. Neither of these exceedance locations is bound downgradient. An additional evaluation of PCB congeners in surface soil at the Area II Landfill is warranted.

SVOCs. A total of 62 surface soil samples were collected from 61 locations at the Area II Landfill and analyzed for SVOCs. Of the 22 SVOCs detected, 9 exceeded 1 or more of the screening criteria. Most of the exceedance samples are located either along the western portion of the northern slope near the valley that runs into the stream located along the northern base of the landfill or along the stream. All 9 SVOCs that exceeded the criteria are bound downstream by 1 or more samples that either did not have detections of the respective SVOCs or did not have detections at concentrations that exceeded the screening criteria. The horizontal extent of the SVOCs in surface soil at the Area II landfill has been evaluated sufficiently. Details regarding the SVOC exceedances are provided below.

BEHP, chrysene, and di-n-butyl phthalate each exceeded 1 or more of the screening criteria at 1 location. BEHP and di-n-butyl phthalate each exceeded the screening criteria at A2BS1045. BEHP was reported at 26,600 µg/kg compared to the ecological (4,900 µg/kg) and human health (4,930 µg/kg) criteria. Di-n-butyl phthalate was reported at 349,000 µg/kg compared to the ecological and human health screening criteria (490 µg/kg each). Chrysene was reported at A2BS0038, at 2,700 µg/kg, compared to the ecological (2,400 µg/kg) and human health (870 µg/kg) screening criteria.

Dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene each exceeded their respective human health screening criteria in 3 samples. Exceedance concentrations of dibenz(a,h)anthracene ranged from 41 µg/kg at A2BS0039 to 280 µg/kg at A2BS0038, compared to the human health screening criterion of 30 µg/kg. Indeno(1,2,3-cd)pyrene exceeded the human health screening criterion (110 µg/kg) at concentrations ranging from 140 µg/kg (A2BS0039) to 1,100 µg/kg (A2BS0038). Benzo(k)fluoranthene exceeded its human health screening criterion of 100 µg/kg at 4 locations, at concentrations ranging from 110 µg/kg (A2BS20) to 1,400 µg/kg (A2BS0038). All except 1 of these exceedances are located along the stream that runs at the bottom of the northern slope toward the northwest. Figure 3.4-4 shows the extent of benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene in the surface soils at the Area II Landfill. Each of the SVOCs is bound downstream by samples that had concentrations reported at levels below the screening criteria.

Most of the exceedances were reported in BAA, BaP, and benzo(b)fluoranthene. Benzo(b)fluoranthene was detected in 14 of the surface soil samples collected and analyzed for SVOCs, exceeding the human health screening criterion of 100 µg/kg in 7 of those samples. Concentrations of benzo(b)fluoranthene ranged from 110 µg/kg (at A2BS20, A2BS28, and A2BS10) to 3,100 µg/kg at A2BS0038. BAA was detected in 16 samples, exceeding the human health screening criterion of 80 µg/kg in 9 of those samples. Concentrations of BaP ranged from 81 µg/kg at NDBS0112 to 2,600 µg/kg at A2BS0038. BaP was detected in 19 of the surface soil samples, exceeding the human health screening criterion of 10 µg/kg in 17 of those samples. Concentrations of BaP ranged from an estimated 22 J µg/kg at A2BS11 to 3,2000 µg/kg at A2BS0038. Figure 3.4-5 shows the extents of BAA, BaP and benzo(b)fluoranthene in surface soils at the Area II Landfill. Although the concentrations generally are higher in the stream that runs along the northern edge at the bottom of the landfill, all 3 of these SVOCs were bound by 1 or more samples that did not have reported detections of the compound.

TPHs. TPHs were detected in 60 of the 70 surface soil samples collected at the Area II Landfill and analyzed for TPH. Only 2 TPHs exceeded the ecological and human health

screening criteria of 100,000 µg/kg each. EFH (C15-C20) exceeded the screening criteria at A2BS28 at an estimated 120,000 J µg/kg. EFH (C21–C30) exceeded the screening criteria in 14 samples at concentrations ranging from 110,000 µg/kg at A2BS33 to an estimated 690,000 J µg/kg at A2BS29. Figure 3.4-6 shows the extent of EFH (C21–C30) in surface soil at the Area II landfill. Most of the exceedance samples were located on the northern slope of the landfill near the valley that runs into the stream at the base of the slope. The exceedance samples are bound downstream by samples that did not have reported exceedances of the comparison criteria. The horizontal extent of TPHs in surface soil at the Area II landfill has been evaluated sufficiently.

VOCs. No VOCS were detected at levels that exceeded the screening criteria in surface soil at the Area II Landfill.

3.4.2 Subsurface Soil Nature and Extent

Sixty-four subsurface soil samples were collected from 52 locations to a maximum depth of 20.5 ft bgs at the Area II Landfill. The subsurface soil at the site was analyzed for dioxins, metals, PCBs (aroclors and congeners mixtures), SVOCs, TPHs and VOCs. In addition, one sample was analyzed for explosives but no explosive compound was detected in the sample. Tables 3.4.-3 and 3.4.-4 list the parameters detected in the subsurface soil samples at the Area II Landfill.

3.4.2.1 Parameters Detected in Subsurface Soil

Dioxins. As with the dioxin investigation in the surface soils, the 4 subsurface soil samples collected to a depth of 5 ft bgs were analyzed for both CDDs and CDFs. Likewise the approach in subsurface soils is to assess the toxicity of these mixtures by using the information regarding the toxic potency of the different congeners and converting them to 2,3,7,8-TCDD TEQs. The frequency of the different CDDs and CDFs that exceeded their respective screening criteria at each location were added together according to chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-), and the 2,3,7,8-TCDD TEQ values were compared to the screening criteria, as summarized in Table 3.4-5.

The 2,3,7,8-TCDD TEQ values exceeded the human health (0.0013 µg/kg) and ecological (0.0043 µg/kg) comparison criteria at A2TS33S01 (0.017 µg/kg) and A2TS33S02 (0.0014 µg/kg) at 3 ft bgs each. All 4 of the subsurface soil samples collected and analyzed for dioxins are located in a tight grouping on the top northwestern edge of the landfill. The exceedances were reported at 3 ft bgs; both of the additional samples collected deeper than 3 ft bgs did not have exceedances of the screening criteria. The vertical extent of dioxins in the subsurface soil at the Area II Landfill has been evaluated sufficiently.

Metals. A total of 49 subsurface soil samples were collected from 46 locations in the Area II Landfill to a maximum depth of 20 ft bgs and analyzed for metals. Of the 25 metals detected, 16 exceeded 1 or more of the screening criteria. Most of the metals were detected at concentrations similar to their respective background concentrations. Except for copper, all of the exceedance metal samples are bound either by additional samples with non-exceedances or by geography, and their characterization has been evaluated sufficiently. Although copper was not sufficiently evaluated in the eastern edge of the landfill, it is expected to be present in the landfill at high concentrations because the landfill received

construction debris, including pipes and wiring. Details regarding the metals exceedances are provided below.

Cobalt and molybdenum exceeded their respective human health and ecological screening values in 1 and 2 samples, respectively at concentrations similar to their respective background values. Cobalt was detected in all samples collected, exceeding both the ecological and human health screening criteria of 8.9 mg/kg at A2TS01S01 (17 ft bgs). Cobalt was reported at an estimated 31.9 J mg/kg, similar to a background value of 21 mg/kg. Molybdenum was detected in 28 of the subsurface soil samples, exceeding both the ecological (0.11 mg/kg) and human health (0.1 mg/kg) screening criteria at A2TS08S02 (8 mg/kg at 14 ft bgs) and A2TS08S08 (8.7 mg/kg at 5 ft bgs). Both of these reported concentrations are similar to the background concentration of 5.3 mg/kg and have been characterized sufficiently.

Aluminum and vanadium also exceeded the screening criteria at concentrations similar to their respective background values. Aluminum was detected in 48 of the samples, exceeding the comparison criteria at 4 locations. Concentrations of aluminum that exceeded the screening criteria ranged from 21,000 mg/kg at A2TS33S04 (4 ft bgs) to an estimated 31,900 J mg/kg at A2TS01S01 (17 ft bgs). These concentrations are similar to the background level of 20,000 mg/kg. Vanadium was detected in 48 samples, exceeding the screening criteria in 3 samples. Exceedance concentrations of vanadium ranged from an estimated 73.6 J mg/kg at A2TS03 (17 ft bgs) to an estimated 87.1 J mg/kg at A2RS01S01 (17 ft bgs), compared to a background level of 62 mg/kg. Vanadium has been characterized sufficiently.

Barium was detected in all samples collected and exceeded the screening criteria in 5 of the samples. Four of those 5 samples exceeded the screening criteria at concentrations similar to background (140 mg/kg), from an estimated 145 J mg/kg at A2TS03 (17 ft bgs) to an estimated 200 J mg/kg at A2TS01S01 (17 ft bgs). One relatively shallow sample at A2TS02 (6 ft bgs) was reported at an estimated 435 J mg/kg. This sample is located at the top of the landfill and is surrounded by samples at similar or deeper depths in which barium either was not detected or did not exceed the criteria. Figure 3.4-7 shows the extent of barium in subsurface soil at the Area II landfill, which has been characterized sufficiently.

Beryllium was detected in all of the samples collected and exceeded only the human health screening criterion of 0.9 mg/kg in 3 of the samples. Exceedance concentrations ranged from an estimated 1.8 J mg/kg at A2TS03 (17 ft bgs) to an estimated 2.4 J mg/kg at A2TS01S01 (17 ft bgs), compared to a background concentration of 1.1 mg/kg. Figure 3.4-8 shows the extent of beryllium in subsurface soil at the Area II landfill, which has been characterized sufficiently. As shown, each exceedance sample is located near the top of the landfill and is surrounded by samples at similar depths where beryllium either was not detected or did not exceed the screening criteria. Also, these subsurface samples only exceeded the human health screening criteria; none exceeded the ecological screening criterion of 5 mg/kg.

Cadmium was detected in 48 of the subsurface soil samples collected, exceeding the screening criteria in 6 of the samples. Four of the 6 samples were reported at concentrations similar to the background concentration of 1 mg/kg. These concentrations ranged from 1.1 mg/kg at A2TS03 (17 ft bgs) to 1.9 mg/kg at A2TS33S01 (3 ft bgs). Two additional

samples were reported at 2.2 mg/kg at A2TS01S01 (17 ft bgs) and 4.1 mg/kg at A2TS08S08 (5 ft bgs). Both of these samples are located on the eastern edge of the top of the landfill. Figure 3.4-9 shows the extent of cadmium in subsurface soil at the Area II landfill, which has been characterized sufficiently.

Chromium was detected in all of the subsurface soil samples collected, exceeding the screening criteria in 5 samples. Three of the 5 samples were reported at concentrations similar to the background concentration of 36.8 mg/kg. These concentrations ranged from an estimated 43.9 J mg/kg at A2TS02 (6 ft bgs) to an estimated 58.5 J mg/kg at A2TS01S01 (17 ft bgs). Two additional samples were reported at an estimated 110 J mg/kg at A2TS08S08 (5 ft bgs) and 350 mg/kg at A2TS08S02 (14 ft bgs). Both of these samples are located on the eastern edge of the top of the landfill, within 1 foot of each other, and are surrounded by samples at similar depths that do not have reported exceedances. Figure 3.4-10 shows the extent of cadmium in subsurface soil at the Area II landfill, which has been characterized sufficiently.

Copper was detected in all of the subsurface soil samples collected, exceeding the screening criteria in 9 of the samples. Four of the 9 samples were reported at concentrations similar to the background concentration of 29 mg/kg. These concentrations ranged from 30 mg/kg at A2TS33S04 (4 ft bgs) to 44 mg/kg at A2TS33S01 (3 ft bgs). Five additional samples were reported at concentrations ranging from 61 mg/kg at A2TS33S02 (3 ft bgs) to 2,600 mg/kg at A2TS08S08 (5 ft bgs). Of these samples, 3 are located along the western edge of the top of the landfill. These locations are bound by samples at similar or deeper depths that did not have exceedances of the criteria. The 2 samples located on the eastern edge of the top of the landfill (A2TS33S02 and AT2S26S01) are not bound by samples at deeper depths in this area. Because these samples were collected from within the landfill, which received construction debris, copper is an expected compound; however, additional subsurface investigation is warranted along the eastern edge of the landfill. Figure 3.4-11 shows the extent of copper in subsurface soil at the Area II landfill.

Lead was detected in all of the subsurface soil samples collected, exceeding the screening criteria in 3 samples. One of the 3 samples, A2TS08S12 (15 ft bgs) was reported at a concentration similar to the background concentration of 34 mg/kg, at 36 mg/kg. The other 2 samples were reported at 86 mg/kg at A2TS08S02 (14 ft bgs) and an estimated 260 J mg/kg at A2TS08S08 (5 ft bgs). Both of these samples are located on the eastern edge of the top of the landfill, within 1 foot of each other, and are surrounded by samples at similar depths that did not have reported exceedances. Figure 3.4-12 shows the extent of lead in subsurface soil at the Area II landfill, which has been characterized sufficiently.

Manganese was detected in all 4 of the subsurface soil samples collected and analyzed for manganese, exceeding the screening criteria in 3 samples. Two of the 3 samples were reported at concentrations similar to the background concentration of 495 mg/kg. At A2TS03 (17 ft bgs), manganese was reported at an estimated 656 J mg/kg; at A2TS02 (6 ft bgs), it was reported at an estimated 908 J mg/kg. At A2TS01S01 (17 ft bgs), manganese exceeded the screening criteria at an estimated 1,090 J mg/kg. Figure 3.4-13 shows the extent of manganese in subsurface soil at the Area II landfill, which has been characterized sufficiently.

Mercury was detected in 44 of the subsurface soil samples collected, exceeding the screening criteria in 4 of the samples. Three of the 4 samples were reported at concentrations similar to the background concentration of 0.09 mg/kg. These concentrations ranged from 0.092 mg/kg at A2TS08S02 (14 ft bgs) to 0.14 mg/kg at A2TS08S08 (5 ft bgs). The maximum exceedance concentration was reported at 0.34 mg/kg at A2TS03 (3 ft bgs). This sample is bound by samples at similar or deeper depths that did not have exceedances of the screening criteria; mercury has been characterized sufficiently. Figure 3.4-14 shows the extent of mercury in subsurface soil at the Area II landfill.

Nickel was detected in all of the subsurface soil samples collected, exceeding the screening criteria in 5 samples. Two of the 5 samples were reported at concentrations similar to the background concentration of 29 mg/kg. At A2TS33S01 (3 ft bgs), nickel was reported at 30 mg/kg, and at A2TS01S01 (17 ft bgs), it was reported at 51.3 mg/kg. The remaining samples were reported at concentrations ranging from an estimated 100 J mg/kg at A2TS08S08 (5 ft bgs) to 220 mg/kg at A2TS08S02 (14 ft bgs). These two samples are located within a foot of each other; the third sample (A2TS08S12 [15 ft bgs]) is located within approximately 20 ft of them. These samples are surrounded by samples at similar or deeper depths that did not have reported exceedances; therefore, nickel has been characterized sufficiently. Figure 3.4-15 shows the extent of nickel in subsurface soil at the Area II landfill.

Silver was detected in 12 of the subsurface soil samples collected, exceeding the screening criteria in 4 of the samples. One of the 4 samples, A2TS08S12 (15 ft bgs), was reported at a concentration similar to the background concentration of 0.79 mg/kg, at 0.86 mg/kg. The remaining samples were reported at concentrations ranging from 2 mg/kg at A2TS08S02 (14 ft bgs) to 3.7 mg/kg at A2TS08S08 (5 ft bgs). Again, these samples are within a foot of each other and bound by numerous samples. A2TS26S01 (6 ft bgs), where silver was reported at a concentration of 2.5 mg/kg, is located within 5 ft of A2TS26S02, where silver was not detected at 8 ft bgs. Figure 3.4-16 shows the extent of silver in subsurface soil at the Area II landfill, which has been characterized sufficiently.

Sodium was detected in all 4 of the subsurface soil samples collected and analyzed for it and exceeded the screening criteria in all 4 samples. Concentrations ranged from an estimated 167 J mg/kg at A2TS03 (3 ft bgs) to an estimated 2,380 J mg/kg at A2TS02 (6 ft bgs), compared to a background value of 110 mg/kg. Like manganese, sodium was not analyzed at all subsurface soil sample locations because it is not a COC at this site. Figure 3.4-17 shows the extent of sodium in subsurface soil at the Area II landfill.

Zinc was detected in all of the subsurface soil samples collected, exceeding the screening criteria in 5 of the samples. Three of the 5 samples were reported at concentrations similar to the background concentration of 110 mg/kg. These concentrations ranged from an estimated 117 J mg/kg at A2TS02 (6 ft bgs) to an estimated 190 J mg/kg at A2TS01S01 (17 ft bgs). Two additional samples were reported at 300 mg/kg at A2TS08S02 (14 ft bgs) and 770 mg/kg at A2TS08S08 (5 ft bgs). Both of these samples are located on the eastern edge of the top of the landfill, within 1 foot of each other, and are surrounded by samples at similar depths that did not have reported exceedances. Therefore, zinc has been characterized sufficiently. Figure 3.4-18 shows the extent of zinc in subsurface soil at the Area II landfill.

PCBs Aroclors/Congeners. A total of 50 subsurface soil samples were collected from 45 locations at the Area II Landfill to a maximum depth of 20.5 ft bgs and analyzed for PCBs

(aroclors and congeners). Only one PCB congener was reported at levels exceeding the screening criteria. PCB-126 was reported at A2BS1048 (10 to 11 ft bgs) at an estimated concentration of 0.03 µg/kg, exceeding both the ecological (0.014 µg/kg) and human health (0.013 µg/kg) screening criteria.

PCB-1254 (Aroclor-1254) was the only PCB aroclor detected in subsurface soil at levels exceeding 1 or more of the screening criteria. PCB-1254 was detected at concentrations ranging from 70 µg/kg at A2TS17S01 (14 ft bgs) to 160 µg/kg at A2TS08S08 (5 ft bgs), compared to the ecological (70 µg/kg) and human health (20 µg/kg) screening criteria. Only sample location, A2TS17S01, does not have any nearby samples collected to a similar or deeper depth to evaluate the vertical extent at this location; however, the sample is located at the edge of the northern slope of the landfill and downhill samples are collected from a surface elevation that is 10 to 20 ft lower than that at A2TS17S01. These samples, therefore, are collected at a similar or deeper subsurface elevation; these samples either did not have exceedances of the comparison criteria or concentrations were not detected. PCB-1254, therefore, has been characterized sufficiently. Figure 3.4-19 shows the extent of PCB-1254 (Aroclor-1254) in the subsurface soil at the Area II Landfill.

SVOCs. A total of 53 subsurface soil samples were collected from 46 locations at the Area II Landfill to a maximum depth of 20 ft bgs and analyzed for SVOCs. Of the 17 SVOCs detected, 4 exceeded their respective human health screening criteria. Benzo(b)fluoranthene and benzo(k)fluoranthene each exceeded their common human health screening criterion (100 µg/kg each) at 2 locations. Both benzo(b)fluoranthene and benzo(k)fluoranthene had exceedances at A2BS19 (4 ft bgs) at 120 µg/kg and 130 µg/kg, respectively, and at A2TS08S08 (5 ft bgs) at 130 µg/kg, each.

BAA exceeded the human health screening criterion of 80 µg/kg in 4 samples. Exceedance concentrations ranged from an estimated 99 J µg/kg at A2TS12S01 (6 ft bgs) to 170 µg/kg at A2TS08S08 (5 ft bgs). Figure 3.4-20 shows the extent of BAA in subsurface soil at the Area II Landfill. As shown in Figure 3.4-20, these exceedance locations are all bound by samples collected at similar or deeper depths that did not have detections of BAA or concentrations did not exceed the screening criteria. Therefore, BAA has been characterized sufficiently.

BaP was reported at concentrations exceeding only the human health screening criterion of 10 µg/kg in 9 samples. The exceedance concentrations ranged from an estimated 13.7 J µg/kg at A2BS1051 (6 ft bgs) to 160 µg/kg at A2BS19 (4 ft bgs). The exceedance samples are distributed laterally across the top of the landfill. Figure 3.4-21 shows the extent of BaP in subsurface soil at the Area II Landfill. The lateral distribution of the exceedance samples indicates there are small isolated pockets of the compound, but it was not reported extensively in the subsurface soils. BaP, therefore, has been characterized sufficiently.

TPHs. TPHs were detected in 28 of the 46 subsurface soil samples collected and analyzed for TPHs. Only EFH (C21–C30) was reported at concentrations that exceeded both the ecological and human health screening criteria of 100,000 µg/kg. EFC (C21–C30) exceeded the criteria in 12 samples at concentrations ranging from 110,000 µg/kg at A2TS05S01 (5 ft bgs) to an estimated 1,100,000 J µg/kg at A2TS07S02 (5 ft bgs). Most of the exceedance samples were collected at relatively shallow depths (10 ft bgs or less), except at A2TS07S01 (15 ft bgs) and A2TS17S01 (14 ft bgs). In each area where exceedance samples are located,

nearby samples from similar or deeper soils had concentrations of EFH (C21–C30) that either were not detected or were detected at concentrations below the screening criteria; therefore, this parameter has been characterized sufficiently. Figure 3.4-22.shows the extent of EFH (C21–C30) in the subsurface soil at the Area II Landfill.

VOCs. No VOCs were reported at concentrations that exceeded the screening criteria in any of the 42 subsurface soil samples collected at the Area II Landfill.

3.4.3 Soil Gas Nature and Extent

A total of 82 soil gas samples were collected at this site from 33 sampling stations to a maximum depth of 19.5 ft bgs. The soil gas samples were analyzed for VOCs and SVOCs at the landfill, and 1 VOC was encountered at a concentration exceeding the screening criteria at only 1 location. Table 3.4-6 lists the parameters detected in the soil gas samples at the landfill. The extent of VOCs encountered in the soil gas samples at the site is detailed below.

One exceedance of benzene was reported at A2SV21 (3.5 ft bgs) at a concentration of 1,000 $\mu g/m^3$, exceeding its human health (570 $\mu g/m^3$) and ecological (36.2 $\mu g/m^3$) comparison criteria. However, this exceedance concentration is the same as the laboratory RL of 1,000 $\mu g/m^3$. This sampling station is situated near other stations that did not have reported detections for benzene. On the basis of this information, the horizontal extent of benzene has been sufficiently characterized.

3.5 Conceptual Site Exposure Model

A generalized CSM for the human health exposure pathways is presented in Section 1.5.3.3. Given the potential future land use, the following receptors will be addressed in the Area II Landfill HHRA:

- Future onsite adult industrial workers potentially exposed to chemicals in soil, indoor air, outdoor air, and seeps and springs (where applicable)
- Hypothetical future onsite adult and child recreationists potentially exposed to chemicals in soil, outdoor air, and seeps and springs (where applicable)
- Hypothetical future onsite adult and child residents potentially exposed to chemicals in soil, indoor air, outdoor air, home-grown produce, groundwater (where applicable), and seeps and springs (where applicable)

In addition, in accordance with California Senate Bill 990, a hypothetical future subsistence agricultural exposure scenario includes the assessing the risks associated with the potential consumption of beef, eggs, milk, swine, fruits, and vegetables. However, pending final agreement of the input assumptions considered in the scenario, the assessment of the subsistence agricultural exposure scenario will be included in a supplemental risk assessment report separate from this RFI Report.

Any deviations from this generalized CSM for the Area II Landfill are presented in Section 3.7.2.

3.6 Fate and Transport Analysis for Chemicals Detected in Groundwater in Surficial Media at the Area II Landfill

No groundwater is present in the SMOU at the Area II Landfill, based on Group 2 RFI characterization efforts to date. Therefore, no fate and transport analysis for this media is warranted at this time. Sampling during the rainy season in 2009 may yield groundwater analytical results that will be evaluated in an addendum to the Group 2 RFI.

3.6.1 Contaminant Sources and Release Mechanisms

The primary release mechanism for contamination at the Area II Landfill is attributed to the waste materials (unused fill materials, vegetation, some drums of unknown content, and construction debris) disposed in the landfill.

3.6.2 Potential Routes of Migration

The primary pathway for contaminant transport from the source areas at the Area II Landfill is the vertical migration of contaminants from the surface soil to subsurface soil. A secondary transport mechanism for this site includes the release of surface soil to the air by wind erosion or volatilization.

3.6.3 Contaminant Persistence

Dioxins, inorganics, SVOCs, PCBs, and TPHs were detected in the surface and subsurface soil at the Area II Landfill at levels above their screening criteria.

3.6.3.1 Area II Landfill Parameters

This subsection describes the chemicals that are applicable to the Area II Landfill.

Dioxins. Dioxins are characterized by extremely low vapor pressures, high log K_{ow}, high K_{oc}, and extremely low water solubilities. Their strong adsorption to soil, low water solubilities, and high K_{oc} values indicate that the rate of transport from the unsaturated zone soils to the water table via rain infiltration would be extremely low. Because dioxins have low vapor pressure, they are not very volatile and tend to stay bound to particles. Dioxins also have very low solubility; thus, any aerially deposited dioxins tend to stay adsorbed to soils in the top few millimeters in the surface soil.

Inorganics. Several metals were detected at the landfill area at levels above the screening criteria. Many metals are naturally occurring and their reported presence may or may not indicate a contaminant release. The mobility of metals is complex and depends on several factors such as the overall groundwater composition, pH, metal complex formation, valence state of the metal, and cation-ion exchange capacity. Metals typically are not volatile except for mercury.

SVOCs. PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances. HMW PAHs are more likely to be transported via particulate emissions, while LMW PAHs have a greater tendency to volatilize (ATSDR, 1995). In general, PAHs are more likely to sorb to soil or organic matter than to partition significantly to water. Photolysis and biodegradation are two common

attenuation mechanisms for PAH compounds (Howard, 1991). Animals and microorganisms can metabolize PAHs to products that ultimately reach complete degradation.

PCBs. PCBs are persistent in the environment. Aroclor-1254 and Aroclor-1260 are characterized by low water solubility, moderate volatility, high affinity for organic matter, and high resistance to chemical or biological degradation. They will strongly sorb to soil and do not tend to leach to groundwater. In surface water, they will partition to sediment and sorb to organic matter. PCBs will bioaccumulate in aquatic organisms.

TPHs. TPHs are defined as the measurable amount of petroleum-based hydrocarbon in an environmental media. The lighter petroleum products such as gasoline contain constituents with higher water solubility and volatility and lower sorption potential than do the heavier petroleum products such as fuel oil. Data compiled from gasoline spills and laboratory studies indicate that these light-fraction hydrocarbons tend to migrate readily through soil, potentially threatening or affecting groundwater supplies. In contrast, petroleum products with HMW constituents, such as fuel oil, are generally more persistent in soils because of their relatively low water solubility and volatility and high sorption capacity (Stelljes and Watkin 1991).

3.6.4 Contaminant Migration

The primary source for contaminant migration is historical leaks and leachate associated with the Area II Landfill operations.

3.6.5 Surface Soil Contaminants

Dioxins, inorganic compounds, SVOCs, PCBs, and TPHs have been identified in surface soil above the background and/or health-based risk criteria. The following observations were made for contaminants in surface soil:

- Dioxins were detected in all 7 of the surface soil samples collected. Only 1 sample (A2BS0035) reported 2,3,7,8-TCDD TEQ at a concentration (0.007 µg/kg) exceeding the screening criteria.
- A total of 47 surface soils were analyzed for metals at the Area II Landfill. Of the metals detected, only 8 metals (aluminum, arsenic, boron, cobalt, lead, mercury, selenium, and silver) exceeded the screening criteria. All except arsenic and boron also were collected in the subsurface.
- A total of 62 surface soil samples were collected from 61 locations at the Area II Landfill and were analyzed for SVOCs. Of the 22 SVOCs detected, 9 exceeded 1 or more of the screening criteria.
- A total of 46 surface soil samples were collected and analyzed for PCB aroclors at the Area II Landfill. PCB aroclors were detected in 6 samples, at levels exceeding 1 or more of the screening criteria in 4 of the samples.
- TPH was detected in 60 of the 70 surface soil samples collected at the Area II Landfill and analyzed for TPH. Only 2 TPHs exceeded the common ecological and human health screening criteria of 100,000 µg/kg.

3.6.6 Subsurface Soil Migration

The following observations were made for the contaminants in subsurface soil:

- The 4 subsurface soil samples collected to a depth of 5 ft bgs were analyzed for both CDDs and CDFs. The 2,3,7,8-TCDD TEQ values exceeded the human health (0.0013 µg/kg) and ecological (0.0043 µg/kg) comparison criteria at A2TS33S01 (0.017 µg/kg) and A2TS33S02 (0.0014 µg/kg) at 3 ft bgs each. Because of the chemical behavior of dioxins and their inclination to remain bound with soil particles, subsurface exceedances probably are from landfill operations that disturbed the soil, rather than through the vertical migration of dioxins from the subsurface.
- A total of 49 subsurface soil samples were collected from 46 locations in the Area II Landfill to a maximum depth of 20 ft bgs and analyzed for metals. Of the 25 metals detected, 16 exceeded 1 or more of the screening criteria. Most of the metals were detected at concentrations similar to their respective background concentrations. With the exception of copper, all of the exceedance metal samples are bound and do not require additional sampling. Although copper was not sufficiently evaluated in the eastern edge of the landfill, it is expected to be present in the landfill at high concentrations because the landfill received construction debris, including pipes.
- A total of 53 subsurface soil samples were collected from 46 locations at the Area II Landfill to a maximum depth of 20 ft bgs and analyzed for SVOCs. Of the 17 SVOCs detected, 4 exceeded their respective human health screening criteria.
- Fifty subsurface soil samples were collected from 45 locations at the Area II Landfill to a maximum depth of 20.5 ft bgs and analyzed for PCBs (aroclors and congeners). Only 1 PCB congener was reported at levels that exceeded the screening criteria. PCB-126 was reported at A2BS1048 (10 to 11 ft bgs) at an estimated concentration of 0.03 µg/kg, exceeding both the ecological (0.014 µg/kg) and human health (0.013 µg/kg) screening criteria.
- TPH was detected in 28 of the 46 subsurface soil samples collected and analyzed for TPH. Only EFH (C21–C30) was reported at concentrations exceeding both the ecological and human health screening criteria of 100,000 µg/kg each.

3.6.7 Soil-to-Groundwater Migration

There are no documented chemical effects on groundwater at the Area II Landfill, according to results obtained in the few CFOU wells that monitor the general vicinity of the SWMU. The occurrence of NSGW at the Area II Landfill is unlikely, based on the tentative results of the five piezometers installed at the study area as part of the Group 2 RFI effort. Groundwater occurrence and any possible chemical impacts at the Area II Landfill in the SMOU have not yet been confirmed and require sampling during the winter rainy season.

The chemicals detected in soil and soil vapor, summarized in Section 3.4, do not correspond to the constituents typically detected in groundwater at the facility. In the surface soil, concentrations at levels above the screening criteria were detected for dioxins, metals, PCBs, SVOCs, and TPHs. The subsurface soil samples also had the same parameter groups detected at levels above the screening criteria as did the surface soil. In the soil gas

sampling performed at the landfill for VOCs, only one location was identified that had a VOC (benzene) detected at levels above the ecological and human health screening criteria. Until sampling results from the winter rainy season are evaluated, there are no data indicating that there is migration of COCs to groundwater at the Area II Landfill.

3.7 Human Health Risk Assessment for Area II Landfill

The objective of this HHRA is to assess whether the environmental media at the Area II Landfill could pose risks to human health that might require remedial action that are eligible for an NFA designation. This HHRA assesses the potential current and future exposures to chemicals in soil, soil vapor, and groundwater at the Area II Landfill. The methods and guidance documents used in the preparation of this HHRA are described in Section 1.5.3 of this report. The HHRA results for the Area II Landfill are discussed below. The results are summarized in Section 3.9.2.

The concentration data, input parameters, and results of the HHRA for the Area II Landfill are presented in Appendix C. An index of the tables (Appendix C human health RA Tables Index) can be used to locate tables that contain information regarding the HHRA data set, EPCs, exposure parameters, toxicity factors, estimated chemical intakes, estimated ELCRs, and estimated non-cancer HIs.

3.7.1 Identification of Chemicals of Potential Concern

Chemicals were selected as COPCs at the Area II Landfill site based on the protocol presented in Sections 1.5.3.1 and 1.5.3.2.

3.7.1.1 Data Evaluation

The soil, soil vapor, and groundwater sampling analytical data at the Area II Landfill site were evaluated to assess their suitability for use in the risk assessment, following the procedures presented in Section 1.5.3.1. Sediment and surface water data were not collected as part of the RFI site characterization activities because neither is present at the Area II Landfill. The locations of the soil, soil vapor, and groundwater samples used in this HHRA are shown in Figure 3.4-1. Table C.7.1-1 lists the samples used in this HHRA by medium, sample ID, sampling depth interval, and date of collection. Table C.7.1-2 presents the target receptor populations by medium. Descriptive summary statistics of these data are provided in Table C.7.1-3.

3.7.1.2 Identification of COPCs in Soil

The results of the COPC screening process for soil at 0 to 2 ft bgs and 0 to 10 ft bgs are listed in Table C.7.1-3. Detected analytes in soil at the Area II Landfill were compared to the background levels. COPCs identified in soil (0 to 2 ft bgs) included 1 inorganic (barium) and 28 organics. COPCs identified in soil (0 to 10 ft bgs) included 1 inorganic (barium) and 29 organics.

3.7.1.3 Identification of COPCs in Groundwater

NSGW data are not available for the Area II Landfill site because of the seasonally dry conditions during the RFI sampling event; therefore, COPCs are not identified for groundwater.

3.7.1.4 Identification of COPCs in Soil Vapor

The results of the COPC screening process for soil vapor at 3 to 10 ft bgs are listed in Table C.7.1-3. The COPCs identified in soil vapor included 15 VOCs.

3.7.2 Exposure Assessment

The exposure assessment component of the HHRA identifies the means by which individuals at or near the Area II Landfill may come into contact with constituents in exposure media. It addresses the current exposures and those that may result in the future under reasonably anticipated potential uses of the site and the surrounding areas. The exposure assessment also identifies the populations that may be exposed; the routes by which individuals may become exposed; and the magnitude, frequency, and duration of the potential exposures. Figure 1.5.3-1 depicts the conceptual exposure model for the Area II Landfill. The exposure scenarios are listed in Table C.7.1-2. The methods and assumptions used in the exposure assessment are discussed in Section 1.5.3.5.

3.7.2.1 Identification of Receptors

The Area II Landfill area recently was used for industrial purposes and is most likely to have a future industrial or recreational land use; however, a hypothetical future residential scenario also was included in the exposure assessment. Future residents are expected to have the greatest level of exposure. Therefore, the hypothetical future residential scenario, assuming adult and child receptors, was the most conservative scenario in the HHRA. In addition to the residential scenario, the industrial worker and recreationist exposure scenarios were evaluated.

As stated in Section 1.5.3.3, an agricultural-based residential exposure scenario will be evaluated to meet the requirements of Senate Bill 990.

3.7.2.2 Identification of Exposure Pathways

Future residents and industrial workers were assumed to be exposed to groundwater, seeps and springs (future residents only), soil vapor (modeled for migration to indoor air and ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Future recreationists were assumed to be exposed to groundwater, soil vapor (modeled for migration to ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Exposure pathways for groundwater, seeps and springs, and soil included direct exposures (ingestion and dermal) and indirect exposures. Inhalation exposures were quantified for the migration of groundwater and soil vapor to ambient air and indoor air. Additionally, exposures were quantified for groundwater and seeps and springs for residential receptors for the inhalation of VOCs in bathroom air while showering or bathing. Residential receptors also were assumed to ingest edible plants and home-grown produce. The exposure pathways and exposure assumptions included in the HHRA for the Area II Landfill are provided in Table C.7.1-6.

3.7.2.3 Exposure Point Concentrations

EPCs for soil at 0 to 2 ft bgs, soil at 0 to 10 ft bgs, soil vapor, seeps and springs, and groundwater at the Area II Landfill are listed in Table C.7.1-3. EPCs were estimated for indirect exposures for the following media: airborne fugitive dusts, ambient air, indoor air, and edible plants (home-grown product consumption). Airborne particulate COPC concentrations were estimated for non-volatile COPCs. The derivation of the PEF for soil is listed in Table C.7.1-7.

Ambient air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs to ambient air and migration from groundwater to ambient air. Parameter values used for soil vapor-to-air migration and for estimation of ambient air EPCs related to soils are presented in Table C.7.1-9. Parameter values used for estimation of ambient air EPCs related to groundwater are also presented in Table C.7.1-9. The estimated ambient air concentrations from migration of volatile COPCs in soil and groundwater are presented in Tables C.7.1-10, C.7.1-11, and C.7.1-12, respectively.

Indoor air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs and from NSGW using the J-E Model (EPA, 2004). The parameter values used in the J-E Model (EPA, 2004) are listed in Table C.7.1-9. Soil vapor data, where available, were preferentially used for indoor air modeling. The estimation of indoor air concentrations from soil vapor and groundwater migration is presented in Tables C.7.1-13 through C.7.1-18.

The derivation of edible plant concentrations is calculated using soil-to-plant uptake factors, as described in the SRAM (MWH, 2005b). COPC concentrations in edible plant tissues from soil at 0 to 2 ft bgs are listed in Table C.7.1-19.

3.7.2.4 Intake Estimates

EPCs were applied to human intake equations, as presented in the SRAM (MWH, 2005b), to calculate the chemical intakes for potential adult and child residential, adult and child recreationist, and industrial worker receptors at the Area II Landfill. The chemical-specific intakes were estimated based on an RME scenario and a CTE scenario. The exposure assumptions and the chemical intakes for soil are listed in Appendix C. See the Appendix C human health RA Tables Index for the exposure parameters and chemical intakes for each exposure scenario.

3.7.3 Risk Characterization

In the risk characterization component of the HHRA process, quantification of risk is accomplished by combining the results of the exposure assessment (estimated chemical intakes) with the results of the dose-response assessment (toxicity values identified in the toxicity assessment; Section 1.5.3.4) to provide numerical estimates of potential health risks. The quantification approach differs for potential noncancer and cancer effects. The methods used in the risk characterization are discussed in Section 1.5.3.5.

The exposure assumptions, EPCs, toxicity factors, and risk characterization result tables for this HHRA are presented in Appendix C (Appendix C human health RA Tables Index**)**. The risk calculation tables present the estimated ELCRs and non-cancer HIs for potentially exposed receptors, as well as the individual exposure routes for soil, indoor air, and

groundwater at the Area II Landfill. The risk tables also list the cumulative risks and HIs across all exposure routes for the RME and CTE scenarios.

3.7.3.1 Hypothetical Future Adult Residential Exposure Scenario

The potential residential adult exposures to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. The potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of home-grown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-7} for the CTE case to 5×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.005 for the CTE case to 0.03 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogencic COPCs for exposure to 0- to 2-foot-bgs soil from the plant consumption exposure route ranges from 3×10^{-5} for the CTE case to 7×10^{-4} for the RME case. The RME and CTE ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. BaP is the main risk driver for the plant consumption exposure route for the RME and CTE cases. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 0.5 for the CTE case to 17 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. Di-n-butyl phthalate is the main risk driver for the RME HI estimate.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-7} for the CTE case to 3×10^{-6} for the RME case. The RME ELCR estimate exceeds the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.005 for the CTE case to 0.03 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated inside a future residence. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-7} for the CTE case to 4×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.003 for the CTE case to 0.008 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 8×10^{-9} for the CTE case to 5×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 4×10^{-5} for the CTE case to 0.0001 for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

3.7.3.2 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Residential Exposure Scenario

Potential residential child exposure to COPCs in soil, soil vapor, seeps and springs, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of home-grown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-6} for the CTE case to 1×10^{-5} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.05 for the CTE case to 0.3 for the RME case. The RME HI does not exceed the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogencic COPCs for exposure to 0- to 2-foot-bgs soil from the plant consumption exposure route ranges from 3×10^{-5} for the CTE case to 2×10^{-4} for the RME case. The RME and CTE ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. BaP is the main risk driver for the plant consumption exposure route for the RME and CTE cases. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 0.8 for the CTE case to 19 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. Di-n-butyl phthalate is the main risk driver for the RME HI estimate.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-6} for the CTE case to 6×10^{-6} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.05 for the CTE case to 0.3 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas is inhalation of vapors that have

migrated inside a future residence. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-6} for the CTE case to 3×10^{-6} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.02 for the CTE case to 0.02 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-8} for the CTE case to 4×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.0002 for the CTE case to 0.0003 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

3.7.3.3 Hypothetical Future Adult Recreational Exposure Scenario

Potential adult recreationist exposures to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-8} for the CTE case to 3×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.0004 for the CTE case to 0.02 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-10} for the CTE case to 6×10^{-9} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 2×10^{-6} for the CTE case to $1 \times 10^{-5}$for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

3.7.3.4 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Recreational Exposure Scenario

Potential child recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. A hypothetical future recreationist child (15-kg body weight) was assumed to be exposed for 350 days per year over 6 years for the RME case and 6 years for the CTE case. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-7} for the CTE case to 3×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. BaP, PCB TEQ, and 2,3,7,8-TCDD TEQ are the main risk drivers for the RME case. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.007 for the CTE case to 0.08 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-9} for the CTE case to 1×10^{-8} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 2×10^{-5} for the CTE case to 9×10^{-5} for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

3.7.3.5 Hypothetical Future Industrial Worker Exposure Scenario

Potential industrial worker exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-7} for the CTE case to 6×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.003 for the CTE case to 0.04 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-7} for the CTE case to 4×10^{-6} for the RME case. The RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.003 for the CTE case to 0.04 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated inside a future industrial building. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-7} for the CTE case to 1×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.0009 for the CTE case to 0.002 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-9} for the CTE case to 5×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 4×10^{-5} for the CTE case to 9×10^{-5} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

3.7.4 Uncertainty Discussion

Uncertainties associated with the results of this HHRA are a function of both the "state of the practice" of human health risk assessment in general and UFs specific to the Area II Landfill. A discussion of the general HHRA uncertainty is presented in Section 1.5.3.6.

3.8 Ecological Risk Assessment for the Area II Landfill

3.8.1 Problem Formulation

The problem formulation describes the site to be assessed, establishes the assumptions and data to be employed, and generally is the foundation of the ERA. Generalized components of the problem formulation, applicable to all RFI sites in Group 2, are described in Section 1.5.4.1. The problem formulation components specific to the Area II Landfill are described below.

3.8.1.1 Site Background

The Area II Landfill was acquired by NASA in 1973, along with the rest of the Area II Property (known as USAF Plant 57 under ownership of the USAF). The 3.6-acre landfill measured 500 ft wide by 150 ft deep by 50 ft across and is located in the northern portions of Areas I and II (SAIC, 1994). The landfill was active from approximately 1955 to 1980, but the years of primary use were between 1965 and 1978 (MWH, 2005d).

The Landfill Area contains a paved service road running east-west that accounts for approximately 6 percent of the total site. Habitat at the site was determined based on a site survey conducted by CH2M HILL staff in April 2008 (Appendix A). On the basis of this survey, the Landfill Area is made up of two habitat types: scrub/shrub and ruderal habitat (Figure 3.8-1). Most of the site, (about 68 percent) is made up of ruderal habitat, consisting of deer weed, red-stern filaree, fiddle head, milk thistle, and mustard. Approximately 23 percent of the site is scrub/shrub, comprised of laurel sumac, yerba santa, chamise, and canyon live oak. The scrub/shrub habitat is located along the border of the site. Evidence or actual observation of the following species was noted during the site visit: spotted towhee, song sparrow, western scrub-jay, California towhee, kangaroo rat (burrows), gopher (burrow), mule deer (tracks), coyote (scat), and cottontail rabbit. Stressed vegetation observed during the site visit accounted for approximately 1.8 percent of the site.

3.8.1.2 Ecological Management Goals, Assessment Endpoints, and Measures

The ecological management goal for the Area II Landfill is the same as that for all Group 2 RFI sites:

> *Maintenance of soil, sediment, water quality, food source, and habitat conditions capable of supporting ecological receptors, including special-status species, likely to be found in the area.*

The habitats present at the Area II Landfill are exclusively terrestrial. Consequently, only terrestrial assessment endpoints and measures were identified for this site (Table 3.8-1).

Representative species and receptor groups considered for the Area II Landfill include the terrestrial plant community (primary producers), the soil invertebrate community (primary consumers), hermit thrush (primary and secondary consumer), red-tailed hawk (tertiary consumer), deer mouse (primary and secondary consumer), mule deer (primary consumer), and bobcat (secondary and tertiary consumer).

3.8.1.3 Ecological Conceptual Site Model

The generalized ecological CSM for Group 2 is presented in Section 1.5.4.4. Because the Area II Landfill is strictly a terrestrial location, only the terrestrial pathways are relevant. The CSM specific to the Area II Landfill is described below and presented in Figure 3.8-2.

The primary contaminant source at the Area II Landfill includes the disposal of waste. Primary release mechanisms include prior waste disposal practices that resulted in leaching and migration of contaminants in soil. Secondary sources of potential contaminants are soils and soil vapors. Secondary release mechanisms include volatilization and wind erosion, and bioaccumulation from soil.

Complete or potentially complete exposure pathways from contaminated soil and biota to ecological receptors exist at the site. Burrowing mammals (deer mice) may be exposed to soil vapors via inhalation. Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, and small mammals resident in or associated with the site soils. Terrestrial wildlife (herbivores, omnivores, invertivores, and carnivores), including reptiles, may be exposed directly to contaminants in soil by incidental ingestion, by dermal contact, or by the inhalation of windborne particles. Terrestrial invertebrates and wildlife (reptiles, birds, and mammals) also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (plants to herbivores, plants and prey animals to omnivores, etc.). Additional descriptions of potential exposure pathways for ecological receptors at the Area II Landfill are summarized in Table 3.8-2, along with the rationale for inclusion or exclusion in the quantitative and qualitative evaluations.

3.8.1.4 Selection of Chemicals of Potential Ecological Concern

The process for selecting CPECs is described in Sections 1.5.4.4 and 1.5.4.5. Analytes detected in media sampled from the Area II Landfill are summarized in Table 3.8-3. Summary statistics for those detected analytes are listed in Table 3.8-4. TEQ values for dioxin/furans (including coplanar PCBs) were calculated as listed in Table 3.8-5. A central tendency background comparison for metals and dioxins/furans in soils was conducted to evaluate whether analytes were consistent with background levels (Table 3.8-6). The comparison of VOCs in soil and soil vapor is shown in Table 3.8-7. Non-detect analytes were evaluated by comparing the maximum SQLs against the minimum ESLs and determining the exceedance frequency of the SQLs (Table 3.8-8). The CPECs identified for the Area II Landfill are summarized in Table 3.8-9. EPCs for each depth interval (0 to 2 ft, 0 to 4 ft, and 0 to 6 ft bgs) are listed in Tables 3.8-10, 3.8-11, and 3.8-12, respectively. EPCs for soil vapor from 0 to 6 ft bgs are listed in Table 3.8-13. Calculations for extrapolating soil vapor concentrations from soil concentrations are listed in Table 3.8-14.

3.8.2 Analysis

The analysis phase, which consists of the exposure characterization and the ecological effects characterization, links the problem formulation (Section 3.8.1) with the risk characterization (Section 3.8.3) and consists of the technical evaluation of ecological and chemical data to assess the potential for ecological exposure and effects. Generalized components of the exposure and ecological effects characterizations are presented in Section 1.5.4. Exposure and effects information specific to the Area II Landfill are presented below.

3.8.2.1 Exposure Characterization

The exposure characterization is used to evaluate the relationship between receptors at the site and potential stressors (CPECs). The methods used to estimate exposure, including receptor-specific exposure models, exposure factors, and assumptions; exposure areas; and the calculation of EPCs, are described in this subsection.

The receptor-specific exposure models, exposure factors, and assumptions presented in Section 1.5.4.4 are used for receptors at the Area II Landfill. Because the Area II Landfill is strictly terrestrial, exposure is based on soil and soil vapor and was evaluated only for terrestrial receptors (plants, soil invertebrates, birds, and mammals).

The Area II Landfill consists primarily of ruderal habitat. Although the Area II Landfill is 5.5 acres, the spatial extent of samples associated with the site is 16.4 acres. All buildings at the site have been removed and paved areas or building foundations represent only a small portion of the site. Consequently, most of the site represents habitat of moderate or better quality.

Summary statistics and EPCs for CPECs in soil at various depths (up to 6 ft bgs) and soil vapor were calculated for the Area II Landfill according to the approach outlined in Section 1.5.4.4. Summary statistics are presented in Table 3.8-4. EPCs for each soil depth are listed in Tables 3.8-10 through 3.8-12. EPCs for soil vapor are listed in Table 3.8-13. Modeled exposure estimates for bird and mammal receptors are presented as part of the risk characterization (Section 3.8.3).

3.8.2.2 Ecological Effects Characterization

The ecological effects characterization consists of an evaluation of available toxicity or other effects information that can be used to relate the exposure estimates to a level of adverse effects. Generalized effects data for all receptors at the SSFL are summarized in Section 1.5.4.4. No effects data specific to the Area II Landfill are available. Consequently, ESLs, Low TRVs, and High TRVs for the terrestrial receptors described in Section 1.5.4.5 were used to evaluate the effects associated with estimated exposures.

3.8.3 Risk Characterization

The risk characterization integrates estimated CPEC exposures with their potential ecological effects on the assessment endpoints for the Area II Landfill. The sequential processes for performing the risk characterization, described in Section 1.5.4.4, were applied to the Area II Landfill. The results of these comparisons are described below.

3.8.3.1 Risk Estimation

The risk estimation focuses primarily on the quantitative methods to evaluate the potential for risk. The results of the quantitative risk estimation are presented as HQs and HIs. HQs and HIs for evaluated receptors are listed in Tables 3.8-15 through 3.8-22. The risk estimations for terrestrial exposures are listed in Table 3.8-23. Estimated incremental risks for terrestrial exposure pathways for the RME, COECs for soil vapor, and COECs for soil are addressed in Tables 3.8-24, 3.8-25, and 3.8-26, respectively. Table 3.8-18 presents an analysis of the depth intervals for the evaluation of burrowing animals (deer mouse). The 0- to 6-foot-depth interval had the greatest HI; therefore, the data from this depth were used to evaluate the deer mouse.

3.8.3.2 Risk Description

The risk description incorporates the results of the risk estimates, along with any other available and appropriate lines of evidence, to evaluate potential chemical impacts on ecological receptors in Group 2. Chemicals that had HQs exceeding 1 were evaluated further to assess the COECs. Information considered in the determination of COECs includes receptor groups that potentially were affected, exceedances of Low and/or High TRVs, magnitude of exceedance, bioavailability, and habitat quality at the site.

To facilitate the interpretation of TRV exceedances, chemicals that exceed one of the TRVs (ESL, Low TRV, or High TRV) were assigned into seven general risk groups (1 through 7, below). These groups were created as an additional tool to assist risk managers in making remedial decisions. The groupings are subjective, based on professional judgment, and the placement of a chemical within a given group is not an absolute indicator of the potential risk:

1. High Risk–HQs>5 for High TRV (RME), or HQs>100 for any EPC/TRV combination. Chemical classes with HIs>10 at High TRV (RME). Four or more receptors showing estimated risks.
2. Medium-High Risk–2<HQs<5 for the High TRV (RME). Chemical classes with 2<HIs<10 at the High TRV (RME) or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.
3. Medium Risk–1<HQs<2 for High TRV (RME), but HQ>10 for Low TRV (RME). Chemical classes with 1<HIs<2 at the High TRV or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.
4. Medium-Low Risk–HQs<1 for the High TRV (RME), but 1<HQs<10 for the Low TRV (RME). Chemical classes with HIs<1 at the High TRV or 2<HIs<10 at the Low TRV. No more than two of six receptors showing estimated risks.
5. Low Risk–HQs<1 for the Low TRV (RME). Chemical classes with HIs<1 at the Low TRV.
6. No Risk–all HQs and associated HIs<1.
7. Uncertain–TRVs unavailable to calculate either HQs or HIs.

Five soil vapor analytes (1,1,2-trichloroethane, 1,1-DCE, carbon tetrachloride [CTC], chloroform, and VC) had HQs above 1 (Table 3.8-17). Of these, all except 1,1,2-trichloroethane (HQ = 17.5) had HQs less than 5, and these analytes were non-detected in all samples. Additionally, if risks were estimated using ½ the SQL, HQs would be less than 1 for all except 1,1,2-trichloroethane (HQ based on ½ the SQL of 9) and chloroform (HQ based on ½ the SQL of 2.1). The inhalation TRV for 1,1,2-trichloroethane was derived from an LD50 using an uncertainty factor of 100. The application of the UF may over- or under estimate a no-effect level. However, because this analyte was non-detect, the confidence in the benchmark is low and 1,1,2-trichloroethane is considered to pose low risk. Because chloroform also was non-detect, the risk for this analyte in soil vapor is highly uncertain, but likely to be low. No detected soil vapor analytes had an HQ above 1 and no risk was predicted for any of these detected soil vapor analytes (Table 3.8-16).

Ten soil analytes (barium, dioxins/furans [2,3,7,8-TCDD TEQ], 2,4,6-trinitrotoluene, BAA, BaP, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, BEHP, and di-n-butylphthalate), were found to have one or more HQs greater than 1 under any scenario. Soil vapor exposures for 5 additional analytes (1,1,2-TCA, 1,1-DCE, CTC, chloroform, and VC) exceeded their respective TRVs (inhalation HQs greater than 1). All other soil analytes and/or analyte groups (with the exception of phthalates and dioxins/furans) were found to pose no risk (all HQs and HIs were less than 1) to any receptor under any scenario (maximum concentration for plants, invertebrates, and soil

vapor exposures; CTE and RME concentrations for birds and mammals) at the Area II Landfill.

One inorganic, barium, was identified as elevated based on non-parametric central tendency background comparisons for soil (Table 3.8-6). This metal had one or more HQs above 1 for at least one receptor in the refined screen. On the basis of the risk ranking described above, barium was found to pose a medium-low risk (two receptors showing risks [hermit thrush and deer mouse] with low TRV-based HQs above 1 but less than 10 in the refined screen and high TRV-based HQs above 1 in the refined screen).

Barium showed predicted risks to the hermit thrush based on the low TRV and CTE and RME exposures (HQs of 1.6 and 1.71, respectively). Barium also showed predicted risks to the deer mouse, with a low TRV-based HQ of 5.7 and a high TRV-based HQ of 1.5, based on the RME exposure. CTE exposures of the deer mouse to barium, based on low TRVs and high TRVs, also exceeded 1 (HQs of 5.1 and 1.3, respectively). However, when accounting for background, risks from barium are low and the incremental risk HQs (the difference between HQs from onsite barium data and HQs based on RME background barium concentrations, as detailed in Section 1.5.4) were all less than 2 (Table 3.8-24). This result suggests that most of predicted exposure is associated with naturally occurring barium concentrations. Consequently, the risks from barium are considered acceptable.

In addition to inorganics, dioxins/furans (as represented by the 2,3,7,8-TCDD TEQ), BAA, BaP, benzo(b)fluoranthene, chrysene, benzo(k)fluoranthene, BEHP, and di-n-butylphthalate, were found to fail one or more screens for one or more receptors (Table 3.8-23). 2,4,6-Trinitrotoluene is only a CPEC in the 0- to 6-foot-bgs soil depth interval, and therefore, is only evaluated for the deer mouse. This analyte was measured in only one soil sample and was undetected. The risk estimates for the deer mouse, based on the SQL, exceeded the low TRV (HQ = 4.47), but not the high TRV (HQ<1). These results suggest a medium-low risk, but there is significant uncertainty associated with this risk conclusion because of the small sample size (n = 1) and insufficient detection limits. Of the remaining analytes, five PAHs failed only the plant screen, suggesting that the actual risks from PAHs probably are low. Dioxins/furans and coplanar PCBs posed risks, based on the 2,3,7,8-TCDD TEQ, to the hermit thrush and to the deer mouse based on the RME exposures (the high TRV-based HQ exceeded 1 for the hermit thrush and the low TRV-based HQ exceeded 1 for the deer mouse). The risks to the hermit thrush were the highest, and dioxins/furans were predicted to pose a medium risk because the refined high TRV-based HQ exceeds 1 (HQ = 1.1) and the low TRV-based HQ exceeds 10 (HQ = 11) for the hermit thrush. PCB-77 appears to be the risk driver for birds (Table 3.8-5); the maximum concentration was located in a surface sample from A2BS1045. Only 2 of 10 dioxin/furan classes were found to be present at concentrations above the ambient conditions, as listed in Table 3.8.6. This result suggests that dioxin/furan concentrations may not be site related and are a result of ambient conditions. Because of the low magnitude of exceedances, isolated occurrence of hot spots, and background comparisons, the risks from dioxins/furans and coplanar PCBs are considered acceptable.

Di-n-butylphthalate also failed the refined screen, based on the RME exposure for the deer mouse, the red-tailed hawk, and the hermit thrush, and was predicted to pose high risks (high TRV-based HQ greater than 1 in the refined screen). However, risks from di-n-butyl phthalate to the deer mouse and red-tailed hawk were minimal, with low TRV-based HQs of

1.1 and 2.29, respectively, and high TRV-based HQs of less than 1. The risks to the hermit thrush, however, were higher, and the high TRV-based HQ from the RME exposure was 252. All risk is driven by one surface soil sample location that had a detected concentration of 349 mg/kg (A2BS1045), which coincides with the elevated PCB-77 detection discussed above. Of the 20 samples analyzed for di-n-butylphthalate, only 2 samples contained detectable concentrations of di-n-butylphthalate. Consequently, although this isolated location has risk potential, because these species are mobile and unlikely to forage in any one area for a given amount of time, the risks posed by di-n-butylphthalate generally are considered low. No other sampled locations contained concentrations high enough to pose a predicted risk. BEHP (26.6 mg/kg) also was detected at elevated concentrations in the same location (A2BS1045), and as a result, was predicted to pose a medium risk. A high bird TRV is not available for BEHP, however, the low TRV-based HQ for RME exposure to the hermit thrush was 95. For the CTE exposure, the low TRV-based HQ for the hermit thrush was 8.3. Because this risk is being driven by one sample, the overall risk on a sitewide basis is considered low. Only 4 of 20 samples contained detected concentrations of BEHP, and 3 of the 4 detections were present at concentrations lower than 0.2 mg/kg.

3.8.3.3 Uncertainty Analysis

Uncertainty is an implicit component in all risk assessments. Generalized uncertainties for ERAs in Group 2 are summarized in Section 1.5.4.5. Additional uncertainties include the following:

- Samples were collected outside of the site boundary in an effort to define and fully characterize potential releases from the Area II Landfill. If sample concentrations decreased with distance from the site, the inclusion of the additional data might underestimate risks in the core portion of the site when these data are integrated into the RME and CTE calculations.
- Depths were unavailable for several historical soil and soil vapor sample locations included in the landfill dataset. The maximum concentrations for many analytes were associated with these “legacy” data. In an effort to be conservative and to ensure completeness, these data were included in the 0- to 2-foot-bgs depth interval for the purposes of risk assessment. There is some uncertainty associated with including these data in this depth interval (especially for soil vapor), and the risk may be overestimated. However, it is likely that the maximum soil concentrations would be detected at shallower depths, so inclusion with the shallowest depth interval for soil is deemed appropriate.
- Aroclor data were not evaluated in this assessment because PCB congener data were available and were used to calculate a TCDD TEQ. PCBs and dioxin/furans were evaluated based on the 2,3,7,8-TCDD TEQs. Concentrations of aroclors were low and are not expected to be significant COCs. However, PCB congener data were only available from 4 sample locations, and thus, may not be representative of the entire site.
- No screening levels were available to evaluate the TPH data; however, PAH data were available and the risks from these constituents were considered low.

3.8.4 Conclusions and Recommendations

Five analytes in soil vapor (1,1,2-TCA, 1,1-DCE, CTC, chloroform, and VC) were considered to pose risks (Table 3.8-17), but all of these analytes were non-detect and the risks from 1,1-DCE, CTC, and VC were considered minimal because the HQs based on ½ the SQL were below 1. The risks from 1,1,2-TCA were the greatest, but also were considered low because of the uncertainty associated with the inhalation TRV.

Of the 50 analytes (dioxins/coplanar PCBs were counted as one analyte) evalauted in soil, di-n-butylphthalate was the only analyte that posed a high risk to the receptors evaluated at the Area II Landfill. However, risks from di-n-butylphthalate ere driven by one sample that had an elevated detection. BEHP was found to pose a medium risk, but also was based on one elevated detection that was co-located with the elevated di-n-butylphthalate exceedance. Dioxins/furans were found to pose a medium risk, with PCB-77 as the greatest contributor to this risk. The sample that had the greatest concentration of PCB-77 is co-located with the elevated phthalates. Consequently, although the phthalates and possibly dioxin/furans represent hot spot contamination, these analyte groups are not considered to pose sitewide risks because they are significantly limited in extent. Barium was found to pose a medium-low risk, but because the magnitude of exceedance and incremental risk relative to background were low, the risks were considered acceptable. Additionally, 2,4,6-trinitrotoluene was found to pose a medium risk; however, this analyte was only analyzed for in one sample and was non-detect, so the risks are considered acceptable. Of the remaining soil analytes, 19 posed no risk and 4 lacked TRVs.

Except for the dioxins/furans and two phthalates, the risks from all analytes were considered acceptable and do not warrant additional investigation. Additional investigation of dioxins/furans and phthalates is not considered necessary because the risks generally are considered low and are the result of one hot spot location. However, the removal of this hot spot location would reduce risks and should be considered during the CMS.

3.9 Summary of Findings and Recommendations for Former Area II Landfill

3.9.1 Nature and Extent of Contamination Summary

To evaluate the nature and extent of potential contaminants at the Area II Landfill, 90 surface soil, 64 subsurface soil, and 83 soil gas samples were collected. In the surface soil samples collected, 10 dioxins, 8 metals, 8 PCBs, 10 SVOCs, and 2 TPHs exceeded 1 or more of the screening criteria. Parameters that exceeded the criteria are listed in Table 3.9-1. In the subsurface soil samples collected, 15 dioxins, 16 metals, 2 PCBs, 4 SVOCs, and 1 TPH were reported at concentrations that exceeded 1 or more of the screening criteria. Only benzene was reported at elevated concentrations in the soil gas samples collected at the site.

Several compounds were reported in the surface and subsurface soil at the landfill. The compounds expected to be detected in the landfill are not completely known, because rusty drums of unknown contents were disposed in the landfill. Of the compounds detected in the surface soil at the site, only PCB congeners were not evaluated sufficiently for horizontal

extent and additional sampling may be warranted to complete an extent evaluation. Only four samples of PCB congeners were collected, on the slope of the landfill, and the sample furthest downhill had reported exceedances. Although most of the samples that exceeded the criteria were located along the stream on the northern base of the landfill, the samples collected furthest downgradient did not have detections of the analyzed compounds or did not have detections at exceedance concentrations.

Of the compounds detected in the subsurface soils, only copper was not sufficiently bound. Copper exceeded the screening criteria at a location on the top edge of the northern slope at a relatively deep sampling interval. However, copper is an expected compound because the landfill received construction debris; copper wire and copper pipe are common components of such debris. Also, the samples collected at the lower elevations along the slope of the landfill were collected at similar elevations, even though they are reported at shallower sample depths.

3.9.2 Risk Assessment Summary

This subsection summarizes the HHRA performed for the Area II Landfill. The HHRA assesses the potential current and future exposures to chemicals in surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater. Section 1.5.3 describes the methods used to prepare the HHRA. The results of the HHRA for the Area II Landfill are presented in Section 3.7.

The surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater samples collected during the RFI sampling activities were evaluated for use in the HHRA. Surface water and sediment samples were not evaluated in this HHRA because they were not collected during the RFI site characterization activities. The HHRA data set is provided in Table C.7.1-3 in Appendix C. The COPCs identified from the Area II Landfill HHRA data set for each exposure area are presented in Table C.7.1-5.

The potential future receptors at the Area II Landfill include recreationists, workers, and residents. The Area II Landfill and surrounding area is likely to have a future recreational or industrial land use; however, a hypothetical future residential scenario also was assessed in the HHRA, along with recreational and industrial exposure scenarios. The residential scenario consists of conservative exposure assumptions, and residents are expected to have the greatest level of exposure. The residential exposure scenario evaluated in this report assumes that exposure can occur through the consumption of fruits and vegetables from a garden. An evaluation of the agricultural residential exposure scenario will be included in a separate report. The assumed exposure pathways for future residents, workers, and recreationists are shown in Figure 1.5.3-1.

Generally, the estimated cumulative cancer risks (ELCRs) less the regulatory risk ranges (range of 1 in a million [1×10^{-6}] to 1 in 10,000 [1×10^{-4}]) and estimated noncancer hazards (HIs) less than the regulatory threshold value of 1 are considered acceptable (EPA, 1993). The estimated ELCRs within the 1×10^{-6} to 1×10^{-4} range are managed on a site-specific basis. The ELCRs and HIs are summarized in Table C.7.5-1.

The following exposure scenarios for the Area II Landfill exceed the regulatory risk range for carcinogenic COCPs:

- Hypothetical future adult and child residents exposed to soil (0 to 2 ft bgs) from plant consumption

The following exposure scenarios for the Area II Landfill are within the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult and child residents exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult and child residents exposed to soil (0 to 10 ft bgs)
- Hypothetical future adult industrial worker exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult industrial worker exposed to soil (0 to 10 ft bgs)
- Hypothetical future residents and industrial workers exposed to indoor air (migration of soil vapor COPCs)
- Hypothetical future child recreationist exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult recreationist exposed to soil (0 to 2 ft bgs)

The following exposure scenarios for the Area II Landfill exceeded the regulatory threshold values for noncarcinogenic COPCs:

- Hypothetical future adult and child residents exposed to soil (0 to 2 ft bgs) from plant consumption

As described in Sections 1.5.3.6 and 3.7.4, there is a degree of uncertainty associated with these risk estimates that should be considered when making risk management decisions.

3.9.3 Recommendations for Area II Landfill

Additional soil samples are warranted to more definitely evaluate the extent of metals, specifically copper, in the subsurface soils. Additional PCB congener surface soil samples also would provide a better understanding of the horizontal extent of contamination in the surface soil.

Of the 50 analytes (dioxins/furans and coplanar PCBs were counted as one analyte) in soil for which ecological risks were evaluated, significant risks were identified for three: di-n-butylphthalate, BEHP, and dioxins/furans and coplanar PCBs. Ecological risk estimates from these analytes were driven by a localized area with elevated concentrations. As a consequence, additional investigation is not considered necessary. The removal of soils that have elevated concentrations, therefore, is recommended at this location, because it would reduce ecological risks.

Potentially significant human health risks were identified for three COCs in soil–BaP and coplanar PCBs–along with a number of benzene (in soil vapor) and PAHs (in surface soil).

Human health risk estimates from chemical generally were driven by a localized area with elevated concentrations. However, it is recommended that the localized extent of benzene in soil gas and PAHs in soil be confirmed to address the risk-based assessment. After confirmation of the extent of contamination, the removal of soils with elevated concentrations is recommended to reduce human health risks.

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4. Expendable Launch Vehicle (ELV), SWMU 5.2, 5.3

On the basis of the historical sampling and the 2008 RFI investigation, additional soil samples are warranted to more definitely evaluate the extents of dioxins and TPHs. Dioxins were encountered at elevated concentrations in the southeastern portion of the site, near the dry pond; additional sampling is needed to further evaluate the horizontal extents of these parameters. Near the Building 2202 wastewater treatment sump and clarifier, DROs (C14-C20) and (C20-C30) do not appear to have been bound in the southerly direction.

Dioxins, SVOCs, TPH groups, VOCs, and several metals parameters may require additional sampling to evaluate the vertical extent near two specific locations: the Building 2202 wastewater treatment sump and clarifier, and the southeastern dry pond. These sample locations consistently had the highest concentrations for these parameters, and an attempt to collect samples at a greater depth is warranted. Additional soil gas samples also would be beneficial in characterizing the VOC contamination in the ELV Area, specifically in the southeastern portion of the area near the dry pond.

Although ecological risks from 40 analytes were evaluated in soil at the ELV, only mercury and dioxin/furans (including coplanar PCBs) were identified as presenting unacceptable risks. Four locations contained highly elevated mercury concentrations (above 10 mg/kg) and probably represent hot spots. Because mercury was analyzed for in 360 samples in the 0- to 2-foot-bgs interval, additional sampling is not likely to be warranted; however, consideration of hot spot removal in the CMS is recommended. Additional characterization of dioxin/furans and coplanar PCBs in soil also is recommended, because the risks estimated for bird and mammal receptors were based on only 16 dioxin/furan sample locations and only 2 PCB congener sampling locations.

Potentially significant human health risks were identified for dioxins/furans in soil and TCE in soil vapor. Human health risk estimates from chemicals generally were driven by a localized area with elevated concentrations. After confirmation of the extent of contamination, removal of soils with elevated concentrations and extraction of soil vapors in areas with elevated VOC concentrations are recommended to reduce human health risks.

4.1 ELV Site Background and History

The ELV area consists of several buildings that supported the development and testing of the ELV and rocket engine components. Fuel tanks associated with the activities in these buildings also are part of the ELV area.

4.1.1 SWMUs and AOCs

The SWMUs and AOCs within the ELV area are in the northern portion of Area II. There are two SWMU sites located in the ELV area, identified as SWMU 5.2, ELV Final Assembly Building 2206, and SWMU 5.3, PCB Storage.

Building 2206 and the buildings that were associated with activities at the ELV have been designated as part of SWMU 5.2. Other buildings included in the SWMU 5.2 boundaries are 2201, 2202, 2203, 2211, 2231, and 2232. Building 2206 formerly was used as a rocket engine component testing facility. SWMU 5.3 was a former PCB Storage Facility located at Building 231 that was closed by DTSC in 1998. Building 2207 is also included in this section because of its proximity to the ELV.

Two AOCs are located in the ELV SWMU boundary. These include the Building 2206 Diesel UST (UT-51) and the Building 2207 UST (UT-53), which were removed in 1987 and 1988, respectively. Both of these USTs were closed by VCEDH in 1996 (MWH, 2004).

4.1.2 Site History

NASA acquired the Area II property formerly known as USAF Plant 57 from the USAF in 1973. Most of the buildings in the ELV area were constructed in the mid- to late-1950s. According to a 1965 master plan, Building 2201 was used for engineering offices, and once was used as an Operations Building.

Building 2202 was used as a cafeteria and also housed a photo laboratory and wastewater treatment clarifier (Rocketdyne, 1956). The building most recently was used for Laser and Electro-Optical System (LEOS) storage.

Building 2203 was last used as a Lasers Lab Facility by LEOS. This building formerly was used as an instrument laboratory in which various types of instruments were repaired and calibrated (DTSC, 2006). According to a 1965 Master Plan, Building 2203 was once used as a Service Building. Operations included polishing, cleaning using small amounts of solvents and other chemicals, assembling, and testing of various components in both open warehouse and clean room environments. According to building plans, the building also contained a lead tinning machine, a vapor degreaser, an aqueous cleaner, a boring mill, a jig bore, a metal shear, a lathe, and a mill. Sand blasting and welding activities also may have taken place at Building 2203. Instrumentation functions at the building included mercury-containing thermometers and manometers. Approximately 1 pound of mercury was spilled inside Building 2203 as a result of a broken power conversion unit (Rockwell, 1988).

Building 2206 was built to test rocket engine components using petroleum based fuels (RP-1 and JP-4) and LOX. The building originally was called the Component Test Laboratory (CTL) and was last used as the ELV Final Assembly Building. Four small test bays are located on the southern side of the building. A long sump runs the length of the building along one wall. Drums of product chemicals were stored outside on the southern side of the building in a fenced drum storage area. TCE was used to wipe clean component parts until the solvent was changed to TCA. Some TCE rinsing operations also may have occurred in the test bays (MWH, 2005d). The Building 2206 Diesel UST (UT-51), which was removed in 1987 and classified as closed by VCEDH in 1996. A small earthen catchment pond southwest of Building 2206 was used to contain testing operations wastes. From 1978 to 1989, the building also housed a machine and welding shop that used lubricating oils and compressed gas.

From 1989 to 2006, Building 2206 was used as engine assembly, chemical storage, and office space. Operations in the building included rocket engine component testing, engine component cleaning, machining of components, welding, brazing, engine assembly,

painting, hazardous materials storage, heat treating, chemical processing, cleaning, vapor degreasing, phosphate treatment, ductile nickel plating, gold plating, copper plating, cadmium plating, hard anodizing aluminum alloys, electroplating, electro-milling and anodizing, hard chromium chromic acid and sulfuric acid anodizing of aluminum alloys, applying chemical films to aluminum, and cleaning and passivating of corrosion-resistant alloys, as well as many other alloys (Macfarlane, 1989; Rockwell, 1989; Rockwell, 1995).

There has been one documented release of 4 to 6 gallons of hydraulic oil inside the building (Ogden, 1996b). There was a reported spill of 0.1 gallon of battery acid in front of the building, as well as 0.1 gallon of RP-1. There was a recorded release of 1 gallon of diesel in the maintenance lot, and 1 gallon of an unknown liquid in the oil yard. Five gallons of oil and water reportedly were released from the reservoir on a pipe cutter trailer. There also has been a documented release of less than 1 quart of methyl n-amyl ketone (MAK) at Building 2206 (ICF, 1993).

Building 2207 is the Protective Services Building and is used as the SSFL Fire Station. There was formerly a drum storage area and a former UST (UT-53) at Building 2207. The 1,500-gallon diesel UST was constructed of steel and was removed in 1988. The UST was an Area II AOC and was closed by VCEDH in 1996. Vehicle washing activities previously occurred in the driveway area of Building 2207.

Building 2211 was once used as an Operations Building, according to a 1965 Master Plan. The building also was used for furniture storage. On the northern side of the building, a partially buried pipeline was discovered leading towards the northern ravine. This pipe conveyed nitrogen gas from Building 2211 to a storage and filling station that was located down the hill. There is an Area II AOC for the Building 2211 Leach Field, but this AOC is included with the Area II Ash Pile and STP area because of its proximity and relationship to the STP.

Building 2231, a former PCB Storage Facility (SWMU 5.3), was closed by DTSC in 1998. The building is adjacent to Building 2206 on the southwestern side and is now used for storage.

Building 2232 formerly was used as the LOX Tank Control Building, while Building 2206 was operating as a test facility and later was used for storage.

Building 2932 was a former Compressor Shelter and a Material Preparations Shelter, located on the eastern side of Building 2203, according to maps. A former paint booth that also served as paint storage adjacent to Building 2206 on the southwestern corner also was referred to as Building 2932. There is no record of a paint booth or of painting activities at or near Building 2203. Building 2932 has been removed, and no building currently exists at either of these locations.

4.1.2.1 Site Inventories

An inventory of the buildings, tanks, transformers, and chemicals used at the ELV Area was completed during the preparation of this RFI. This information was obtained from historical document reviews, facility drawings, and visual site inspections. These features

are shown in Figure 4.1-1, as applicable. The inventories are included in the following tables:

- Building Inventory–Table 4.1-1
- Tank Inventory–Table 4.1.2
- Transformer Inventory–Table 4.1-3
- Chemical Inventory–Table 4.1-4

4.1.3 Site Chemical Use Areas

Building 2201 formerly was used as an Operations Building, but it is unknown what specific activities occurred in the building. There was a former work area that used liquid nitrogen in the southeastern corner of the building. A plot plan dated March 25, 1955, delineated a 7,500-gallon AST on the eastern side of Building 2201. Piping diagrams indicate that the fuel oil also might have been used by Buildings 2202 and 2211. The exact use of the AST is unknown, but it presumably was used to store gasoline to power emergency generators for Buildings 2201, 2202, 2203, and 2211.

Building 2202 formerly served as a cafeteria and contained a photo laboratory and wastewater treatment clarifier. The kitchen was on the eastern side of the building and the clarifier was outside the southwestern corner. The former photo laboratory was in the western portion of the building. A former oil storage area was located on concrete north of Building 2202. The area was identified during an interview conducted in 2005. An excavation of approximately 3,000 yd^3 of mercury-contaminated soil was conducted north of Buildings 2202 and 2203 in 1994.

Building 2203 was last used as a Lasers Lab Facility, but formerly was used as an Instrument Laboratory and Service Building. Various pieces of machinery including a lead tinning machine, a vapor degreaser, and a boring mill were used in locations throughout the building. Activities such as sand blasting and welding also may have occurred in, or just outside, Building 2203. A former oil storage area was located on asphalt north of Building 2203. The area was identified during an interview conducted in 2005. An excavation of approximately 3,000 yd^3 of mercury-contaminated soil was conducted north of Buildings 2202 and 2203 in 1994. An equipment cleaning area used to clean parts with solvents was located between Buildings 2202 and 2203. Adjacent to Building 203 on the eastern side was former Building 932, referred to as a Compressor Shelter and Materials Preparation Shelter.

A covered drum storage area south of Building 2206 formerly stored drums containing solvents and oil. . The area drained toward the roadway on the south. A paint booth, Building 2932, was located near the southwestern corner of Building 2206. Paint products were stored and used in the building, including chromic acid and hexavalent chromium (Kim, 1992). There was a former equipment cleaning area on the eastern side of Building 2206, where solvents were used to clean parts. The test bays to the south of Building 2206 were used to test components, and there may have been TCE rinsing conducted in these areas. TCE, and later TCA, were used to wipe clean parts and equipment.

Petroleum-based fuels, such as RP-1 and JP-4, and LOX were used in the component test bays. Testing wastes may have flowed through pipes and the sump, which ran along the

southern wall of the test bays. There is a catchment pond southeast of Building 2206. The pond was used to contain testing operations wastes that may have been burned in the pond. A concrete vault, 12 ft by 18 ft by 8 ft deep, is located on the southern side of Building 2206. The vault's purpose is unknown, but it may have been associated with the test bays and drainage pond for Building 2206. Several ASTs formerly were located on the southern side of Building 2206; only the concrete supports and secondary containment remain. A drainage hole was observed in the secondary containment used for the ASTs, but may have been added after the ASTs were removed to limit the accumulation of rain water. An Area II AOC exits for the Building 2206 Diesel UST (UT-51), which was removed in 1987 and closed by VCEDH in 1996. Compressed gas, various oils, and various other chemicals would have been used in at Building 206 during welding, brazing, metal plating, vapor degreasing, testing, and assembly operations.

Building 2207 formerly had a drum storage area and a former UST (UT-53), which was removed in 1988 and closed by VCEDH in 1996. A former vehicle washing area was located on the northern side of the building, and rinse water flowed to a storm drain to the southeast of the building.

There is an area of staining on the northern side of the floor in Building 2211. The source of the staining is unknown. There is an Area II AOC for the Building 2211 Leach Field, but this AOC is included with the Area II STP.

Building 2231 is a former PCB Storage Facility (SWMU 5.3) that was closed by DTSC in 1998. There is no documentation of other chemical use at this facility.

Building 2232 is the former LOX Tank Control Building; there is no documentation of chemical use at this facility.

4.1.4 Site Conditions

Currently Building 2201 is vacant. The former AST on the eastern side of the building has been removed and there is a partial cinderblock bermed area where the AST formerly was located.

Building 2202 currently is vacant; the clarifier has been cleaned out and wipe samples reportedly have been collected. A surface water retention pond to the northwest of Building 2202 captures runoff from Buildings 2202 and 2203. The hillside leading down to the pond has been partially paved with concrete and the area is an NPDES sampling location (Outfall 010).

Building 2203 is currently vacant. Laser lab operations were conducted in the building until 2006. The machines discussed in Section 4.1.2 have been removed. Former Building 2932 was adjacent to the eastern side of Building 2203, but has been removed. A surface retention pond to the northwest of Building 2202 captures runoff from Buildings 2202 and 2203. The hillside leading down to the pond has been partially paved with concrete and the area is a NPDES sampling location (Outfall 010).

Building 2206 is currently vacant. The test bays on the southern side of the building remain, although there are no test stands, and the machines from previous building operations are no longer present. Concrete supports for former ASTs remain on the southern side of the

building, as well as a concrete vault. Building 2932, a former paint booth near the southwestern corner of Building 2206, has been removed.

Building 2207 currently is used as the SSFL Fire Station and also is known as the Protective Services Building. No vehicle washing activities are performed at the building.

Building 2211 is currently vacant. An Area II AOC, the Building 211 Leach Field, is associated with this building, but is discussed with the Area II STP.

Building 2231 is currently vacant, but is being used for storage. The building formerly was used as PCB Storage (SWMU 5.3), but was closed by DTSC in 1998. There are no PCBs currently being stored in the building.

Building 2232 is currently vacant and empty.

Building 2932 has been removed.

4.1.5 Site Habitats/Land Cover

Most of the ELV area is developed. In the western portions of the area are rock outcrops and chaparral, as well as coast live oak woodland, ruderal habitat, and venturan coastal sage scrub. The central and eastern portions of the site include more venturan coastal sage scrub, rock outcrops, mulefat scrub, and coast live oak woodland. The area to the west of the ELV primarily is developed, with areas covered with rock outcrop, and coast live oak woodland. The catchment pond for Building 2206 is reported as open water. Rock outcrops, rock outcrops with chaparral, and developed areas are to the southwest of the ELV. On the southeast of the ELV are venturan coastal sage scrub, rock outcrops with venturan coastal sage scrub, and coast live oak woodland. The areas north and east of the ELV primarily are developed, but there are areas with rock outcrops and venturan coastal sage scrub. To the north and west of the ELV lies coast live oak woodland, ruderal habitat, nonnative grassland, mulefat scrub, and developed areas with venturan coastal sage scrub (Figure 4.1-2).

There is habitat for the Santa Susana tarplant in the eastern portion of the site and to the north of the ELV. Habitat for the sharp-shinned hawk and mule deer lie to the northwest of the site (The Boeing Company, 2008a).

4.1.6 Historical Document Reviews

As described in Section 1.5.1, a historical document review was completed of documents applicable to the Group 2 RFI. As a result of this historical document review, five new potential features were identified at the ELV. The feature was identified as the cement containment pool behind the UV Peroxide treatment system at the RD-9 Area SWMU (SWMU 5.4), a potential pipeline from Building 2206 Catchment Pond leading toward the Storage Propellant Area (SPA) AOC, a leach pit associated with the Sump and Clarifier at the LOX Plant (SWMU 4.5), a potential sewer leach field located at the LOX Plant, and the USEFF located to the southwest of the STP AOC.

4.2 RFI Characterization Activities

This subsection describes the sampling objectives, sampling scope, and key decision points associated with defining the nature and extent of the chemical impacts for the surface soil, subsurface soil, and groundwater at the ELV.

4.2.1 Sampling Objectives

To characterize the extent of potential chemical impacts at the ELV, soil and groundwater samples were collected. The objectives of the soil investigation were as follows:

- Define the lateral and vertical extent of chemical impacts.
- Define the potential gradients of chemicals.
- Develop a sufficient data set for performing a risk assessment.

These objectives contributed to the selection of sampling locations, analytical methods, and depths while incorporating site-specific information such as the following:

- Site conditions observed at the location of proposed sampling
- Historical sampling results and/or previous remediation activities
- Fate and transport characteristics of chemicals
- SSFL background concentrations of chemical parameters
- SSFL SRAM-based screening concentrations for human health and ecological receptors

4.2.2 Sampling Scope

Provided in this report are all of the characterization results for soil matrix, soil vapor, and groundwater information. The total number of historical samples and samples collected as part of the RFI report for soil matrix, soil vapor, and groundwater are summarized below:

- Soil Matrix: 353
- Soil Vapor: 41
- Groundwater: 5

These samples were collected between 1993 and 2008 to identify the potential chemical impacts associated with the activities at the ELV. These samples are described further in Section 4.4.

4.2.3 Key Decision Points

The site-specific decision points identified for the ELV represent the assumptions and/or decisions made during the sampling phase component of this RFI, as follows:

- For historical sample points where the sample depth had not been recorded, it was assumed that these sample points were taken between the 0- to 2-foot-bgs range.

4.3 RFI Characterization Results

The characterization results and interim measures from previous soil matrix, soil vapor, groundwater, and surface water investigations at the ELV are summarized below.

4.3.1 Soil Matrix and Soil Vapor Findings

Surface soil samples have been collected at the ELV from 1993 through 2007 as part of the previous RFI investigations and interim measures. The primary features investigated at the ELV include the photographic clarifier at Building 2202, Equipment Cleaning Area northwest of Building 2203, Building 2203 Mercury Release Area, Building 2206 Former Test Bays, Building 2206 Drum Storage Area, Building 2206 Diesel UST (UT-51), Building 2206 Catchment Pond, Building 207 UST (UT-53), and Building 2231 PCB Storage area. The investigations that have been performed at these areas are further described below.

Building 2202–Photographic Laboratory Clarifier. The investigation at the clarifier included two locations (EVBS02 and EVBS20) that were sampled for metals and TPHs in 1997. At the same time, an additional sample (EVSU01) was collected in the sump and was sampled for metals, SVOCs, TPHs, and VOCs. At sample locations EVBS02 and EVBS20, TPH concentrations exceeded both the ecological and human health screening criteria. At EVSU01, 14 metals were detected at concentrations that exceeded both the ecological and human health screening criteria.

Building 2203–Former Equipment Cleaning Area. As part of an interim measure, approximately 250 yd^3 of soil were excavated to a depth of 8 ft bgs in the area of the former equipment cleaning area (to the north of Building 2203). Before the interim measure, the soil was investigated for the presence of VOCs and SVOCs. In 1997, soil sample EVBS03 and soil gas sample EVSV04 indicated detections of TCE that exceeded both the ecological and human health screening criteria. Subsequent to the removal of soil as part of the interim measure, the analytical results at soil sample EVBS21 indicated a concentration TCE of 34 J µg/kg, which slightly exceeded its human health criteria of 30 µg/kg.

Building 2203–Mercury Release Area. As part of an interim measure, approximately 3,000 yd^3 of soil affected from a mercury release were excavated and removed in an area to the north of Buildings 2203 and 2203 in 1994 (DTSC, 2005). Before the interim measure, the soil was investigated for the presence of mercury. The highest mercury detections were recorded downgradient of the release at a concentration of 50 mg/kg. As part of the interim measure, 330 samples were collected. The post-interim measure residual soil mercury concentrations are mostly below the interim measure action level of 0.09 mg/kg, with a few exceptions because of oak tree roots, slope stability issues, or difficult access behind rock outcrops (MWH, 2005a).

Building 2206–Text Bays and Drum Storage Area. In 1993, 1997, and 2002, soil sampling for metals, SVOCs, TPHs, and VOCs was performed around the perimeter of Building 2206, near the test bays, and adjacent to the drum storage area. These sample locations identified dioxins, metals, SVOCs, TPHs, and VOCs that exceeded one or both of the ecological and human health screening criteria. Soil gas surveys for VOCs in these areas were performed in 1993, 1997, 2000, and 2001. Locations EVSV02, EVSV04, EVSV15, EVSV16, EVSV17, EVSV18, and SV-5.2-9 showed exceedances of VOCs at levels above the screening criteria.

Building 2206–UST. On August 21, 1987, underground storage tank UT-51 was removed. As part of the removal process, two soil borings were advanced (B-206-1 and B-206-2), one near each end of the UST to a total depth of 15 ft. These sample locations were analyzed for

TPHs and BTEX. No TPHs or BTEX were detected from the samples collected. UT-51 was closed by VCEDH in 1996 (Groundwater Technology, 1996a).

Building 2206–Catchment Pond. In 1997, soil sampling for dioxins, metals, SVOCs, TPHs, and VOCs was performed at the 2206 Catchment Pond. These sample locations identified dioxins, metals, TPHs, and VOCs that exceeded one or both of the ecological and human health screening criteria.

Building 2207–UST. On July 1, 1988, UT-53 was removed. A subsequent soil investigation on January 24, 1996, included four soil borings (B-207-1, B-207-1A, B-207-2, and B-207-3). These sample locations were analyzed for TPHs and BTEX. No TPHs or BTEX were detected from the samples collected. UT-53 was closed by VCEDH in 1996 (Groundwater Technology, 1996b).

Building 2231, PCB Storage. Building 2231 (SWMU 5.3), which used as a PCB storage area, located to the southwest of Building 2206. Samples taken at this building included wipe samples, concrete samples, and soil samples. Three wipe samples were collected on August 26, 1996, from the eastern wall adjacent to the PCB Storage Unit pad. On September 4, 1996, three concrete samples were collected from the PCB Storage Unit pad and three soil samples were collected in the area of the asphalt loading area. PCBs were not detected from any of the samples collected, except for one concrete sample that had a reported concentration equal to the method RL. The PCB Storage unit was closed by DTSC in 1998.

4.3.2 Groundwater Findings

4.3.2.1 Background

The ELV Final Assembly Building 206 SWMU 5.2 area is an approximately 8.5-acre area located in the northern section of Area II. The elevation varies from approximately 1,850 ft above msl in the northwestern section of the area to 1,780 ft above msl in the southeastern section of the area.

NSGW monitoring has been conducted at well RS-29 beginning with its installation in 1993 (Figure 4.3.2-1). Six piezometers were installed at the ELV as part of this RFI (PZ-138, PZ-139, PZ-140, PZ-141, PZ-143, and PZ-144), as shown in Figure 4.3.2-1. The piezometers were screened within the weathered Chatsworth formation or across the boundary of the weathered and unweathered Chatsworth formation. Table 4.3.2-1 provides a well construction data summary for the newly installed piezometers and existing wells. Construction logs and boring logs for the newly installed piezometers are provided in Appendix D.

Five Chatsworth formation groundwater monitoring wells (RD-51A, RD-51B, RD-51C, RD-56A, and RD-56B) also are present. One deep corehole, C-7, is located in the southeastern section of the site just north of a closed surface water impoundment. The location of the Chatsworth formation monitoring wells is shown in Figure 4.3.2-1. Well construction summaries are provided in Table 4.3.2-1.

4.3.2.2 Local Geology

This area is underlain by deposits of the Upper Burro Flats Member of the Chatsworth formation, which consists primarily of fine-grained sandstone, siltstone, and shale. The ELV

member of the Chatsworth formation borders the ELV area to the east and has been encountered at depth in nearby boreholes to the west. Figures 4.3.2-2, 4.3.2-3, 4.3.2-4, and 4.3.2-5 are geologic and hydrogeologic profiles across the ELV site.

During rock-coring activities at PZ-138, PZ-139, PZ-140, PZ-141, PZ-143, and PZ-144, fill materials and alluvium were encountered at the surface to depths ranging from approximately 4 ft to greater than 75 ft bgs. The alluvium consists of brown to light yellowish-brown clayey silt to silty sands. The thinnest alluvium deposits were encountered at PZ-141 and PZ-144, located at the western margin of the ELV area. The thickest alluvium deposits (greater than 75 ft) were encountered at PZ-143, located north of the northern boundary of the ELV. PZ-143 is thought to be located north of the north fault, which is oriented east-west across the northern boundary of the ELV. Some fill materials, consisting of very dark gray to dark brown clayey and sandy silt, were encountered at PZ-138 and PZ-144.

Weathered Chatsworth formation bedrock was encountered below the alluvium and ranged in thickness from approximately 14 ft to more than 50 ft. The weathered Chatsworth formation consists predominantly of brown to yellow to gray silty sandstone. Oxidation is prevalent throughout much of the matrix of the weathered rock.

Fill material and alluvial deposits form a relatively thick and narrow corridor in the area of RS-29 and the RD-51 well cluster (Figures 4.3.2-2 and 4.3.2-3). The north fault is thought to splay into two traces in this region; one of the splays probably most likely the area of the RD-51 well cluster and has produced a zone of thick alluvial deposits and deeply weathered bedrock. Woody material has been described from cuttings from several boreholes in this area to depths of approximately 30 ft bgs.

Unweathered Chatsworth formation consists typically of light gray silty sandstone. Some fracturing is present and occasionally oxidation bands will be present along the margins of fracture planes extending several inches into the adjacent rock matrix.

4.3.2.3 Local Hydrogeology

The occurrence of NSGW at the ELV is ephemeral and is compartmentalized by the North Fault splays in the study area. RS-29 has been dry during various times in the past and several of the recently installed piezometers also were dry. The depth to groundwater in RS-29 in January 2008 was approximately 32 ft bgs; in May 2008, RS-29 was dry. Groundwater present in RS-29 is found in a localized thick fill and alluvium section that has eroded the weathered bedrock interval. The groundwater present in RS-29 may be perched; however, there may be a hydraulic connection with unweathered bedrock near the total depth of the well. The depth to groundwater measured in July 2008 at the newly installed piezometers installed in weathered bedrock ranged from approximately 16 ft bgs at PZ-140 to approximately 46 ft at PZ-139. PZ-138 and PZ-143 were dry. Groundwater measured in PZ-139, PZ-140, and PZ-141 are connected to CFOU groundwater. The water level measured in PZ-144 was present in the unweathered bedrock interval that corresponds to the CFOU.

Figure 4.3.2-6 shows groundwater elevations over time in RS-29 and also in nearby clustered wells RD-51A, RD-51B, and RD-51C, which are screened in fresh bedrock of the Chatsworth

formation. The depth to groundwater in these wells ranged from 237 ft at RD-51C to 250 ft in RD-51B.

Figures 4.3.2-2, 4.3.2-3, and 4.3.2-4 show the occurrence of NSGW in cross sections across the ELV area. A zone of thicker NSGW occurs at PZ-140, in the northeastern section of the ELV and thins to the west toward a bedrock high. Within the area of intersection of the north fault with the RD-51 well cluster and newly installed piezometers PZ-138, PZ-139, and PZ-140, NSGW levels vary significantly vertically, laterally, and temporally. The vertical variation in NSGW level elevation is shown in Figure 4.3.2-2. The NSGW level in PZ-140 was measured at approximately 16 ft bgs on July 18, 2008. Although no concurrent NSGW level was gauged in July at nearby RS-29, RS-29 was dry in May 2008. Nearly 26 ft of elevation separates the elevation of NSGW in PZ-140 to the base of the screened interval at RS-29. PZ-138 was dry when measured in July 2008.

Figure 4.3.2-5 is a cross-section linking the ELV area with the Building 515 STP to the south. One of the features noted on the cross-section is the location of a catchment that has been used in the past to contain TCE piped from four test cells that were operated on the southern side of Building 206. It is believed that wastes in the earthen catchment pond were burned, similar to procedures used at the larger test stand skim ponds. Seepage from this pond, and possibly overflows to the valley below, may have contributed to near-surface and Chatsworth formation groundwater contamination in the RD-09 (Building 515 STP) area. The pond is no longer used but remains uncovered. Sampling of sediments from the catchment pond has determined the presence of petroleum hydrocarbons, metals, dioxins, and VOCs (TCE).

The occurrence of NSGW appears to be truncated to the north of the North Fault, which may act as a possible barrier to NSGW flow (Figure 4.3.2-4). PZ-143 was advanced to a depth of 75 ft bgs and was completed in alluvium. Unweathered Chatsworth formation was not encountered. PZ-143 was dry on July 18, 2008, which is screened approximately 40 to 50 ft below the elevation of NSGW measured in PZ-141 located south of the North Fault.

The elevation of the top of the Chatsworth formation surface is shown in Figure 4.3.2-7 and depicts an irregular surface that probably reflects the surface topography before construction. A trough is interpreted to extend from Building 203 to the Helipad area. This subsurface trend at the top of the CFOU may be a geologic discontinuity related to faulting or an area high fracture density adjacent to the fault that may act as a preferential pathway.

4.3.2.4 Characterization Results

Data collected from monitoring well RS-29 are used herein to provide the latest available interpretation of NSGW conditions. Historic sampling events at RS-29 have been sporadic. Data have been collected from RS-29 beginning in 1993 and extend into 1998.

New piezometers have been installed and sampled to refine the understanding of the nature and extent of contamination as part of this RFI. The results of sampling of the newly installed piezometers are pending and will be included in an addendum to this RFI report. Locations sampled and the dates on which sampling occurred are provided in Section 4.4.

Groundwater analytical results to date for the SMOU at the ELV are represented by the analyses of VOCs only. Table 4.3.2-2 summarizes NSGW sampling events at the ELV.

NSGW sampling was conducted at selected previously installed wells and piezometers in May 2008. Sampling also was scheduled for September 2008. Table 4.4-1 lists the wells and piezometers and the analytes that were sampled in May 2008. The results of the May 2008 sampling event were not available for inclusion herein. The results of the May sampling event, and all other subsequent sampling events, will be provided in an addendum to this RFI report. Groundwater analytical results are provided in Appendix D.

4.3.2.5 VOCs

VOCs have been the focus of analytical investigations involving groundwater because of their historic use at the SSFL (principally TCE). NSGW samples have been collected from RS-29 intermittently beginning in 1993 and extending into 1998.

4.3.2.6 Near-surface Groundwater

Table 4.3.2-3 summarizes the VOCs detected in NSGW at the ELV. The only VOCs detected in groundwater samples from RS-29 include acetone detected at 9 µg/L and cis-1,2-DCE at 1.6 µg/L, both reported in a sample collected in May 1998. Acetone and cis-1,2-DCE were not detected in prior sampling events. Screening levels were not exceeded for either compound. Figure 4.3.2-8 presents selected VOCs (halogenated ethenes and ethanes, which are the most commonly detected VOCs at the SSFL) concentrations over time at RS-29.

4.3.2.7 Chatsworth formation Groundwater

VOCs have affected Chatsworth formation groundwater at the ELV, probably as a result of TCE rinsing operations and possibly from containment of testing operation wastes at a small unlined catchment pond at the ELV. Contamination extends into bedrock beneath the site to depths of at least 400 ft bgs. The known extent of contamination in groundwater extends some 1,200 ft laterally, covering an area from the Building 515 STP northward across the ELV area and extending toward the north fault.

An overview of the most frequently detected VOCs is provided to relate the NSGW impacts with those in the Chatsworth formation groundwater.

Figure 4.3.2-9 presents selected halogenated ethene and halogenated ethane VOC concentrations over time in groundwater samples collected from Chatsworth formation groundwater monitoring wells. TCE, cis-1,2-DCE, and trans-1,2-DCE (and to a lesser extent VC) are the most frequently detected chlorinated VOCs in Chatsworth formation groundwater. TCE, cis-1,2-DCE, trans-1,2-DCE, and VC have also been detected in RD-51A and RD-51B, located in the northeastern section of the ELV. Halogenated VOCs (primarily TCE and cis-1,2-DCE) have been detected in RD-56A northwest of the ELV, but not in RD-56B, which monitors a deeper section of the Chatsworth formation groundwater. Halogenated ethenes and ethanes have not been detected in groundwater samples collected at RD-70 north of the north fault. VOCs that have been detected at RD-70 include 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), methylene chloride, benzene, ethylbenzene, m,p-xylene, o-xylene, toluene, and chloromethane. Benzene is the only VOC that has exceeded the screening criteria.

Rock core was collected and sampled at Corehole 7 (C-7) and analyzed for VOCs. The results indicate that nearly 100 percent of the total equivalent mass of TCE resides in an approximately 100-foot-thick interval between 1,750 ft to 1,650 ft in elevation. The top

interval corresponds with the top of the water table and the bottom interval corresponds with the occurrence of the unlithified hard sandstone (University of Waterloo, 2003). Upward hydraulic gradients in this interval have been measured and thus may have a bearing on the distribution of VOCs in NSGW at both ELV and south to the STP 515 SWMU.

4.3.3 Surface Water Findings

Surface water features at the ELV consist of a small drainage north of Building 203 and a small catchment pond used to contain testing operation wastes. Surface water releases through this drainage are monitored under an NPDES permit. The catchment pond is no longer used.

Surface water samples were not collected during this RFI investigation because of the seasonally dry conditions.

4.3.4 Completeness of Characterization

Areas of known exceedances and areas of potential contamination at the ELV were further investigated using soil and soil vapor samples. The predominantly detected contaminants at the ELV are dioxins, metals, SVOCs, TPHs, and VOCs. The dioxins, metals, SVOCs, and TPHs detected are attributed to the burning of residual engine test cell wastes that were drained to the 2206 Catchment Pond. Additional metals and TPHs are attributable to the clarifier at Building 2202. The metals and VOCs at Building 2203 are attributable to the Former Equipment Cleaning Area and mercury release that occurred on the northern side of Building 2203.

4.3.4.1 Near-surface Groundwater Characterization

The occurrence of NSGW at the SSFL, including the ELV, is ephemeral and believed to be related to seasonal variations in precipitation. Fracturing associated with the North Fault may have some influence on groundwater occurrence. Newly installed piezometers (PZ-138, PZ-139, PZ-140, PZ-141, PZ-143, and PZ-144) have been sounded for the presence of groundwater, and where groundwater has been present, sampling of the groundwater has occurred. PZ-138 and PZ-143 were dry. Additional synoptic gauging of piezometers for the occurrence of NSGW and sampling of NSGW, when present, is planned across several seasons to include late-winter and early-spring events when precipitation is anticipated to increase. The current NSGW monitoring network should provide sufficient sampling locations to characterize groundwater in the SMOU under optimum conditions.

4.3.4.2 Surface Water

NPDES monitoring of surface water discharges at the designated point north of the ELV area will continue. Drainages at the Area II Landfill are directed to this point.

4.4 ELV Nature and Extent

Surface soil, subsurface soil, and soil gas samples were collected at the ELV, per the protocol described in Section 4.2; the data collected at this site are provided in Appendix D. Figure 4.4-1 shows the sample locations, including historical and recent samples collected, as part of this RFI investigation. Table 4.4-1 lists the parameters analyzed for in the sample

media at the ELV. The nature and extent of potential contamination that exceeded the applicable comparison criteria are detailed below.

4.4.1 Surface Soil Nature and Extent

To evaluate the nature and extent of potential contaminants in the ELV Area, 260 surface soil samples were collected at this site and analyzed for 1 or more of the following: dioxins, 1,2-diphenylhydrazine, TAL metals (including hexavalent chromium), PCBs (aroclors and cogeners), SVOCs, TIC, TPHs, and VOCs. Table 4.4-2 lists the parameters detected in the surface soil samples at the ELV Area.

The compound 1,2-diphenylhydrazine, analyzed for in 25 surface soil samples, was not detected at this site.

4.4.1.1 Parameters Exceeding Criteria

The nature and horizontal extent of parameters encountered at concentrations exceeding their respective comparison criteria are detailed below.

Dioxins. Sixteen surface soil samples were analyzed for dioxins at this site, which included both CDDs and CDFs. Fourteen of those samples reported a combined 15 dioxin parameters at concentrations exceeding their respective human health comparison criteria. The current approach to assessing the toxicity of these mixtures is to use information regarding the toxic potency of the different congeners to convert the congener concentrations to a toxicologically equivalent concentration of the most potent congener, 2,3,7,8-TCDD. The 2,3,7,8-TCDD TEQs also were reported by the laboratory for some of the ELV surface soil dioxin samples. However, the laboratory did not provide the 2,37,8-TCCD TEQs for the most recent ELV Area dioxin samples, so they were calculated using the standard TEF values (Van den Berg et al., 1998) and assuming one half of the RL for parameters that were not detected.

The samples were evaluated for nature and extent by comparing the frequency of the different CDDs and the CDFs that exceeded the screening criteria at each location. The CDD and CDF exceedances, where added together according to the chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-), and the 2,3,7,8-TCDD TEQ values were compared to the ecological screening criteria (0.0043 µg/kg) and the more conservative human health screening criteria (0.0013 µg/kg). Table 4.4-3 summarizes these values; the nature and extent of the 2,3,7,8-TCDD TEQ values are discussed below.

Fourteen of the 16 samples with dioxin congener exceedances also exceeded the 2,3,7,8-TCDD TEQ human health screening criteria (0.0013 µg/kg), and 5 of those also exceed the ecological (0.0043 µg/kg) screening criteria. The exceedances ranged from 0.0025 µg/kg at RF992 to 0.0743 µg/kg at EVBS1056. These sampling locations are concentrated in the southeastern portion of the ELV area and may require additional sampling to further evaluate the horizontal extent of the dioxin exceedances. The horizontal extent of the 2,3,7,8-TCDD TEQ concentrations has been adequately characterized at this site, as shown in Figure 4.4-2. The vertical extent of these parameters is addressed in Section 4.4.2.

Metals. Of the 219 samples analyzed for metals, 70 reported a combined 17 TAL metals parameters that were detected at levels exceeding the applicable comparison criteria. Most of those parameters were encountered at concentrations mostly similar to their respective background values, and probably are indicative of natural occurrence. The nature and extent of metals exceedances in the ELV Area are detailed below.

In 2004, there was an excavation effort conducted under the guidance of MWH on the northern side of Buildings 2202 and 2203. The effort was in response to a reported mercury spill, and approximately 3,000 yd^3 of soil were removed from the site. A number of samples were collected before and during the excavation effort, which reflect concentrations of mercury and various other potential contaminants that are no longer applicable at the site. The results from the samples representing removed soils were not considered for the nature and extent evaluation. Confirmatory sampling was conducted, producing analytical data that are representative of the soil that remains at the ELV site.

Three parameters, antimony, nickel, and vanadium, each were encountered once at exceeding concentrations mostly indicative of natural occurrence. Antimony was detected at an elevated concentration of 13.1 mg/kg (EVBS1040), compared to its background value of 8.7 mg/kg. Nickel was detected at 48.8 mg/kg (EVBS1040), compared to its background value of 29 mg/kg, and vanadium was encountered at 67.6 mg/kg (EVBS1022), compared to its background value of 62 mg/kg. Each of these sole exceedances was reported at a concentration mostly similar to the parameter's background value, suggesting that these parameters are occurring naturally at this site at the reported concentrations. The horizontal extents of antimony, manganese, nickel, and vanadium have been addressed sufficiently.

Elevated concentrations of aluminum and silver were encountered in two samples, and barium was encountered in four samples at concentrations mostly similar to their respective background values. Aluminum was detected at concentrations of 22,700 mg/kg (EVBS1042) and 23,300 mg/kg (EVBS1022), compared to its background value of 20,000 mg/kg. Silver exceedances were detected at concentrations of 1.23 mg/kg (EVBS1030) and 1.30 mg/kg (EVBS1012), compared to its background value of 0.79 mg/kg. Barium was reported at elevated concentrations ranging from 153 mg/kg (EVBS1039) to an estimated 208 J mg/kg (EVBS1023), compared to its background value of 140 mg/kg. Aluminum, silver, and barium exceedances were reported at concentrations suggestive of natural occurrence, and not of operational processes. Additionally, these sampling stations are bound horizontally by other surface soil samples that had non-exceeding or non-detect concentrations of these parameters. The horizontal extents of aluminum, silver, and barium have been evaluated adequately.

Sole exceedances of boron, hexavalent chromium, molybdenum, and selenium were reported at this site. Hexavalent chromium was encountered at a concentration of 0.276 mg/kg (EVBS1014), exceeding its common ecological and human health criteria of 0.200 mg/kg. The exceedances of boron, molybdenum, and selenium were isolated to sampling location EVBS1040, which is located inside Building 2203. Boron was detected at a concentration of 40.1 mg/kg (EVBS1040), exceeding its common ecological and human health criteria of 6.76 mg/kg. Molybdenum was detected at 13.2 mg/kg (EVBS1040), exceeding its ecological (0.110 mg/kg) and human health (0.100 mg/kg) comparison criteria, and selenium was detected at 1.2 mg/kg (EVBS1040), exceeding its common ecological and human health criteria of 0.17 mg/kg. The sampling stations with the boron,

hexavalent chromium, molybdenum, and selenium exceedances are bound horizontally by the building structure or, in the case of hexavalent chromium, other surface soil samples that had non-exceeding or non-detect concentrations of these parameters. The horizontal extents of these metals have been evaluated adequately.

Two arsenic, three chromium, five copper, and eight cadmium exceedances were detected in the surface soil at this site. Elevated concentrations of arsenic were 27 mg/kg (EVBS1055) and an estimated 33.2 J mg/kg (EBVS1065), exceeding its human health and ecological (1.9 mg/kg) comparison criteria. Elevated concentrations ranged from 39.8 mg/kg (EVBS1030) to 69 mg/kg (EVBS17), exceeding its human health criteria of 1.58 mg/kg. Copper was detected at concentrations ranging from 30 mg/kg (EBSV1017) to 73.2 mg/kg (EVBS1040), exceeding its human health and ecological (1.1 mg/kg) comparison criteria. Cadmium exceedances ranged from 1.4 mg/kg (EVBS1045) to 7.34 mg/kg (EVBS1030), exceeding its ecological and human health (0.02 mg/kg) comparison criteria. Each of these exceedances is closer in concentration to the respective background values. These exceedances are mostly bound horizontally through additional surface soil sampling. The Service Area Road and Parking Lot Road also provide a horizontal boundary to the south and east of some exceedances reported in and around the dry pond in the southeastern corner of this site. The horizontal extents of arsenic, chromium, copper, and cadmium have been evaluated adequately, as shown in Figure 4.4-3.

Lead and zinc were encountered multiple times at concentrations exceeding their respective comparison criteria. Five lead exceedances ranging in concentration from 36.8 mg/kg (EVBS1015) to 120 mg/kg (EVBS17), exceeding its ecological and human health (0.06 mg/kg) criteria. The 10 exceedances of zinc ranged in concentration from an estimated 120 J mg/kg (EVBS1024) to 1,330 mg/kg (EVBS1030), exceeding its human health and ecological (21 mg/kg) comparison criteria. Lead and silver exceedances are bound horizontally through additional samples had non-exceeding concentrations of each parameter. Zinc is mostly bound through additional sampling, and also by the Service Area Road to the south of the dry pond. The horizontal extents of lead and zinc have been evaluated adequately, as shown in Figure 4.4-4.

A total of 51 samples had reported elevated concentrations of mercury at this site, post-excavation, as described previously. Mercury exceedances ranged in concentration from 0.091 mg/kg (EVBM12) to an estimated 0.81 J mg/kg (EVBS71), each exceeding the human health criteria (0.09 mg/kg), and 44 of 51 also surpassing the ecological comparison criteria (0.10 mg/kg). Two of these exceedances were encountered at stations near the dry pond in the southeastern portion of the site; these locations are bound horizontally through additional sampling to the north, east, and west, and the Service Area Road to the south. The remaining mercury exceedances were detected north of Buildings 2202 and 2203, on the outskirts of the 2004 excavation, and along the stream running from the area to the northwest. This particular area is bound to the north, east, and south through additional sampling that did not have reported elevated concentrations of mercury. An exceedance was detected at the most northwesterly station along the stream (EVSS03, 0.096 mg/kg); however, this exceedance was reported at a concentration mostly similar to the mercury background value of 0.09 mg/kg. The next upgradient station, EVSS02, did not report an exceedance of mercury. It is most likely that the horizontal extent of mercury has been

evaluated adequately in surface soils at the ELV Area. Figure 4.4-5 illustrates the extent of mercury at this site.

Fourteen of the 17 metals parameters detailed here also were encountered in subsurface soil samples at elevated concentrations. These exceedances, along with additional parameters encountered, is addressed in Section 4.4.2.

PCB Aroclors/Congeners. Six surface soil samples were analyzed for PCB aroclors and cogeners at the ELV Area. No PCBs were detected at concentrations that exceeded the applicable screening criteria at this site.

SVOCs. Of the 61 surface soil samples analyzed for SVOCs, 3 had reported exceedances of a combined two SVOC parameters, BaP and BEHP. Two exceedances of BaP were detected at concentrations of 19 µg/kg (EVBS1030) and 42.2 µg/kg (EVBS1016), exceeding its human health criterion of 10 µg/kg. BEHP was encountered at an estimated concentration of 14,700 J µg/kg (EVBS1040), exceeding its ecological and human health (4,930 µg/kg) comparison criteria. BaP exceedances were detected within the dry pond area in the southeastern portion of the site. These detections are bound horizontally through additional sampling inside the dry pond boundary and sampling conducted along natural overflow drainage paths. The BEHP exceedance was detected form a sample collected inside Building 2203, and samples around the building did not exhibit elevated concentrations of the parameter. The horizontal extents of BaP and BEHP have been addressed sufficiently in the ELV Area.

TPHs. Of the 66 surface soil samples analyzed for TPHs, 16 exhibited elevated concentrations of a combined 4 TPH groups. Each TPH exceedance reported surpassed the common ecological and human health comparison criteria of 100,000 µg/kg. These exceedances are detailed below.

DRO groups (C14-C20) and (C20-C30) were encountered at elevated concentrations in three and six surface soil samples, respectively. Exceedances of DROs (C14-C20), each reported as estimated values, ranged from 140,000 J µg/kg (EVBS16) to 640,000 J µg/kg (EVBS02); DRO (C20-C30) detections, also reported at estimated values, ranged from 120,000 J µg/kg (EVBS20) to 1,900,000 J µg/kg (EVBS01). DROs (C14-C20) have been bound horizontally through additional sampling, with the exception of the exceedance reported at EVBS02. However, station EVBS02 is close to station EVBS20, which did not have a reported (C14-C20) exceedance; hence, it may be inferred that (C14-C20) exceedances in this particular area may be limited to the immediate vicinity of station EVBS02. DRO (C20-C30) exceedances also have been bound horizontally through additional sampling, except in the area of stations EVBS02 and EVBS20. Additional sampling near these stations, located to the southeast of the Building 2202 wastewater treatment sump and clarifier, are needed to complete a horizontal extent assessment of (C20-C30) in the surface soil. The horizontal extents of the DRO groups (C14-C20) and (C20-C30) are illustrated in Figure 4.4-6.

The EFH (C15-C20) group was encountered once, and the EFH (C21-C30) group was encountered in 10 samples at concentrations exceeding their common ecological and human health comparison criteria of 100,000 µg/kg. EFH (C15-C20) was detected at a concentration of 5,140,000 µg/kg (EVBS1040), and EFH (C21-C30) exceedances ranged from 126,000 µg/kg (EVBS1047) to 26,400,000 µg/kg (EVBS1040). The two exceedances that were significantly

higher than the others were detected at station EVBS1040, which is inside the southeastern portion of Building 2203. The nature of these exceedances may require additional investigation to complete the extent evaluation of EFH TPHs around Building 2203. Other reported EFH (C21-C30) exceedances are localized around the Building 2202 wastewater treatment sump and clarifier and near Building 2206. These exceedances have been bound horizontally through additional sampling and paved areas, specifically in toward the southeast where rain events potentially may migrate surface soil contaminants. The horizontal extents of the EFH groups (C15-C20) and (C21-C30) are shown in Figure 4.4-7. The vertical extent of TPHs at the ELV Area is addressed in Section 4.4.2.

VOCs. Of the 64 samples analyzed for VOCs at the ELV Area, only 4 exhibited concentrations of 2 parameters, methylene chloride and TCE, at levels exceeding the human health comparison criteria. Elevated concentrations of methylene chloride were reported in 3 samples, ranging in concentration from 13.9 µg/kg (EVBS1040) to an estimated 25.1 J µg/kg (EVBS1030), exceeding its human health criteria of 10 µg/kg. The sole TCE exceedance was a reported 34 J µg/kg (EVBS21), exceeding its human health criteria of 30 µg/kg. Stations reporting these exceedances are located near the northwestern corner of Building 2203, inside Building 2203, and in the dry pond in the southeastern portion of this site. Each VOC exceedance discussed here has been bound horizontally through additional sampling that had non-exceeding or non-detect concentrations of methylene chloride and TCE. The horizontal extents of these parameters have been evaluated adequately, as shown in Figure 4.4-8.

4.4.2 Subsurface Soil Nature and Extent

To evaluate the vertical extent of potential contaminants in the ELV Area, 93 subsurface soil samples were collected from 82 sampling stations to a maximum depth of 25 ft bgs. The subsurface soil at the site was analyzed for 1 or more of the following: dioxins, 1,2-diphenylhydrazine, TAL metals (including hexavalent chromium), PCBs (aroclors and congeners), SVOCs, TPHs, and VOCs. Additionally, 3 locations (EVBS1014, EVBS1035, and EVBS1036) were analyzed for octamethylcyclotetrasiloxane and n-eicosane. Table 4.4-4 lists the parameters detected in the subsurface soil samples at the ELV Area.

The compound 1,2-diphenylhydrazine was analyzed for in 22 subsurface soil samples from 15 locations. Similar to the surface soil results, 1,2-diphenylhydrazine was not detected in any of the samples analyzed; hence, its vertical extent has been addressed sufficiently.

4.4.2.1 Parameters Exceeding Criteria

The nature and vertical extent of parameters encountered at concentrations exceeding their respective comparison criteria are detailed below.

Dioxins. As with the dioxin investigation in the surface soils, the 3 subsurface soil samples collected from 2 locations to a depth of 9 ft bgs were analyzed for both CDDs and CDFs. A total of 16 dioxin congeners exceeded their respective screening criteria, with all exceedances coming from the EVBS10 location at a depth of 3 ft bgs. Similar to the surface soil, nature and extent were evaluated by using the information regarding the toxic potency of the different congeners and then calculating the 2,3,7,8-TCDD TEQs. The frequency of the different CDDs and CDFs that exceeded their respective screening criteria at EVBS10 were added according to the chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-), and the

2,3,7,8-TCDD TEQ values were compared to the screening criteria, as summarized in Table 4.4-5.

The 2,3,7,8-TCDD TEQ values exceeded the human health (8.7E-4 µg/kg) and ecological (4.3E-3 µg/kg) comparison criteria at EVBS10 (3 to 3 ft bgs) only, with a concentration of 0.0249 µg/kg. Figure 4.4-9 shows the extent of 2,3,7,8-TCDD TEQs in subsurface soil at the ELV area. Additional samples at depth from this location are warranted to further evaluate the extent of dioxins in the subsurface soil.

Metals. A total of 86 subsurface soil samples, collected from 86 sampling stations, were analyzed for metals to a maximum depth of 25 ft bgs. Of those, 10 exhibited elevated concentrations of a combined 16 metals parameters. Three of the parameters detected at elevated concentrations (beryllium, cobalt, and thallium) were not encountered at exceeding concentrations in the surface soil samples analyzed. The highest concentrations of metals were detected at sampling location EVSU01, which is associated the sump on the southwestern corner of Building 2202 that received wastewater from the photographic laboratory inside the building. Subsurface soil metals exceedances are detailed below.

One exceedances of beryllium was reported at this site, at a concentration indicative of natural occurrence. The beryllium exceedance was detected at a concentration of 1.2 mg/kg (EVBS1044, 4.5 to 5.5 ft bgs), compared to its background value of 1.1 mg/kg. This elevated concentration is mostly similar to its background value, suggesting that beryllium may be naturally occurring at this site, at the reported concentration. The vertical extent of beryllium has been addressed sufficiently.

Antimony was encountered at an elevated concentration of 25 J mg/kg (EVBS10, 3 ft bgs), exceeding its common ecological and human health criteria of 0.09 mg/kg and its background value of 8.7 mg/kg. This sample was the sole subsurface soil sample collected from the dry pond southeast of the building complex at this site; the antimony exceedance in the surface soil was encountered in another portion of the site. Additional sampling is required to complete the vertical extent evaluation of antimony in the dry pond area.

Seven parameters (arsenic, cobalt, molybdenum, nickel, selenium, silver, and thallium) had reported elevated concentrations only at EVSU01 at 3 ft bgs. This station is west of the wastewater treatment sump and clarifier on the southwestern corner of Building 2202. With the exception of cobalt, which was detected at a concentration similar to its background level, most of these parameters were reported multiple times at concentrations over their respective background values. The heavy metals probably are associated with the photograph laboratory operations in the building. The greatest difference reported was with the common photograph development chemical, silver, which was detected at an estimated concentration of 328 mg/kg, above its background level of 0.79 mg/kg. Station EVSU01 was not sampled in other subsurface soil intervals. The nearby sample EVBS20, 4 ft bgs, did not exhibit exceeding concentrations of metals parameters, but additional sampling at deeper intervals and around the sump and clarifier is required to further evaluate the vertical extent of contamination in the immediate area of the ELV site. Silver was the sole metals parameter encountered at an exceeding concentration in the surface soil near the sump and clarifier. Surface soil exceedances of arsenic, molybdenum, nickel, and selenium were reported in other areas of this site; thus, the vertical extents of these exceedances have been sufficiently evaluated.

Cadmium, copper, and lead each were encountered twice at exceeding concentrations in subsurface soil in the ELV Area. Cadmium was detected at 9.0 mg/kg (EVBS10, 3 ft bgs) and an estimated 244 J mg/kg (EVSU01, 3 ft bgs), exceeding its ecological, human health , and background (1 mg/kg) comparison values. Copper was encountered at an estimated 260 J mg/kg (EVBS10, 3 ft bgs) and 1,790 J mg/kg (EVSU01, 3 ft bgs), exceeding all applicable criteria, including its background value of 29 mg/kg. Lead was detected at 60 mg/kg (EVBS10, 3 ft bgs) and an estimated 1,360 J mg/kg (EVSU01, 3 ft bgs). Station EVBS10 is in the southeastern dry pond and station EVSU01 is near the Building 2202 wastewater treatment sump and clarifier. As noted above, exceedances reported in the subsurface soil at these stations require additional sampling to complete the vertical extent evaluation.

Three barium exceedances were reported in subsurface soils in the ELV Area. Elevated concentrations ranged from 167 mg/kg (EVBS1029, 5.5 to 6 ft bgs) to an estimated 753 J mg/kg (EVSU01, 3 ft bgs), exceeding all of the applicable criteria at concentrations mostly similar to the background value of 140 mg/kg. These exceedances were encountered in the only subsurface soil sample collected at its respective sampling station. Sampling stations EVBS1029 and EVBS1039 are localized near the northeastern corner of Building 2202, and station EVSU01, as noted, is west of the Building 2202 wastewater treatment sump and clarifier. There are no apparent subsurface soil samples near the northeastern corner of Building 2202 that were sampled for metals that might imply a vertical extent boundary; hence, additional sampling is required to complete the vertical extent evaluation of barium in the ELV Area. The extent of barium in the subsurface soil is shown in Figure 4.4-10.

Three chromium exceedances were reported in subsurface soils in the ELV Area. Elevated concentrations ranged from 41 mg/kg (EVBS1039, 5 to 6 ft bgs) to an estimated 1,720 J mg/kg (EVSU10, 3 ft bgs), each exceeding its background value (36.8 mg/kg) and human health criteria (1.58 mg/kg); one also surpassed its ecological comparison criteria of 930 mg/kg. Exceedances reported at stations EVBS1039 and EVBS1044 are at concentrations mostly similar to its background value, which may suggest these chromium exceedances are residuals of natural occurrence. The greatest exceedance was encountered at station EVSU10, which as discussed, need additional sampling to complete the vertical extent assessment. The vertical extent of chromium is illustrated in Figure 4.4-11.

Mercury exceedances were reported in 7 of the 86 subsurface soil samples analyzed at this site. Elevated concentrations ranged from an estimated 0.11 J mg/kg (EVBS42, 2 to 2.5 ft bgs) to an estimated 20.1 J mg/kg (EVSU10, 3 ft bgs), each exceeding all of the applicable comparison criteria, most similar to its ecological comparison criteria of 0.10 mg/kg. As previously discussed, subsurface soil exceedances at EVSU01 (wastewater treatment sump) and EVBS10 (dry pond) require additional sampling to complete the vertical extent assessment of mercury. The other 5 mercury exceedances were detected in the sole subsurface soil sample collected at each given station; however, several sampling intervals equal to or deeper than the ones that had reported mercury exceedances are situated close to the exceedances, which provides an implied vertical extent boundary. With the exception of detections at EVBS10 and EVSU01, the vertical extent of mercury at the ELV Area has been sufficiently evaluated. Figure 4.4-12 illustrates the subsurface soil extent of mercury at this site.

Vanadium was encountered at an elevated concentration in the surface soil, but was not detected above the screening criteria in the subsurface soil samples analyzed at this site. Hence, the vertical extent of vanadium in the ELV Area has been evaluated adequately.

PCBs Aroclors/Congeners. Three subsurface soil samples from two sampling stations were analyzed for PCBs at this site. Similar to the surface soil results, no PCBs were detected in the subsurface soil at concentrations exceeding the comparison criteria.

SVOCs. A total of 45 samples were collected from 34 stations and analyzed for SVOCs in the ELV Area. Of those, only sample location EVBS10, 3 ft bgs, exhibited elevated concentrations of 2 SVOC parameters. BEHP was encountered at a concentration of 5,600 µg/kg, exceeding its ecological (4,900 µg/kg) and human health (4,930 µg/kg) criteria, and phenanthrene was encountered at 1,800 µg/kg, exceeding its ecological (1,300 µg/kg) and human health (1,310 µg/kg) criteria. As stated in the metals portion of this subsection, the 3-foot-bgs interval was the only subsurface sample collected at this station, and there are no other sampling stations in the immediate vicinity of the southeastern dry pond area. Additional sampling is required to complete a vertical extent assessment of SVOC exceedances at this site.

BaP was the sole SVOC parameter encountered at elevated concentrations in the dry pond area. The vertical extent of SVOC exceedances detected in surficial soils at this site has been evaluated adequately.

TPHs. A total of 26 subsurface soil samples were collected from 19 sampling stations to investigate the vertical extent of TPHs at the ELV Area. Of those, 3 samples had reported elevated concentrations of a combined 5 TPH groups, each reported as an estimated value. The vertical extents of these exceedances are detailed below.

One station, EVBS10, 3 ft bgs, reported exceedances of 4 of the 5 TPH groups at concentrations above their common ecological and human health (100,000 µg/kg) comparison criteria. The C12-C14 (kerosene range) group was detected at a concentration of 1,900,000 J µg/kg, DROs (C14-C20) at 8,100,000 J µg/kg, DROs (C20-C30) at 1,300,000 J µg/kg, and the EFH (C8-C11) group at 210,000 J µg/kg. This sample was collected from beneath the southeastern dry pond. No additional subsurface soil samples were collected from this station or in the immediate vicinity of the dry pond. Additional subsurface soil sampling is required to complete the vertical extent assessment of TPHs in the area of the pond.

Station EVSU01, 3 ft bgs, reported an exceedance of DROs (C20-C30) at a concentration of 210,000 J µg/kg, and station EVBS1008, 5 to 6 ft bgs, reported an exceedance of the EFH (C21-C30) group at a concentration of 153,000 J µg/kg. Each of these exceedances surpassed the common ecological and human health comparison criteria of 100,000 µg/kg. These stations are positioned along the southern wall of Building 2202, and neither sampling station was sampled at an interval deeper than the sample exhibiting these exceedances. Additional subsurface soil samples collected from similar and deeper intervals along this southern wall and to the north provide an implied extent of these parameter groups; however, additional sampling is needed to provide the vertical extent and horizontal subsurface extent to the south.

VOCs. A total of 44 subsurface soil samples were collected from 33 sampling stations and analyzed for VOCs. Of those, 3 samples from 3 stations exhibited elevated concentrations of a combined 3 VOC parameters: 1,1,1-TCA, methylene chloride, and TCE. The vertical extents of these parameters are detailed below.

The parameters 1,1,1-TCA and methylene chloride each were encountered once at an exceeding concentration. The 1,1,1-TCA was reported at an estimated concentration of 4,400 J µg/kg (EVBS10, 3 ft bgs), exceeding its human health criteria of 1,000 µg/kg. This parameter was not encountered at elevated concentrations in the surface soil samples collected. As previously noted, this sampling station, located in the southeastern dry pond, requires additional sampling to complete the vertical extent evaluation of 1,1,1-TCA. Methylene chloride was detected at a concentration of 112 µg/kg (EVBS04, 5 ft bgs), exceeding its human health criteria of 10 µg/kg. Station EVBS04 was sampled and analyzed for VOCs at a deeper interval, 11.5 ft bgs, but did not have a reported detection of methylene chloride. The vertical extent of methylene chloride in the ELV Area has been addressed sufficiently.

TCE was encountered in 2 samples at estimated concentrations exceeding its human health criteria of 30 µg/kg. Exceedances of TCE were reported at 3,000 J µg/kg (EVBS03, 8 ft bgs) and 66,000 J µg/kg (EVBS10, 3 ft bgs); the latter concentration also exceeded its ecological comparison criteria of 3,000 µg/kg. Neither station was analyzed for TCE at deeper intervals. The vertical extent of TCE, which should be further evaluated at deeper intervals, is shown in Figure 4.4-13.

4.4.3 Soil Gas Nature and Extent

A total of 41 soil gas samples were collected at this site from 30 sampling stations to a maximum depth of 13 ft bgs. The soil gas samples were analyzed for VOCs at the ELV Area, and 4 VOC parameters were encountered at exceeding concentrations. Table 4.4-6 lists the parameters detected in the soil gas samples at the ELV Area. The extent of VOCs encountered via soil gas sampling at this site is detailed below.

One exceedances of chloroform was reported at this site. Chloroform was reported at EVSV22, 2 ft bgs, at16,000 µg/m^3, exceeding its ecological comparison criteria of 240 µg/m^3. Soil gas samples surrounding stationEVSV22 did not have reported chloroform exceedances in similar and deeper sampling intervals, suggesting that the extent of chloroform soil vapors has been addressed sufficiently.

Two exceedances of both cis-1,2-DCE and PCE were detected at the ELV Area. Elevated concentrations of cis-1,2-DCE were reported at 2,100 µg/m^3 (EVSV0025, 3.5 ft bgs) and 6,600 µg/m^3 (EVSV02, 3 to 3.5 ft bgs), exceeding its ecological comparison criteria of 1,900 µg/m^3. Elevated concentrations of PCE were reported at 1,700 µg/m^3 (EVSV17, 4 ft bgs) and 2,300 µg/m^3 (EVSV16, 2 ft bgs), exceeding its human health comparison criteria of 180 µg/m^3. The cis-1,2-DCE and PCE soil gas exceedances are localized around Building 2206, where there are additional soil gas samples close by that did not have reported exceedances of these parameters. However, there appears to be a lack of soil gas data to the south of stations EVSV02, EVSV16, and EVSV17, and to the north of station EVSV0025. Additional soil gas sampling is required to bound the extent of the

cis-1,2-DCE and PCE exceedances at the ELV Area. The extents of these parameters in soil gas at this site are shown in Figure 4.4-14.

Fifteen soil vapor samples from 12 sampling stations exhibited elevated concentrations of TCE at this site. The reported concentrations ranged from 1,100 µg/m^3 (EVSV0036, 4 ft bgs) to an estimated 2,500,000 J µg/m^3 (EVSV04, 9 to 9.5 ft bgs), each exceeding its human health criteria of 528 µg/m^3; 11 also exceeded its ecological screening criteria of 6,400 µg/m^3. Most of the TCE exceedances are localized in and around the northwestern corner of Building 2203 and along the southern side of Building 2206. These exceedances were encountered in the deepest intervals sampled and analyzed for VOCs at this site. TCE also has been encountered in the shallow subsurface soil samples at this site, suggesting that the parameter potentially is migrating vertically. The extent of TCE in soil gas has been sufficiently evaluated, as shown in Figure 2.4-15.

4.5 Conceptual Site Exposure Model

A generalized CSM for the human health exposure pathways is presented in Section 1.5.3.5. Given the potential future land use, the following receptors will be addressed in the ELV HHRA:

- Future onsite adult industrial workers potentially exposed to chemicals in soil, indoor air, outdoor air, seeps and springs (where applicable).
- Hypothetical future onsite adult and child recreationists potentially exposed to chemicals in soil, outdoor air, seeps and springs (where applicable).
- Hypothetical future onsite adult and child residents potentially exposed to chemicals in soil, indoor air, outdoor air, home-grown produce, groundwater (where applicable), and seeps and springs (where applicable).

In addition, in accordance with California Senate Bill 990, a hypothetical future subsistence agricultural exposure scenario includes assessing the risks associated with the potential consumption of beef, eggs, milk, swine, fruits, and vegetables. However, pending final agreement of the input assumptions considered in the scenario, the assessment of the subsistence agricultural exposure scenario will be included in a supplemental risk assessment report separate from this RFI Report.

Any deviations from this generalized CSM for the ELV re presented in Section 4.7.2.

4.6 Fate and Transport Analysis for Chemicals Detected in Groundwater in Surficial Media at the ELV

No groundwater results are available to evaluate the fate and transport in the SMOU at the ELV, based on Group 2 RFI characterization efforts to date. Therefore, no fate and transport analysis for this medium is warranted at this time. The analytical results for the July 2008 sampling efforts will be reviewed when available, and 2009 rainy season samples may yield groundwater analytical results that will be evaluated in an addendum to the Group 2 RFI.

4.6.1 Contaminant Sources and Release Mechanisms

The primary release mechanism for contamination at the ELV Area is attributed to the oils, lubricants, solvents, and cleaners used at the area, as well as to transformers that support the large machinery associated with the ELV Area.

4.6.2 Potential Routes of Migration

The primary pathway for contaminant transport from the SAs at the ELV Area is the vertical migration of contaminants from the surface soil to subsurface soil. A secondary transport mechanism for this site includes the release of surface soil to the air by wind erosion or volatilization.

4.6.3 Contaminant Persistence

Dioxins, inorganics, SVOCs, TPHs, and VOCs were detected in the soil at the ELV Area at levels above their screening criteria.

4.6.3.1 Parameters Exceeding Criteria

This subsection describes the chemicals applicable to the ELV Area.

Dioxins. Dioxins are characterized by extremely low vapor pressures, high log K_{ow}, high K_{oc}, and extremely low water solubilities. Their strong adsorption to soil, low water solubilities, and high K_{oc} values indicate that the rate of transport from unsaturated zone soils to the water table via rain infiltration would be extremely low.

Because dioxins have low vapor pressure, they are not very volatile and tend to stay bound to particles. Dioxins also have low solubility; thus, any aerially deposited dioxins tend to stay adsorbed to soils in the top few millimeters in surface soil.

Inorganics. Several metals were detected at the ELV Area at levels above the screening criteria. Many metals are naturally occurring and their reported presence may or may not indicate a contaminant release. The mobility of metals is complex and depends on several factors such as the overall groundwater composition, pH, metal complex formation, valence state of the metal, and cation-ion exchange capacity. Metals typically are not volatile, except for mercury. In the water phase, the total metal concentration includes the dissolved metal concentration and the suspended metal concentration, which is sorbed to colloidal particles. Therefore, elevated metals concentrations in groundwater may be due to the suspended load and not just to the dissolved aqueous chemistry.

SVOCs. PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances. HMW PAHs are more likely to be transported via particulate emissions, while LMW PAHs have a greater tendency to volatilize (ATSDR, 1995). In general, PAHs are more likely to sorb to soil or organic matter than to partition significantly to water. Photolysis and biodegradation are two common attenuation mechanisms for PAH compounds (Howard, 1991). Animals and microorganisms can metabolize PAHs to products that ultimately reach complete degradation.

TPHs. TPHs are defined as the measurable amount of petroleum-based hydrocarbon in an environmental media. The lighter petroleum products such as gasoline contain constituents with higher water solubility and volatility and lower sorption potential than heavier petroleum products such as fuel oil. Data compiled from gasoline spills and laboratory studies indicate that these light-fraction hydrocarbons tend to migrate readily through soil, potentially threatening or affecting groundwater supplies. In contrast, petroleum products with heavier molecular weight constituents, such as fuel oil, are generally more persistent in soils because of their relatively low water solubility and volatility and high sorption capacity (Stelljes and Watkin, 1991).

VOCs. VOCs are characterized by relatively high vapor pressures, Henry's Law constants, and generally high solubility in water. VOCs have a tendency to partition to the vapor phase from either soil or surface water and could be released through volatilization from contaminated soil. The sorption potential of VOCs is variable; some may persist in soil or sediment, while some are highly mobile in soil. VOCs will leach to groundwater and may persist, depending on their ability to degrade or transform in the environment.

TCE was the most prevalent VOC in the soil gas samples collected. Although TCE does not have a high K_{oc}, it may sorb to soil, sediment, or organic matter and persist in the environment for a long time. It also may persist in groundwater. TCE does not accumulate in plants or animal tissue and undergoes biotic and abiotic degradation via natural attenuation processes.

4.6.4 Contaminant Migration

The primary source for contaminant migration is from historical spills and leaks associated with the ELV Area operations.

4.6.5 Surface Soil Contaminants

Dioxins and organic and inorganic compounds have been identified in surface soil at levels above the background and/or health-based risk criteria. The following observations were made for contaminants in surface soil:

- Fifteen dioxin constituents were detected in 14 of the 16 surface soil locations at concentrations that exceeded their respective screening criteria.
- Seventeen metals were detected in surface soil at levels exceeding the applicable comparison criteria. Most of those parameters were encountered at concentrations mostly similar to their respective background values, and probably are indicative of natural occurrence. Fifty-one samples had reported elevated concentrations of mercury at this site.
- Of the 61 surface soil samples analyzed for SVOCs, 3 reported exceedances of a combined 2 SVOC parameters (BaP and BEHP), encountered in surface soil.

- Of the 66 surface soil samples analyzed for TPHs, 16 exhibited elevated concentrations of a combined 4 TPH groups. Each TPH exceedance reported surpassed its common ecological and human health comparison criteria of 100,000 µg/kg.
- Of the 64 samples analyzed for VOCs at the ELV Area, only 4 sample locations exhibited concentrations of 2 parameters (methylene chloride and TCE) at levels that exceeded the human health comparison criteria.

4.6.6 Subsurface Soil Migration

The following observations were made for the contaminants in subsurface soil:

- The highest concentrations of contaminants typically were found at the subsurface soil sample location EVSU01, which was associated with sump that received wastewater from the photographic laboratory; and from sample location EVBS10, which associated with the dry pond in the southeastern portion of the ELV area.
- A total of 16 dioxin congeners exceeded their respective screening criteria in subsurface soil. All exceedances were encountered at EVBS10 at a depth of 3 ft bgs.
- Ten subsurface sample locations exhibited elevated concentrations of a combined 16 metals parameters. Three of the parameters detected at elevated concentrations (beryllium, cobalt, and thallium) was not encountered at exceeding concentrations in the surface soil samples analyzed.
- Of the 45 samples were collected from 34 stations and analyzed for SVOCs in the ELV Area, only 1 sample exhibited elevated concentrations of 2 SVOC parameters (BaP and BEHP) at a depth of 3 ft bgs. Both of these SVOC parameters also were detected in surface soil at levels in exceedance of their respective screening criteria.
- Of the 26 subsurface soil samples collected from 19 sampling stations for TPHs at the ELV Area, 3 samples reported elevated concentrations of a combined 5 TPH groups.
- Of the 44 subsurface soil samples collected from 33 sampling stations for VOCs, 3 samples from 3 stations exhibited elevated concentrations of a combined 3VOC parameters (1,1,1-TCA, methylene chloride, and TCE). Although methylene chloride and TCE also were detected in surface soil at concentrations that exceeded their respective screening criteria, 1,1,1-TCA did not exceed its surface soil screening criteria.

4.6.7 Soil-to-Groundwater Migration

Chemical effects on groundwater at the ELV generally are characterized by TCE and its daughter products in the CFOU, much like site conditions at other SWMUs at SSFL. The distribution of TCE and other VOCs is typically shown within a north-south trending footprint that extends to the RD-09 Area. NSGW has been delineated in the weathered bedrock along the North Fault at PZ-141 in the alleyway between Buildings 2202 and 2203, as well as at PZ-140 and PZ-139 at the helipad area. The occurrence of NSGW in the localized alluvium deposit at RS-29 has been confirmed by recent gauging. Localized distributions of mainly elevated TCE concentrations have been delineated from surface soil, subsurface soils, and soil vapor results as part of the Group 2 RFI field effort. Localized distributions of TCE and other VOCs are found near the release area located between

Buildings 2202 and 2203, south of Building 206, and at the ELV Catchment Pond. The rock-core crushing analytical results generated from corehole C-7 at the ELV Catchment Pond (Waterloo, 2007) provide definitive confirmation of soil-to-groundwater migration at the site. A more refined evaluation of site conditions in the SMOU will be obtained from sampling and gauging conducted during the winter rainy season.

In addition to the analytical results from Corehole C-7, the areas of chemical impacts and probable groundwater source areas at the ELV can be delineated by the TCE distribution in soil and soil vapor as the benchmark for site conditions, as shown in Figures 4.4-8, 4.4-13, and 4.4-15. Elevated EFH (C15-C30) and (C21-C30) concentrations also were detected in the surface soil at Building 2203, as shown in Figure 4.4-7. Elevated concentrations of metals have not been detected in groundwater at the ELV to date.

The analytical results obtained from the rock core at C-7 show a continuous profile of contaminant mass distribution at a likely source area; Figure 4.3.2-5 shows this in respect to the SMOU. Although the TCE distribution in the SMOU is negligible, most of the contaminant mass is distributed in the shallow section of the CFOU between 100 to 200 ft bgs and can be connected to the SMOU by upward gradients at those depths.

TCE releases from site operations at the ELV probably resulted in the entry of immiscible-phase liquid into and below the water table by the interconnected fracture network within the Chatsworth formation. The North Fault and associated splays also could be a significant pathway for soil-to-groundwater COC migration. Spills and overflow at the ELV Catchment Pond probably are the main source of migration of TCE from soil to groundwater at the SWMU; however, operations at Buildings 2203 and 2206 may have resulted in releases, as well. Affected soil in the vicinity of Buildings 2202 and 2203 coincides with a localized depression interpreted at the top of the unweathered Chatsworth formation surface (Figure 4.3.2-7), which might relate to an area of relatively high fracture density along the North Fault. This geologic feature could provide a pathway for contaminant migration in the subsurface. Wells RD-51A and RD-51B, situated along this faulted area, have displayed the most elevated TCE concentrations at the ELV, with levels ranging from 5 to 100 µg/L. Data from C-7 indicates that the ELV Catchment Pond is the likely source of groundwater contamination at the ELV and RD-09. In this case, contaminant migration may follow a pathway from the shallow CFOU bedrock aquifer to the weathered bedrock interval of the SMOU, following upward gradients. This possible migration pathway may be more significant than the migration of COCs from affected soil to the groundwater at the ELV.

4.7 Human Health Risk Assessment for Former Expendable Launch Vehicle

The objective of this HHRA is to assess whether the environmental media at the ELV Area could pose risks to human health that might require remedial action, or are eligible for an NFA designation. This HHRA assesses the potential current and future exposures to chemicals in soil, soil vapor, and groundwater at the ELV. The methods and guidance documents used in the preparation of this HHRA are presented in Section 1.5.3 of this

report. A discussion of the HHRA results for the ELV is presented below. The results are summarized in Section 4.9.2.

The concentration data, input parameters, and results of the HHRA for the ELV are presented in Appendix D. An index of the tables (Appendix D HHRA Tables Index) can be used to locate tables that contain information regarding the HHRA data set, EPCs, exposure parameters, toxicity factors, estimated chemical intakes, estimated ELCRs, and estimated noncancer HIs.

4.7.1 Identification of Chemicals of Potential Concern

Chemicals were selected as COPCs at the ELV site based on the protocol, as described in Sections 1.5.3.1 and 1.5.3.2.

4.7.1.1 Data Evaluation

The soil, soil vapor, and groundwater sampling analytical data at the ELV site were evaluated to determine their suitability for use in the risk assessment following the procedures presented in Section 1.5.3.1. Sediment and surface water data were not collected as part of the RFI site characterization activities. The locations of the soil, soil vapor, and groundwater samples used in this HHRA are shown in Figure 4.4-1. The samples used in this HHRA are listed in Table D.7.1-1 by medium, sample ID, sampling depth interval, and date of collection. Table D.7.1-2 presents the target receptor populations by medium. Descriptive summary statistics of these data are provided in Table D.7.1-3.

4.7.1.2 Identification of COPCs in Soil

The results of the COPC screening process for soil at 0 to 2 ft bgs and 0 to 10 ft bgs are presented in Table D.7.1-3. Detected analytes in soil at the ELV were compared to background levels. COPCs identified in soil (0 to 2 ft bgs) included 4 inorganics (barium, mercury, vanadium, and zinc) and 43 organics. COPCs identified in soil (0 to 10 ft bgs) included 4 inorganics (barium, mercury, vanadium, and zinc) and 46 organics.

4.7.1.3 Identification of COPCs in Groundwater

The results of the COPC screening process for groundwater are presented in Table D.7.1-3. Detected analytes in groundwater at the ELV were screened using groundwater comparison concentrations. The COPCs identified in groundwater included 1 organic (cis-1,2-DCE).

4.7.1.4 Identification of COPCs in Soil Vapor

The results of the COPC screening process for soil vapor at 3 to 10 ft bgs are presented in Table D.7.1-3. The COPCs identified in soil vapor included TCE, PCE, 1,1-DCE, and 1,1,2-trichloro-1,2,2-trifluoroethane .

4.7.2 Exposure Assessment

The exposure assessment component of the HHRA identifies the means by which individuals at or near the ELV may come into contact with constituents in exposure media. It addresses current exposures and those that may result in the future under reasonably anticipated potential uses of the site and the surrounding areas. The exposure assessment also identifies the populations that may be exposed, the routes by which individuals may

become exposed, and the magnitude, frequency, and duration of potential exposures. Figure 1.5.3-1 depicts the conceptual exposure model for the ELV. Table D.7.1-2 summarizes the exposure scenarios. The methods and assumptions used in the exposure assessment are discussed in Section 1.5.3.3.

4.7.2.1 Identification of Receptors

The ELV Area formerly was used for industrial purposes, and is most likely to have a future industrial or recreational land use; however, a hypothetical future residential scenario was included in the exposure assessment. Future residents are expected to have the greatest level of exposure. Therefore, the hypothetical future residential scenario, assuming adult and child receptors, was the most conservative scenario in the HHRA. In addition to the residential scenario, the industrial worker and recreationist exposure scenarios were evaluated.

As stated in Section 1.5.3.3, an agricultural-based residential exposure scenario will be evaluated to meet the requirements of Senate Bill 990.

4.7.2.2 Identification of Exposure Pathways

Future residents and industrial workers were assumed to be exposed to groundwater, soil vapor (modeled for migration to indoor air and ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Future recreationists were assumed to be exposed to groundwater, soil vapor (modeled for migration to ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Exposure pathways for groundwater and soil included direct exposures (ingestion and dermal) and indirect exposures. Inhalation exposures were quantified for migration of groundwater and soil vapor to ambient air and indoor air. Additionally, exposures were quantified for residential receptors for the inhalation of VOCs in bathroom air while showering or bathing for groundwater. Residential receptors were assumed to ingest edible plants and home-grown produce, as well. The exposure pathways and exposure assumptions included in the HHRA for the ELV are provided in Table D.7.1-6.

4.7.2.3 Exposure Point Concentrations

EPCs for soil at 0 to 2 ft bgs, soil at 0 to 10 ft bgs, soil vapor, and groundwater at the ELV are listed in Table D.7.1-3. EPCs were estimated for indirect exposures for the following media: airborne fugitive dusts, ambient air, indoor air, and edible plants (home-grown consumption). Airborne particulate COPC concentrations were estimated for non-volatile COPCs. The derivation of the PEF for soil is listed in Table D.7.1-7.

Ambient air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs to ambient air and migration from groundwater to ambient air. Parameter values used for soil vapor-to-air migration and for estimation of ambient air EPCs related to soils are presented in Table D.7.1-9. Parameter values used for estimating ambient air EPCs related to groundwater also are listed in Table D.7.1-9. The estimated ambient air concentrations from the migration of volatile COPCs in soil and groundwater are listed in Tables D.7.1-10, D.7.1-13, and D.7.1-14, respectively.

Indoor air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs and from NSGW using the J-E Model (EPA, 2004). The

parameter values used in the J-E Model (EPA, 2004) are listed in Table D.7.1-9. Soil vapor data, where available, were preferentially used for indoor air modeling. The estimation of indoor air concentrations from soil vapor and groundwater migration are presented in Tables D.7.1-11, D.7.1-12, D.7.1-15, D.7.1-16, D.7.1-17, and D.7.1-18.

The derivation of edible plant concentrations is calculated using soil-to-plant uptake factors, as described in the SRAM (MWH, 2005b). COPC concentrations in edible plant tissues from soil at 0 to 2 ft bgs are presented in Table D.7.1-19.

4.7.2.4 Intake Estimates

EPCs were applied to human intake equations, as presented in the SRAM (MWH, 2005b), to calculate chemical intakes for potential adult and child residential, adult and child recreationist, and industrial worker receptors at the ELV. The chemical-specific intakes were estimated based on an RME scenario and a CTE scenario. The exposure assumptions and the chemical intakes for soil are presented in Appendix D. See Appendix D HHRA Tables Index for the exposure parameters and chemical intakes for each exposure scenario.

4.7.3 Risk Characterization

In the risk characterization component of the HHRA process, quantification of risk is accomplished by combining the results of the exposure assessment (estimated chemical intakes) with the results of the dose-response assessment (toxicity values identified in the toxicity assessment; Section 1.5.3.4) to provide numerical estimates of potential health risk. The quantification approach differs for potential noncancer and cancer effects. The methods used in the risk characterization are discussed in Section 1.5.3.5.

The exposure assumptions, EPCs, toxicity factors, and risk characterization result tables for this HHRA are presented in Appendix D (Appendix D HHRA Tables Index). The risk calculation tables present the estimated ELCRs and noncancer HIs for potentially exposed receptors and individual exposure routes for soil, indoor air, and groundwater at the ELV, as well as the cumulative risks and HIs across all exposure routes for the RME and CTE scenarios.

4.7.3.1 Hypothetical Future Adult Residential Exposure Scenario

Potential residential adult exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of home-grown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For exposure to 0 to 2 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-7} for the CTE case to 2×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The main risk driver for exposure to 0 to 2 ft bgs is 2,3,7,8-TCDD TEQ from the ingestion exposure pathway. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects range from 0.05 for the CTE case to 0.4 for the RME case. The CTE and RME HI

estimates do not exceed the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogenic COPCs for exposure to 0 to 2 ft bgs soil from the plant consumption exposure route ranges from 3×10^{-5} for the CTE case to 1×10^{-3} for the RME case. The RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ is the main risk driver for the plant consumption exposure route for the RME case. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 3 for the CTE case to 40 for the RME case. The RME and CTE HI estimates exceed the regulatory threshold value of 1. The parameter 2,3,7,8-TCDD TEQ is the main risk driver for the RME and CTE HI estimates.

- For exposure to 0 to 10 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-7} for the CTE case to 3×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. the parameter 2,3,7,8-TCDD TEQ is the main risk driver for the RME ELCR estimate. For exposure to 0 to 10 ft bgs soil, the HI estimates for noncancer effects range from 0.05 for the CTE case to 0.8 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated inside a future residence. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-5} for the CTE case to 4×10^{-4} for the RME case. The RME and CTE ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver (99 percent) for the CTE and RME cases. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.07 for the CTE case to 1 for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

- For indoor air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For indoor air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 9×10^{-5} for the CTE case to 0.0002 for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-7} for the CTE case to 5×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver for the RME case. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.001 for the CTE case

to 0.01 for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 6×10^{-7} for the CTE case to 1×10^{-6} for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Groundwater. Potential routes of exposure to COPCs in groundwater include ingestion, dermal contact, and inhalation of vapors during assumed hypothetical domestic use. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For exposure to COPCs in NSGW, there were no carcinogenic COPCs identified. For exposure to COPCs in NSGW, the HI estimates for noncancer effects range from 0.01 for the CTE case to 0.02 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

4.7.3.2 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Residential Exposure Scenario

Potential residential child exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of home-grown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For exposure to 0 to 2 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-6} for the CTE case to 4×10^{-5} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The main risk driver for the CTE and RME cases is 2,3,7,8-TCDD TEQ from the ingestion exposure pathway. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects range from 0.5 for the CTE case to 4 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. The parameter 2,3,7,8-TCDD TEQ from the ingestion and inhalation exposure pathways is the main risk driver for the RME case. The cumulative ELCRs and HIs do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogenic COPCs for exposure to 0 to 2 ft bgs soil from the plant consumption exposure route ranges from 3×10^{-5} for the CTE case to 4×10^{-4} for the RME case. The RME and CTE ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The main risk driver for the RME and CTE cases is the parameter 2,3,7,8-TCDD TEQ. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 4 for the CTE case to 44 for the RME case. The CTE and RME HI estimates exceed the regulatory threshold value of 1. The parameter 2,3,7,8-TCDD TEQ is the main risk driver for the CTE and RME HI estimates.

- For exposure to 0 to 10 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-6} for the CTE case to 7×10^{-5} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ from the ingestion exposure pathway is the main risk driver for the CTE and RME ELCR estimate. For exposure to 0 to 10 ft bgs soil, the HI estimates for noncancer effects range from 0.4 for the CTE case to 7 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. The parameter 2,3,7,8-TCDD TEQ from the ingestion exposure pathway is the main risk driver for the RME case.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas is the inhalation of vapors that have migrated inside a future residence. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from $4x\ 10^{-5}$ for the CTE case to 3×10^{-4} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver for the CTE and RME cases. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.4 for the CTE case to 3 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. TCE is the main risk driver for the RME case.

- For indoor air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For indoor air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 0.001 for the CTE case to 0.001 for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 5×10^{-7} for the CTE case to 4×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver for the RME case. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.005 for the CTE case to 0.04 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 4×10^{-6} for the CTE case to 4×10^{-6} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Groundwater. Potential routes of exposure to COPCs in groundwater include ingestion, dermal contact, and inhalation of vapors during assumed hypothetical domestic use. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For exposure to COPCs in NSGW, there were no carcinogenic COCPs identified. For exposure to COPCs in NSGW, the HI estimates for noncancer effects range from 0.05 for the CTE case to 0.08 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

4.7.3.3 Hypothetical Future Adult Recreational Exposure Scenario

Potential adult recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below:

- For exposure to 0 to 2 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 5×10^{-8} for the CTE case to 5×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ from the dermal exposure pathway is the main risk driver for the RME case. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects range from 0.004 for the CTE case to 0.1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-9} for the CTE case to 6×10^{-7} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 5×10^{-5} for the CTE case to 0.001 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 3×10^{-8} for the CTE case to 1×10^{-7} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

4.7.3.4 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Recreational Exposure Scenario

Potential child recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. A hypothetical future recreationist child (15-kg body weight) was assumed to be exposed for 350 days per year over 6 years for the RME case and 6 years for the CTE case. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For exposure to 0 to 2 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-7} for the CTE case to 1×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ from the ingestion exposure pathway is the main risk driver for the RME case. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects range from 0.07 for the CTE case to 1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-8} for the CTE case to 1×10^{-6} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.0004 for the CTE case to 0.01 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.
- For ambient air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 3×10^{-7} for the CTE case to 1×10^{-6} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

4.7.3.5 Hypothetical Future Industrial Worker Exposure Scenario

Potential industrial worker exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For exposure to 0 to 2 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-7} for the CTE case to 2×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ from the ingestion pathway is the main risk driver for the RME case. For exposure to 0 to 2 ft bgs soil, the HI estimates for noncancer effects range from 0.03 for the CTE case to 0.6 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For exposure to 0 to 10 ft bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-7} for the CTE case to 5×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ from the ingestion pathway is the main risk driver for the RME case. For exposure to 0 to 10 ft bgs soil, the HI estimates for noncancer effects range from 0.03 for the CTE case to 1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated inside a future industrial building. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-6} for the CTE case to 1×10^{-4} for the RME case. The CTE and RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver for the CTE and RME case. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.02 for the CTE case to 0.3 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For indoor air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For indoor air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 3×10^{-5} for the CTE case to 5×10^{-5} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-7} for the CTE case to 5×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver for the RME case. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.0009 for the CTE case to 0.01 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, there were no carcinogenic COPCs identified. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 6×10^{-7} for the CTE case to 1×10^{-6} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

4.7.4 Uncertainty Discussion

Uncertainties associated with the results of this HHRA are a function of both the "state of the practice" of human health risk assessment in general and UFs specific to the ELV. The general human health risk assessment uncertainty is discussed in Section 1.5.3.

4.8 Ecological Risk Assessment for Expendable Launch Vehicle

4.8.1 Problem Formulation

The problem formulation describes the site to be assessed, establishes the assumptions and data to be employed, and generally is the foundation of the ERA. Generalized components of the problem formulation, applicable to all RFI sites in Group 2 are described in Section 1.5.4.1. Problem formulation components specific to the ELV site are described below.

4.8.1.1 Site Background

The ELV area contains many buildings that have been used for a variety of purposes since the 1950s, including a rocket engine component testing facility, PCB storage facility, engineering offices, operations building, cafeteria, photo laboratory, wastewater treatment clarifier, LEOS storage, lasers lab facility, service building, machine and welding shop, engine assembly, chemical storage, office space, fire station, drum storage, compressor shelter, materials preparations shelter, paint booth, and paint storage. Chemicals used in or stored at the ELV area include solvents, PCBs, mercury, petroleum-based fuels, lubricating oils, compressed gas, heavy metals, hydraulic oil, and battery acid. A more detailed discussion of site conditions and history is presented in Sections 4.1.1 through 4.1.4.

Habitat at the site was determined based on a site survey conducted by CH2M HILL staff in April 2008. The survey indicated that the ELV Area is made up of scrub-shrub, ruderal, and a small portion of woodland habitat (Figure 4.8-1). Approximately 15 percent of the site along the southern boundary is made up of scrub-shrub habitat consisting of laurel sumac, yerba santa, and deer weed. Ruderal habitat makes up approximately 11 percent of the site. The ruderal habitat is located near the center of the site and along the northern boundary and is dominated by red brome, dove weed, and wild cucumber. Woodlands, located near the western edge, account for less than 1 percent of the site. Areas of stressed vegetation (0.4 acre) were noted throughout the scrub-shrub and ruderal habitats. Evidence or actual observation of the following species was noted during the site visit: spotted towhee, American crow, mourning dove, house finch, red-tailed hawk, white-throated swift, gopher (burrows), cottontail, and western fence lizard. It also was noted that this area was burned in 2005 and standing burned woody vegetation is present.

4.8.1.2 Ecological Management Goals, Assessment Endpoints, and Measures

The ecological management goal for the ELV site is the same as that for all Group 2 RFI sites, as follows:

> *Maintenance of soil, sediment, water quality, food source, and habitat conditions capable of supporting ecological receptors, including special-status species, likely to be found in the area.*

Habitats present at the ELV site are exclusively terrestrial. Consequently, only terrestrial assessment endpoints and measures were identified for this site (Table 4.8-1).

Representative species and receptor groups considered for the ELV site include the terrestrial plant community (primary producers), the soil invertebrate community (primary consumers), hermit thrush (primary and secondary consumer), red-tailed hawk (tertiary consumer), deer mouse (primary and secondary consumer), mule deer (primary consumer), and bobcat (secondary and tertiary consumer).

4.8.1.3 Ecological Conceptual Site Model

The generalized ecological CSM for Group 2 is presented in Section 1.5.4.4. Because the ELV site is strictly a terrestrial location, only the terrestrial pathways are relevant. The CSM specific to the ELV is described below and presented in Figure 4.8-2.

The primary contaminant sources at the ELV include chemical use and storage (PCB, LEOS, and paint storage) and operations of a spray booth, wastewater treatment clarifier, photo laboratory, engine component testing facility, and laser labs. Primary release mechanisms include spills and leakage to surface and subsurface soils. Secondary sources of potential contaminants are soils and soil vapors. Secondary release mechanisms include volatilization and wind erosion and bioaccumulation from soil.

Complete or potentially complete exposure pathways from contaminated soil, soil vapor, and biota to ecological receptors exist at the site. Burrowing mammals (deer mice) may be exposed to soil vapors via inhalation. Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, and small mammals resident in or associated with site soils. Terrestrial wildlife (herbivores, omnivores, invertivores, and carnivores), including reptiles, may be exposed directly to contaminants in soil by incidental ingestion, by dermal contact, or by the inhalation of wind-borne particles. Terrestrial invertebrates and wildlife (reptiles, birds, and mammals) also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (plants to herbivores, plants and prey animals to omnivores, etc.). Additional potential exposure pathways for ecological receptors at the ELV are summarized in Table 4.8-2, along with the rationale for the inclusion or exclusion in the quantitative and qualitative evaluations.

4.8.1.4 Selection of Chemicals of Potential Ecological Concern

The process for selecting the CPECs is described in Sections 1.5.4.4 and 1.5.4.5. Detected analytes in soil and soil vapor are listed in Table 4.8-3. Summary statistics for those detected analytes are presented in Table 4.8-4. TEQ values for dioxin/furans were calculated (Table 4.8-5). A central tendency background comparison for metals and dioxins/furans in soils was conducted to determine which analytes were not consistent with background

(Table 4.8-6). Soil VOCs were compared to soil vapor analyses to determine which soil VOC analytes to retain, as presented in Table 4.8-7. If VOCs were detected in soil and analyzed for in soil vapor, the VOC soil analytes were dropped from further evaluation. If VOCs were detected in soil and not analyzed for in soil gas, soil VOC concentrations were used to model soil vapor concentrations. Non-detect analytes were evaluated by comparing the maximum SQLs against the minimum ESL and determining the exceedance frequency of the SQLs (Table 4.8-8). The CPECs identified for the ELV site are summarized in Table 4.8-9. EPCs for each depth interval (0 to 2 ft, 0 to 4 ft, and 0 to 6 ft bgs) are presented in Tables 4.8-10, 4.8-11, and 4.8-12, respectively. EPCs for soil vapor from 0 to 6 ft bgs are presented in Table 4.8-13. Calculations to extrapolate soil vapor concentrations from soil are presented in Table 4.8-14.

4.8.2 Analysis

The analysis phase, which consists of the exposure characterization and the ecological effects characterization, links the problem formulation (Section 4.8.1) with the risk characterization (Section 4.8.3) and consists of the technical evaluation of ecological and chemical data to determine the potential for ecological exposure and effects. Generalized components of the exposure and ecological effects characterizations are presented in Section 1.5.4.4. Exposure and effects information specific to the ELV site is presented below.

4.8.2.1 Exposure Characterization

The exposure characterization is used to evaluate the relationship between receptors at the site and potential stressors (CPECs). The methods used to estimate exposure, including receptor-specific exposure models, exposure factors, and assumptions; exposure areas; and the calculation of EPCs are described in this section.

The receptor-specific exposure models, exposure factors, and assumptions presented in Section 1.5.4.2.4 are used for receptors at the ELV site. Because the ELV site is strictly terrestrial, exposure is based on soil and soil vapor and only was evaluated for terrestrial receptors (plants, soil invertebrates, birds, and mammals).

Although the ELV is 8.5 acres, the spatial extent of samples associated with the site is 11.1 acres. Land cover consists primarily of shrub/scrub and ruderal habitat. It is assumed that all buildings at the site will be removed and that the site will revert to natural conditions.

Summary statistics and EPCs for CPECs in soil at various depths (up to 6 ft bgs) and soil vapor were calculated for the ELV according to the approach outlined in Section 1.5.4.4. These values are presented in Tables 4.8-4 and Tables 4.8-10 through 4.8-13. Modeled exposure estimates for bird and mammal receptors are presented as part of the risk characterization (Section 4.8.3). Tables 4.8-15 through 4.8-17 present the risk estimation for terrestrial plants, soil invertebrates, and burrowing mammals, respectively.

4.8.2.2 Ecological Effects Characterization

The ecological effects characterization consists of an evaluation of available toxicity or other effects information that can be used to relate the exposure estimates to a level of adverse effects. Generalized effects data for all receptors at the SSFL are summarized in

Section 1.5.4.4. No effects data specific to the ELV site are available. Consequently, ESLs, Low TRVs, and High TRVs for the terrestrial receptors described in Section 1.5.4.5 were used to evaluate the effects associated with the estimated exposures.

4.8.3 Risk Characterization

The risk characterization integrates the estimated CPEC exposures with their potential ecological effects on the assessment endpoints for the ELV site. The sequential processes for performing the risk characterization, described in Section 1.5.4.4, were applied to the ELV site. The results of these comparisons are presented below.

4.8.3.1 Risk Estimation

The risk estimation focuses primarily on quantitative methods to evaluate the potential for risk. The results of the quantitative risk estimation are presented as HQs and HIs. CPECs with HQs and HIs exceeding 1 are retained for WoE evaluation in the risk description. Table 4.8-18 presents an analysis of the depth intervals for evaluating burrowing animals (deer mouse). The 0- to 6-foot-bgs depth interval had the greatest HI; therefore, the data from this depth were used to evaluate the deer mouse. Tables 4.8-19 through 4.8-21, respectively, contain the risk estimation for terrestrial birds and mammals (CTE), HIs for terrestrial birds and mammals (CTE), and risk estimation for terrestrial birds and mammals (RME).

4.8.3.2 Risk Description

The risk description incorporates the results of the risk estimates, along with any other available and appropriate lines of evidence, to evaluate the potential chemical impacts on ecological receptors in Group 2. Chemicals that had HQs exceeding 1 were further evaluated to determine the COECs. Information considered in the determination of COECs includes receptor groups potentially affected, exceedance of Low and/or High TRVs, magnitude of exceedance, bioavailability, and habitat quality at the site.

To facilitate the interpretation of TRV exceedances, chemicals that exceed one of the TRVs (ESL, Low TRV, or High TRV) were assigned into seven general risk groups (1 through 7, below). These groups were created as an additional tool to assist risk managers in making remedial decisions. The groupings are subjective, based on professional judgment, and the placement of a chemical within a given group is not an absolute indicator of the potential risk:

1) High Risk–HQs>5 for High TRV (RME), or HQs>100 for any EPC/TRV combination. Chemical classes with HIs>10 at High TRV (RME). Four or more receptors showing estimated risks.

2) Medium-High Risk–2<HQs<5 for the High TRV (RME). Chemical classes with 2<HIs<10 at the High TRV (RME) or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.

3) Medium Risk–1<HQs<2 for High TRV (RME), but HQ>10 for Low TRV (RME). Chemical classes with 1<HIs<2 at the High TRV or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.

4) Medium-Low Risk–HQs<1 for the High TRV (RME), but 1<HQs<10 for the Low TRV (RME). Chemical classes with HIs<1 at the High TRV or 2<HIs<10 at the Low TRV. No more than two of six receptors showing estimated risks.

5) Low Risk–HQs<1 for the Low TRV (RME). Chemical classes with HIs<1 at the Low TRV.

6) No Risk–all HQs and associated HIs<1.

7) Uncertain–TRVs unavailable to calculate either HQs or HIs.

Eight soil analytes (barium, hexavalent chromium, mercury, vanadium, zinc, BEHP, dioxins/furans [including coplanar PCBs], and TCE), were found to have one or more HQs greater than 1 under at least one scenario. All other soil analytes and/or analyte groups (with the exception of phthalates and dioxins/furans) were found to pose no risk (all HQs and HIs less than 1) to any receptor under any scenario (maximum concentration for plants, invertebrates, and soil vapor exposures; CTE and RME concentrations for birds and mammals) at the ELV site.

Four inorganics including barium, mercury, vanadium, and zinc were identified as elevated based on non-parametric central tendency background comparisons for soil (Table 4.8-6). Background values were not available for hexavalent chromium. These metals had one or more HQs above 1 for at least one receptor in the refined screen. On the basis of the risk ranking discussed above, barium was found to pose medium risk (1<HQs<2 for High TRV [RME], but HQ>10 for Low TRV [RME]). The incremental risk for barium (site HQ minus background HQ, as discussed in Section 1.5.4) generally was low, suggesting that exposure is highly related to naturally occurring concentrations of barium (Table 4.8-22). Because the magnitude of exceedances for all HQs and incremental risks are low, the risks posed by barium are considered acceptable.

Hexavalent chromium was found to pose low risk (only soil invertebrates had HQ above 1 but less than 2; Table 4.8-14). Because invertebrates were the only receptor with an HQ above 1 and the magnitude of exceedance was low (HQ = 1.4), the risks are considered acceptable.

Mercury was found to pose a medium risk (three receptors showing estimated risks). Mercury had a low TRV-based HQ above 1, based on the RME exposure for the hermit thrush, although it was less than 2 and the high TRV-based HQ was less than 1 (Table 4.8-19). Of the 322 detected concentrations, 90 detections (25 percent) exceeded the plant TRV of 0.3 mg/kg and 20 detections (approximately 6 percent) exceeded the invertebrate TRV of 2.5 mg/kg. Four locations had detected concentrations above 10 mg/kg, including EVBS14, EVBS84, EVBK05, and EVST01.

Vanadium was found to pose a medium risk because only 1 receptor (deer mice) had HQs above 1 under any scenario (Table 4.8-21). On the basis of the RME exposure, the deer mouse had low TRV and high TRV-based HQs above 1, although the high TRV-based HQ was low (HQ = 2.4) (Table 4.8-19). Because the magnitude of exceedance and the incremental risk (Table 4.8-22) are low, the risks posed by vanadium are considered acceptable.

Zinc was found to pose a medium high risk (four receptors showing estimated risk) (Table-4.8-21). Of the 59 samples in which zinc concentrations were detected, only 10

(approximately 6 percent of samples) exceeded the plant TRV (131 mg/kg) and 8 exceeded the invertebrate TRV (199 mg/kg). On the basis of the RME exposure, the high TRV-based HQ for the deer mouse was only 2.4 (Table 4.8-19). On the basis of the CTE exposure, the high TRV-based HQ was 2.3 (Table 4.8-17). The predicted risk for the hermit thrush was low, with a high TRV-based HQ of 1.1 (RME) and less than 1 (CTE). The incremental risk for zinc was above 1 and suggests that isolated areas may pose risks (Table 4.8-22). However, one area of elevated zinc (1,330 mg/kg in 0.5-foot sample from EVBS1030) probably drives most of the predicted risk. The next highest concentration at the site was 283 mg/kg, suggesting that the sitewide risks probably are acceptable.

The BEHP HQs exceeded 1 for the hermit thrush at the Low TRV based on an RME exposure (Table 4.8-19) and was found to pose a medium-low risk because only one receptor showed the predicted risk. A high TRV was not available. The low TRV-based HQ, based on the CTE exposure, also was above 1, but the magnitude of exceedance was low (HQ = 3; Table 4.8-17). One hot spot drove the risks for BEHP, with a detected concentration of 14.7 mg/kg (EVBS1040). All other detected concentrations were less than 1 mg/kg. Because only one receptor showed an estimated risk and only one location contained elevated concentrations of BEHP, the risks were considered acceptable.

Dioxins/furans (including coplanar PCBs) based on the 2,3,7,8-TCDD TEQ were found to pose a high risk. The high TRV-based RME HQs exceeded 1 for the hermit thrush and deer mouse (Table 4.8-19). In addition, the chemical class HI exceeded 1 for both receptors at Low and High TRVs (Table 4.8-20). The risk was driven by dioxin/furans. One location (EVBS1056) contained elevated concentrations of dioxin/furan congeners and may represent an isolated hot spot. Table 4-8.23 lists the summary of risk estimation for terrestrial exposures.

The measured or maximum SQL concentrations of six VOCs (1,1,2-TCA, 1,1-DCE, CTC, cis-1,2-DCE, TCE, and VC) exceeded the inhalation TRVs (HQ>1), as listed in Table 4.8-24. The magnitude of exceedances for 1,1-DCE, CTC, and VC is low and the predicted risk is considered acceptable. The magnitude of exceedance for 1,1,2-TCA was slightly higher, but this analyte was never detected. Concentrations of cis-1,2-DCE were elevated (23 mg/m^3) in a sample from EVSV01. Detected concentrations in two other samples were an order of magnitude lower. Additionally, cis-1,2-DCE was only detected in 3 of 35 samples (9 percent) and the risks are considered acceptable. TCE was detected in 17 of 36 samples (47 percent) and had an HQ of 16.3, based on the maximum detection. Of the 17 detected concentrations, 11 exceeded the inhalation TRV, suggesting that concentrations of TCE may pose risks to burrowing receptors. The risk from TCE is considered high.

Tables 4.8-25 and 4.8-26 provide the chemicals of ecological concern for soil and the chemicals of ecological concern for soil vapor, respectively.

4.8.3.3 Uncertainty Analysis

Uncertainty is an implicit component in all risk assessments. Generalized uncertainties for ecological risk assessments in Group 2 are summarized in Section 1.5.4.5. Uncertainties specific to the ELV site are summarized below:

- Samples were collected outside of the site boundary in an effort to define and fully characterize potential releases from the ELV. If sample concentrations decreased with distance from the site, the inclusion of these additional data could underestimate risks in the core portion of the site when these data ere integrated into the RME and CTE calculations.
- Depths were unavailable for several historical soil and soil vapor sample locations included in the ELV dataset. In an effort to be conservative and to ensure completeness, these data were included in the 0- 2-foot-bgs depth interval for the purposes of the risk assessment. There is some uncertainty associated with including these data in this depth interval (especially for soil vapor) and the risks could be overestimated. However, it is likely that maximum soil concentrations would be detected at shallower depths, so the inclusion with the shallowest depth interval for soil is deemed appropriate.
- Aroclor data were not evaluated in this assessment because PCB congener data were available and were used to calculate a TCDD_PCB TEQ. PCBs and dioxin/furans were evaluated based on the 2,3,7,8-TCDD TEQs. Concentrations of aroclors were low and are not expected to be significant contaminants of concern. However, PCB congener data were only available from two sample locations and may not be representative of the entire site.
- No screening levels were available to evaluate the TPH data; however, the PAH data were available and the risks from these constituents ere considered low.

4.8.4 Conclusions and Recommendations

Of the 40 analytes (dioxins/coplanar PCBs were counted as one analyte) in soil that were evaluated, mercury and dioxin/furans (including coplanar PCBs) were the only analytes found to pose unacceptable risks. Mercury was found to pose a medium risk, while dioxins/furans were found to pose a high risk. Of the remaining soil analytes, 6 were found to pose an acceptable risk, 24 posed no risk, and 8 lacked TRVs. All analytes in soil vapor were considered to pose low risks,based on further qualitative evaluation. Except for mercuy and dioxins/furans, the risks from all analytes were considered acceptable and do not warrant additional investigation.

Mercury and dioxins/furans were the only analytes considered to warrant additional evaluation or action. Four locations contained mercury at levels above 10 mg/kg (EVBS14, EVBS84, EVBK05, and EVST01) and probably represent isolated hot spot areas. Because mercury was analyzed for in 360 samples (in the 0- to 2-foot-bgs interval), additional sampling probably is not warranted; however, evaluation in the CMS is recommended.

Dioxin/furans and coplanar PCBs (based on the 2,3,7,8-TCDD TEQ) also are recommended for evaluation in the CMS, because risks were estimated for two receptors that had high

TRV-based HQs of more than 5. Only 16 sample locations for dioxins/furans were collected within the 0- to 2-foot-bgs interval, with hot spots identified near (EVBS1056). PCB congener data were only collected at two locations. Additional sampling for dioxin/furans and PCB congeners may be warranted.

4.9 Summary of Findings and Recommendations for the Area II ELV Site

4.9.1 Nature and Extent of Contamination Summary

To evaluate the nature and extent of potential contaminants at the ELV Area, 260 surface soil, 93 subsurface soil, and 41 soil gas samples were collected and analyzed for targeted potential contaminants. Of the surface soil samples collected, 17 dioxins, 17 metals, 2 SVOCs, 4 TPH groups, and 2 VOCs exceeded 1 or more of the screening criteria. Of the subsurface soil samples collected, 16 dioxins, 16 metals, 2 SVOCs, 5 TPH groups, and 3 VOCs were reported at concentrations that exceeded 1 or more of the screening criteria. Four VOCs were detected in soil gas samples at levels exceeding their respective screening criteria. A list of parameters that exceeded the applicable comparison criteria is provided in Table 4.9-1. The extents of the parameters that exceeded the screening criteria at the ELV Area mostly have been evaluated sufficiently.

Dioxins were encountered at elevated concentrations in the southeastern portion of the site, near the dry pond, and additional sampling may be required to further evaluate the horizontal extent of these parameters. Near Building 2202, the wastewater treatment sump and clarifier, DROs (C14-C20) and (C20-C30) do not appear to have been bound in the southerly direction. Additional surface soil sampling for dioxins and DROs should be collected in these specific locations to complete the horizontal extent assessment at this site.

Dioxins, SVOCs, TPH groups, VOCs, and several metals parameters may require additional sampling to evaluate the vertical extent near two specific locations: the Building 2202 wastewater treatment sump and clarifier, and the southeastern dry pond. Samples EVSU01, 3 ft bgs, and EVBS10, 3 ft bgs, were the deepest intervals analyzed at their respective stations, with each having reported elevated concentrations of 1 or more of the potential contaminants. Dioxin, SVOC, TPH, and VOC subsurface exceedances were detected beneath the southeastern dry pond at 3 ft bgs. Because there are no known additional subsurface soil samples at this station or close to it, additional subsurface soil sampling may be required in this area to complete the vertical extent evaluation of these parameters. Nearly all of the subsurface metals exceedances were encountered near the wastewater treatment sump; approximately half of the exceedances were encountered beneath the southeastern dry pond, as well. Samples from deeper intervals, if accessible, as well as subsurface soil samples in the 3–foot-bgs interval, should be collected to complete the vertical extent evaluation of metals in the ELV Area.

Three VOC parameters, cis-1,2-DCE, PCE, and TCE, were detected in the soil gas samples collected on the southern side of Building 2206. Several soil gas samples surrounding this area did not have reported elevated concentrations of VOCs; however, there appears to be a lack of extent, particularly in the southern direction. Additionally, deeper soil gas samples may aid in providing a vertical bound of these parameters. Additional soil gas sampling

should be completed at the ELV Area, specifically south of Building 2206, to complete the extent evaluation.

4.9.2 Risk Assessment Summary

This section summarizes the HHRA performed for the ELV Area. The HHRA assesses the potential current and future exposures to chemicals in surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater. The methods used to prepare the HHRA are described in Section 1.5.3. The results of the HHRA for the ELV are presented in Section 4.7.

The surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater samples collected during the RFI sampling activities were evaluated for use in the HHRA. Surface water and sediment samples are not evaluated in this HHRA because they were not collected during the RFI site characterization activities. The HHRA data set is presented in Table D.7.1-3 in Appendix D. The COPCs identified from the ELV HHRA data set for each exposure area are presented in Table D.7.1-5.

The potential future receptors at the ELV include recreationists, workers, and residents. The ELV and surrounding area are likely to have a future recreational or industrial land use; however, a hypothetical future residential scenario also was assessed in the HHRA, along with recreational and industrial exposure scenarios. The residential scenario consists of conservative exposure assumptions, and residents are expected to have the greatest level of exposure. The residential exposure scenario evaluated in this report assumes that exposure can occur through the consumption of fruits and vegetables from a garden. The evaluation of an agricultural residential exposure scenario will be included in a separate report. The assumed exposure pathways for future residents, workers, and recreationists are shown in Figure 1-1.5.3-1.

Generally, estimated cumulative cancer risks (ELCRs) less the regulatory risk range (range of 1 in a million [1 x 10-6] to 1 in 10,000 [1 x 10-4])and estimated noncancer hazards (HIs) less than the regulatory threshold value of 1 are considered acceptable (EPA, 1993). Estimated ELCRs within the 1 x 10-6 to 1 x 10-4 range are managed on a site-specific basis. The ELCRs and HIs are summarized in Table D.7.5-1.

The following exposure scenarios for the ELV Area exceeded the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult resident exposed to soil (0 to 2 ft bgs) from plant consumption
- Hypothetical future adult resident exposed to indoor air from the migration of soil vapor COPCs
- Hypothetical future child resident exposed to soil (0 to 2 ft bgs) from plant consumption
- Hypothetical future child resident exposed to indoor air from the migration of soil vapor COPCs

The following exposure scenarios for the ELV are within the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult resident exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult resident exposed to soil (0 to 10 ft bgs)
- Hypothetical future adult resident exposed to ambient air from migration of soil vapor COPCs
- Hypothetical future child resident exposed to soil (0 to 2 ft bgs)
- Hypothetical future child resident exposed to soil (0 to 10 ft bgs)
- Hypothetical future child resident exposed to ambient air from migration of soil vapor COPCs
- Hypothetical future adult industrial worker exposed to soil (0 to 2 ft bgs)
- Hypothetical future adult industrial worker exposed to soil (0 to 10 ft bgs)
- Hypothetical future adult industrial worker exposed to ambient air from migration of soil vapor COPCs
- Hypothetical future adult industrial worker exposed to indoor air from migration of soil vapor COPCs
- Hypothetical future adult recreationist exposed to soil (0 to 2 ft bgs)
- Hypothetical future child recreationist exposed to soil (0 to 2 ft bgs)
- Hypothetical future child recreationist exposed to ambient air from migration of soil vapor COPCs

The following exposure scenarios for the ELV exceed the regulatory threshold values for non-carcinogenic COPCs:

- Hypothetical future adult resident exposed to soil (0 to 2 ft bgs) from plant consumption
- Hypothetical future child resident exposed to soil (0 to 2 ft bgs)
- Hypothetical future child resident exposed to soil (0 to 2 ft bgs) from plant consumption
- Hypothetical future child resident exposed to soil (0 to 10 ft bgs)
- Hypothetical future child resident exposed to indoor air from migration of soil vapor COPCs
- Hypothetical future industrial worker exposed to soil (0 to 10 ft bgs)

As described in Sections 1.5.3.6 and 4.7.4, there is a degree of uncertainty associated with these risk estimates that should be considered when making risk management decisions.

4.9.3 Recommendations for the Area II ELV Site

Additional soil samples are warranted to more definitely evaluate the extents of dioxins and TPHs. Dioxins were encountered at elevated concentrations in the southeastern portion of the site, near the dry pond; additional sampling is needed to further evaluate the horizontal extents of these parameters. Near the Building 2202 wastewater treatment sump and clarifier, DROs (C14-C20) and (C20-C30) do not appear to have been bound in the southerly direction.

Dioxins, SVOCs, TPH groups, VOCs, and several metals parameters may require additional sampling to evaluate the vertical extent near two specific locations: the Building 2202 wastewater treatment sump and clarifier, and the southeastern dry pond. These sample locations consistently had the highest concentrations for these parameters, and an attempt to collect samples at a greater depth is warranted. Additional soil gas samples also would be beneficial in characterizing the VOC contamination in the ELV Area, specifically in the southeastern portion of the area near the dry pond.

Although ecological risks from 40 analytes were evaluated in soil at the ELV, only mercury and dioxin/furans (including coplanar PCBs) were identified as presenting unacceptable risks. Four locations contained highly elevated mercury concentrations (above 10 mg/kg) and probably represent hot spots. Because mercury was analyzed in 360 samples in the 0- to 2-foot-bgs interval, additional sampling is not likely to be warranted; however, consideration of hot spot removal in the CMS is recommended. Additional characterization of dioxin/furans and coplanar PCBs in soil also is recommended, because the risks estimated for bird and mammal receptors were based on only 16 dioxin/furan sample locations and only 2 PCB congener sampling locations.

Potentially significant human health risks were identified for dioxins/furans in soil and TCE in soil vapor. Human health risk estimates from chemicals generally were driven by a localized area with elevated concentrations. After confirmation of the extent of contamination, removal of soils with elevated concentrations and extraction of soil vapors in areas with elevated VOC concentrations are recommended to reduce human health risks.

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5. Former Area II Incinerator Ash Pile, SWMU 5.6, and Building 515 Sewage Treatment Plant (STP)

On the basis of the historical sampling and the 2008 RFI investigation, additional soil samples may be warranted to more definitely evaluate the extent of metals, dioxins/furans, and SVOCs in the surface and subsurface soils. Additional soil gas samples also would be beneficial in characterizing the VOC contamination in the Ash Pile at the STP area.

As indicated by the ERA, barium was isdentified as an ecological risk driver. Risks were associated with one localized hot spot, near the Ash Pile site boundary, although concentrations were above background in more than half of the sampled locations. This result suggests that elevated concentrations are present throughout the area. Consequently, additional action or investigation is recommended to reduce the risks posed by barium to wildlife receptors.

Potentially significant human health risks were identified for dioxins/furans and barium in soil and for PCE in soil vapor. Human health risk estimates from chemicals generally were driven by a localized that had elevated concentrations. After confirmation of the extent of contamination, removal of soils with elevated concentrations and extraction of soil vapors in areas with elevated VOC concentrations are recommended at this location to reduce human health risks.

5.1 Former Area II Incinerator Ash Pile and STP Site Background and History

The Incinerator area was operational from the mid-1950s through the 1970s. It consisted of a brick structure with a metal smokestack and waste storage pad. The Incinerator was used to burn nonhazardous wastes, primarily trash, photographs, and paper (MWH, 2005d). The Incinerator and associated structures were demolished in 2006 (The Boeing Company, 2008; The Boeing Company, date unknown).

The RD-9 Treatment System also is located in the Incinerator area. The investigation of this area was completed previously and an NFA decision was made for the RD-9 Treatment System.

The STP was acquired by NASA in 1973, along with the rest of the Area II property (known as USAF Plant 57 under ownership of the USAF). The STP was operational from 1961 to 1987 and is now inactive on standby. The site is an approximately 0.5-acre area located north of the Alfa and Bravo Areas and south of the ELV (MWH, 2005d).

5.1.1 SWMUs and AOCs

The former Incinerator Ash Pile has been designated as SWMU 5.6 and the RD-9 Area UV/H_2O_2 Treatment System, designated as SWMU 5.4, will be discussed in the following subsection, along with the Building 515 STP, which is an Area II AOC. The STP site includes the STP clarifier and STP Control Building (Building 776). An Area II AOC exists for UT-52, which is a UST located to the southwest of the STP. This UST was removed in 1993 and closed by VCEHD in 1994. Also discussed in this subsection is another Area II AOC, the Area II Service Area Building 211 Leach Field. There are no other SWMUs or AOCs discussed in this subsection; however, the USEFF is addressed in this subsection because of its proximity to the STP. The locations of the SWMUs and AOCs associated with the former Incinerator Ash Pile and STP sites are shown in Figure 5.1-1.

5.1.2 Site History

The Incinerator area was acquired by NASA in 1973, along with the remaining Area II property (known as USAF Plant 57 under ownership of the USAF). The Incinerator, Building 758, was operational from the mid-1950s through the 1970s. It consisted of a brick structure approximately 10 ft long by 8 ft wide, and was 10 ft high with a metal smokestack approximately 30 ft high. A chute led from the incinerator door to a cinder-block storage pad with a metal roof. The waste storage pad was called Building 758A, or the Incinerator Platform, and was used as a staging and loading area for the Incinerator. The Incinerator was used to burn nonhazardous wastes, primarily trash, photographs, and paper (MWH, 2005d). The Incinerator and associated structures were demolished in 2006 by Onyx and soil samples were collected by MWH (The Boeing Company, 2008; The Boeing Company, date unknown).

Waste from the Incinerator was deposited in an ash pile located in an unpaved area to the south of the Incinerator. The former Ash Pile was approximately 35 ft long by 15 ft wide and 2 ft high.

The RD-9 Area UV/H_2O_2 Treatment System is located near the intersection of Parking Lot Road and Service Area Road, northeast of the former Ash Pile. The system was built in the late 1980s and used periodically during 1990 and 1991. The RD-9 Area UV/H_2O_2 Treatment System treated "batches" of contaminated water that were trucked in from several sources, including the following:

- Engineering Chemistry Lab (ECL) collection tanks and runoff tanks (Area III)
- Purge water from the Delta treatment system (Area II)
- Systems Test Laboratory (STL)-IV Treatment System Tank (Area III)

In 1992, groundwater extracted from the ECL area was treated at the Delta and Bravo treatment systems, and water from well RD-9 was treated periodically at the RD-9 Area UV/H_2O_2 Treatment System. Treated water was discharged to the Silvernale Reservoir, which is part of the SSFL water reclamation system. The treatment system was deactivated in 2001 (ICF Kaiser Engineers, 1993). The RD-9 Area UV/H_2O_2 area has received a status of NFA under the RFI Program (Ogden, 1995).

UT-52 was a 12,000-gallon unleaded gasoline UST near the USEFF, to the southwest of the STP. VCEHD closed the tank in 1994.

When the STP was in operation, it received both sanitary sewage and cooling water discharges from small air conditioning and heat exchanger units in Area II (De Leuw, Cather & Company, 1987). Cooling water may have contained traces of solvents and/or fuels. The STP was designed to treat 50,000 gallons per day (gpd), but received an average flow of approximately 4,000 gpd from Area II. The unit is below grade and concrete lined. The facility consists of a comminutor (a device used to cut up solids in wastewater), source aeration unit, and clarifier (Ogden, 1996b).

Treatment of sewage at SSFL was stopped in approximately 2001. Although the STP in Area III was still active, Area II sewage was pumped from the treatment plant in Area II to the treatment plant in Area III, where the sewage was treated and secondary effluent was discharged to the R-2A Pond (SAIC, 1994).

An interview with a former employee resulted in the possible identification of a new activity to the southwest of the STP. This area has been identified as a USEFF and also has been called the Storable Propellant Flow Bench. Flowmeter calibration and testing occurred in this location at three "lean-to structures." According to the former employee, the area was active between 1965 and 1970. The activity at the site involved pushing product through the flowmeter and then transferring the product into a catch container, where it could be used for another test (The Boeing Company, 2006).

The service area, Building 211 Leach Field, was active from approximately 1954 to 1959. It is located to the east of the STP and has been inactive since the STP was constructed. This leach field served Building 211 and adjacent buildings in the ELV service area.

5.1.2.1 Site Inventories

Inventories of the buildings, tanks, transformers, and chemicals used at the Ash Pile and STP site were compiled during the preparation of this RFI report. This information was obtained from historical document reviews, facility drawings, and VSIs. These features are shown in Figure 5.1-1, as applicable. The inventories are included in the following tables:

- Building Inventory–Table 5.1-1
- Tank Inventory–Table 5.1.2
- Transformer Inventory–Table 5.1-3
- Chemical Inventory–Table 5.1-4

5.1.3 Site Chemical Use Areas

The Incinerator was used to burn nonhazardous wastes, primarily trash, photographs, and paper (MWH, 2005d). Heavy metals and dioxins were detected in soil during sampling in 1991, and the former Ash Pile and underlying soil were removed in 1993. A building checklist from 1995 indicated that the Incinerator Building contained asbestos (The Boeing Company, date unknown), and the building and structures have been removed.

Groundwater contaminated with VOCs was trucked to the RD-9 Area UV/H_2O_2 Treatment System from Areas II and III. The RD-9 Area UV/H_2O_2 Treatment System consisted of five vertical ASTs. Contaminated water that was stored in two of these fiberglass ASTs was oxidized by exposure to UV radiation and hydrogen peroxide and was then pumped into two additional ASTs. The end-products of this process are carbon dioxide and water. The

treated water was discharged to the Silvernale Reservoir. A concrete berm provides secondary containment for the entire treatment system.

Soil surrounding UT-52 was sampled during the tank removal in 1993, and VOCs and TPHs were found at levels below the VCEHD screening criteria. Total lead levels detected were consistent with the background levels. UT-52 was closed by VCEHD in 1994.

When the STP was active, aerated sewage flowed into the clarifier, where solids settled to the bottom and clarified effluent was removed from the top. An organic polymer was added to coagulate the sludge for additional settling. The settled sludge was removed from the bottom of the settling tanks and hauled away for disposal approximately once per month. The treated water was then pumped to a drainage ditch that conveyed the secondary effluent to the Silvernale Reservoir (Ogden, 1996b).

At the USEFF, used from 1965 to 1970, each "lean-to" structure was dedicated to testing a particular product: NTO, MMH, and Freon trichlorofluoroethene (TF). Product was pushed through the flowmeters, then transferred into a catch container where it could be used for another test (The Boeing Company, 2006).

5.1.4 Site Conditions

The former Ash Pile and underlying soil were removed in 1993. The Incinerator building and associated structures were removed in 2006. All concrete foundations, electrical, water, and gas lines also were removed. The area was regraded to the natural slope and samples were collected following the demolition.

The RD-9 Area UV/H_2O_2 Treatment System is part of the groundwater treatment system, but is currently inactive. The unit was placed on "stand-by" status in 2001 as part of a Post-closure Permit modification granted by DTSC (Haley and Aldrich, 2008). The RD-9 Area UV/H_2O_2 area has received a status of NFA under the RFI program.

UT-52 was removed in 1993 and closed by VCEHD in 1994.

Currently, the sewage from Area II flows to the STP, where it is pumped to the STP in Area III. From there it is pumped by vacuum truck and is trucked offsite for treatment. None of the structure has been removed, and the STP still consists of a belowgrade, concrete-lined unit that includes a comminutor, a source aeration unit, and a clarifier.

The USEFF has been removed and there are no remnants of the structures used at the facility. The area surrounding the former facility has been razed; AST structures remain at the location.

5.1.5 Site Habitats/Land Cover

The former Incinerator Ash Pile and STP area is accessed via a paved road running east-west that is considered developed. To the south of the road is coast live oak woodland. There is also coast live oak woodland to the north of the road, on the western portion of the site. Also to the north of the road is non-native grassland, mulefat scrub, and baccharis scrub. The area to the south of the former Ash Pile is primarily coast live oak woodland. On the east is developed area, ruderal habitat, coast live oak woodland, and baccharis scrub. On the northern side of the site are more baccharis scrub, mulefat scrub, non-native

grassland, rock outcrops, and coast live oak woodland. Developed area and coast live oak woodland are found to the west of the former Ash Pile. The habitats and land cover present at the Ash Pile Area are shown in Figure 5.1-2.

The RD-9 Area UV/H_2O_2 Treatment System is a developed area surrounded by asphalt. Coast live oak woodland surrounds the treatment system on the western, southern, and eastern sides. The Service Area Road is located along the northern border of the side, and to the north of the road is non-native grassland. The habitats and land cover present at the RD-9 Area UV/H_2O_2 Treatment System are shown in Figure 5.1-2.

The western portion of the STP specifically is developed and consists of the control building, the belowgrade, concrete-lined unit, and pavement surrounding the area. Most of the eastern portion of the site is made up of the inactive Building 211 Leach Field and is covered in baccharis scrub and non-native grassland. Baccharis scrub surrounds the northern, eastern, and parts of the southern portions of the site. Also found to the south of the STP are rock outcrops, mulefat scrub, non-native grassland, and developed areas (roads). To the west are venturan coastal sage scrub and coast live oak woodland, as shown in Figure 5.1-2.

The USEFF consists of ruderal habitat in the southern portion of the site, coast live oak woodland in the northeastern portion of the site, rock outcrops towards the central area, and venturan coastal sage scrub in all other areas. There is a developed area, mostly paved, to the south and east of the site. Ruderal habitat and coast live oak woodland can be found on the western side of the site, and to the north is coast live oak woodland, venturan coastal sage scrub, and chaparral (Figure 5.1-2).

5.1.6 Historical Document Reviews

As described in Section 1.5.1, a historical document review was completed of documents applicable to the Group 2 RFI. As a result of this historical document review, one new potential feature was identified. The feature was identified as a cement containment pool behind the UV Peroxide Treatment System at the RD-9 Area, SWMU 5.4.

5.2 RFI Characterization Activities

This subsection describes the sampling objectives, sampling scope, and key decision points associated with defining the nature and extent of chemical impacts for the surface soil, subsurface soil, and groundwater at the former Incinerator Ash Pile and STP site.

5.2.1 Sampling Objectives

To characterize the extent of potential chemical effects on the former Incinerator Ash Pile and STP site, soil, soil vapor, and groundwater samples were collected. The objectives of the investigation were as follows:

- Define the lateral and vertical extent of chemical impacts.
- Define the potential gradients of chemicals.
- Develop a sufficient data set for performing a risk assessment.

These objectives contributed to the selection of sampling locations, analytical methods, and depths, while incorporating site-specific information such as the following:

- Site conditions observed at the location of proposed sampling
- Historical sampling results and/or previous remediation activities
- Fate and transport characteristics of chemicals
- SSFL background concentrations of parameters
- SSFL SRAM-based screening concentrations for human health and ecological receptors

5.2.2 Sampling Scope

Provided in this report are all of the characterization results for soil matrix, soil vapor, and groundwater information. The total numbers of historical and samples collected as part of this report for soil matrix samples, soil vapor samples, and groundwater samples are summarized below.

- Soil Matrix: 222 Samples
- Soil Vapor: 61 Samples
- Groundwater: 73

These samples were collected between 1993 and 2008 to identify the potential chemical impacts associated with the activities at the Former Incinerator Ash Pile and STP site. A detailed summary for all of these samples is provided in Section 5.4.

Note that three wells installed in the vicinity of the former incinerator were not sampled because of the seasonally dry conditions. Sampling will be completed during the next wet season.

5.2.3 Key Decision Points

The site-specific decision points identified for the Ash Pile and STP site represent the assumptions and/or decisions made during the sampling phase component of this RFI, as follows:

- For historical sample points where the sample depth had not been recorded, it was assumed that these sample points were taken between the 0- to 2-foot-bgs range.

5.3 RFI Characterization Results

The characterization results from the previous soil matrix, soil vapor, groundwater, and surface water investigations at the Ash Pile and STP site are summarized below.

5.3.1 Soil Matrix and Soil Vapor Findings

Surface soil samples were collected at the Ash Pile and STP site from 1993 through 2007. The Ash Pile and several inches of underlying soil were removed in 1993 as part of the accelerated cleanup program. Before the removal of the Ash Pile, the underlying soil was investigated for the presence of metals. Soil samples C-2-01 through C-2-04 were collected in February 1993 at the interface between the bottom of the ash pile and at the native soil at a depth of 0.5 ft bgs. The analytical results indicated detections of 13 metals; however, only 7 of those (antimony, barium, cadmium, copper, lead, silver, and zinc) had detections that

were above background concentrations and also exceeded both the ecological and human health screening criteria. Because sample locations C-2-01 through C-2-04 were taken before the Ash Pile removal, the concentrations for the following metals were above the ecological and human health screening criteria: barium, cadmium, lead, silver, and zinc. Subsequent to the removal of the Ash Pile, additional samples were collected in July 1993. Metals that exceeded both the ecological and human health screening criteria after the Ash Pile removal included barium, cadmium, and silver.

To further characterize this site, subsequent soil investigations after 1993 at the Incinerator Ash Pile and STP area also included analyses for dioxins, metals, PCBs, SVOCs, TPHs, and VOCs. Surface soil samples collected at the Ash Pile and STP area for VOCs in 1997 did not identify any exceedances. However, later surface soil investigations have identified dioxins, metals, PCBs, PCB congeners, and SVOCs at levels that exceeded both the ecological and human health screening criteria. Subsurface soil samples were collected at this site in 2000, 2001, and 2006 for metals, VOCs, SVOCs, and TPHs. Detections were reported for metals, SVOCs, and TPHs. Metals, including cadmium, chromium, mercury, silver, thallium, and zinc, were detected at levels above both the ecological and human health screening criteria. Although TPHs and SVOCs were detected, the concentrations did not exceed the ecological or human health screening criteria from subsurface soil samples. SVOCs were only reported at elevated concentrations.

On December 22, 1993, UT-52 was removed. As part of the removal process, nine soil samples were collected and analyzed for lead, TPHs (modified for gasoline), and VOCs. No VOCs or TPHs were detected from these samples. Total lead was detected in each sample at concentrations consistent with the previously established background levels.

In 2007, soil gas samples from 47 Ash Pile and STP locations identified VOCs (PCE, TCE, and cis-1,2-DCE) at levels that exceeded both the ecological and human health screening criteria. Additional details regarding the analytes detected at the Ash Pile and STP site as a result of the previous investigations performed are described in Section 5.4.

5.3.2 Groundwater Findings

The following discussion regarding the groundwater findings at the Former Ash Pile is based primarily on findings at the Building 515 STP area because of the geographic proximity of these units and because prior to this investigation, no NSGW monitoring wells were present at the Former Ash Pile. Three piezometers were installed at the Former Ash Pile (PZ-146, PZ-147, and PZ-148) during this investigation. The results from sampling these piezometers are pending and will be provided as an addendum to this report.

5.3.2.1 Background

The former Area II Incinerator Ash Pile AOC–Building 515 STP is located in the north-central section of Area II. The area is situated along the axis of a surface water drainage feature that slopes to the northeast. The elevation varies from approximately 1,800 ft above msl in the southwestern section of the area to 1,760 ft msl toward the northeast.

NSGW is monitored by a system of 20 shallow groundwater monitoring wells and piezometers, as shown in Figure 5.3.2-1. Two Chatsworth formation monitoring wells also

are present. Some piezometers are equipped with multi-port samplers and extend into the Chatsworth formation. Well construction summaries are provided in Appendix E.

Four piezometers were installed in the vicinity of this site during this investigation (PZ-145, PZ-146, PZ-147, and PZ-148). PZ-146 through PZ-148 were installed to investigate potential saturated conditions in the weathered bedrock upslope and hydraulically upgradient of this area and to define the extent of contamination. PZ-145 was installed down slope of the area and hydraulically down gradient to provide additional data regarding the extent of contamination and saturated conditions in the near-surface weathered bedrock.

5.3.2.2 Local Geology

The former Incinerator Ash Pile and STP area is underlain by deposits of the Lower Burro Flats Member of the Chatsworth formation, which consists primarily of medium-grained sandstone but also may contain significant siltstone and shale interbeds.

During rock-coring activities at PZ-145, PZ-146, PZ-147, and PZ-148, alluvium was encountered from 4 ft to 19.2 ft bgs. The alluvium consisted of brown to pale yellow silty sands and sandy silts. Weathered Chatsworth formation was encountered to depths ranging from 22 ft to 37.5 ft bgs and consisted predominantly of brown to yellow to gray silty sandstone. Unweathered Chatsworth formation consisted typically of light gray silty sandstone. Weathered and unweathered Chatsworth formation occasionally was fractured with oxidized fracture planes and surrounding rock matrix. NSGW monitoring wells were constructed at each location. Piezometer construction logs and boring logs are presented in Appendix E.

5.3.2.3 Local Hydrogeology

The occurrence of NSGW at this site is ephemeral. It has been common for some wells to not have water, especially during dry seasons. During the drilling and installation of PZ-146, PZ-147, and PZ-148, dry conditions were encountered at PZ-146 and PZ-148. Figure 5.3.2-2 shows long-term hydrographs of the NSGW monitoring wells at this site.

Figure 5.3.2-3 shows the configuration of the water table as measured in April 2008. The depth to the first-occurring water ranged from approximately 10 ft bgs to 33 ft bgs at upslope location PZ-125. NSGW flow is toward the northeast following the long axis of the valley that leads away from the Building 515 STP. A horizontal groundwater gradient of 0.015 feet per foot (ft/ft) was measured.

Figure 5.3.2-4 shows the water table in cross section, as measured in April 2008, from the southwest to northeast (along the axis of the valley) and from the northwest to southeast (perpendicular to the valley's long axis). A thickening wedge of saturated weathered Chatsworth formation deposits extends toward the northeast away from the STP. The saturated weathered Chatsworth formation deposits thin toward the southwest and the southeast up against a rising unweathered bedrock surface.

A similar situation also is postulated to the northwest where the Chatsworth formation bedrock crops out at the surface. Concurrent water level measurements collected from the Chatsworth formation monitoring wells WS-SP and RD-09, compared with water levels observed in piezometers and NSGW monitoring wells (Figure 5.3.2-4), indicate that the NSGW probably is in communication with the Chatsworth formation groundwater. The

vertical gradients range from 0.0008 ft/ft upward (RD-09/PZ-001) to 0.017 ft/ft downward (ES-19/RD-09).

5.3.2.4 Characterization Results

Data collected from the monitoring wells and piezometers installed between 1985 and 2003 are used to provide the latest available interpretation of the NSGW conditions. Historic sampling events have been intermittent through time and have included various NSGW monitoring wells and piezometers.

New piezometers have been installed and sampled to refine the understanding of the nature and extent of contamination. Additionally, previously installed wells and piezometers were resampled as part of this RFI for confirmation of the previous results and to provide the most up-to-date data for interpreting the nature and extent of contamination. The sampling results for the newly installed piezometers and concurrent sampling of the previously installed wells and piezometers are pending and will be included in an addendum to this RFI report. The locations sampled and the dates on which sampling occurred are provided in Section 5.4.

The historic NSGW characterization results for this area are presented by five major chemical groups (Appendix E):

- VOCs
- SVOCs
- Dioxins
- Metals (total and dissolved)
- Perchlorate

5.3.2.5 Volatile Organic Compounds

Characterizing VOCs in groundwater has been the focus of investigations in the Group 2 RFI study area because of historic practices principally using TCE. Groundwater samples have been collected intermittently at the STP beginning in 1985 and extending into 2008.

Near-surface Groundwater. VOCs in NSGW are characterized by the analysis of samples from 16 monitoring wells and piezometers. The most current data reported were collected in August 2007. The recently installed NSGW monitoring wells PZ-145, PZ-146, PZ-147, and PZ-148 were sampled on July 16, 2008. No samples were collected from PZ-146 and 148, however, because the wells were dry. Data from the newly installed wells were not available for inclusion in this report.

Appendix E summarizes the VOCs detected in NSGW at the STP. The most frequently detected VOCs are halogenated ethenes consisting of TCE, cis-1,2-DCE, and trans-1,2-DCE. Screening levels for these compounds have been exceeded. Other VOCs detected include halogenated ethanes, halogenated methanes, and several non-halogenated VOCs. Except for detections of methylene chloride and toluene, none of the other VOCs that excluded the halogenated ethenes have been corroborated in subsequent sampling events.

Lateral and Vertical Distribution of Halogenated Ethenes. Figure 5.3.2-5 shows the areal distribution and concentrations of cis-1,2-DCE, trans-1,2-DCE, TCE, and VC based on the most recent analytical data. In some cases, the most recent analytical data date back to

March 1992. Figure 5.3.2-6 illustrates the configuration of the top of unweathered bedrock surface, or CFOU. This trough-like depression developed along the bedrock surface corresponds to the surface water drainage and probably is related to a geologic discontinuity resulting from a high density of fractures. The preferential pathway formed by this subsurface feature trends to the northeast and corresponds to VOC distribution and groundwater flow.

The vertical distributions of TCE, cis-1,2-DCE, and trans-1,2-DCE are shown in a cross section in Figure 5.3.2-7. Figure 5.3.2-8 shows the concentrations of TCE, cis-1,2-DCE, and trans-1,2-DCE over time in NSGW. Time-trend charts of TCE, cis-1,2-DCE, trans-1,2-DCE, and VC are presented for each non-ported NSGW monitoring well or piezometer in Figure 5.3.2-9. Time-trend charts of TCE and cis-1,2-DCE for multi-ported piezometers are presented in Figure 5.3.2-10. Trans-1,2-DCE and VC are not included in the vertical profiles because they typically were not detected. Letter designations associated with these concentrations indicate monitoring port assignments.

Halogenated ethenes detected in NSGW extend the length of the monitoring well network from PZ-125 downgradient to PZ-021. The highest concentrations generally were detected in groundwater samples in the southwestern section of the monitoring well network toward the STP. Lower concentrations of halogenated ethenes were detected in samples from groundwater wells located perpendicular to the axis of the ravine toward the northwest. No halogenated ethenes were detected in samples PZ-009 and ES-18, thus defining the lateral extent to the southeast.

Halogenated ethanes detected at the STP include 1,1-dichloroethane, trichloro-fluoromethane, and methylene chloride. Only methylene chloride has been corroborated in subsequent sampling and has been reported only in groundwater samples from PZ-009 (ports E and F).

Halogenated methanes have been detected at the former Incinerator Ash Pile and STP site; however, only chloroform has been detected more than once in more than 200 analyses. Chloroform, however, has not been corroborated in the more recent sampling events in groundwater samples in which it was detected.

Non-halogenated VOCs have been detected in this area; however, only toluene has been corroborated in subsequent sampling. The most recent reported concentrations of toluene range from 1 J µg/L to 87 µg/L. Isopropanol was detected in a sample collected from ES-18 in November 1986 at 7,300 µg/L and at ES-19 at 130 µg/L.

1,4-Dioxane has been detected at concentrations ranging from 0.87 µg/L to 2.2 µg/L. The screening level of 6.11 µg/L has not been exceeded. 1,4-Dioxane has been analyzed in groundwater samples from ES-21, ES-22, PZ-001, PZ-009, PZ-010, PZ-125, and RS-21. 1,4-Dioxane also has been analyzed in groundwater from RD-09. Detections have occurred in samples from PZ-009, PZ-125, and RD-09 only. The screening criteria were not exceeded.

VOCs in Chatsworth Formation Groundwater. VOCs have affected the Chatsworth formation groundwater at this area. Although an input location (or locations) of VOCs into groundwater at the Building 515 STP is unknown, a groundwater VOC plume has been identified extending approximately 1,200 ft from the Building 515 STP toward the ELV area

and approaching the north fault. A brief overview of the most frequently detected VOCs is provided to relate the NSGW impacts with those in the Chatsworth formation groundwater.

Halogenated ethenes have been detected in the Chatsworth formation groundwater samples at the Building 515 STP. TCE, cis-1,2-DCE, and trans-1,2-DCE are the most commonly detected halogenated VOCs. The co-occurrence of these compounds in the Chatsworth formation groundwater with the overlying NSGW at the STP, along with hydrogeologic data, indicates that the two waters are in communication with each other.

Time-trend charts of the halogenated ethenes TCE, cis-1,2-DCE, trans-1,2-DCE, and VC in samples from RD-09 and WS-SP are provided in Figure 5.3.2-11. The concentration trends of TCE, cis-1,2-DCE, trans-1,2-DCE, and VC in the Chatsworth Formation groundwater are illustrated in Figure 5.3.2-12.

5.3.2.6 Semivolatile Organic Compounds

Near-surface Groundwater. The SVOC analyses at the former Incinerator Ash Pile and STP site are summarized in Appendix E. No SVOCs have been detected in NSGW samples in this area. N-nitrosodimethylamine, a product of waste material or wastewater containing unsymmetrical dimethyl hydrazine (a propellant), has been analyzed in samples collected from ES-21, ES-22, PZ-009 (ports A and B), PZ-019, PZ-020, and PZ-021. N-nitrosodimethylamine was not detected in any of the samples.

5.3.2.7 Dioxins/Furans

Appendix E details the dioxins/furans analyses at the site. Dioxins were analyzed for in groundwater samples from PZ-009 in July 2005 and in PZ-020 in August 2008. No dioxins were detected in samples from PZ-009. Three dioxins were detected in PZ-020 and include 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin (2.21 $x10^{-6}$J µg/L), 2,3,7,8-TCDD TEQ (6.63 x 10^{-10}J µg/L), and octachlorodibenzo-p-dioxin (2.21 x 10^{-6}J µg/L. No comparison criteria have been established for the dioxins that have been detected.

5.3.2.8 Metals

Near-surface Groundwater. Analyses for the dissolved metals in NSGW are characterized by the analysis of samples from five monitoring wells, including ES-19, ES-21, PZ-020, RS-21, and RS-22. Appendix E summarizes the metals (dissolved) analyses at the site. The dissolved concentrations have not exceeded the screening criteria.

The total metals in NSGW are characterized by the analysis of samples from five monitoring wells, including ES-21, PZ-009 (sampling ports E and F), PZ-020, RS-21, and RS-22. The metals (total) analyses at the site are detailed in Appendix E. The screening criterion for lead (total) was exceeded in ES-21 in a sample collected in May 2007, but not in a subsequent sampling event in August 2007. The screening criteria also were exceeded for aluminum, arsenic, iron, lead, manganese, potassium, and vanadium in a sample collected from PZ-009 (sampling port E) in June 2003. No analyses of these samples for dissolved concentrations were available. No subsequent sampling has been conducted.

The background concentration for sodium was exceeded at PZ-009 (sampling ports E and F) in a sample collected in June 2003.

5.3.2.9 Perchlorate

The characterization of perchlorate in NSGW is characterized by the analysis of eight samples from seven monitoring wells. Perchlorate was sampled in wells ES-18, ES-19, ES-20, ES-21, ES-22, RS-21, and RS-22 between June 1998 and August 1999. Appendix E summarizes the perchlorate analyses at the site. Perchlorate was not detected in any of the groundwater samples at levels above the laboratory RL of 4 µg/L.

5.3.3 Surface Water Findings

Surface water features at the Former Area II Incinerator Ash Pile AOC–Building 515 STP consist of an ephemeral drainage channel that leads to the northeast from the STP. Flow in this channel is brief and intermittent and depends the on surface water runoff. Flow in this channel ultimately is directed northward and exits the operational boundary of the SSFL through an NPDES-monitored discharge point.

No surface water samples were collected during this RFI investigation because of the seasonally dry conditions.

5.3.4 Completeness of Characterization

Areas of known exceedances in the vicinity of this area were further investigated using soil and soil vapor samples. The predominantly detected contaminants at this site are dioxins and metals. It is possible that the leach field may have received metals contaminants (silver) from the Building 2202 photographic laboratory sump and clarifier. The dioxins detected in the leach field area may be attributable to the burning of paper and other nonhazardous wastes at the Ash Pile.

5.3.4.1 Near-surface Groundwater Characterization

Data from the recently installed NSGW monitoring wells (PZ-145 through PZ-148) will aid in defining the lateral extent of halogenated ethenes. A data gap still exists along the axis of the surface water divide. Access and traffic issues prevented the piezometer installation in this area during the initial Group 2 RFI characterization effort. Depending on the analytical results from PZ-145, an additional piezometer may be needed to delineate the lateral extent of the VOC distribution to the northeast.

5.4 Former Area II Incinerator Ash Pile, SWMU 5.6, and Building 515 STP Nature and Extent

Surface soil, subsurface soil, and soil gas samples were collected at this area, per the protocol described in Section 5.2 and the data provided in Appendix E. Figure 5.4-1 shows the historical sample locations and the most recent soil samples collected as part of this RFI investigation. Table 5.4-1 lists the parameters analyzed in the sample media at the former Incinerator Ash Pile and STP. The nature and extent of contamination that exceeded the comparison criteria values in the media sampled are described below.

5.4.1 Surface Soil Nature and Extent

A total of 90 surface soil samples were collected at this site and analyzed for one or more of the following: dioxins, hydrazines, TAL metals, PCBs (aroclors and congeners), SVOCs, TPHs, and VOCs. Five of these sample locations also were sampled for hexavalent chromium. Table 5.4-2 lists the parameters detected in the surface soil samples at the Former Incinerator Ash Pile and STP site.

5.4.1.1 Parameters Exceeding Criteria

The nature and horizontal extents of parameters encountered at concentrations exceeding their respective comparison criteria are detailed below.

Hydrazines. Although compounds containing hydrazine were used at the USEFF in the late 1960s, no hydrazines were detected in the 11 surface soil samples analyzed at concentrations that exceeded the applicable screening criteria.

Dioxins. A total of 31 surface soil samples were analyzed for dioxins at this site, including both CDDs and CDFs. Dioxins were detected in29 of the surface soil samples collected. The current approach to assessing the toxicity of these mixtures is to use information regarding the toxic potency of the different congeners to convert the congener concentrations to a toxicologically equivalent concentration of the most potent congener, 2,3,7,8-TCDD. The 2,3,7,8-TCDD TEQs were reported by the laboratory for the surface soil dioxin samples. The samples were evaluated for nature and extent by comparing the frequency of the different CDDs and the CDFs that exceeded the screening criteria at each location. The CDD and CDF exceedances were added together according to the chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-), and the 2,3,7,8-TCDD TEQ values were compared to the ecological screening criteria (0.0043 µg/kg) and the more conservative human health screening criteria (0.0013 µg/kg). These data are summarized in Table 5.4-3.

Eighteen of the sample locations had reported 2,3,7,8-TCDD TEQ values at levels exceeding the human health screening criterion (0.0013 µg/kg), eight of which also exceeded the ecological screening criterion (0.0043 µg/kg). These eight samples, which represent the highest concentrations, are located within or near the site boundary. Figure 5.4-2 shows the extent of the 2,3,7,8-TCDD TEQs in surface soil at the former Incineration Ash Pile and STP site. Dioxin exceedances are bound to the north and east through additional sampling, and to the west by an increase in surface elevation. Additional sampling to the south may be required to complete the horizontal evaluation of dioxins at this site. The vertical extent of these parameters is addressed in Section 5.4.2.

Metals. Metals were detected in 60 of the 66 surface soil samples collected and analyzed for metals, exceeding both the human health and ecological screening risk criteria at 44 of the sample locations. Of the metals detected in the surface soil at the former Incineration Ash Pile and STP site, 11 metals were reported at concentrations exceeding 1 or more of the criteria. Samples in the immediate vicinity of the former Incinerator Ash Pile and STP site had reported concentrations of barium, cadmium, copper, lead, silver, and zinc at levels exceeding the human health and ecological screening criteria. The metals exceedances are described below.

Only 1 exceedance each was reported for antimony, chromium, copper, mercury, and nickel. Chromium, mercury, and nickel each exceeded at sample location APBS0058. Chromium and mercury each exceeded their only respective ecological screening criteria at 270 mg/kg and 0.097 mg/kg, respectively. Nickel exceeded both the human health and ecological screening criteria at an estimated 180 J mg/kg. Antimony and copper each exceeded both the human health and ecological screening criteria at location C-2-03, at reported concentrations of 9 mg/kg and 53 mg/kg, respectively. All of these exceedances are located within the former Incinerator Ash Pile boundary.

Boron exceeded the screening criteria at four locations within the former Incineration Ash Pile boundary. Concentrations in these samples ranged from 12 mg/kg at APBS0047 to 17 mg/kg at APBS0058, compared to a background value of 9.7 mg/kg, and were bound either by samples with non-exceedances or by geographic boundaries. All of the exceedance samples were reported at concentrations greater than both the human health and ecological screening criteria.

Barium and cadmium exceeded their respective screening criteria at 6 and 11 locations, respectively. Cadmium concentrations in the 6 exceedance samples ranged from 1.1 mg/kg (APBS0058) to 4.9 mg/kg (C-2-03), compared to a background value of 1 mg/kg. All of these samples are located within the site boundary, as shown in Figure 5.4-3. Barium exceedance concentrations ranged from 150 mg/kg (APSS02) to 5,200 mg/kg (C-2-03), compared to a background value of 140 mg/kg. Although some of these samples are located outside the site boundary, downstream along the intermittent stream, additional samples collected further downstream did not exceed the screening criteria. Figure 5.4-3 shows the extent of barium and cadmium in surface soils at the former Incineration Ash Pile and STP site.

Lead exceeded the screening criteria at 6 sample locations. Concentrations of these samples ranged from 35 mg/kg at APSS01 to 3,000 mg/kg at C-2-01, compared to a background value of 34 mg/kg. Each of these samples exceeded both the human health and ecological screening values. All of these samples are located within the site boundary, as shown in Figure 5.4-4, which shows the extent of lead in surface soils at the site.

Silver exceeded its screening criteria at 39 locations, with concentrations ranging from 0.81 mg/kg at APBS0051 to 180 mg/kg at C-2-01, compared to a background value of 0.79 mg/kg. All of these samples exceeded both the human health and ecological screening criteria. This area is near a photographic laboratory and the elevated silver concentrations may be associated with those operations. Zinc exceeded its screening criteria at 7 locations, with exceedances ranging from an estimated 120 J mg/kg at APBS0045 to 3,000 mg/kg at C-2-01, compared to a background value of 110 mg/kg. Although some of these samples are located outside the site boundary to the northeast (downgradient), additional samples collected further downstream did not have exceedances of the screening criteria. Figure 5.4-5 shows the extents of silver and zinc in surface soils at the site.

Surface soil contamination is expected to migrate downgradient (northeast) only because the former Incineration Ash Pile and STP site is located at the head of the intermittent stream valley, which is bounded by higher elevations, except to the northeast. Silver was reported furthest downgradient at concentrations exceeding 1 or more of the screening criteria; however, 2 samples, APBS0053 and APBS0056, which did not exceed the screening

criteria for any metals, bound the samples downstream. The horizontal extent of metals in the surface soil at the former Incineration Ash Pile and STP site has been evaluated sufficiently. The vertical extent of these parameters is addressed in Section 5.4.2.

PCB Aroclors/Congeners. PCB aroclors were analyzed at 13 locations in the surface soil at the former Incineration Ash Pile and STP site. One PCB aroclor, Aroclor-1254, was reported at 1 location at a concentration exceeding the comparison criteria in the surface soil at the site. At APBS0058, Aroclor-1254 was reported at 100 µg/kg, compared to the human health screening criterion of 70 µg/kg.

PCB congeners were analyzed for at six locations in the surface soil surrounding a transformer in the vicinity of the former Incinerator Ash Pile. Of the nine PCB congeners detected in the surface soil at the former Incinerator Ash Pile, PCB-126 exceeded the screening criterion at one location, APBS1010. PCB-126 was reported at 0.015 µg/kg at this location. This concentration is slightly higher than the human health comparison criterion of 0.014 µg/kg and is indicative of a potential isolated release that may have occurred at the site. The concentration, however, is not sufficiently elevated to indicate a continual operational release of PCB-containing oils. Because this sample point is not bounded to the north by any other sample locations that were sampled for PCB congeners, additional characterization is warranted. The vertical extent of these parameters is addressed in Section 5.4.2.

SVOCs. SVOCs were analyzed at 29 locations in the surface soil samples collected at the former Incineration Ash Pile and STP site. SVOCs were detected at all of the sample locations, but exceeded the ecological screening criteria only at 2 locations. BaP exceeded the screening criterion at APBS0017 (21 µg/kg) and APBS0058 (22 µg/kg), compared to the ecological screening criterion of 10 µg/kg. Of the samples collected and analyzed for SVOCs, APBS0017 is located furthest downstream along the intermittent stream (the only migration pathway from the former Ash Pile). Additional samples may be necessary to further characterize the extent of contamination in the surface soil. The vertical extents of these parameters are addressed in Section 5.4.2.

TPHs. No TPHs were reported at levels exceeding the screening criteria at any of the 21 surface soil locations sampled and analyzed for TPHs at the former Incineration Pile and STP site. This result correlates with the CSM, because no petroleum hydrocarbons were known to be used in the operational processes performed at the site. The vertical extents of these parameters are addressed in Section 5.4.2.

VOCs. No VOCs were reported at levels exceeding the screening criteria in surface soils at the former Incineration Ash Pile and STP site. This result correlates with the CSM, because all VOCs delivered to the site were supposed to be treated through the UV/H_2O_2 Treatment System. The vertical extents of these parameters are addressed in the following subsection.

5.4.2 Subsurface Soil Nature and Extent

A total of 132 subsurface samples were collected from 84 sampling stations to a maximum depth of 29.4 ft bgs at the site. The subsurface soil at the site was analyzed for 1 or more of the following: dioxins, hydrazines, TAL metals, PCB aroclors and congeners, SVOCs, TPHs, and VOCs. Two of these sample locations were analyzed for hexavalent chromium

(included in the metals discussion). Table 5.4-4 lists the parameters detected in the subsurface soil samples at the former Incinerator Ash Pile and STP site.

Hydrazines. Twelve subsurface soil samples, from 12 sampling stations, were analyzed for hydrazines. Consistent with the results from the surface soil sampling, no hydrazines were encountered at concentrations that exceeded the applicable screening criteria at this site. The nature and extent of hydrazines at the Former Incinerator Ash Pile and STP site have been assessed sufficiently.

Dioxins. As with the dioxin investigation in the surface soils, the 11 subsurface soil samples collected from 9 locations to a maximum depth of 10 ft bgs were analyzed for both CDDs and CDFs. Likewise, the approach in subsurface soils is to assess the toxicity of these mixtures by using the information regarding the toxic potency of the different congeners and converting them to 2,3,7,8-TCDD TEQs. The frequency of the different CDDs and CDFs that exceeded their respective screening criteria at each location were added according to the chlorine designation (tetra-, penta-, hexa-, hepta-, and octa-), and the 2,3,7,8-TCDD TEQ values were compared to the screening criteria, as summarized in Table 5.4-5.

The 2,3,7,8-TCDD TEQ values exceeded the human health (0.0013 µg/kg) and ecological (0.0043 µg/kg) comparison criteria at APBS0019 (4.5 to 5 ft bgs) and BTBS1008 (5 to 6 ft bgs) at a reported 0.043 µg/kg and 0.048 µg/kg, respectively. These sample locations are near other sampling intervals where dioxins were undetected at both similar and deeper sampling intervals. Table 5.4-5 summarizes the subsurface soil dioxin exceedances. The vertical extent of dioxins in subsurface soil at the site has been evaluated sufficiently. Figure 5.4-6 shows the extent of the 2,3,7,8-TCDD TEQs in subsurface soil at the former Incineration Ash Pile and STP site.

Metals. Twenty-six metals were detected in 78 of the 113 subsurface soil samples collected at the former Incineration Ash Pile and STP site and analyzed for metals. Of those, 9 parameters, including hexavalent chromium, were encountered at concentrations exceeding their respective screening criteria. The vertical extents of these metals are detailed below.

Cadmium, copper, nickel, and zinc each were encountered at elevated concentrations mostly similar to their respective background values. Three cadmium exceedances were reported, ranging from 1.1 mg/kg (BTTS02, 6.5 to 7 ft bgs) to 1.4 J mg/kg (BTBS1015, 5 to 6 ft bgs), compared to its background value of 1 mg/kg. One copper exceedance was reported at a concentration of 37.2 J mg/kg (APBS1000, 10 to 11 ft bgs), compared to its background value of 29 mg/kg, which in itself is significantly higher than its human health screening criterion of 1.09 mg/kg. Nickel was reported at a concentration of 41.1 mg/kg (APBS1000, 10 to 11 ft bgs), compared to its background value of 29 mg/kg, which is also significantly greater than its human health comparison value of 0.1 mg/kg. Zinc was detected once at a concentration of 137 mg/kg (BTTS02, 6.5 to 7 ft bgs), compared to its background value of 110 mg/kg. These detections are mostly indicative of natural occurrence. The vertical extents of cadmium, copper, nickel, and zinc have been evaluated adequately.

Hexavalent chromium was encountered at an elevated concentration of 1.06 J mg/kg (APBS1001, 3.5 to 4.5 ft bgs), exceeding its common ecological and human health screening criteria of 0.2 mg/kg. Hexavalent chromium was sampled for in three other stations at this

site, all at deeper intervals, but none of these samples had reported detections of this parameter. Because there also were no detections in the surface soil, it is likely that the vertical extent of hexavalent chromium has been evaluated adequately.

Sole exceedances of mercury and thallium were encountered, and two chromium exceedances were detected in the subsurface soil at this site. Chromium was reported at 43 mg/kg (APBS02, 4 ft bgs) and an estimated concentration of 189 J mg/kg (BTTS02, 6.5 to 7 ft bgs), each exceeding its human health criterion of 1.58 mg/kg. Mercury was encountered at 0.18 mg/kg (BTTS02, 6.5 to 7 ft bgs), exceeding its ecological (0.10 mg/kg) and human health (0.09 mg/kg) comparison criteria. Thallium was encountered at 3.9 mg/kg (BTTS08, 6.5 to 7 ft bgs), exceeding its ecological comparison criterion of 2.9 mg/kg. The chromium and mercury exceedances were detected in the deepest interval sampled at stations reporting these concentrations. However, there are several stations close to both APBS02 and BTTS02 that did not have reported exceedances of these parameters in a similar sampling interval. Coupled with the infrequency of exceedances of these parameters, the exceedances appear to be localized to these specific sampling stations. Station BTTS08 also was sampled in the 10- to 10.5-foot-bgs interval; however, it did not have a reported exceedance of thallium. The vertical extents of chromium, mercury, and thallium have been evaluated adequately.

Sodium exceedances were encountered in 3 of 5 subsurface soil samples analyzed. Elevated concentrations ranged from an estimated 136 J mg/kg (BTTS10, 7.5 to 8 ft bgs) to an estimated 251 J mg/kg (BTTS08, 6.5 to 7 ft bgs), compared to its common background and human health value of 110 mg/kg. All 5 of the samples analyzed for sodium had reported detections. Two of the 3 exceedances were detected at concentrations suggestive of natural occurrence. The vertical extent of sodium in subsurface soil at the Former Incinerator Ash Pile and STP site is shown in Figure 5.4-7.

Forty-seven of the 54 subsurface soil samples analyzed for silver had reported detections, 25 of which had reported concentrations in excess of its human health (0.53 mg/kg) and ecological (0.54 mg/kg) comparison criteria. Elevated concentrations of silver ranged from 1 mg/kg (BTTS17, 7.5 to 8 ft bgs) to an estimated 350 J mg/kg (BTTS02, 6.5 to 7 ft bgs). Most of the samples with reported silver exceedances are localized to the former leach field area and probably are attributable to the Building 2202 photographic laboratory sump and clarifier discharging to the leach field. Five of the subsurface soil exceedances were bound vertically through additional sampling at deeper intervals, including exceedances reported at BTTS08, BTTS10, BTTS11, BTTS14, and BTTS15. Additionally, the deepest sample intervals analyzed for silver, located within the leach field exceedances grouping, did not have elevated concentrations of the parameter reported. Although vertical boundaries, through additional sampling, were not established for each individual subsurface soil exceedance, it may be inferred that the vertical extent of silver has been evaluated adequately at this site. The vertical extent of silver in the subsurface soil is illustrated in Figure 5.4-8.

Antimony, barium, boron, and lead were not detected at elevated concentrations in the subsurface soil at this site; the vertical extents of these parameters have been assessed sufficiently. The vertical extent of metals in subsurface soil at the former Incineration Ash Pile and STP site has been evaluated sufficiently.

PCBs Aroclors/Congeners. No PCB aroclors or PCB congeners were detected in the subsurface soil at concentrations exceeding the comparison criteria. This result is expected, because PCB aroclors and congeners did not exceed the comparison criteria at many locations in the surface soil at the site.

SVOCs. No SVOCs were detected in the subsurface soil at levels exceeding the comparison criteria at the site. This result is probable because only one SVOC was reported in surface soils at concentrations exceeding the screening criteria.

TPHs. No TPHs were reported at levels exceeding the screening criteria in the subsurface soils at the site. This result correlates with the CSM, because no petroleum hydrocarbons were known to be used in the operational processes performed at the site.

VOCs. No VOCs were reported at levels exceeding the screening criteria in subsurface soils at the former Incineration Ash Pile and STP site. This result correlates with the CSM, because all VOCs delivered to the site were supposed to be treated through the UV/H_2O_2 Treatment System.

5.4.3 Soil Gas Nature and Extent

Sixty-one soil gas samples were collected at the Former Incineration Ash Pile and STP site from 31 locations to a maximum depth of 30 ft bgs. Three VOCs–cis-1,2-DCE, PCE, and TCE–were detected in the samples at levels exceeding the screening criteria. Table 5.4-6 lists the parameters detected in the soil gas samples collected in this area. The extent of VOCs encountered via soil gas sampling at this site is detailed below.

Seven exceedances of cis-1,2-DCE were reported at the Former Incinerator Ash Pile and STP site. The exceedance concentrations of cis-1,2-DCE ranged from 3,700 µg/m^3 at APSV0002 (10 ft bgs) to 39,000 µg/m^3 at APSV0006 (30 ft bgs), compared to the ecological screening criteria of 1,900 µg/m^3 and human health comparison criterion of 15,900 µg/m^3 (1 sample). Figure 5.4-9 shows the extent of cis-1,2-DCE in the soil gas at the former Incineration Ash Pile and STP site.

Two exceedances of PCE were reported at this site, at concentrations of 2,100 µg/m^3 (BTSV08, 4 ft bgs) and 41,000 µg/m^3 (BTSV09, 5 ft bgs), each exceeding its human health criterion (180 µg/m^3); the latter concentration also exceeded its ecological comparison criterion (24,000 µg/m^3). Each exceedance is bound horizontally through additional sampling that had non-exceeding or non-detectable concentrations of PCE reported. Station BTSV08 was sampled for soil gas in the 10-foot-bgs interval, thus providing a vertical extent. Although station BTSV09 was not sampled at deeper intervals, the subsurface soil gas samples collected from nearby BTSV08, BTSV10, BTSV0012, and BTSV0013 may provide an implied vertical boundary. The extent of PCE as soil vapors at this site has been addressed sufficiently, as shown in Figure 5.4-10.

Twenty soil gas samples exhibited elevated concentrations of TCE, ranging from 1,000 µg/m^3 at APSV0005 (20 ft bgs) to 272,000 µg/m^3 at BTSV11 (0 to 2 ft bgs), compared to the ecological screening criterion of 6,400 µg/m^3 and the human health screening criterion of 528 µg/m^3. Figure 5.4-11 shows the extent of TCE in soil gas at the former Incineration Ash Pile and STP site.

Soil gas concentrations for both analytes generally increased with depth. The soil gas concentrations probably are caused by groundwater contamination of both cis-1,2-DCE and TCE, which correlates to the increased concentrations at depth, which decrease as the gas travels upward through the subsurface. The soil gas detections at the Former Incinerator Ash Pile and STP site are listed in Table 5.4-6.

5.5 Conceptual Site Exposure Model

A generalized CSM for the human health exposure pathways is presented in Section 1.5.3.3. Given the potential future land use, the following receptors will be addressed in the former Area II Ash Pile and Building 515 STP HHRA:

- Future onsite adult industrial workers potentially exposed to chemicals in soil, indoor air, outdoor air, and seeps and springs (where applicable).
- Hypothetical future onsite adult and child recreationists potentially exposed to chemicals in soil, outdoor air, and seeps and springs (where applicable).
- Hypothetical future onsite adult and child residents potentially exposed to chemicals in soil, indoor air, outdoor air, home-grown produce, groundwater (where applicable), and seeps and springs (where applicable).

In addition, in accordance with California Senate Bill 990, a hypothetical future subsistence agricultural exposure scenario includes assessing the risks associated with the potential consumption of beef, eggs, milk, swine, fruits, and vegetables. However, pending final agreement of the input assumptions considered in the scenario, the assessment of the subsistence agricultural exposure scenario will be included in a supplemental risk assessment report separate from this RFI Report.

Any deviations from this generalized CSM for the former Area II Ash Pile and the Building 515 STP are presented in Section 5.7.2.

5.6 Fate and Transport Analysis for Chemicals Detected in Groundwater and Surficial Media

The samples from the STP to date indicate that halogenated ethenes (TCE, cis-1,2-DCE, and trans-1,2-DCE) are present in the NSGW and soil that make up the SMOU. Contamination at the Building 515 STP is the result of past releases of wastes containing TCE and other solvents being piped to a pond from four test cells that operated on the southern side of Building 206, with the TCE and other solvents being the primary COPCs in the soil and groundwater beneath the Building 515 STP SWMU SA.

The NSGW in the SMOU at the Building 515 STP SWMU is connected hydraulically to the CFOU. Field monitoring data from both the MOU and CFOU suggest that TCE is undergoing a reduction to cis-1, 2-DCE and that additional attenuation is occurring. However, VC and ethane have not been detected in significant amounts, so that if transformation is occurring, a process other than reductive dechlorination must be responsible.

Degradation of chlorinated ethenes occurring in groundwater at SSFL has been verified in rock core analysis (Waterloo, 2007) and bench-scale studies have shown that both biotic and abiotic processes are taking place (Darlington, et al, 2008). Additional study of the degradation processes will be performed as a part of an interim actions evaluation and the CMS that will follow the sitewide CFOU RFI.

5.6.1 Contaminant Sources and Release Mechanisms

The primary release mechanism for contamination at the former Incinerator Ash Pile and STP area is attributed to the incinerated nonhazardous wastes (primarily trash, photographs, and paper) that were stored in this area, historic releases to the leach field from the STP, and potential leaks and spills from the STP and USEFF operations.

The primary release mechanism for contamination at the STP is attributed to historic releases to the leach field and potential leaks and spills from the STP and USEFF operations. A second primary release mechanism is releases from the adjacent Ash Pile Incinerator operations.

5.6.2 Potential Routes of Migration

The primary pathway for contaminant transport from the SAs at this site is the vertical migration of contaminants from the surface soil to subsurface soil. A secondary transport mechanism for this site includes the release of surface soil to the air by wind erosion or volatilization.

The primary pathway for contaminant transport from the source areas at the STP is the vertical migration of contaminants into subsurface soils. A secondary transport mechanism for this site includes the release of surface soil to the air by wind erosion or volatilization.

5.6.3 Contaminant Persistence

Dioxins, inorganics, PCBs, and SVOCs were detected in the soil at the Incinerator Ash Pile and STP site at levels above their screening criteria. Additionally, VOCs were detected in the soil gas at concentrations above their screening criteria. This subsection describes the chemicals applicable to this area.

Dioxins and inorganics were detected in the soil at the STP at levels above their screening criteria. VOCs were detected in the soil gas at concentrations above their screening criteria in the STP area.

5.6.3.1 Parameters Exceeding Criteria

Dioxins, inorganics, SVOCs, and PCBs are detailed below.

Dioxins. Dioxins are characterized by extremely low vapor pressures, high log K_{ow}, high K_{oc}, and extremely low water solubilities. Their strong adsorption to soil, low water solubilities, and high K_{oc} values indicate that the rate of transport from unsaturated zone soils to the water table via rain infiltration would be extremely low.

Dioxins were detected at levels above the screening criteria in the surface and subsurface. Because dioxins have low vapor pressure, they are not very volatile and tend to stay bound to particles. Dioxins also have low solubility; thus, any aerially deposited dioxins tend to

stay adsorbed to soils in the top few millimeters in surface soil. The presence of elevated dioxin concentrations in the subsurface may be related to construction activities disturbing the soils, because dioxins are not likely to mobilize through the soil

Inorganics. Several metals were detected at this site at levels above the screening criteria. Several metals were detected at the STP at levels above the screening criteria in the subsurface soil. Many metals are naturally occurring and their reported presence may or may not indicate a contaminant release. The mobility of metals is complex and depends on several factors such as the overall groundwater composition, pH, metal complex formation, valence state of the metal, and cation-ion exchange capacity. Metals typically are not volatile. In the water phase, the total metal concentration includes the dissolved metal concentration and the suspended metal concentration, which is sorbed to colloidal particles. Therefore, elevated metals concentrations in groundwater may be due to the suspended load and not just to the dissolved aqueous chemistry.

VOCs. VOCs are characterized by relatively high vapor pressures, Henry's Law constants, and generally high solubility in water. VOCs have a tendency to partition to the vapor phase from either soil or surface water and could be released through volatilization from contaminated soil. The sorption potential of VOCs is variable; some may persist in soil or sediment, while some are highly mobile in soil. VOCs will leach to groundwater and may persist, depending on their ability to degrade or transform in the environment.

TCE was the most prevalent VOC in the soil gas samples collected. Although TCE does not have a high K_{oc}, it may sorb to soil, sediment, or organic matter and persist in the environment for a long time. It also may persist in groundwater. TCE does not accumulate in plants or animal tissue and undergoes biotic and abiotic degradation via natural attenuation processes.

SVOCs. PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances. HMW PAHs are more likely to be transported via particulate emissions, while LMW PAHs have a greater tendency to volatilize (ATSDR, 1995). In general, PAHs are more likely to sorb to soil or organic matter than to partition significantly to water. Photolysis and biodegradation are two common attenuation mechanisms for PAH compounds (Howard, 1991). Animals and microorganisms can metabolize PAHs to products that ultimately reach complete degradation.

PCBs. PCBs are persistent in the environment. Aroclor-1254 and Aroclor-1260 are characterized by low water solubility, moderate volatility, high affinity for organic matter, and high resistance to chemical or biological degradation. They will strongly sorb to soil and do not tend to leach to groundwater. In surface water, they will partition to sediment and sorb to organic matter. PCBs will bioaccumulate in aquatic organisms.

VOCs. VOCs are characterized by relatively high vapor pressures, Henry's Law constants, and generally high solubility in water. VOCs have a tendency to partition to the vapor phase from either soil or surface water and could be released through volatilization from contaminated soil. The sorption potential of VOCs is variable; some may persist in soil or sediment, while some are highly mobile in soil. VOCs will leach to groundwater and may persist, depending on their ability to degrade or transform in the environment.

TCE was the most prevalent VOC in the soil gas samples collected. Although TCE does not have a high K_{oc}, it may sorb to soil, sediment, or organic matter and persist in the environment for a long time. It also may persist in groundwater. TCE does not accumulate in plants or animal tissue and undergoes biotic and abiotic degradation via natural attenuation processes.

5.6.4 Contaminant Migration

The primary source for contaminant migration is from historical leaching and potential leaks and spills from the STP associated with the Incinerator Ash Pile and STP area.

The primary source for contamination at the STP is attributed to historic releases to the leach field and potential leaks and spills from the STP and USEFF operations. Source contamination exists to the west of Buildings 2515 and 2776. The dioxins are not expected to have migrated through the soil to groundwater.

5.6.5 Surface Soil Contaminants

Dioxins, metals, PCBs, and SVOCs have been identified in surface soil at levels above the background and/or health-based risk criteria. The following observations were made for contaminants in surface soil:

- Dioxins were detected in all 31 of the surface soil samples collected. Eighteen of the sample locations reported 2,3,7,8-TCDD TEQ values at levels exceeding the human-health screening criterion. Eight of those also exceeded the ecological screening criterion.
- Of the metals detected in the surface soil at the Ash Pile Area, 11 metals were reported at concentrations exceeding 1 or more of the criteria.
- Of the 13 sample locations collected for PCBs in the surface soil at the Ash Pile Area, 1 PCB (Aroclor-1254) was reported at 1 location at a concentration exceeding the comparison criterion in the surface soil at the site. At APBS0058, Aroclor-1254 was reported at 100 µg/kg, compared to the human health screening criterion of 70 µg/kg.
- Of the 61 surface soil samples analyzed for SVOCs, 3 had reported exceedances of a combined 2 SVOC parameters (BaP and BEHP) detected in surface soil.
- Of the 18 surface soil locations collected for SVOCs in the surface soil samples at the Ash Pile Area, SVOCs exceeded the ecological screening criteria at 2 locations. BaP exceeded the screening criterion at APBS0017 (21 µg/kg) and APBS0058 (22 µg/kg), compared to the ecological screening criterion of 10 µg/kg.

Only dioxins were identified in surface soil at levels exceeding the screening criteria at the STP site. The dioxins probably are attributed to the activities at the nearby Ash Pile Incinerator.

5.6.6 Subsurface Soil Migration

The following observations were made for the contaminants in subsurface soil:

- Eleven subsurface soil samples collected from 9 locations to a depth of 10 ft bgs were analyzed for both CDDs and CDFs. The 2,3,7,8-TCDD TEQ values exceeded the human health (8.7E, 4 µg/kg) and ecological (4.3E, 3 µg/kg) comparison criteria at APBS0019 (4.5 to 5 ft bgs) and BTBS1008 (5 to 6 ft bgs). These sample locations are immediately adjacent to other sampling stations where dioxins were undetected down to 9.5 to 10 ft bgs.
- Twenty-six metals were detected in the subsurface soil samples analyzed at the Incinerator Ash Pile and STP area for metals. Of these detected metals, cadmium, copper, chromium, hexavalent chromium, mercury, nickel, thallium, and zinc each exceeded their respective screening criteria at one location only (BTTS02, in the 6.5- to 7-foot-bgs sample interval).

The following observations were made for the contaminants in subsurface soil at the STP:

- Dioxins were detected at lower concentrations in the subsurface than in the surface soil samples; these detections could be the result of construction activities in the area and might not be related to migration from the surface soil.
- The metals exceedances were primarily in the leach field and probably were associated with subsurface discharges of metals-containing wastes, rather than being associated with the surface operations.
- Silver was the most prevalent metal in the subsurface soil and was detected at levels above the screening criteria in the leach pit area from a depth interval of 3 to 10 ft bgs. In sample locations that had multiple depth intervals sampled, the silver concentrations decreased with depth. Additionally, silver was not detected in the soil at depths greater than 11 ft bgs.

5.6.7 Soil-to-Groundwater Migration

Chemical effects on groundwater at the contiguous B-515 STP, Ash Pile, and RD-09 Areas generally are characterized by TCE and its daughter products in the both the CFOU and SMOU, mirroring site conditions at other SWMUs at the facility. The distribution of TCE and other VOCs typically is shown within a north-south trending footprint that extends to the ELV site. Historical monitoring and characterization results indicate that groundwater is not affected by constituents other than VOCs. Historical investigations and the current Group 2 RFI characterization effort did not detect VOCs in either surface or subsurface soils. Soil vapor results from the current and past investigations detected limited distributions of TCE and its daughter products, with the detections attributed to affected shallow groundwater.

Affected groundwater at the STP 515, Ash Pile, and RD-09 areas probably is the result of TCE released from site operations at the ELV migrating from the soil surrounding the Catchment Pond and ultimately migrating within the hydraulically connected CFOU and SMOU in the study area (Figures 4.3.2-2 and 4.3.2.5). In this scenario, affected groundwater probably is a result of the entry of immiscible-phase liquid into and below the water table at

the ELV, which then flowed into the STP 515, Ash Pile, and RD-09 Areas along upward gradients along the interconnected fracture network within the shallow Chatsworth formation into weathered bedrock present in the bedrock trough. Wells RD-09 and WS-SP historically have had TCE concentrations in the CFOU ranging from 1,000 to 10,000 µg/L. Shallow well RS-22 has exhibited TCE concentrations ranging from 1,000 to 10,000 µg/L, while other wells and piezometers monitoring the SMOU, including PZ-001, PZ-010, and ES-22, have exhibited TCE concentrations ranging from 100 to 1,000 µg/L. The proximity of the subsurface TCE accumulation beneath the ELV probably is responsible for the elevated concentrations of TCE and its daughter products in the CFOU and SMOU, as well as for the ineffectiveness of the RD-09 UV groundwater remediation system operations at mitigating the affected groundwater in both OUs.

5.7 Human Health Risk Assessment for Former Ash Pile and STP

The objective of this HHRA is to assess whether the environmental media at the Ash Pile and STP could pose risks to human health that might require remedial action, or that are eligible for an NFA designation. This HHRA assesses the potential current and future exposures to chemicals in soil, soil vapor, and groundwater at the Ash Pile and STP. The methods and guidance documents used in the preparation of this HHRA are presented in Section 1.5.3 of this report. The HHRA results for the Ash Pile and STP are discussed below. The results are summarized in Section 5.9.2.

The concentration data, input parameters, and results of the HHRA for the Ash Pile and STP are presented in Appendix E. An index of the tables (Appendix E human health RA Tables Index) is provided that can be used to locate tables that contain information regarding the HHRA data set, EPCs, exposure parameters, toxicity factors, estimated chemical intakes, estimated ELCRs, and estimated non-cancer HIs.

5.7.1 Identification of Chemicals of Potential Concern

Chemicals were selected as COPCs at the Ash Pile and STP based on the protocol presented in Sections 1.5.3.1 and 1.5.3.2.

5.7.1.1 Data Evaluation

The soil, soil vapor, and groundwater sampling analytical data at the Ash Pile and STP were evaluated to determine their suitability for use in the risk assessment following the procedures presented in Section 1.5.3.1. Sediment and surface water data were not collected as part of the RFI site characterization activities. The locations of the soil, soil vapor, and groundwater samples used in this HHRA are shown in Figure 5.4-1. The samples used in this HHRA are listed in Table E.7.1-1 by medium, sample ID, sampling depth interval, and date of collection. Table E.7.1-2 provides the target receptor populations by medium. Descriptive summary statistics of this data are provided in Table E.7.1-3.

5.7.1.2 Identification of COPCs in Soil

The results of the COPC screening process for soil at 0 to 2 ft bgs and 0 to 10 ft bgs are listed in Table E.7.1-3. Detected analytes in soil at the Ash Pile and STP were compared to

background levels. COPCs identified in soil (0 to 2 ft bgs) included 2 inorganics (barium and silver) and 26 organics. COPCs identified in subsurface soil (0 to 10 ft bgs) included 1 inorganic (barium) and 31 organics.

5.7.1.3 Identification of COPCs in Groundwater

The results of the COPC screening process for groundwater are listed in Table E.7.1-3. Detected analytes in groundwater at the Ash Pile and STP were screened using groundwater comparison concentrations. The COPCs identified in groundwater included 18 inorganics and 10 organics.

5.7.1.4 Identification of COPCs in Soil Vapor

The results of the COPC screening process for soil vapor at 3 to 10 ft bgs are listed in Table E.7.1-3. The COPCs identified in soil vapor included TCE, isopropanol, PCE, VC, cis-1,2-DCE, and trans-1,2-DCE.

5.7.2 Exposure Assessment

The exposure assessment component of the HHRA identifies the means by which individuals at or near the Ash Pile and STP may come into contact with constituents in exposure media. It addresses current exposures and those that may result in the future under reasonably anticipated potential uses of the site and the surrounding areas. The exposure assessment also identifies the populations that may be exposed; the routes by which individuals may become exposed; and the magnitude, frequency, and duration of potential exposures. Figure 1.5.3-1 depicts the conceptual exposure model for the Ash Pile and STP. The exposure scenarios are summarized in Table E.7.1-2. The methods and assumptions used in the exposure assessment are discussed in Section 1.5.3.3.

5.7.2.1 Identification of Receptors

The Ash Pile and STP area formerly was used for industrial purposes and is most likely to have a future industrial or recreational land use; however, a hypothetical future residential scenario also was included in the exposure assessment. Future residents are expected to have the greatest level of exposure. Therefore, the hypothetical future residential scenario, assuming adult and child receptors, was the most conservative scenario in the HHRA. In addition to the residential scenario, the industrial worker and recreationist exposure scenarios were evaluated.

As stated in Section 1.5.3.3, an agricultural-based residential exposure scenario will be evaluated to meet the requirements of Senate Bill 990.

5.7.2.2 Identification of Exposure Pathways

Future residents and industrial workers were assumed to be exposed to groundwater, soil vapor (modeled for migration to indoor air and ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Future recreationists were assumed to be exposed to groundwater, soil vapor (modeled for migration to ambient air), and soil at two depth intervals (0 to 2 ft bgs and 0 to 10 ft bgs). Exposure pathways for groundwater and soil included direct exposures (ingestion and dermal) and indirect exposures. Inhalation exposures were quantified for the migration of groundwater and soil vapor to ambient air

and indoor air. Additionally, exposures were quantified for residential receptors for the inhalation of VOCs in bathroom air while showering or bathing for groundwater. Residential receptors also were assumed to ingest edible plants and home-grown produce. The exposure assumptions included in the HHRA for the Ash Pile and STP are provided in Table E.7.1-6.

5.7.2.3 Exposure Point Concentrations

EPCs for surface soil at 0 to 2 ft bgs, subsurface soil at 0 to 10 ft bgs, soil vapor, and groundwater at the Ash Pile and STP are listed in Table E.7.1-3. EPCs were estimated for indirect exposures for the following media: airborne fugitive dusts, ambient air, indoor air, and edible plants (home-grown consumption). Airborne particulate COPC concentrations were estimated for non-volatile COPCs. The derivation of the PEF for soil is detailed in Table E.7.1-7.

Ambient air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs to ambient air and migration from groundwater to ambient air. Parameter values used for soil vapor-to-air migration and for estimating the ambient air EPCs related to soils are listed in Table E.7.1-9. The parameter values used for estimating the ambient air EPCs related to groundwater also are listed in Table E.7.1-9. The estimated ambient air concentrations from the migration of volatile COPCs in soil and groundwater are provided in Tables E.7.1-10, E.7.1-11, and E.7.1-12, respectively.

Indoor air COPC concentrations were estimated for volatile COPCs by modeling migration from soil vapor at 0 to 10 ft bgs and from NSGW using the J-E Model (EPA, 2004). The parameter values used in the J-E Model (EPA, 2004) are listed in Table E.7.1-9. Soil vapor data, where available, preferentially were used for indoor air modeling. The estimation of indoor air concentrations from soil vapor and groundwater migration is detailed in Tables E.7.1-13 through E.7.1-18.

The derivation of edible plant concentrations is calculated using soil-to-plant uptake factors, as described in the SRAM (MWH, 2005b). COPC concentrations in edible plant tissues from soil at 0 to 2 ft bgs are listed in Table E.7.1-19.

5.7.2.4 Intake Estimates

EPCs were applied to human intake equations, as presented in the SRAM (MWH, 2005b), to calculate the chemical intakes for potential adult and child residential, adult and child recreationist, and industrial worker receptors at the Ash Pile and STP. The chemical-specific intakes were estimated based on an RME scenario and a CTE scenario. The exposure assumptions and the chemical intakes for soil are presented in Appendix E. The Appendix E human health RA Tables Index provides for the exposure parameters and chemical intakes for each exposure scenario.

5.7.3 Risk Characterization

In the risk characterization component of the HHRA process, quantification of risk is accomplished by combining the results of the exposure assessment (estimated chemical intakes) with the results of the dose-response assessment (toxicity values identified in the toxicity assessment [Section 1.5.3.4]) to provide numerical estimates of potential health risks.

The quantification approach differs for potential noncancer and cancer effects. The methods used in the risk characterization are discussed in Section 1.5.3.5.

The exposure assumptions, EPCs, toxicity factors, and risk characterization result tables for this HHRA are presented in Appendix E (Appendix E human health RA Tables Index). The risk calculation tables present the estimated ELCRs and noncancer HIs for potentially exposed receptors and individual exposure routes for soil, indoor air, ambient air, and groundwater at the Ash Pile and STP, as well as the cumulative risks and HIs across all exposure routes for the RME and CTE scenarios.

5.7.3.1 Hypothetical Future Adult Residential Exposure Scenario

Potential residential adult exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. The potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of home-grown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-8} for the CTE case to 7×10^{-7} for the RME case. The RME and CTE ELCR estimates are less than the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.005 for the CTE case to 0.02 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogenic COPCs for exposure to 0- to 2-foot-bgs soil from the plant consumption exposure route ranges from 4×10^{-6} for the CTE case to 1×10^{-4} for the RME case. The RME and CTE ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. BaP and 2,3,7,8-TCDD TEQ are the main carcinogenic risk drivers for the plant consumption exposure route for the RME and CTE cases. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 0.4 for the CTE case to 4 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. Barium and 2,3,7,8-TCDD TEQ are the main risk drivers for the RME HI estimate.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-8} for the CTE case to 8×10^{-7} for the RME case. The RME and CTE ELCR estimates are less than the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects are less than the regulatory threshold value of 1 for the CTE and RME cases.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is the inhalation

of vapors that have migrated inside a future residence. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-6} for the CTE case to 4×10^{-5} for the RME case. The CTE and RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. PCE is the main risk driver (99 percent) for the RME case, and TCE is the main risk driver (51 percent) for the CTE scenario. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.02 for the CTE case to 0.1 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For indoor air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 8×10^{-7} for the CTE case to 4×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver (79 percent) for the RME case. For indoor air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 0.003 for the CTE case to 0.01 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is the inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-8} for the CTE case to 4×10^{-7} for the RME case. The CTE and RME ELCR estimates are less than the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.0002 for the CTE case to 0.001 for the RME case. The CTE and RME HI estimate do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-9} for the CTE case to 3×10^{-8} for the RME case. The CTE and RME ELCR estimates are less than the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 4×10^{-5} for the CTE case to 8×10^{-5} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Groundwater. Potential routes of exposure to COPCs in groundwater include ingestion, dermal contact, and the inhalation of vapors during assumed hypothetical domestic use. The ELCR and HI estimates for the future resident adult exposure scenario are discussed below:

- For exposure to COPCs in NSGW, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-4} for the CTE case to 1×10^{-3} for the RME case. The CTE and RME ELCR estimates exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For both the CTE and RME cases, the main risk driver is arsenic (87 percent). The CTE and RME ELCR estimates without arsenic do not exceed the upper end of the

regulatory risk range; however, the RME ELCR estimate without arsenic still exceeds the upper end of the regulatory risk range. For exposure to COPCs in NSGW, the HI estimates for noncancer effects range from 82 for the CTE case to 126 for the RME case. The CTE and RME HI estimates exceed the regulatory threshold value of 1. TCE is the main risk driver (92 percent) for the CTE and RME cases. The HI estimates for the CTE and RME cases exceed the regulatory threshold value of 1 without TCE.

5.7.3.2 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Residential Exposure Scenario

Potential residential child exposures to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, inhalation of vapors and fugitive dust in ambient air, and consumption of home-grown produce that has accumulated COPCs from soil. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-7} for the CTE case to 2×10^{-6} for the RME case. The CTE ELCR estimate does not exceed the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The RME ELCR is at the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The analyte 2,3,7,8-TCDD TEQ is the primary risk driver for the RME scenario. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.05 for the CTE case to 0.2 for the RME case. The CTE and RME HI estimates for exposure to 0- to 2-foot-bgs soil are below the regulatory threshold value of 1. The cumulative ELCR and HI do not include the ELCR and HI estimates from the plant consumption exposure route. The ELCR estimates for carcinogenic COPCs for exposure to 0- to 2-foot-bgs soil from the plant consumption exposure route range from 5×10^{-6} for the CTE case to 3×10^{-5} for the RME case. The RME and CTE ELCR estimates are within the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects from the plant consumption exposure route range from 0.6 for the CTE case to 5 for the RME case. The RME HI estimate exceeds the regulatory threshold value of 1. Barium and 2,3,7,8-TCDD TEQ are the main risk drivers for the RME HI estimate.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 5×10^{-7} for the CTE case to 2×10^{-6} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. 2,3,7,8-TCDD TEQ is the main risk driver (63 percent) for the RME ELCR estimate. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.04 for the CTE case to 0.2 for the RME case. The CTE and RME HI estimates are below the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas is the inhalation of vapors that

have migrated inside a future residence. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 7×10^{-6} for the CTE case to 3×10^{-5} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. PCE and TCE are the main risk drivers for the CTE and RME cases. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.1 for the CTE case to 0.3 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For indoor air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-6} for the CTE case to 3×10^{-6} for the RME case. The CTE and RME ELCR estimates exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver (79 percent) for the CTE and RME cases. For indoor air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 0.03 for the CTE case to 0.03 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 8×10^{-8} for the CTE case to 3×10^{-7} for the RME case. The CTE and RME ELCR estimates are less than the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.001 for the CTE case to 0.004 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-8} for the CTE case to 2×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 0.0002 for the CTE case to 0.0002 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Groundwater. Potential routes of exposure to COPCs in groundwater include ingestion, dermal contact, and inhalation of vapors during assumed hypothetical domestic use. The ELCR and HI estimates for the future resident child exposure scenario are discussed below:

- For exposure to COPCs in NSGW, the cumulative ELCR estimates for carcinogenic COPCs range from 8×10^{-3} for the CTE case to 1×10^{-3} for the RME case. The CTE and RME ELCR estimate exceed the upper end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. Arsenic is the main carcinogenic risk driver (87 percent) for the CTE and RME cases. The ELCR estimate for the CTE and RME cases exceeds the upper end of the regulatory risk range when arsenic is not included. For exposure to COPCs in NSGW,

the HI estimates for noncancer effects range from 286 for the CTE case to 477 for the RME case. The CTE and RME HI estimates exceed the regulatory threshold value of 1. TCE is main risk driver (92 percent) for the CTE and RME cases. When TCE is not included in the HI estimates, the HI estimates exceed the regulatory threshold value of 1.

5.7.3.3 Hypothetical Future Adult Recreational Exposure Scenario

Potential adult recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 5×10^{-9} for the CTE case to 3×10^{-7} for the RME case. The CTE and RME ELCR estimates do not exceed the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.0004 for the CTE case to 0.006 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist adult exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 1×10^{-9} for the CTE case to 5×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.00001 for the CTE case to 0.0001 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 3×10^{-10} for the CTE case to 3×10^{-9} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 2×10^{-6} for the CTE case to 0.00001 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

5.7.3.4 Estimated Risks/Hazard Indexes for the Hypothetical Future Child Recreational Exposure Scenario

Potential child recreationist exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust

in ambient air. A hypothetical future recreationist child (15-kg body weight) was assumed to be exposed for 350 days per year over 6 years for the RME case and 6 years for the CTE case. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-8} for the CTE case to 4×10^{-7} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.007 for the CTE case to 0.06 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future recreationist child exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-9} for the CTE case to 9×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.0001 for the CTE case to 0.001 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.
- For ambient air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-9} for the CTE case to 6×10^{-9} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 2×10^{-5} for the CTE case to 7×10^{-5} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

5.7.3.5 Hypothetical Future Industrial Worker Exposure Scenario

Potential industrial worker exposure to COPCs in soil, soil vapor, and groundwater were evaluated under this hypothetical scenario.

Estimated Risks/Hazard Indexes for COPCs in Soil. Potential routes of exposure to COPCs in soil include incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust in ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For exposure to 0- to 2-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-8} for the CTE case to 9×10^{-7} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For exposure to 0- to 2-foot-bgs soil, the HI estimates for noncancer effects range from 0.003 for the CTE case to 0.03 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For exposure to 0- to 10-foot-bgs soil, the cumulative ELCR estimates for carcinogenic COPCs range from 4×10^{-8} for the CTE case to 1×10^{-6} for the RME case. The RME ELCR estimate equals the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. The parameter 2,3,7,8-TCDD TEQ from the ingestion pathway is the main risk driver for the RME case. For exposure to 0- to 10-foot-bgs soil, the HI estimates for noncancer effects range from 0.002 for the CTE case to 0.02 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Indoor Air. For the indoor air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is the inhalation of vapors that have migrated inside a future industrial building. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For indoor air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 6×10^{-7} for the CTE case to 1×10^{-5} for the RME case. The RME ELCR estimate exceeds the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. PCE is the main risk driver for the RME case. For indoor air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.006 for the CTE case to 0.03 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For indoor air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-7} for the CTE case to 1×10^{-6} for the RME case. The RME ELCR estimate equals the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main risk driver for the RME case. For indoor air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 0.002 for the CTE case to 0.003 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

Estimated Risks/Hazard Indexes for COPCs in Ambient Air. For the ambient air pathway, the potential route of exposure to COPCs detected in soil gas and groundwater is the inhalation of vapors that have migrated to ambient air. The ELCR and HI estimates for the future industrial worker exposure scenario are discussed below:

- For ambient air exposure via soil vapor intrusion, the cumulative ELCR estimates for carcinogenic COPCs range from 2×10^{-8} for the CTE case to 4×10^{-7} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via soil vapor intrusion, the HI estimates for noncancer effects range from 0.0002 for the CTE case to 0.001 for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

- For ambient air exposure via vapor intrusion from groundwater, the cumulative ELCR estimates for carcinogenic COPCs range from 5×10^{-9} for the CTE case to 3×10^{-8} for the RME case. The CTE and RME ELCR estimates do not exceed the lower end of the regulatory risk range of 1×10^{-6} to 1×10^{-4}. For ambient air exposure via vapor intrusion from groundwater, the HI estimates for noncancer effects range from 4×10^{-5} for the CTE case to 7×10^{-5} for the RME case. The CTE and RME HI estimates do not exceed the regulatory threshold value of 1.

5.7.4 Uncertainty Discussion

Uncertainties associated with the results of this HHRA are a function of both the "state of the practice" of performing HHRAs in general and UFs specific to the Ash Pile and STP. The general HHRA uncertainty is discussed in Section 1.5.3.

5.8 Ecological Risk Assessment for Former Incinerator Ash Pile and Building 515 STP

5.8.1 Problem Formulation

The problem formulation describes the site to be assessed, establishes the assumptions and data to be employed, and is generally the foundation of the ERA. Generalized components of the problem formulation, applicable to all RFI sites in Group 2, are described in Section 1.5.4.1. Problem formulation components specific to the former Incinerator Ash Pile and STP are described below.

5.8.1.1 Site Background

The Incinerator was used to burn nonhazardous wastes, primarily trash, photographs, and paper (MWH, 2005d). Waste from the Incinerator was deposited in an ash pile located in an unpaved area to the south of the Incinerator. A more detailed discussion of site conditions and history is presented in Sections 5.1.2, 5.1.3, and 5.1.4.

The Incinerator and former Ash Pile Area contain a paved road running east-west that is considered developed. The habitat at the site was determined based on a site survey conducted by CH2M HILL staff in April 2008 (Appendix A). This survey indicated that the Ash Pile Area is made up of three habitat types, including woodland, scrub-shrub, and ruderal habitat. Most of the site (about 50 percent) is made up of woodland habitat consisting mainly of coastal live oak. Approximately 17 percent of the site is made up of scrub-shrub habitat consisting of yerba santa, elderberry, and California sage. The scrub-shrub habitat is located in the northeastern portion of the site. Ruderal habitat makes up about 33 percent of the site and is dispersed evenly across the site. It is dominated by red brome, yellow sweetclover and rip-gut brome (Figure 5.8-1). Evidence or actual observation of the following species was noted during the site visit: dark-eyed junco, Anna's hummingbird, Nutall's woodpecker, woodrat (scat and dens), cottontail, kangaroo rat (burrows, tracks), and gopher (burrows). It also was noted that this area was burned in 2005 and standing burned woody vegetation is present. No evidence of stressed vegetation (except for the burned areas) was observed during the site visit.

When the STP was in operation, it received both sanitary sewage and cooling water discharges from small air conditioning and heat exchanger units in Area II (De Leuw, Cather & Company, 1987). Cooling water may have contained traces of solvents and/or fuels. The STP consists of a comminutor (a device used to cut up solids in wastewater), source aeration unit, and clarifier (OEES, 1996). In addition, the Service Area Building 211 Leach Field is located to the east of the STP. The USEFF also is addressed in conjunction with the STP because of its proximity. A more detailed discussion of site conditions and history is presented in Sections 5.1.1, 5.1.2, 5.1.3, and 5.1.4.

The habitat at the STP site was determined based on a site survey conducted by CH2M HILL staff in April 2008 (Appendix A). This survey indicated that the STP is made up of three habitat types, including woodland, scrub-shrub, and ruderal habitat (Figure 5.8-1). Most of the site (76 percent) is composed of dense shrub/scrub habitat, consisting mostly of yerba santa, coyote brush, mustard, and California dodder. Approximately 15 percent of the site is composed of patchy ruderal habitat, consisting mostly of red brome and red-stemmed filaree. The ruderal habitat is located in the southwestern portion of the site. A small portion of the site (approximately 3 percent), located along the site boundaries, is composed of woodland habitat. It dominated by an overstory of coast live oak and an understory of elderberry. Evidence or actual observation of the following species was noted during the site visit: dark-eyed junco, black phoebe, Anna's hummingbird, spotted towhee, western scrub-jay, yellow-rumped warbler, orange-crowned warbler, cottontail, kangaroo rat (burrows), gopher (burrows), coyote (scat), and western fence lizard. It also was noted that this area was burned in 2005 and standing burned woody vegetation is present. Stressed vegetation and spray areas are located southwest of the Building 515 STP portion of the site (Figure 5.8-1). Although the Service Area Building 211 Leach Field and USEFF were not surveyed, these areas are likely to contain comparable habitat, because of their proximity to the STP.

5.8.1.2 Ecological Management Goals, Assessment Endpoints, and Measures

The ecological management goal for the former Incinerator Ash Pile and STP is the same as that for all Group 2 RFI sites, as follows:

> *Maintenance of soil, sediment, water quality, food source, and habitat conditions capable of supporting ecological receptors, including special-status species, likely to be found in the area.*

The habitats present at the former Incinerator Ash Pile site are exclusively terrestrial. Consequently, only terrestrial assessment endpoints and measures were identified for this site (Table 5.8-1).

Representative species and receptor groups considered for the former Incinerator Ash Pile site include the terrestrial plant community (primary producers), soil invertebrate community (primary consumers), hermit thrush (primary and secondary consumer), red-tailed hawk (tertiary consumer), deer mouse (primary and secondary consumer), mule deer (primary consumer), and bobcat (secondary and tertiary consumer). It should be noted that because no evidence of stressed vegetation was indicated, the plants were not evaluated quantitatively.

5.8.1.3 Ecological Conceptual Site Model

The generalized ecological CSM for Group 2 is presented in Section 1.5.4.4. Because the former Incinerator Ash Pile and STP is strictly a terrestrial location, only the terrestrial pathways are relevant. The CSM specific to the former Incinerator Ash Pile is described in Section 5.5 and presented in Figure 5.8-2.

The primary contaminant sources at the former Incinerator Ash Pile portion of the site include the ash pile south of the incinerator. Primary release mechanisms include disposal to the ground of contaminated ash. Secondary sources of potential contaminants are soils

and soil vapors. Secondary release mechanisms include volatilization and wind erosion, and bioaccumulation from soil.

The CSM specific to the former Incinerator Ash Pile and the Building 515 STP is described below and presented in Figure 5.8-2.

The primary contaminant sources at the Building 515 STP include the STP and the leach field associated with Building 211 and the adjacent buildings. Primary release mechanisms include leaks or spills from the STP and disposal of potentially contaminated water to the leach field. Secondary sources of potential contaminants are soils and soil vapors. Secondary release mechanisms include volatilization and wind erosion, and bioaccumulation from soil.

Complete or potentially complete exposure pathways from contaminated soil, soil vapor, and biota to ecological receptors exist at the sites. Burrowing mammals (deer mice) may be exposed to soil vapors via inhalation. Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, and small mammals resident in and associated with the site soils. Terrestrial wildlife (herbivores, omnivores, invertivores, and carnivores), including reptiles, may be exposed directly to contaminants in soil by incidental ingestion, by dermal contact, or by the inhalation of wind-borne particles. Terrestrial invertebrates and wildlife (reptiles, birds, and mammals) also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (plants to herbivores, plants and prey animals to omnivores, etc.). Additional descriptions of the potential exposure pathways for ecological receptors at the former Incinerator Ash Pile and at Building 515 STP are summarized in Table 5.8-2, along with the rationale for inclusion or exclusion in the quantitative and qualitative evaluations.

5.8.1.4 Selection of Chemicals of Potential Ecological Concern

The process for the selection of CPECs is described in Sections 1.5.4.4 and 1.5.4.5. Detected analytes in soil and soil vapor are presented in Table 5.8-3. Summary statistics for those detected analytes are presented in Table 5.8-4. TEQ values for dioxin/furans were calculated and are listed in Table 5.8-5. A central tendency background comparison for metals and dioxins/furans in soils was conducted to determine whether or not analytes were consistent with background (Table 5.8-6). Volatile organics in soil and soil vapor are compared in Table 5.8-7. Non-detect analytes were evaluated by comparing the maximum SQLs against the minimum ESL and determining the exceedance frequency of the SQLs (Table 5.8-8). The CPECs identified for the former Incinerator Ash Pile and STP are summarized in Table 5.8-9. EPCs for each depth interval (0 to 2 ft, 0 to 4 ft, and 0 to 6 ft bgs) are listed in Tables 5.8-10, 5.8-11, and 5.8-12, respectively. EPCs for soil vapor from 0 to 6 ft bgs are provided in Table 5.8-13. The calculations for extrapolating soil vapor concentrations from soil concentrations are listed in Table 5.8-14.

5.8.2 Analysis

The analysis phase, which consists of the exposure characterization and the ecological effects characterization, links the problem formulation (Section 5.8.1) with the risk characterization (Section 5.8.3), and consists of the technical evaluation of ecological and chemical data to determine the potential for ecological exposure and effects. Generalized components of the exposure and ecological effects characterizations are presented in

Section 1.5.4. Exposure and effects information specific to the former Incinerator Ash Pile and STP are presented below.

5.8.2.1 Exposure Characterization

The exposure characterization is used to evaluate the relationship between receptors at the site and potential stressors (CPECs). The methods used to estimate exposure, including receptor-specific exposure models, exposure factors, and assumptions; exposure areas; and the calculation of EPCs, are described in this section.

The receptor-specific exposure models, exposure factors, and assumptions presented in Section 1.5.4.4 are used for receptors at the former Incinerator Ash Pile and STP. Because the former Incinerator Ash Pile and STP are strictly terrestrial, exposure is based on soil and soil vapor and was evaluated only for the terrestrial receptors (plants, soil invertebrates, birds, and mammals).

Although the former Incinerator Ash Pile and STP are about 1.7 acres combined, the spatial extent of samples associated with the site is 6.97 acres. Land cover at the Ash Pile consists primarily of woodland and ruderal habitat types, with no buildings or roads present. As a consequence, most of the site represents habitat of moderate or better quality. Land cover at the STP consists primarily of scrub/shrub habitat. In the eastern portion of the site, all buildings have been removed. The western portion of the STP is developed and consists of the control building, the belowgrade concrete-lined unit, and pavement surrounding the area. Consequently, only a portion of the site represents habitat of moderate or better quality. It is assumed that all buildings in the western portion of the site eventually will be removed and the site will revert to natural conditions.

Summary statistics, EPCs for CPECs in soil at various depths (up to 6 ft bgs), and soil vapor were calculated for the former Incinerator Ash Pile, according to the approach outlined in Section 1.5.4.2. These values are listed in Tables 5.8-4 through 5.8-14. Direct exposure estimates for terrestrial invertebrates and modeled exposure estimates for bird and mammal receptors are presented as part of the risk characterization (Section 5.8.3).

5.8.2.2 Ecological Effects Characterization

The ecological effects characterization consists of an evaluation of available toxicity or other effects information that can be used to relate the exposure estimates to a level of adverse effects. Generalized effects data for all receptors at the SSFL are summarized in Section 1.5.4.4. No effects data specific to the former Incinerator Ash Pile and STP are available. Consequently, the ESLs, Low TRVs and High TRVs for terrestrial receptors described in Section 1.5.4.5 were used to evaluate the effects associated with the estimated exposures.

5.8.3 Risk Characterization

The risk characterization integrates estimated CPEC exposures with their potential ecological effects on the assessment endpoints for the former Incinerator Ash Pile and STP. The sequential processes for performing the risk characterization, described in Section 1.5.4.4, were applied to the site. The results of these comparisons are presented below.

5.8.3.1 Risk Estimation

The risk estimation focuses primarily on quantitative methods to evaluate the potential for risks. The results of the quantitative risk estimation are presented as HQs and HIs. HQs and HIs for the evaluated receptors are listed in Tables 5.8-15 through 5.8-22. Table 5.8-18 presents an analysis of the depth intervals for the evaluation of burrowing animals (deer mouse). The 0- to 2-foot-bgs depth interval had the greatest HI; therefore, the data from this depth were used to evaluate the deer mouse. Tables 5.8-23 through 5.8-26, respectively, summarize the risk estimation for terrestrial exposures, estimation of incremental risks for terrestrial exposure pathways for the RME, and COECs for soil.

5.8.3.2 Risk Description

The risk description incorporates the results of the risk estimates, along with any other available and appropriate lines of evidence, to evaluate potential chemical impacts on ecological receptors in Group 2. Chemicals that had HQs exceeding 1 were further evaluated to determine the COECs. Information considered in the determination of COECs includes receptor groups potentially affected, exceedance of Low and/or High TRVs, frequency of detection, magnitude of exceedance, bioavailability, and habitat quality at the site.

To facilitate the interpretation of TRV exceedances in the refined screen, chemicals that exceed one of the TRVs (Low TRV or High TRV) were assigned into seven general risk groups (1 through 7, below). These groups were created as an additional tool to assist risk managers in making remedial decisions. The groupings are subjective, based on professional judgment, and the placement of a chemical within a given group is not an absolute indicator of the potential risk:

1) High Risk–HQs>5 for High TRV (RME), or HQs>100 for any EPC/TRV combination. Chemical classes with HIs>10 at High TRV (RME). Four or more receptors showing estimated risks.

2) Medium-High Risk–2<HQs<5 for the High TRV (RME). Chemical classes with 2<HIs<10 at the High TRV (RME) or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.

3) Medium Risk–1<HQs<2 for High TRV (RME), but HQ>10 for Low TRV (RME). Chemical classes with 1<HIs<2 at the High TRV or HIs>10 at the Low TRV. Three or more (of six) receptors showing estimated risks.

4) Medium-Low Risk–HQs<1 for the High TRV (RME), but 1<HQs<10 for the Low TRV (RME). Chemical classes with HIs<1 at the High TRV or 2<HIs<10 at the Low TRV. No more than two of six receptors showing estimated risks.

5) Low Risk–HQs<1 for the Low TRV (RME). Chemical classes with HIs<1 at the Low TRV.

6) No Risk–all HQs and associated HIs<1.

7) Uncertain–TRVs unavailable to calculate either HQs or HIs.

Soil vapor CPECs were identified and evaluated as part of this ERA. Six analytes were detected in soil vapor, 10 soil and 6 soil vapor non-detect analytes were carried forward

based on a comparison of SQLs to ESLs, and the concentration of 2 analytes (acetone and styrene) were modeled based on soil (Table 5.8-14). Of these, 5 analytes (2 detects and 3 non-detects) had HQs greater than 1 (Table 5.8-17). Cis-1,2-DCE was detected in only 4 percent of soil vapor samples (1 out of 24 samples) and had an HQ of only 4.4, based on the maximum detection. When calculated using the RME for cis-1,2-DCE, the high TRV-based HQ is only 1.17.

Because the detection frequency and magnitude of exceedance were low, cis-1,2-DCE is considered to pose a low risk. TCE was detected in 23 percent of samples (6 out of 26) and had a maximum HQ of 14. When calculated using the RME for TCE (30 mg/m^3), the high TRV is only 1.6. The maximum detected concentration for TCE (at BTSV11) was based on legacy data at an unknown depth. The other 5 TCE detections that had known depths were two orders of magnitude lower than the maximum detection and suggest that TCE is not likely to be present in soil gas from 0 to 6 ft bgs at the concentration detected in BTSV11. Because TCE was detected in less than half of the samples, the maximum detected concentration probably is not representative of exposure in the 0- to 6-foot-bgs depth interval, and the magnitude of exceedance, based on the RME, is low. Therefore, the risks posed by TCE are considered to be acceptable. Three non-detected analytes–1,1,-DCE, chloroform, and 1,1,2-TCA–also had HQs above 1, although none of the analytes was detected in any of the 23 samples collected (24 samples for 1,1-DCE). 1,1-DCE (HQ = 1.7) and chloroform (HQ = 4.2) all had low HQs and were considered to pose a low risk, based on the low magnitude of exceedance and the fact that they were all non-detect. Additionally, if risks were estimated using ½ the SQL, HQs would be less than 1 for 1,1-DCE. 1,1,2-TCA had an HQ of 18. The inhalation TRV/ESL for 1,1,2-TCA was derived from an LD50 using an uncertainty factor of 100. The application of the uncertainty factor may over- or underestimate a no-effect level. However, because this analyte was non-detect, the confidence in the benchmark is low, and no other VOCs were deemed as posing a risk, 1,1,2-TCA is considered to pose a low risk. Although some analytes showed exposures, with HQs above 1, overall, the risk was considered acceptable because, in general, detection frequencies were low, magnitude of exceedances were low, risks were based on maximum detected concentrations or SQLs, and some analytes were not detected (Table 5.8-25).

Only five soil analytes (barium, silver, hexavalent chromium, hexachlorobenzene, and dioxins/furans [2,3,7,8-TCDD TEQ]) were found to have one or more HQs greater than 1 under any scenario. It should be noted that hexavalent chromium and hexachlorobenzene were not detected in any samples, but were retained based on the SQL screen (Table 5.8-8). All other soil analytes and/or analyte groups were found to pose no risks (all HQs and HIs were less than 1) to any receptor under any scenario (maximum concentration for plants, invertebrates, and soil vapor exposures; CTE and RME concentrations for birds and mammals) at the former Incinerator Ash Pile and STP.

Two detected inorganics, barium and silver, were identified as significantly elevated relative to background, based on the non-parametric central tendency background comparisons for soil (Table 5.8-5). Both metals had one or more HQs above 1 for at least one receptor in the refined screen. On the basis of the risk ranking discussed above, barium was found to pose a high risk (four receptors [plants, invertebrates, hermit thrush, and deer mouse] showing estimated risk with high TRV-based HQs above 5 in the refined screen) and silver was

found to pose a medium risk (two receptors [plant and deer mouse] showing estimated risk with low TRV-based HQ above 10, but high TRV-based HQ between 1 and 2).

Barium showed predicted risks to plants with an HQ of 10 and to terrestrial invertebrates, with an HQ of 16. However, only three sample locations exceeded the invertebrate ESL for barium, which represents less than 6 percent of the available samples. Additionally, all 3 locations were based on legacy data, with no available depth information, which introduces uncertainty as to whether the sample truly represents the soil depths in which terrestrial invertebrates would occur. Consequently, the risks to terrestrial invertebrates are highly localized to areas around C-2-01, C-2-03, and RF717.

Barium showed predicted risks to the hermit thrush, based on the high TRV and RME in the refined screen (HQs of 8.2) and to the deer mouse, with a high TRV-based HQ of 12. High TRV-based HQs for the hermit thrush and deer mouse, based on the CTE, also exceeded 1 (2.8 and 4.2, respectively). Because the maximum concentration for barium is based on legacy data that have unknown depth intervals, the risks associated with this analyte are uncertain, but probably are localized to a few hot spot areas. The areas with locations that contained the highest barium concentrations included C-2-01, C-2-03, and APSS01, and all are located close to one another within the Ash Pile and STP boundary. On the basis of a back-calculation, a barium concentration of 60 mg/kg in soil for the deer mouse and 90 mg/kg in soil for the hermit thrush would result in a high TRV-based HQ of 1 in the refined screen. More than 60 percent of samples exceeded the 90-mg/kg level. On the basis of the background data set, the mean concentration for barium is 83 mg/kg, suggesting that the current concentrations of barium probably are site-related and that barium is present at levels that have the potential to pose risks to wildlife receptors.

Silver showed predicted risks to terrestrial plants with an HQ of 90. Of the 65 samples analyzed for silver, 3 sample locations exceeded 100 mg/kg (C-2-01, APBS0015, and APBS0016). All other samples had levels less than 35 mg/kg, with 40 of the 65 samples (62 percent) containing silver at concentrations less than 10 mg/kg. Silver also posed risks to the deer mouse under both the RME and CTE scenarios; the high TRV-based HQ was less than 1. Risks from silver probably are limited to a few small hot spot areas, similar to those for barium. One location, C-2-01 was elevated for both barium and silver. The other two locations, APBS0015 and APBS0015, are located close to one another to the northeast of the site. On a sitewide basis, silver is not likely to have significant effects on receptors, but isolated impacts may occur in two areas. However, based on the fact that none of the high TRV-based HQs exceeded 1 for birds or mammals, the overall risk probably is low.

Hexavalent chromium was retained based on the SQL screen (Table 5.8-8). It was analyzed for in 5 samples within the 0- to 2-foot-bgs soil interval, with no detected concentrations. Hexavalent chromium failed only the invertebrate screen, with a high TRV-based HQ of 5, and was found to pose a medium-low risk. Because hexavalent chromium did not fail for any receptor except invertebrates, the magnitude of exceedance was low, and hexavalent chromium was not detected in any sample, the risks posed by hexavalent chromium are considered to be low.

In addition to inorganics, hexachlorobenzene and dioxins/furans (based on the 2,3,7,8-TCDD TEQ) were found to fail one or more screens for one or more receptors. Although the low TRV-based HQ for RME exposure to 2,3,7,8-TCDD TEQ exceeded 1 for the

hermit thrush (HQ = 1.3) and the deer mouse (HQ = 10), the high TRV-based HQ was less than 1 for all of the receptors, suggesting that the risks posed by dioxins/furans (including coplanar PCBs) is medium-low. Additionally, the low-TRV based HQ for CTE exposure was less than 1 for the hermit thrush, but was 5.9 for the deer mouse, although both of the high TRV-based HQs for the CTE exposure were less than 1. Although the 2,3,7,8-TCDD TEQ concentration includes both dioxins/furans and coplanar PCBs, most of the risks are attributed to dioxins/furans (Table 5.8-5).

Hexachlorobenzene was retained based on the SQL screen (Table 5.8-8). It was analyzed for in 5 samples, none of which contained detected concentrations. Four SQLs exceeded the minimum ESL (0.34 mg/kg), but only by a small fraction. SQLs ranged from 0.035 to 0.348 mg/kg. On the basis of the maximum SQL, hexachlorobenzene was found to pose risks to the deer mouse and an overall medium-low risk. However, the high TRV-based HQ was only 1, with a low TRV-based HQ of 3.7, suggesting that sitewide risks are unlikely. Because this analyte was non-detect and only was found to pose risk to one analyte, with a low magnitude of exceedance, the overall risk is considered low.

5.8.3.3 Uncertainty Analysis

Uncertainty is an implicit component in all risk assessments. Generalized uncertainties for ERAs in Group 2 are summarized in Section 1.5.4.5. Additional uncertainties are described below:

- Samples were collected outside of the site boundary in an effort to define and fully characterize the potential releases from the Ash Pile and STP. If sample concentrations decreased with distance from the site, the inclusion of the additional data might underestimate risks in the core portion of the site when these data are integrated into the RME and CTE calculations.
- Depths were unavailable for several historical soil and soil vapor sample locations included in the Ash Pile and STP dataset. The maximum concentrations for many analytes (including barium and silver in soil and TCE in soil gas) were associated with these "legacy" data. In an effort to be conservative and to ensure completeness, these data were included in the 0- to 2-foot-bgs depth interval for the purposes of risk assessment. There is some uncertainty associated with including these data in this depth interval (especially for soil vapor), and the risks may be overestimated. However, it is likely that the maximum soil concentrations would be detected at shallower depths, so inclusion with the shallowest depth interval for soil is deemed appropriate.
- Aroclor data were not evaluated in this assessment because PCB congener data were available and were used to calculate a TCDD TEQ. PCBs and dioxin/furans were evaluated based on the 2,3,7,8-TCDD TEQs. The concentrations of aroclors were low and are not expected to be significant COCs.
- No screening levels were available to evaluate the TPH data; however, PAH data were available and no risks from these constituents were predicted. Additionally, no BTEX concentrations (TPH constituents) were detected in soil or soil vapor.
- Non-detect soil vapor analytes were included in the soil vapor screening, per the procedure dictated by the SRAM (MWH, 2005b). Because these analytes were not

detected in any of the 23 to 24 collected samples, it is unlikely that these analytes are present at the site at concentrations that would pose ecological risks. This approach probably overestimates the risks from exposure to soil vapor.

5.8.4 Conclusions and Recommendations

Of the 29 analytes (dioxins/coplanar PCBs were counted as 1 analyte) in soil that were evaluated, barium in soil was the only analyte that posed high risks to the receptors evaluated at the former Incinerator Ash Pile and STP. Silver and dioxins/furans (including coplanar PCBs) were found to pose medium risk and medium-low risks, respectively. In addition, two non-detect analytes–hexavalent chromium and hexachorobenzene–were found to pose medium-low risks. Of the remaining soil analytes, 23 posed no risk and 1 lacked TRVs. All analytes in soil vapor were considered to pose a low risk, based on further qualitative evaluation. Except for barium, the risks from all analytes were considered acceptable and do not warrant additional investigation.

Barium was the only analyte considered to warrant additional evaluation. One localized hot spot, located in the Ash Pile and STP boundary, was found to exist for barium, although concentrations were above background in more than half of the sampled locations, suggesting that elevated concentrations are present throughout the area. The depths of some samples, including those at the localized hot spot area, are not known and were assumed to be located within the 0- to 2-foot-bgs interval. Consequently, additional action or investigation is recommended to reduce the risks posed by barium to wildlife receptors.

5.9 Summary of Findings and Recommendations for Former Area II Ash Pile and STP

5.9.1 Nature and Extent of Contamination Summary

To evaluate the nature and extent of potential contaminants at the former Area II Incineration Ash Pile and STP area, 90 surface soil, 132 subsurface soil, and 61 soil gas samples were collected. Of the surface soil samples collected, dioxins (compared as 2,3,7,8-TCDD TEQ) exceeded the applicable screening criteria; 11 of those exceeded the metals screening criteria, and 1 location exceeded a PCB aroclor and a PCB congener screening criteria. The parameters that exceeded the criteria are listed in Table 5.9-1. Although the data indicate some migration along the intermittent stream (the only migration pathway from the site), most of the exceedance locations are bound downgradient by samples that did not have reported exceedances. The exceptions to this are the reported exceedances of PCB-126 and BaP at APBS1010 and APBS0017, respectively. The reported concentration of PCB-126 was only slightly higher than the human health comparison criterion; however, the sample point is not bound to the north by any other sample locations that were sampled for PCB congeners. Although BaP only exceeded the screening criterion at two locations, APBS0017 is located furthest downstream and is not bound by any other locations that were sampled for SVOCs. Therefore, additional characterization for SVOCs is warranted to complete the extent evaluation.

Of the subsurface soil samples collected, dioxins (compared as 2,3,7,8-TCDD TEQ) and 10 metals were reported at concentrations that exceeded 1 or more of the screening criteria.

The parameter 2,3,7,8-TCDD TEQ exceeded the screening criteria in 2 of the 11 subsurface soil samples analyzed for dioxins. Because only 1 sample depth was collected from these locations, nearby sample locations were sampled to deeper depths; the vertical extent of dioxins in the subsurface soil has been evaluated sufficiently.

Of the metals that exceeded the screening criteria, only sodium was reported at the maximum depth at concentrations that exceeded the screening criteria. Sodium is an essential nutrient and it is unlikely that this metal is a COC; therefore, the vertical extent of sodium in the subsurface has been evaluated sufficiently.

Three VOCs–cis-1,2-DCE, PCE, and TCE–were reported at levels that exceeded the screening criteria in soil gas collected at the site. The VOCs had reported concentrations that generally increased with depth. The likely source of the soil gas contamination is the groundwater; these contaminants should be further evaluated as part of the area groundwater investigation.

5.9.2 Risk Assessment Summary

Of the 29 analytes (dioxins/coplanar PCBs were counted as 1 analyte) in soil that were evaluated in the ERA, barium in soil was the only analyte that posed high risks to the receptors evaluated at the former Incinerator Ash Pile/STP. Silver and dioxins/furans (including coplanar PCBs) were found to pose medium risk and medium-low risks, respectively. In addition, two non-detect analytes, hexavalent chromium and hexachorobenzene, were found to pose medium-low risks. Of the remaining soil analytes, 23 posed no risk and 1 lacked TRVs. All analytes in soil vapor were considered to pose a low risk, based on further qualitative evaluation. Except for barium, the risks from all analytes were considered acceptable and do not warrant additional investigation.

Barium was the only analyte considered to warrant additional evaluation based on the ecological risks. One localized hot spot, located in the Ash Pile site boundary, was found to exist for barium, although concentrations were above background in more than 60 percent of the sampled locations, suggesting that elevated concentrations are present throughout the area.

The HHRA assesses the potential current and future exposures to chemicals in surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater. The methods used to prepare the HHRA are presented in Section 1.5.3. The results of the HHRA for the Ash Pile and STP are presented in Section 5.7.

The surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), soil vapor, and groundwater samples collected during the RFI sampling activities were evaluated for use in the HHRA. Surface water and sediment samples are not evaluated in this HHRA because they were not collected during the RFI site characterization activities. The HHRA data set is presented in Table E.7.1-3 in Appendix E. The COPCs identified from the Ash Pile and STP HHRA data set for each exposure area are presented in Table E.7.1-5.

The potential future receptors at the Ash Pile and STP include recreationists, workers, and residents. The Ash Pile, STP, and surrounding area are likely to have a future recreational or industrial land use; however, a hypothetical future residential scenario was assessed in the HHRA, along with recreational and industrial exposure scenarios. The residential

scenario consists of conservative exposure assumptions, and residents are expected to have the greatest level of exposure. The residential exposure scenario evaluated in this report assumes that exposure can occur through the consumption of fruits and vegetables from a garden. The evaluation of an agricultural residential exposure scenario will be included in a separate report. The assumed exposure pathways for future residents, workers, and recreationists are shown in Figure 1.5.3-1.

Generally, the estimated cumulative cancer risks (ELCRs) less the regulatory risk range (range of 1 in a million [1 x 10-6] to 1 in 10,000 [1 x 10-4]) and estimated noncancer hazards (HIs) less than the regulatory threshold value of 1 are considered acceptable (EPA, 1993). Estimated ELCRs within the 1 x 10-6 to 1 x 10- 4 range are managed on a site-specific basis. The ELCRs and HIs are listed in Table E.7.5-1.

The following exposure scenarios for the Ash Pile and STP exceed the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult resident exposed to NSGW
- Hypothetical future child resident exposed to NSGW

The following exposure scenarios for the Ash Pile and STP are within the regulatory risk range for carcinogenic COPCs:

- Hypothetical future adult resident exposed to indoor air from the migration of soil vapor
- Hypothetical future adult resident exposed to soil (0 to 2 ft bgs) through the plant consumption exposure route
- Hypothetical future adult resident exposed to indoor air from migration of volatile groundwater COPCs
- Hypothetical future child resident exposed to soil (0 to 2 ft bgs)
- Hypothetical future child resident exposed to soil (0 to 2 ft bgs) through the plant consumption exposure route
- Hypothetical future child resident exposed to soil (0 to 10 ft bgs)
- Hypothetical future child resident exposed to indoor air from the migration of soil vapor
- Hypothetical future child resident exposed to indoor air from the migration of volatile groundwater COPCs
- Hypothetical future adult industrial worker exposed to indoor air from the migration of soil vapor
- Hypothetical future adult industrial worker exposed to indoor air from the migration of volatile groundwater COPCs
- Hypothetical future adult industrial worker exposed to soil (0 to 10 ft bgs)

The following exposure scenarios for the Ash Pile exceed the regulatory threshold values for non-carcinogenic COPCs:

- Hypothetical future adult resident exposed to groundwater
- Hypothetical future child resident exposed to groundwater

As described in Sections 1.5.3.6 and 5.7.4, there is a degree of uncertainty associated with these risk estimates that should be considered when making risk management decisions.

5.9.3 Recommendations for Former Area II Ash Pile and STP

Additional soil samples may be warranted to more definitely evaluate the extent of metals, dioxins/furans, and SVOCs in the surface and subsurface soils. Additional soil gas samples also would be beneficial in characterizing the VOC contamination in the Ash Pile at STP area.

As indicated by the ERA, barium was isdentified as an ecological risk driver. Risks were associated with one localized hot spot, near the Ash Pile site boundary, although concentrations were above background in more than half of the sampled locations. This result suggests that elevated concentrations are present throughout the area. Consequently, additional action or investigation is recommended to reduce the risks posed by barium to wildlife receptors.

Potentially significant human health risks were identified for dioxins/furans and barium in soil and for PCE in soil vapor. Human health risk estimates from chemicals generally were driven by a localized area with elevated concentrations. After confirmation of the extent of contamination, removal of soils with elevated concentrations and extraction of soil vapors in areas with elevated VOC concentrations are recommended at this location to reduce human health risks.

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6. Springs and Seeps

No contamination has been detected as part of the springs and seeps characterization efforts in the hill slopes north of the Group 2 RFI study area. On the basis of these results, no risk assessment is warranted at this time. The direction for characterizing the SMOU near or along the hill slopes in relation to potential spring and seep exposures may develop as the CFOU investigation progresses.

6.1 Springs and Seeps Background

The land immediately north of the Group 2 RFI area consists of undeveloped land owned by SSFL and 2,500 acres owned by the BBI (Figure 6.1-1). Groundwater discharges through springs and seeps on the hill slopes adjacent to the Group 2 RFI study area. The origin and flow paths of the groundwater exiting the springs and seeps currently are not known, but are being studied as part of the sitewide CFOU RFI. Because there is a potential for hydraulic connection and offsite transport of COPCs from the Group 2 RFI SWMUs, the risk associated with springs and seeps discharge is evaluated in a qualitative manner.

This section discusses the potential migration of COPCs from the Group 2 SMOU to offsite areas through groundwater flow. Several sampling programs have been conducted in these areas; the results from the analyses of samples collected from seeps, springs, and wells in the northern offsite area is discussed.

6.1.1 Site Conditions Related to Seeps and Springs

NSGW is discontinuous in the Group 2 RFI study area, and where it occurs, there is a wide variation in the depth to water bgs. Groundwater in the SMOU typically is found in the onsite surface water drainage areas. There is typically a downward vertical gradient toward the Chatsworth formation and a horizontal gradient along the axis of thick alluvium deposits. In the offsite area to the north, wells completed in the Chatsworth formation show an upward gradient and produce artesian flow, suggesting a connection with a deep groundwater flow path within the bedrock aquifer system.

Seeps and springs are found primarily in the Chatsworth formation, though they also are found in the Simi member north of the site. Many of the seeps maintain active, visible flow, with discharge rates varying over time.

6.1.2 Site Habitats/Land Cover

The hill slopes surrounding the facility are primarily ruderal habitats. Mulefat scrub and non-native grassland can be found to the north. Intermittent streams run in ravines and in low-lying areas throughout the northern borders of the site. Mule deer and bobcat habitats run along the area north of SSFL.

6.2 Springs and Seeps Sampling and Offsite Characterization Activities

Groundwater monitoring wells, seeps, and springs in the northern offsite area have been sampled during several monitoring and sampling programs. These programs and their results are described in more detail in the Offsite Data Evaluation Report (MWH, 2007b). The programs that included groundwater in the offsite area north of the Group 2 RFI sites include the following :

- ***Offsite Groundwater Sampling Program (1985 to present)***. This program has sampled about 400 monitoring points in and around the SSFL, and 35 wells, springs, and seeps are located offsite. The primary purpose of this program is to monitor for perchlorate and VOCs. The sampling efforts and results are presented in quarterly and annual monitoring reports (Haley & Aldrich, 2007).
- ***Springs and Seeps Sampling Program (1985 to present)***. The offsite sampling program area includes springs and seeps identified through extensive field observations within approximately 2.5 miles of the SSFL boundary. Spring and seep samples were analyzed to determine whether chemicals found in groundwater at the SSFL also were present in water emerging from the seeps and springs and to evaluate the relationships and hydrogeologic connections between springs and seeps and groundwater. This information was collected to evaluate the potential transport of COPCs in groundwater beneath SSFL and for use in the surficial media OU risk assessments.
- ***BBI and Santa Monica Mountains Conservancy Project (1992 to 1994).*** These sampling efforts focused on offsite areas that could have received contamination from SSFL through surface water runoff or other transport mechanisms or pathways. The media sampled included soil/sediment, groundwater, surface water, and fruit.
- ***Perchlorate Study (Northern Drainage) (2003)***. Samples were collected from drainage sediment, surface water, and selected bedrock and mineral deposits adjacent to springs and seeps to evaluate the potential transport of perchlorate by surface water from SSFL into the Northern Drainage. Samples were collected from springs and seeps to evaluate the potential transport of perchlorate in groundwater.
- ***OW-9R Multi-Level Groundwater Monitoring System Program (2002 and 2003).*** Well OS-9R is located adjacent to existing offsite well OS-9 on the BBI property, approximately 4,600 ft north of the SSFL and BBI property boundary. Well OS-9 is an artesian well, and perchlorate reportedly was detected in 4 of 6 samples collected by DTSC in May and June 2003. The two May 30, 2003, samples were analyzed at American Technologies Laboratory (ATL) and reportedly contained 140 and 150 µg/L perchlorate. DTSC collected four additional samples on June 11, 2003, and analyzed two at the DTSC laboratory and sent two to ATL. The DTSC laboratory samples were reported to not contain perchlorate, while the two ATL samples were reported to contain 36 and 39 µg /L perchlorate. The OW-9R multi-level well installation and sampling program was initiated by Boeing to evaluate whether perchlorate is present in groundwater beneath the BBI. The analyses also included 1,4-dioxane, VOCs, tritium, and radionuclides (MWH, 2003f).

6.3 Sampling Results

The data from these and other sampling programs were evaluated (MWH, 2007b) to determine the completeness of the offsite data and the significance of the measured concentrations. The data were compiled from all offsite sampling programs conducted by Boeing, NASA, or DOE that collected and analyzed environmental samples. Some offsite data were collected to provide background concentrations and were used to compare concentrations from the samples located closer to SSFL or to assess other sources of contamination. The metals sampling data were compared to DTSC's approved background groundwater comparison concentrations (GWCCs). All of the sampling results were compared to risk-based or agency-published screening levels. Spring and seep analytical results are provided in Appendix F.

The offsite sampling results were evaluated to determine whether the data suggest a spatial trend or are indicative of a specific migration and transport pathway from onsite source areas. The offsite dataset, particularly the older data, contained low concentrations of typical laboratory or field contaminants, although false positives still occur. These laboratory contaminants include methylene chloride, acetone, methyl ethyl ketone, solvent preservatives such as hexane, certain freons, phthalates, and others (EPA, 1999). Contamination from field sampling equipment included toluene, benzene, carbon disulfide, and others (Haley & Aldrich, 2007). Although these detections were considered for the offsite data analysis, they typically were found at concentrations less than screening levels, and there were no observed patterns relative to SSFL operations and onsite results.

The following summarizes the offsite data evaluation conducted by MWH:

- **VOCs**. There are no consistent offsite VOC detections the above screening levels in groundwater or springs and seeps north of the Group 2 RFI area that are related to SSFL operations. Spring and seep data mostly area non-detect for VOCs, although detections of common laboratory contaminant occur. There are no offsite data gaps and groundwater and spring and seep sampling is ongoing. These data should continue to be evaluated for significance and patterns when available. The analytical results for VOC compounds detected in the samples collected since 2002 from locations north of the Group 2 RFI area are provided in Table 6.3-1.

- **Perchlorate.** There have been no detections of perchlorate in groundwater or spring and seep samples collected to date, with the exception of the four samples collected by DTSC in May and June 2003 from well OS-9. Numerous samples collected from this well since that time and the multi-level sampling program at OS-9R have been non-detect for perchlorate. The perchlorate sampling results since 2002 are listed in Tables 6.3-2 and 6.3-3. The evaluation did not identify any data indicating that offsite transport of perchlorate has occurred, and no data gaps were identified.

- **Radionuclides.** Potassium-40 is the most prevalent of all naturally occurring radionuclides and is not generally considered a product of nuclear operations. However, because some reactors used a sodium-potassium alloy as a coolant, this compound was included in sample analyses in onsite and offsite locations. Potassium-40 was measured at 234 picocuries per liter (pCi/L) in spring and seep S-14

in June 2002 (MWH, 2003g). There is no drinking water standard established for this compound. The evaluation identified no offsite data gaps.

- **Other Compounds.** No other compounds have been detected at levels above the screening levels in groundwater or seeps and springs north of the Group 2 RFI area. Additional details are provided in the Offsite Data Evaluation Report (MWH, 2007ba).

6.4 Nature and Extent of Contamination

The analyses of available data, including the offsite sampling results presented in the Offsite Data Evaluation Report (MWH, 2007b) indicate that the groundwater flow system has not transported contaminants from beneath SSFL to offsite locations north of the Group 2 RFI area (MWH, 2007ba).

6.5 Conceptual Site Exposure Model

The generalized ecological CSM for Group 2 is presented in Section 1.5.4.1. Because the hill slopes adjacent to SSFL are strictly terrestrial locations, only the terrestrial pathways are relevant. The generalized CSM specific to the hill slopes and offsite area is an area with undefined flow paths and no specific exposure points, where there is no apparent connection to the SMOU in the Group 2 RFI study area. Because VOCs are not detected in the springs and seeps, retardation of plumes may occur within the flow paths that probably extend from beneath SSFL to the hill slopes, thus further lessening the potential of transport over significant distances and the creation of exposure pathways.

6.6 Fate and Transport for Chemicals in Surfical Media

Because no chemicals have been detected in surficial media on the hill slopes and offsite areas that would relate to COPCs in the Group 2 RFI SMOU, no fate and transport analysis is warranted.

6.7 Human Health Risk Assessment for Seeps and Springs

Because no COPCs have been detected in the seeps and springs, no HHRA is warranted. The elevated Potassium-40 concentration was not evaluated because it is an essential nutrient and discharge through the surficial media is not confirmed.

6.8 Ecological Health Risk Assessment for Seeps and Springs

Because no COPCs have been detected in the seeps and springs, an ERA is not warranted.

6.9 Summary of Findings and Recommendations for Springs and Seeps

No contamination has been detected as part of the springs and seeps characterization efforts in the hill slopes north of the Group 2 RFI study area. On the basis of these results, no risk assessment is warranted at this time. The direction for characterizing the SMOU near or along the hill slopes in relation to potential spring and seep exposures may develop as the CFOU investigation progresses.

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7. Group 2 RFI Summary

7.1 Summary of RFI Findings for Group 2

The data presented in this document from the historical review, nature and extent of contamination, human health, and risk evaluations have provided sufficient information to gather the necessary data to support the CMS. Additional data are recommended to further evaluate the extent of contamination, as well as the human health and ecological risk factors, to support CMS evaluations. Furthermore, additional groundwater sampling during the wet season, sampling from within Group 2 buildings, sampling at debris areas, and sampling associated with the sewer in Group 2 are planned.

7.2 Recommendations for Consideration during CMS, Human Health Risk Summary, and COCs by Media and Receptors

Several chemicals significantly contribute to the estimated human health risks and hazards for the exposure areas in the Group 2 Reporting Area. The identified chemical risk drivers (COCs), and their associated risks and hazards, are used as the basis for the CMS site action recommendations.

The HHRA COCs for the Group 2 Reporting Area are summarized in Table 7.2-1.

7.2.1 LOX Plant

On the basis of the results of the HHRA, the LOX Plant requires further evaluation in the CMS. The total ELCR exceeds the upper end of the regulatory risk range (1×10^{-4}) for one or more exposure scenarios for the following media: surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), and soil vapor. The primary COCs for the LOX Plant are benzidine, arsenic, and BaP in soil and multiple chlorinated VOCs in soil vapor. Benzidine in surface soil (0 to 2 ft bgs) exceeds the upper end of the regulatory risk range (1×10^{-4}) for the residential and industrial worker exposure scenarios. Benzidine in surface soil (0 to 2 ft bgs) also exceeds the lower end of the regulatory risk range (1×10^{-6}) for the recreational scenario. BaP in surface soil (0 to 2 ft bgs) exceeds the lower end of the regulatory risk range (1×10^{-6}) for the residential, recreational, and industrial worker exposure scenarios. Benzidine and BaP exceed the upper end of the regulatory risk range (1×10^{-4}) for the plant consumption exposure pathway. TCE, PCBs, methylene chloride, and 6 PAHs exceed the lower end of the regulatory risk range (1×10^{-6}) for the plant consumption pathway. Benzidine, TCE, 2,4-dimethylphenol, 2-methylphenol, and 3-methylphenol exceed the regulatory HI threshold of 1 for the plant consumption pathway. Benzidine in subsurface soil (0 to 10 ft bgs) exceeds the upper end of the regulatory risk range (1×10^{-4}) for the residential and industrial worker exposure scenarios. Arsenic and BaP in soil (0 to 10 ft bgs) exceed the lower end of the regulatory risk range (1×10^{-6}) for the residential and industrial worker exposure scenarios. For the soil vapor pathways, the ELCRs exceed the upper end of the regulatory risk range (1×10^{-4}) and the HIs exceed 1 for the residential, industrial, and

recreational scenarios. The COCs identified for soil vapor include VC, cis-1,2-DCE, trans-1,2-DCE, TCE, PCE, and 1,1-DCE.

7.2.2 Area II Landfill

On the basis of the results of the HHRA, the Area II Landfill requires further evaluation in the CMS. The total ELCR exceeds the lower end of the regulatory risk range (1×10^{-6}) for one or more exposure scenarios for the following media: surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), and soil vapor. The primary COCs for the Area II Landfill are BaP, PCBs, and dioxins/furans in soil and benzene in soil vapor. BaP and PCBs in surface soil (0 to 2 ft bgs) exceed the lower end of the regulatory risk range (1×10^{-6}) for the residential scenario. BaP in surface soil (0 to 2 ft bgs) exceeds the lower end of the regulatory risk range (1×10^{-6}) for the recreational and industrial worker scenarios. The ELCR for the residential plant consumption pathway exceeds the upper end of the regulatory risk range (1×10^{-4}) and the HI for the residential plant consumption pathway exceeds the regulatory threshold of 1. PCBs, BEHP, di-n-butyl phthalate, dioxins/furans, and PAHs in soil (0 to 2 ft bgs) are identified as COCs for the residential plant consumption exposure scenario. BaP, dioxins/ furans, and PCBs in soil (0 to 10 ft bgs) exceed the lower end of the regulatory risk range for the residential exposure scenario. BaP in subsurface soil (0 to 10 ft bgs) exceeds the lower end of the regulatory risk range (1×10^{-6}) for the industrial worker exposure scenario. Benzene in soil vapor exceeds the lower end of the regulatory risk range (1×10^{-6}) for residential and industrial worker exposure pathways.

7.2.3 Ash Pile and STP

On the basis of the results of the HHRA, the Ash Pile and STP require further evaluation in the CMS. The primary COCs for the Ash Pile and STP are dioxins/furans, PAHs, PCBs, and barium in soil; PCE and cis-1,2-DCE in soil vapor; and arsenic and TCE in groundwater. The total ELCR exceeds the lower end of the regulatory risk range (1×10^{-6}) for one or more exposure scenarios for the following media: surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), and soil vapor. The total ELCR for groundwater exceeds the upper end of the regulatory risk range (1×10^{-4}). The HI for soil (0 to 2 ft bgs) for the plant consumption pathway and the HI for groundwater both exceed the regulatory HI threshold of 1. Dioxins/furans, PAHs, PCBs, methylene chloride, and 1-methylnaphthalene in surface soil (0 to 2 ft bgs) exceed the lower end of the regulatory risk range for the plant consumption exposure pathway. Barium in soil (0 to 2 ft bgs) exceeds the target HI of 1 for the plant consumption pathway. Dioxins/furans in subsurface soil (0 to 10 ft bgs) exceed the lower end of the regulatory risk range for the residential exposure scenario. PCE and TCE in soil vapor exceed the lower end of the regulatory risk range (1×10^{-6}) for the residential and industrial worker exposure scenarios.

The ELCR for groundwater exceeds the upper end of the regulatory risk range (1×10^{-4}) for the residential exposure scenario. The carcinogenic COCs in groundwater include arsenic, methylene chloride, TCE, and VC. The total HI for groundwater exceeds the regulatory threshold value of 1 for the residential exposure scenario. The noncarcinogenic COCs identified for the groundwater residential exposure scenario include 1,2-DCE, TCE, methylene chloride, VC, and seven inorganics (aluminum, antimony, arsenic, iron, manganese, vanadium, and cadmium).

7.2.4 ELV

The primary COCs for the ELV are dioxins/furans in soil and TCE in soil vapor.

On the basis of the results of the HHRA, the ELV requires further evaluation in the CMS. The total ELCR exceeds the lower end of the regulatory risk range (1×10^{-6}) for one or more exposure scenarios for surface soil (0 to 2 ft bgs) and subsurface soil (0 to 10 ft bgs). The total ELCR exceeds the upper end of the regulatory risk range (1×10^{-4}) for soil vapor. The total HI exceeds the regulatory threshold value of 1 for one or more exposure scenarios for the following media: surface soil (0 to 2 ft bgs) and subsurface soil (0 to 10 ft bgs) and soil vapor. The primary COCs for the ELV are dioxins/furans in soil and TCE in soil vapor. Dioxins/furans in surface soil (0 to 2 ft bgs) exceed the lower end of the regulatory risk range (1×10^{-6}) for the residential, recreational, and industrial worker exposure scenarios. The HI for dioxins/furans in surface soil (0 to 2 ft bgs) exceeds the regulatory threshold of 1. The ELCR for dioxins/furans in soil (0 to 2 ft bgs) exceeds the upper end of the regulatory risk range (1×10^{-4}) for the plant consumption exposure pathway. The HI for dioxins/furans in surface soil (0 to 2 ft bgs) also exceeds the regulatory threshold of 1 for the plant consumption pathway. Dioxins furans in soil (0 to 10 ft bgs) exceed the lower end of the regulatory risk range (1×10^{-6}) and exceed the regulatory HI threshold of 1. The ELCR for TCE in soil vapor exceeds the upper end of the regulatory risk range (1×10^{-4}) for the residential and industrial worker scenarios and the lower end of the regulatory risk range (1×10^{-6}) for the recreational scenario. TCE in soil vapor also exceeds the regulatory HI threshold of 1 for the residential scenario.

7.3 Ecological Risk Summary and COCs by Media

A combination of literature-based and site-specific data were used to evaluate risks to ecological receptors at the four sites located in Group 2. Because no aquatic habitat is present at any site in Group 2, only terrestrial receptors were evaluated. Receptor groups included terrestrial plants (evaluated quantitatively if field observations indicated the presence of stressed plants), soil invertebrates, birds (hermit thrush and red-tailed hawks), and mammals (deer mouse, bobcat, and mule deer). All receptor groups were evaluated based on direct or indirect (through food-web transfer) exposure to soil. In addition, inhalation exposure of deer mice (as a representative burrowing animal) to contaminants in soil vapor was evaluated. The results of the ecological risk evaluation for Group 2 are summarized in Table 7.3-1.

Initial screens identified several metals (barium, chromium, mercury, silver, vanadium, and zinc), several PAHs (BAA, BaP, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene), two phthalates (di-n-butyl and bis(2-ethylhexyl)), dioxin/furan and PCB congeners, and hexachlorobenzene as potential risk drivers in soil (Table 7.3-1). Eleven VOCs (1,1,2-TCA, CTC, chloroform, cis-1,2-DCE, methylene chloride, n-propylbenzene, PCE, toluene, trans-1,2-DCE, TCE, and VC) were identified as potential risk drivers in soil vapor. This initial list of analytes was reduced through consideration of detection limits, frequency and magnitude of TRV exceedances, refined exposure estimates, and incremental risks relative to background (for inorganics only). At the conclusion of the refinements to the risk evaluations at each site, significant risk drivers (those that present unacceptable risks) were reduced to barium,

mercury, dioxin/furan and PCB congeners, and phthalates in soil, and 10 VOCs in soil gas. These significant risk drivers should be carried forward for additional evaluation as part of the CMS.

All four Group 2 RFI sites had unacceptable risks identified for at least one receptor from at least one COC. Unacceptable risks from barium in soil to hermit thrush and deer mice were identified at the LOX and Ash Pile and STP sites. Dioxin/furan and PCB congeners in soil present a risk to hermit thrush at the landfill and ELV sites; dioxin/furan and PCB congeners in soil also present a risk to deer mice at the ELV site. Phthalates (di-n-butyl and bis(2-ethylhexyl)) in soil present a risk to hermit thrush at the landfill site. Plants at the ELV site are at risk for mercury in soil. Only two sites, the LOX and ELV sites, had significant risks from VOCs in soil vapor. Whereas 10 VOCs present risks at the LOX site, only TCE presents a significant inhalation risk at the ELV site.

7.4 Cross Media Transfer

Cross media transfer in SMOU groundwater in the Group 2 RFI study area probably occurs at the Building 515 STP SWMU in the RD-9 area. At this location, contaminated groundwater in the CFOU is connected hydraulically to the SMOU groundwater, present mainly in the weathered bedrock interval. Upward gradients were measured in the upper CFOU in Corehole C-7, which is situated near the steeply sloping hillside on the southern boundary of the ELV. The shallow 100-foot-depth interval where nearly all of the TCE mass resides in C-7 is proximal to the affected groundwater present in the weathered bedrock interval near the Building 515 STP SWMU (Figure 4.3.2-5).

7.5 CMS Recommendations for Group 2

On the basis of the evaluations presented in this document and the risk summaries presented in Sections 7.2 and 7.3, further sampling is recommended in the CMS evaluations for all five locations to further evaluate the extent of contamination, as well as the human health and ecological risk factors.

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