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Prepared by
Ramboll
Emeryville, California

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BASELINE HEALTH RISK ASSESSMENT WORK PLAN FOR OU-1 AND OU-2 SOIL GAS AND GROUNDWATER, REVISION 1

NEVADA ENVIRONMENTAL RESPONSE TRUST SITE HENDERSON, NEVADA

RAMBOLL

Baseline Health Risk Assessment Work Plan for OU-1 and OU-2 Soil Gas and Groundwater, Revision 1

Nevada Environmental Response Trust
(Former Tronox LLC Site)
Henderson, Nevada

Nevada Environmental Response Trust (Trust) Representative Certification

I certify that this document and all attachments submitted to the Division were prepared at the request of, or under the direction or supervision of the Trust. Based on my own involvement and/or my inquiry of the person or persons who manage the system(s) or those directly responsible for gathering the information or preparing the document, or the immediate supervisor of such person(s), the information submitted and provided herein is, to the best of my knowledge and belief, true, accurate, and complete in all material respects.

Office of the Nevada Environmental Response Trust

Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee not individually, but solely as President

Signature: Jay A Steinberg, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Name: Jay A. Steinberg, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Title: Solely as President and not individually

Company: Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Date: 12/18/18

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(Former Tronox LLC Site)
Henderson, Nevada

Responsible Certified Environmental Manager (CEM) for this project

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and, to the best of my knowledge, comply with all applicable federal, state and local statutes, regulations and ordinances.

__________________________________ December 18, 2018

John M. Pekala, PG **Date**
Principal

Certified Environmental Manager
Ramboll US Corporation
CEM Certificate Number: 2347
CEM Expiration Date: September 20, 2020

The following individuals provided input to this document:

John M. Pekala, PG
Allan J. DeLorme, PE
Jessica E. Donovan, PG
Elizabeth Miesner, MS
Christopher M. Stubbs, PhD, PE
Kun Zhao, MS
Alexander E Marr, PG
Shuo Yu, PhD
Yuan Zhuang, PhD
Kimberly Souder, PhD
Jonathan Hunt, PhD
Peyton Ward, MEM
Ruben So

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Ramboll
2200 Powell Street
Suite 700
Emeryville, CA 94608
USA

T +1 510 655 7400
F +1 510 655 9517
http://www.ramboll.com/

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ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
AP	Ammonium Perchlorate
API	American Petroleum Institute
atm	atmosphere
ATSDR	Agency for Toxic Substances & Disease Registry
BCL	basic comparison level
bgs	below ground surface
BHRA	baseline health risk assessment
BMI	Black Mountain Industrial
BRC	Basic Remediation Company LLC
Cal/EPA	California Environmental Protection Agency
CFR	Code of Federal Regulations
cm	centimeter
COPC	Chemical(s) of potential concern
CSM	conceptual site model
DUE	data usability evaluation
DVSR	data validation summary report
ENSR	ENSR Corporation
ENVIRON	Environ International Corporation
EPC	exposure point concentration
Exponent	Exponent, Inc.
ft	feet
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HRA	health risk assessment
IF	intake factor
IRIS	Integrated Risk Information System
ITRC	Interstate Technology Regulatory Council
IUR	inhalation unit risk
IWF	interceptor well field

Kerr-McGee	Kerr-McGee Chemical Corporation
L	liter
LOU	Letter of Understanding
m^3	cubic meter
mm Hg	millimeter of mercury
mol	mole
mph	mile per hour
MRL	minimal risk level
NCP	National Contingency Plan
NDEP	Nevada Division of Environmental Protection
NFA	No Further Action
NERT	Nevada Environmental Response Trust
Northgate	Northgate Environmental Management, Inc.
OEHHA	Office of Environmental Health Hazard Assessment
Operations Area	the area comprising the Site, excluding Parcels C, D, E, F, G, and H
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU-1	Operable Unit 1
OU-2	Operable Unit 2
OU-3	Operable Unit 3
PPRTV	Provisional Peer Reviewed Toxicity Values
Q/C	site-specific dispersion factor
Qal	quaternary alluvial deposit
Ramboll	Ramboll US Corporation
Ramboll Environ	Ramboll Environ US Corporation
RfC	reference concentration
RI/FS	remedial investigation/feasibility study
RSL	regional screening level
Site	Nevada Environmental Response Trust Site
Tronox	Tronox, LLC
Trust	Nevada Environmental Response Trust
µg	microgram
UMCf	Upper Muddy Creek Formation

USEPA	United States Environmental Protection Agency
VER	vacuum enhanced recovery
VOC	volatile organic compound

1. INTRODUCTION

This Soil Gas and Groundwater Baseline Health Risk Assessment (BHRA) Work Plan has been prepared by Ramboll US Corporation (Ramboll) on behalf of the Nevada Environmental Response Trust (NERT or the Trust) for Operable Unit 1 (OU-1) and the portion of the NERT Off-Site Study Area in Operable Unit 2 (OU-2).

The NERT Site ("Site") comprises 346 acres and has been designated as OU-1 for the Remedial Investigation and Feasibility Study (RI/FS) currently in progress (Figures 1-1 and 1-2). Within OU-1, the Operations Area[1] is a 259-acre area used by the Trust and their tenant, Tronox, LLC (Tronox), for site operations. Tronox currently leases approximately 114 acres within the Operations Area, on which it operates a chemical manufacturing business; two subtenants to Tronox (Angelo & Newton and Industrial Supply) also have facilities within the Operations Area (Figure 1-3). The Operations Area excludes six parcels owned by the Trust (Parcels C, D, E, F, G, and H, comprising 87 acres) that are not currently used by the Trust or Tronox and have been evaluated outside of the RI/FS. Separate post-remediation health risk assessments (HRAs) for Parcels C, D, F, G and H have been completed in late 2017 and early 2018. The Trust reviewed information on the historical use of Parcel E, and submitted a sampling plan as the *RI Phase 2 Modification No. 12* (Ramboll 2018a), approved by Nevada Division of Environmental Protection (NDEP) on July 19, 2018, to investigate soil, soil gas, and groundwater in Parcel E. A separate HRA will be performed for Parcel E since this parcel is not contiguous with the Operations Area. Therefore, the Operations Area is designated as the Study Area for the OU-1 soil gas and groundwater BHRA. Ultimately both the Operations Area and Parcel E will be evaluated in the FS.

OU-2 comprises the Eastside Sub-Area to the east of Pabco Road and the southern portion of the NERT Off-Site Study Area to the west of Pabco Road and is bordered to the south by Warm Springs Road, and to the north by the mid-plume containment boundary line[2], including areas previously owned by Tronox or the Trust, referred to as Parcels A, B, I, and J in the southwestern portion of OU-2 (Figures 1-1 and 1-4). The NERT Off-Site Study Area in OU-2 is primarily residential housing, known as the Pittman Neighborhood, with commercial operations adjacent to major roadways. Parcels A and B were sold in 2013, and Parcels I and J were sold in 2008[3]. These parcels now represent neighboring properties to the north of the NERT Site (Figure 1-4). NDEP has determined no further action (NFA) or remediation is required for Parcels A and B for both soil direct contact (NDEP 2008a) and the vapor intrusion pathway (NDEP 2013). Parcel I has received the NFA determination for the top 10

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[1] The Operations Area is equivalent to the area referred to as the "Facility Area" in previous reports (with the exception of Parcel E, previously considered as part of the Facility Area for risk assessment purposes). These reports include, e.g., the *Remedial Investigation and Feasibility Study Work Plan* (ENVIRON 2014a) and the associated risk assessment work plan and report (ENVIRON 2014b, Ramboll US Corporation [Ramboll Environ] 2015).

[2] The mid-plume containment boundary line is the boundary between OU-2 and OU-3 and represents the Remedial Action Objective (RAO) for OU-2 of mid-plume containment and mass removal.

[3] According to assessor's office records from Clark County, Parcels A and B were sold by the Trust to Treco LLC on December 4, 2013; Parcel I was sold by Tronox to Rolly Properties LLC on June 27, 2008; Parcel J was sold by Tronox to Ellis Living Trust on January 31, 2008. Clark County Assessor's Office Open Web Mapping Applications. Accessed May 9, 2018. http://www.clarkcountynv.gov/gis/services/Pages/OpenWeb.aspx.

feet of soil but not for the vapor intrusion pathways through groundwater or soil gas (NDEP 2009). Parcel J has not received an NFA determination to date.[4]

The Eastside Sub-Area is approximately 1,983 acres and located east of Pabco Road, west of Lake Mead Parkway, northeast of N. Boulder Highway, and south of Galleria Drive (Figure 1-1). Much of the Eastside Sub-Area is currently vacant, although the majority of the Eastside Sub-Area is being redeveloped as a mixed-use, master-planned community named Cadence[5]. Home building has taken place on the eastern portion of this area with development anticipated to proceed toward the west. The southern portion of the Eastside Sub-Area is currently occupied by a number of commercial businesses. Since 2008, the Eastside Sub-Area has been remediated by Basic Remediation Company LLC (BRC) under the oversight of NDEP. The clean-up of the impacted areas was completed in 2015. As each section of this area was remediated, HRAs and closure reports were prepared (BRC 2011a, 2011b and 2011c) and NFAs were prepared that describe that any remaining shallow soil contamination is minimal and does not pose unacceptable risks for the intended residential use. Figure 1-5 highlights the areas within OU-2 that received NFAs. NDEP's NFA determinations were restricted to the upper 10 feet of the soil horizon and were consistent with proposed future land uses (BRC 2014). As the surface soils have been remediated within the Eastside Sub-Area, NDEP's NFA determinations and closure documentation are sufficient to conclude that no additional evaluation is warranted for the Eastside Sub-Area.

As noted in the *Remedial Investigation and Feasibility Study Work Plan* (RI/FS Work Plan) (ENVIRON 2014a), businesses and residences located within or downgradient of the Site are connected to a municipal water supply. NDEP has conducted a survey of identified private well owners in the area downgradient of the Site to confirm that the wells are no longer present, and none were identified. Based on the available information, groundwater is not currently used as a source of drinking water, and given the high concentrations of TDS, will not be used in the future as a drinking water source.

As NERT is only responsible for chemical impacts associated with perchlorate and chlorate in groundwater in the Eastside Sub-Area, and these chemicals are not volatile and groundwater is deeper than 20 feet, there are no completed pathways for groundwater or soil gas exposure in the Eastside Sub-Area. Therefore, the BHRA for OU-2 will focus on the portion of the NERT Off-Site Study Area located to the west of Pabco Road in OU-2, and will exclude the Eastside Sub-Area. In addition, Parcels A and B within the NERT Off-Site Study Area will also be excluded from the BHRA for OU-2 since these parcels have received NFA determinations from NDEP for soils less than 10 feet below ground surface (bgs) based on health risk assessments performed for soil direct contact and vapor intrusion pathways and no longer need to be evaluated.

A separate BHRA report will be prepared for OU-3 (Northeast Area, the Downgradient Study Area, and the portion of the NERT Off-Site Study Area north of the mid-plume containment boundary line) (Figure 1-1). The OU-3 BHRA is expected to address the potential migration of Site-related chemicals in groundwater to surface water at Las Vegas Wash, which flows into Lake Mead and is a source of drinking water. The OU-3 BHRA Work Plan is anticipated to

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[4] Based on email communication with NDEP on May 15, 2018 (NDEP 2018a), Parcel J was sold but NDEP does not have additional information about it. Assuming Parcel J has not received its NFA determination to date, this parcel will be included in the soil gas and groundwater evaluations for the vapor intrusion pathways in the BHRA for OU-2.
[5] Developer map of the Eastside Sub-Area: http://cadencenv.com/builders/

be submitted to NDEP in the second quarter of 2019 and the OU-3 BHRA report is anticipated to be submitted to NDEP in 2020.

1.1 Scope of BHRA

The NERT Site has been the subject of extensive environmental investigations since the 1970s, during which time HRAs have been prepared for specific subareas of the NERT Site to evaluate potential risks associated with soil and soil gas exposure pathways. In 2010, Northgate Environmental Management, Inc. (Northgate) and Exponent, Inc. (Exponent) prepared a HRA Work Plan (the 2010 HRA Work Plan) that described the risk assessment methodology for evaluating soil and soil gas exposure pathways in future HRAs prepared for the NERT Site (Northgate and Exponent 2010a). The 2010 HRA Work Plan was approved by NDEP on March 16, 2010 (NDEP 2010a).

Northgate and Exponent (2010b) conducted a Site-Wide Soil Gas Human Health Risk Assessment (2010 Site-Wide Soil Gas HRA), which evaluated the soil gas samples collected in May 2008 during the Phase B soil gas investigation (ENSR Corporation [ENSR] 2008a), but this HRA was not submitted to or reviewed by NDEP.

In 2014, a separate BHRA Work Plan (2014 BHRA Work Plan) was prepared by ENVIRON International Corporation (ENVIRON) as part of the RI/FS Work Plan, which incorporated all relevant elements from the 2010 HRA Work Plan, updated background information at the Site, and presented preliminary summary statistics for the soil and soil gas data sets representative of current conditions and available for the BHRA (ENVIRON 2014b). In addition, the conceptual site model (CSM) (ENSR 2005) was significantly revised in the 2014 BHRA Work Plan to identify additional transport pathways, evaluate off-Site populations in the downgradient groundwater Study Area (not previously included in the 2010 HRA Work Plan), and consider interim soil removal actions that have been completed since 2010.

In 2017, the RI Study Area has been expanded and divided into three OUs via the *2017 RI/FS Work Plan Addendum, Phase 3 RI, Revision 1* (Ramboll Environ 2017a), and separate BHRAs will be conducted for each OU.

For this BHRA Work Plan and with respect to the Operations Area in OU-1, the focus is evaluating potential risks associated with the vapor intrusion pathway from soil gas and groundwater. The BHRA for the Operations Area in OU-1 will update the draft 2010 Site-Wide Soil Gas HRA for consistency with current risk assessment guidance, and groundwater data will also be incorporated in the BHRA to provide an additional line of evidence for the vapor intrusion risk analysis. Complete, direct contact exposure pathways for surface and near surface soils have also been identified in the Operations Area of OU-1. However, as noted above, the BHRA discussed in this work plan will only focus on evaluating potential risks associated with the vapor intrusion pathway. In accordance with the 2014 BHRA Work Plan (ENVIRON 2014b) and the *Identification of COPCs and Decision Units for OU-1 Soils, Revision 1* (2017 interim COPC/DU report) (Ramboll Environ 2017b), a separate BHRA report for soils in the Operations Area in OU-1 is currently being prepared, and will be submitted to NDEP in early 2019. Complete, direct contact pathways have not been identified for groundwater, which is not used as a source of drinking water at the NERT Site.

For this BHRA Work Plan and with respect to the NERT Off-Site Study Area in OU-2, the potential exposure pathway of concern is vapor migration from soil gas and groundwater to ambient or indoor air. Complete, direct contact pathways have not been identified for groundwater, which is not used as a source of drinking water in the NERT Off-Site Study

Area in OU-2. The BHRA for the NERT Off-Site Study Area in OU-2 discussed in this work plan will focus on evaluating potential risks associated with the vapor intrusion pathway using soil gas and shallow groundwater data representative of the current conditions in this area. The BHRA for the NERT Off-Site Study Area in OU-2 will be conducted in accordance with current risk assessment guidance, and incorporate additional recent soil gas and groundwater data from RI Phase 2 and annual groundwater sampling in 2018 to provide multiple lines of evidence for the vapor intrusion risk analysis.

Leaching of soil contaminants to groundwater is being addressed as a separate evaluation within the RI/FS process, i.e. in the forthcoming OU-1/OU-2 RI report anticipated to be submitted to NDEP in the first quarter of 2019. The *2017 RI/FS Work Plan Addendum, Phase 3 RI, Revision 1* (Ramboll Environ 2017a) has established a long-term RAO to mitigate discharge of chemicals of potential concern (COPCs) in groundwater to the Las Vegas Wash (part of OU-3).

1.2 Work Plan Organization

The remainder of this work plan is organized as follows:

- Section 2 OU-1 and OU-2 Overview: provides an overview of OU-1 and OU-2, including background, climate, and geologic and hydrogeological setting.
- Section 3 Environmental Investigations: summarizes the environmental investigations of soil gas and groundwater conducted within the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2.
- Section 4 Risk Assessment Data Sets and Data Usability Evaluation: describes the sources and types of soil gas and groundwater data that will be considered in the BHRAs, as well as the data usability evaluation (DUE) process.
- Section 5 Risk Assesment Methodology: presents the methodology from each of the four steps of the risk assessment, i.e., 1) identification of COPCs, 2) exposure assessment, 3) toxicity assessment, and 4) risk characterization.
- Section 6 Schedule: provides the schedules for implementing the BHRAs for soil gas and groundwater.
- Section 7 References: lists the references cited in this work plan.

Supporting tables, figures, and appendices follow the text of the work plan.

2. OU-1 AND OU-2 OVERVIEW

The following sections provide an overview of the background, climate, geologic and hydrogeological setting in OU-1 and the NERT Off-Site Study Area in OU-2, and briefly describe environmental investigations of soil gas and groundwater conducted since the 2005 CSM (ENSR 2005) in these two Study Areas.

2.1 Background

The 346-acre NERT Site is located in an unincorporated area of Clark County, Nevada, within Sections 1, 12, and 13 of Township 22 S, Range 62 E (Figure 1-1). The NERT Site is located within the Black Mountain Industrial (BMI) complex, which consists of several facilities that are owned and/or operated by various chemical companies. The City of Henderson surrounds the BMI complex. Tronox currently leases a portion of the NERT Site from the Trust, on which it operates a chemical manufacturing facility.

The BMI complex including the NERT Site has a long, complex ownership and operational history. The BMI complex was first developed by the U.S. government in 1942 as a magnesium plant for World War II operations. Following the war, the NERT Site continued to be the location of industrial activities, including production of perchlorates, boron, and manganese compounds. Former industrial and waste management activities conducted at the NERT Site, as well as those conducted at adjacent properties, resulted in contamination of environmental media at the NERT Site, including soil, groundwater, and surface water.

The NERT Site, including the Operations Area, has been the subject of extensive environmental investigations and removal actions since the 1970s. In 1994, NDEP issued a Letter of Understanding (LOU) identifying 69 specific areas or items of interest at the NERT Site and the level of environmental investigation required for each LOU (NDEP 1994). The LOUs for the NERT Site (NDEP 1994) are shown in Figure 2-1. In 2005, a CSM Report was prepared for the NERT Site that integrated information from the soil and groundwater investigations conducted to date in order to document information on Site-specific sources, release mechanisms, transport pathways, exposure routes, and potentially exposed populations (ENSR 2005). Historical site investigations conducted since completion of the 2005 CSM Report include primarily the Phase A and Phase B Source Area Investigations, which were designed to further characterize soil, groundwater, and soil gas across the NERT Site, as described in the RI/FS Work Plan (ENVIRON 2014a). Tronox continued field investigation and remediation efforts at the NERT Site until February 14, 2011, on which date the Trust took title to the NERT Site and assumed responsibility for all investigation and removal activities pursuant to an Interim Consent Agreement with NDEP. The recent environmental investigations conducted by the Trust at the NERT Site are detailed in Section 3.

OU-2 comprises the Eastside Sub-Area to the east of Pabco Road and the southern portion of the NERT Off-Site Study Area to the west of Pabco Road and is bordered to the south by Warm Springs Road, and to the north by the mid-plume containment boundary line[6], including areas referred to as Parcels A, B, I, and J at the southwestern portion of OU-2 and now represent neighboring properties to the north of the NERT Site (Figures 1-

[6] The mid-plume containment boundary line is the boundary between OU-2 and OU-3 and represents the RAO for OU-2 of mid-plume containment and mass removal.

1 and 1-4). The southern portion of the NERT Off-Site Study Area has been the subject of subsurface investigations related to the downgradient migration of groundwater contaminants originating from the NERT Site (OU-1), but was mostly vacant by the early 1950s with scattered structures located north and south of what is now North Boulder Highway. By the early 1980s, much of the western portion of OU-2 had been developed with a combination of commercial and residential structures. The portion of OU-2 located west of Pabco Road continues to be used primarily for residential housing, known as the Pittman Neighborhood, with commercial operations adjacent to major roadways.

2.2 Climate

The climate of Las Vegas Valley is arid, consisting of mild winters and dry, hot summers. Average annual precipitation as measured in Las Vegas from 1971 to 2000 was 4.49 inches (ENVIRON 2014a). Precipitation generally occurs during two periods, December through March and July through September. Winter storms generally produce low intensity rainfall over a large area. Summer storms generally produce high intensity rainfall over a smaller area for a short duration. The violent summer thunderstorms account for most of the documented floods in the Las Vegas area. Winds frequently blow from the south or northwest at a mean velocity of approximately nine miles per hour (mph); however, velocities in excess of 50 mph are not atypical when weather fronts move through the area. During these windy events, dust, sand, and soil at the ground surface can become airborne and may travel several miles. Temperatures can rise to 120°F in the summer, and the average relative humidity is approximately 20% (Schevenell 1996).

2.3 Geologic and Hydrogeological Setting

OU-1 and OU-2, as part of the NERT RI Study Area, are located within Las Vegas Valley, which occupies a topographic and structural basin trending northwest-southeast and extending approximately 55 miles from near Indian Springs on the north to Railroad Pass on the south. The valley is bounded by the Las Vegas Range, Sheep Range, and Desert Range to the north, by the Frenchman and Sunrise Mountains to the east, by the McCullough Range and River Mountains to the south and southeast, and by the Spring Mountains to the west. The mountain ranges bounding the east, north, and west sides of the valley consist primarily of Paleozoic and Mesozoic sedimentary rocks (limestones, sandstones, siltstones, and fanglomerates), whereas the mountains on the south and southeast consist primarily of Tertiary volcanic rocks (basalts, rhyolites, andesites, and related rocks) that overlie Precambrian metamorphic and granitic rocks (ENSR 2007).

OU-1 and OU-2 are located on Quaternary alluvial deposits (Qal) that slope north toward Las Vegas Wash. The thickness of the alluvial deposits ranges from less than one foot to more than 50 feet (ft) beneath OU-1. Soil types identified in on-Site soil borings include poorly sorted gravel, silty gravel, poorly sorted sand, well sorted sand, and silty sand (ENSR 2005). The Upper Muddy Creek Formation (UMCf) of Pleistocene age occurs in Las Vegas Valley as valley-fill deposits that are coarse-grained near mountain fronts and become progressively finer-grained toward the center of the valley. Where encountered beneath the NERT Site, the UMCf is composed of at least two thicker units of fine-grained sediments of clay and silt (the first and second fine-grained facies, respectively) interbedded with at least two thinner units of coarse-grained sediments of sand, silt, and gravel (the first and second coarse-grained facies, respectively) (ENSR 2005). Within the NERT Off-Site Study Area to the north, topographic elevations range from 1,701 to 1,535 ft above mean sea level (amsl). The topographic surface continues at approximately the same gradient as within the NERT Site to approximately Sunset Road, at which point it flattens to a gradient of approximately 0.01 ft/ft to the Las Vegas Wash.

Across the Operations Area in OU-1, the depth to groundwater ranges from approximately 20 to 60 ft bgs, with the majority of the samples between 30 and 50 ft bgs. Groundwater is generally deepest in the southernmost portion of the NERT Site. In the NERT Off-Site Study Area in OU-2, the depth to groundwater ranges from approximately 15 to 70 ft bgs, with the majority of the samples between 25 and 50 ft bgs. Groundwater is generally deepest in the southernmost portion of this area. The groundwater flow direction at the NERT Site is generally north to north-northwesterly, whereas north of the Site, the direction changes slightly to the north-northeast in the NERT Off-Site Study Area in OU-2 (ENVIRON 2014a).

A major feature of the alluvial deposits is the stream-deposited sands and gravels that were laid down within paleochannels that were eroded into the surface of the UMCf during infrequent flood runoff periods. These deposits are thickest within the paleochannel boundaries, which are narrow and linear and trend northeastward. The paleochannels act as preferential pathways for groundwater flow, which may significantly influence the chemical distribution in the alluvium (ENSR 2005). Additional details on the regional and local geology and hydrogeology, including information on the water-bearing zones, are provided in the RI/FS Work Plan (ENVIRON 2014a) and will be summarized in the forthcoming RI report for OU-1 and OU-2.

As shown on Figure 1-3, an extraction well field, referred to as the interceptor well field (IWF), and groundwater barrier wall are present at the NERT Site. The groundwater barrier wall was constructed in 2001 as a physical barrier across the higher concentration portion of an existing perchlorate/chromium plume. The IWF generally captures groundwater with higher contaminant concentrations and is located downgradient of on-Site source areas. The interceptor wells and barrier wall have significantly decreased chemical concentrations in the Qal downgradient of the IWF (Ramboll Environ 2017c).

3. ENVIRONMENTAL INVESTIGATIONS

The BHRAs for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2 as outlined in this work plan will rely on soil gas investigations conducted since approximately 2006 and groundwater sampling results from the shallow monitoring wells (with top of well screens less than 60 ft bgs) collected within the past four years (2015-2018). Additional soil gas samples have also been proposed for collection as part of *Phase 2 RI Modification No. 11* (Ramboll 2018b), and will be incorporated into the soil gas data sets for the BHRAs. The major soil gas and groundwater investigations performed during these time periods are discussed below.

3.1 Soil Gas

The following sections present the soil gas investigations conducted in the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2 which will be used as the data sources for the BHRAs.

3.1.1 Phase B Soil Gas Investigation

In OU-1, the primary soil gas investigation is the Phase B soil gas investigation which was conducted in May 2008. Details of the soil gas sampling are provided in the *Phase B Source Area Investigation Soil Gas Survey Work Plan* (ENSR 2008a) and summarized in the draft 2010 Site Wide Soil Gas HRA (Northgate and Exponent (2010b). Soil gas sample locations were selected based on the following: 1) results of the Phase A investigation (ENSR 2007), which identified the presence of several volatile organic compounds (VOCs) in soil and/or groundwater samples collected at the NERT Site; 2) historic soil and groundwater data collected during investigations prior to 2006; and 3) an assessment of former chemical usage at the individual LOUs. A total of 18 LOUs were identified as potential sources of VOCs or in areas where VOCs had been detected in soil or groundwater (ENSR 2008a, see Figure 2-1):

- Former Hardesty Chemical Company site (LOU 4)
- On-site portion of the Beta Ditch, including small diversion ditches (LOU 5)
- Old P-2, Old P-3, and New P-2 Ponds, and Ponds S-1 and P-1 (LOUs 7, 8, 9, 13, and 14)
- Ammonium Perchlorate (AP) Ponds (AP-1 through AP-5) (LOUs 16, 17, 18, and 19)
- Former Truck Emptying/Dumping site (LOU 35)
- Satellite Accumulation Point/AP Maintenance Shop (LOU 39)
- Unit 4 Basement and Old Sodium Chlorate Plant Decommissioning (LOU 43)
- Diesel Storage Tank Area (LOU 45)
- AP Plant Area Change House/Laboratory Septic Tank (LOU 54)
- Acid Drain System (LOU 60)
- Former State Industries, including impoundments and catch basin (LOU 62)

A total of 91 soil gas samples were collected in 2008 at 73 locations within the Operations Area, most of which were collected at 5 ft bgs. Five samples were collected at 20 ft bgs at four locations in the vicinity of Unit 3, Unit 5, and Unit 6 (Northgate and

Exponent 2010b). In a July 18, 2007 conference call (NDEP 2007), NDEP and Tronox agreed that deeper soil gas samples would be collected from areas with higher chemical concentrations in groundwater, as well as from less impacted areas. Further, as specified in NDEP's March 26, 2008 approval (NDEP 2008b) of the Soil Gas Work Plan (ENSR 2008a), NDEP stated that samples in the vicinity of Unit 3 should be collected below the depth of the Unit 3 basement, which was occupied with engineering staff (Northgate and Exponent 2010b). Based on these discussions, 20 ft bgs samples were collected as follows: SG-41, near Unit 3; SG-36, near an area of higher chloroform concentrations in groundwater; and SG-37 and SG-38, near areas with relatively lower chloroform concentrations in groundwater (ENSR 2008a).

A total of 11 soil gas samples were collected in 2008 at 10 locations within the NERT Off-Site Area in OU-2 (excluding Parcel A), and all of which were collected at 5 ft bgs.

Analytical results for samples collected during the Phase B soil gas investigation were presented in a data validation summary report (DVSR) (ENSR 2008b) that was submitted to NDEP on October 13, 2008, and approved by NDEP on October 20, 2008.

3.1.2 Phase 1 RI

In accordance with the 2011 Interim Consent Agreement between the Trust and NDEP, the Trust is in the process of conducting a RI/FS. Per the RI/FS Work Plan (ENVIRON 2014a), Ramboll Environ collected soil gas samples as part of a Phase 1 RI data gap investigation (Phase 1 RI) in March 2015. As described in the *Phase 1 RI Field Sampling Plan* (ENVIRON 2014a) and the *Technical Memorandum of the RI Data Evaluation* (Ramboll Environ 2016a), soil gas samples were collected adjacent to the three chloroform assessment wells in OU-2 with the highest chloroform concentrations in the southern, central, and northern portions of the chloroform groundwater plume extending onto the NERT Off-Site Study Area of OU-2. As shown in Figure 3-1, soil gas sampling location RISG-1 is adjacent to well PC-67, RISG-2 is adjacent to well PC-24, and RISG-3 is adjacent to well PC-21A[7]. Soil gas samples were collected from depths of 5 ft and 13 ft at RISG-1 and from depths of 5 ft and 15 ft at RISG-2 and RISG-3 using temporary soil gas probes.

Analytical results for soil gas samples collected during the Phase 1 RI were presented in a DVSR (Ramboll Environ 2017d) that was submitted to NDEP on November 3, 2017, and approved by NDEP on January 25, 2018.

3.1.3 Phase 2 RI

Because groundwater is considered to be the primary source of VOCs in soil gas, review and identification of data gaps needs in the existing soil gas data sets was completed following further evaluation of VOC data in shallow groundwater in the Operations Area of OU-1 and the NERT Off-Site Study Area in OU-2. In the *Phase 2 RI Modification No. 11* (Ramboll 2018b), which was submitted on May 23, 2018 and approved by NDEP on June 21, 2018 (NDEP 2018b), Ramboll proposed soil gas sampling for VOCs at 17 locations identified in the Operations Area of OU-1 and 13 locations identified in the NERT Off-Site Study Area in OU-2, in response to NDEP comments received on July 13, 2016 (NDEP 2016a) on *the Technical Memorandum, Remedial Investigation Data Evaluation* (Ramboll Environ 2016a) and NDEP comments received on August 23, 2016 (NDEP 2016b) on the

[7] As shown on Figure 3-1, RISG-1, RISG-2, and RISG-3 will be re-sampled as proposed in the *Phase 2 RI Modification No. 11* (Ramboll 2018b).

NERT Response to NDEP Comments, Remedial Investigation Data Evaluation/Phase 2 Work Plan (Ramboll Environ 2016b). The proposed locations are shown in Figures 3-1 and 3-2.

In OU-1, the *Phase 2 RI Modification No. 11* proposed 17 soil gas sample locations (Figure 3-2) to evaluate areas where high chloroform concentrations were detected in the previous soil gas and/or groundwater sampling, and to obtain data at a deeper depth (15 ft bgs) consistent with current vapor intrusion guidance (United States Environmental Protection Agency [USEPA] 2015) recommending samples closer to the source (i.e., VOCs in groundwater).These 17 soil gas sample locations are summarized as below:

- Four proposed locations are within the main chloroform groundwater plume area in the western portion of the NERT Site, which will be sampled at both 5 and 15 ft bgs;
- One proposed location is to the north of the main chloroform groundwater plume and to the west of the GW-11 pond, which will be sampled at both 5 and 15 ft bgs;
- Two proposed locations are within the chloroform groundwater plume near the IWF, which will be sampled at both 5 and 15 ft bgs;
- Three proposed locations are in the central portion of the NERT Site with high previous soil gas chloroform concentrations located outside the main chloroform groundwater plume, which will be sampled at both 5 and 15 ft bgs;
- One proposed location is between the L'Hoist property and the Tronox Leach Plant, which will be sampled at both 5 and 15 ft bgs; and
- Six proposed locations are in the Unit 4 Building area, where no soil gas samples were collected during the Unit 4/5 Buildings Investigation. Two proposed locations are at the southern edge of the main chloroform plume area near the Unit 4 Building, which will be sampled at both 5 and 15 ft bgs. Four proposed locations are beneath the currently existing basement slab in the center of the Unit 4 Building with relatively higher concentrations of chloroform detected in grab groundwater samples (Tetra Tech 2017a), which will be sampled at approximately 15 ft bgs.

In OU-2, 13 soil gas sample locations have been proposed (Figure 3-1). Seven locations are proposed in the main chloroform groundwater plume area in the eastern portion of the NERT Off-Site Study Area in OU-2, and six locations are proposed to better understand the lateral extent of VOCs in soil gas to the west. These proposed soil gas locations will be sampled at 5 ft bgs, as well as at 15 ft bgs to obtain data at a deeper depth consistent with current vapor intrusion guidance (USEPA 2015) recommending samples closer to the source (i.e., VOCs in groundwater). In addition, to perform a more representative site-specific vapor intrusion modeling, soil physical properties, including soil classification (grain size distribution/Atterberg Limits), total organic carbon, bulk density, water content, and total porosity will be collected at 5 ft bgs, 10 ft bgs, and 15 ft bgs at all 13 proposed locations where the soil properties have not been collected previously[8] in the NERT Off-Study Area in OU-2 (Ramboll 2018b).

[8] Soil classification (grain size distribution/Atterberg Limits) and total organic carbon have previously been collected at PC-172 (co-located with RISG-4, at 13.5 ft bgs), PC-167 (co-located with RISG-7, at 11.0 ft bgs), and PC-166 (co-located with RISG-9, at 11.5 ft bgs) during the Phase 2 RI.

Each 5-foot sample location relative to infrastructure and soil cover in the immediate area of the sample will be documented and this information will be included in the forthcoming soil gas and groundwater BHRA reports for OU-1 and OU-2. VOCs in the soil gas samples will be analyzed using USEPA Method TO-15, as described in the RI/FS Work Plan (ENVIRON 2014a) and the NERT RI Quality Assurance Project Plan (Ramboll Environ 2017e). Data collected in this investigation will be used in the BHRAs for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2.

3.2 Groundwater Investigations

The following sections present the groundwater investigations conducted in the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2, which will be used as the data sources for the BHRAs.

3.2.1 Phase 1 RI

In accordance with the 2011 Interim Consent Agreement between the Trust and NDEP, the Trust is in the process of conducting a RI/FS. Per the RI/FS Work Plan (ENVIRON 2014a), Ramboll Environ conducted field work for a Phase 1 RI between October 2014 and May 2015. The Phase 1 RI was deemed necessary for areas that required further characterization to determine the nature and extent of COPCs in soil and groundwater. The Phase 1 RI for groundwater comprised new on-Site and off-Site monitoring well installations, collection of grab groundwater samples, slug tests, and sampling of existing groundwater monitoring wells.

The results of the Phase 1 RI were summarized in the *Technical Memorandum, Remedial Investigation Data Evaluation* (Ramboll Environ 2016a). Additional data gaps to be addressed in the Phase 2 RI Data Gap Investigation (Phase 2 RI) were identified in the same submittal. Analytical results for groundwater samples collected during the Phase 1 RI were presented in the DVSR (Ramboll 2018c) that was submitted to NDEP on June 22, 2018, and approved by NDEP on August 14, 2018.

In the Operations Area of OU-1, 76 groundwater samples were collected at 59 monitoring well locations shallower than 60 ft bgs during the Phase 1 RI, and the data for volatile compounds[9] from these shallow groundwater samples are included in the BHRA data set for the Operations Area in OU-1.

In the NERT Off-Site Study Area in OU-2 (excluding Parcel A), 13 groundwater samples (including two field duplicate samples) were collected at 11 groundwater well locations shallower than 60 ft bgs during the Phase 1 RI, and the data for volatile compounds from these shallow groundwater samples are included in the BHRA data set for the NERT Off-Site Study Area in OU-2.

3.2.2 Phase 2 RI

In accordance with the *Remedial Investigation Data Evaluation Technical Memorandum* (Ramboll Environ 2016a), the Trust implemented a second phase of remedial investigation (Phase 2 RI) from January to November 2017. Field work was conducted both at the NERT Site (OU-1) and within the NERT Off-Site Study Area (including part of OU-2 and OU-3). The primary purposes of the Phase 2 RI were to obtain data necessary

[9] Volatile compounds are identified using the following criteria consistent with USEPA (2018a): 1) vapor pressure greater than 1 millimeter of mercury (mm Hg) or 2) Henry's Law constant greater than 0.00001 atmosphere-cubic meter per mole (atm-m^3/mole).

to further understand the nature and extent of impacts to soil and groundwater and conduct feasibility study evaluations for the selection of the final remedy.

In the Operations Area of OU-1, new monitoring wells were installed as part of the Phase 2 RI in areas including 1) the downgradient NERT Site boundary, 2) between the IWF/barrier wall and the downgradient NERT Site boundary, 3) the central area of the NERT Site, 4) west of the GW-11 pond, and 5) upgradient of the IWF.

In the NERT Off-Site Study Area in OU-2, new monitoring wells were installed as part of the Phase 2 RI to further characterize the lateral and vertical extent of COPCs and chloroform in groundwater within the alluvium and underlying UMCf. Areas of investigation included Parcel A/B, the downgradient Pittman neighborhood, and the area between the Pittman neighborhood and the Seep Well Field.

All monitoring well installations were completed using rotary sonic drilling methods. Groundwater at each newly installed monitoring well was sampled twice, including during the initial round immediately following the well development and during the second round a couple of months after well development when groundwater conditions had stabilized. The groundwater was considered stabilized when the depth to groundwater was no longer recovering from pumping during well development and was consistent with the depth to groundwater in other comparable monitoring wells in the vicinity. In addition, existing monitoring wells in OU-1 and in the NERT Off-Site Study Area in OU-2 were sampled once during the Phase 2 RI.

Analytical results for groundwater samples collected during the Phase 2 RI will be presented in two DVSRs (separated by sampling dates) currently being prepared.

In the Operations Area of OU-1, 63 groundwater samples were collected at 39 monitoring wells shallower than 60 ft bgs during the Phase 2 RI, and the data for volatile compounds from these groundwater samples are included in the BHRA data set for the Operations Area in OU-1.

In the NERT Off-Site Study Area in OU-2 (excluding Parcel A[10]), 69 groundwater samples (including eight field duplicate samples) were collected at 31 monitoring wells shallower than 60 ft bgs during the Phase 2 RI, and the data for volatile compounds from these groundwater samples are included in the BHRA data set for the NERT Off-Site Study Area in OU-2.

3.2.3 Phase 3 RI

As discussed in the *RI/FS Work Plan Addendum: Phase 3 Remedial Investigation, Revision 1* (Ramboll Environ 2017a), submitted to NDEP on October 27, 2017 and approved by NDEP on November 8, 2017, the Trust implemented a third phase of remedial investigation (Phase 3 RI) within the Eastside Study Area (including the Eastside Sub-Area in OU-2 and Northeast Sub-Area in OU-3), located immediately east of the NERT Site and NERT Off-Site Study Area. The investigation was designed to determine the extent of COPC contamination originating from the NERT Site in the Eastside Study Area, to obtain data to support future feasibility study evaluations to address COPCs, and to assist in the selection of the final remedy for COPCs in the Eastside Study Area. The Phase 3 RI groundwater data collected in the Eastside Study

[10] Parcel B is adjacent to Parcel I and therefore the samples collected in Parcel B are included to support the evaluation for Parcel I.

Area will *not* be used in the BHRA since human health risks are not being evaluated in the Eastside Sub-Area due to NDEP's prior NFAs.

Aside from being incorporated into this BHRA work plan and the forthcoming BHRA reports, the results of the Phase 1, Phase 2, and Phase 3 RIs, along with the results of the Tetra Tech Unit 4/5 Buildings Investigation (see discussion below), will be incorporated into the RI report for OU-1 and OU-2 and a subsequent RI Report for OU-3.

3.2.4 Unit 4/5 Buildings Investigation

As part of the RI/FS, the *Unit 4 and 5 Buildings Investigation Work Plan* (Tetra Tech 2015) was submitted to NDEP on March 30, 2015 and approved by NDEP on April 13, 2015. The work plan documented the proposed environmental investigation in the area of the Unit 4 and 5 buildings located at the NERT Site. The work plan replaced Section 5.4.1.2 of the RI/FS Work Plan and included demolition of the Unit 4 building floor, construction of an access ramp, and an environmental investigation using conventional drilling techniques on the basement level of the building.

Fieldwork for the first mobilization was conducted in late 2015, and included advancing four boreholes and collecting discrete-depth grab groundwater samples from the four exterior corners of the Unit 4 cell floor. Fieldwork for the second mobilization was conducted from June 2016 to January 2017, and included advancing 69 boreholes and collecting discrete-depth grab groundwater samples at selected intervals throughout the area of the Unit 4 and 5 buildings. Since groundwater samples were only collected from temporary wells and adequate groundwater data from shallow groundwater monitoring wells are available in the area of Unit 4/5 Buildings, the data from these two mobilizations are not representative of long term groundwater concentrations and are therefore not included in the groundwater BHRA data set for the Operations Area in OU-1. Only groundwater data from permanent monitoring wells will be used for the vapor intrusion analysis. The analytical results for the temporary wells will be presented in the *Unit 4 and 5 Buildings Investigation Source Characterization Report* currently being prepared, which will be incorporated as an appendix to the forthcoming OU-1/OU-2 RI Report.

Fieldwork associated with the third mobilization was completed in December 2017. The third mobilization included installing 20 groundwater monitoring wells inside 13 boreholes at seven locations around the Unit 4 and Unit 5 buildings to confirm the results obtained from discrete-depth groundwater samples collected from temporary wells. (Tetra Tech 2015). Any applicable groundwater data collected at monitoring wells with top of well screens less than 60 ft bgs from the third mobilization will be included in the groundwater BHRA data set for the Operations Area in OU-1. The construction details and sampling data for all wells will be presented in the *Unit 4 and 5 Buildings Investigation Source Characterization Report* currently being prepared, which will be incorporated as an appendix to the forthcoming OU-1/OU-2 RI Report.

3.2.5 Annual Groundwater Monitoring

Monitoring for chloroform and other volatile compounds was first added to the groundwater monitoring program as part of the 2016 Groundwater Monitoring Optimization Plan (Ramboll Environ 2016c) after initial evaluations of Phase 1 RI data suggested that these chemicals were present at detectable levels throughout the NERT Site and the NERT Off-Site Study Area (Ramboll Environ 2016a). The *2016 Annual*

Remedial Performance Report for Chromium and Perchlorate (Ramboll Environ 2016d) detailed the results of groundwater sampling from the second half of 2015 through the first half of 2016, which was submitted to NDEP on October 31, 2016 and approved by NDEP on December 6, 2016. The analytical results for groundwater samples were also presented in the DVSR (Ramboll 2018d) submitted on June 20, 2018, and approved by NDEP on July 10, 2018. Groundwater samples collected in February and June 2016 were analyzed for volatile compounds.

Additional groundwater sampling for volatile compounds was also conducted in the third quarter of 2016 as part of the Phase 1 RI supplementary sampling event. The analytical results for groundwater samples collected during this sampling event were detailed in the *2017 Annual Remedial Performance Report for Chromium and Perchlorate* (Ramboll Environ 2017c), and were also presented in the DVSR (Ramboll Environ 2017f) submitted on July 26, 2017 and approved by NDEP on August 17, 2017. Groundwater samples collected in September 2016 were analyzed for volatile compounds.

Comprehensive groundwater sampling for volatile compounds has been conducted on an annual basis (usually in May every year) as part of the annual groundwater sampling event since 2017. The *2017 Annual Remedial Performance Report for Chromium and Perchlorate* (Ramboll Environ 2017c) detailed the results of groundwater sampling from the July 2016 through June 2017, which was submitted to NDEP on December 8, 2017 and approved by NDEP on February 6, 2018. The analytical results for groundwater samples collected during the first half of 2017 were also presented in the DVSR (Ramboll 2018e) submitted on February 13, 2018 and approved by NDEP on March 5, 2018. Groundwater samples collected in May and June 2017 were analyzed for volatile compounds.

In summary, in the Operations Area of OU-1, 85 groundwater samples were collected at 58 monitoring wells shallower than 60 ft bgs during the February 2016-June 2017 groundwater monitoring sampling events, and the data for volatile compounds from these groundwater samples are included in the groundwater BHRA data set for the Operations Area in OU-1. In the NERT Off-Site Study Area of OU-2 (excluding Parcel A), 74 groundwater samples were collected at 56 monitoring wells shallower than 60 ft bgs during the February 2016-June 2017 groundwater monitoring sampling events, and the data for volatile compounds from these groundwater samples are included in the groundwater BHRA data set for the NERT Off-Site Study Area for OU-2.

The results of groundwater sampling for volatile compounds conducted in May 2018 are presented in the *2018 Annual Remedial Performance Report for Chromium and Perchlorate* and the corresponding DVSR (Ramboll 2018f), which was submitted on November 9, 2018 and is currently under NDEP review. The data for volatile compounds from these groundwater samples will also be included in the groundwater BHRA data sets.

3.2.6 In-Situ Chromium Treatability Study

Tetra Tech performed field treatability studies on in-situ hexavalent chromium reduction in groundwater at the NERT Site in accordance with the *In-Situ Chromium Treatability Study Work Plan* (Tetra Tech 2016), approved by NDEP on June 28, 2016. Field work for the biological reduction study was conducted in the Central Retention Basin between November 2016 and October 2017; field work for the chemical reduction study was conducted in the AP Area Treatability Study area near the AP-5 Pond between August 2016 and October 2017. The primary purpose of the field treatability studies was to separately evaluate biological and chemical reduction of hexavalent chromium. Results of this study were described in the *In-Situ Chromium Treatability Study Results Report, Revision 1* (Tetra Tech 2018a) submitted to NDEP on June 22, 2018 and approved by NDEP on August 3, 2018, and also presented in the DVSR (Tetra Tech 2018b) submitted on August 29, 2018 and approved by NDEP on September 20, 2018.

Groundwater samples were collected from monitoring wells after development and prior to injection to establish baseline conditions at shallow and deep locations. A total of nine groundwater samples, including one field duplicate, were collected from four locations at 19 to 24 ft bgs for shallow monitoring wells and 34 to 54 ft bgs for deep monitoring wells, and were analyzed for volatile compounds. These monitoring well samples are included in the groundwater BHRA data set for the Operations Area in OU-1.

The chemical reduction study utilized injection and monitoring wells installed as part of the AP Area Treatability Study, including four triple cluster injection wells (12 borings in total) and three triple-nested monitoring wells (three borings in total) in each of two plots (a total of eight triple-cluster injection wells and six triple-nested monitoring wells). Groundwater samples were collected from monitoring wells to establish baseline conditions at shallow, intermediate, and deep depths. However, these samples were not analyzed for volatile compounds. Ten monitoring wells shallower than 60 ft bgs within the AP Area have been added to the 2018 groundwater monitoring program, and groundwater samples were collected and analyzed for volatile compounds. The data from these samples will be included in the groundwater BHRA data set for the Operations Area in OU-1.

3.2.7 Vacuum Enhanced Recovery Treatability Study

The *Vacuum Enhanced Recovery (VER) Treatability Study Work Plan for the NERT Site* (Tetra Tech 2017b) was submitted to NDEP on August 23, 2017 and approved by NDEP on September 18, 2017. The study objectives were to evaluate the extent to which vacuum-enhancement will improve groundwater recovery in the UMCf compared to conventional pumping and the extent to which operating deeper groundwater extraction wells close to the IWF may affect operation of the IWF. The VER Treatability Study area was located in the vicinity of the IWF within the former AP production area, on the upgradient side of the barrier wall.

Field activities for the VER Treatability Study were conducted from September 2017 to March 2018, which included drilling six soil borings within the study area to obtain lithologic information, physical parameters, and contaminant concentrations, collection of grab groundwater samples, and installation of two dual-cluster monitoring wells (one intermediate well at 55-70 ft bgs and one deep well at 90-110 ft bgs), one intermediate VER extraction well, and one deep VER extraction well at the locations of the six soil borings. Baseline groundwater sampling was conducted approximately one week after the completion of well development and included analysis for VOCs as well as other constituents and parameters. Results of this study were described in the *Vacuum Enhanced Recovery Treatability Study Results Report* (Tetra Tech 2018c) submitted to NDEP on July 12, 2018 and approved by NDEP on September 6, 2018, and also presented in the DVSR (Tetra Tech 2018d) submitted on October 15, 2018 and approved by NDEP on October 30, 2018. Baseline groundwater data for VOCs collected from the intermediate monitoring wells at 55-70 ft bgs will be included in the groundwater BHRA data set for the Operations Area in OU-1.

4. DATA COLLECTION/EVALUATION: RISK ASSESSMENT DATA SETS AND DATA USABILITY EVALUATION

This section describes the sources and types of data that will be considered in the soil gas and groundwater BHRAs for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2, as well as the DUE process. As part of the data collection and evaluation for the BHRA, relevant site data has been gathered from various site investigations as described in Section 3. For the BHRA data sets, the first component of the DUE focuses on the quality of each individual data point to ensure that only data of appropriate quality to meet the specific objectives of the DUE will be used in the BHRAs. The second component of the DUE, data analysis, focuses on the data set as a whole. The sources of BHRA data sets are described in Section 4.1, the DUE is discussed in Section 4.2, and the data analysis is discussed in Section 4.3.

4.1 BHRA Data Sets

4.1.1 Operations Area in OU-1

Soil Gas

The soil gas BHRA data set for the Operations Area in OU-1 comprises the analytical results that are representative of current conditions within the Operations Area. Specifically, the data set will include data for volatile compounds from soil gas samples collected at five and 20 ft bgs as part of the 2008 Phase B Soil Gas Investigation (which were also used in the draft 2010 Site-Wide Soil Gas HRA), as well as from soil gas samples proposed to be collected at 5 and 15 ft bgs in the *Phase 2 RI Modification No. 11* (Ramboll 2018b, these data are currently not available). In addition, the soil gas sample collected at 5 ft bgs at one location (E-SG-8) as part of the 2013 parcel investigation which was previously believed to be in Parcel G, is now considered to be within the Operations Area; this sample will also be included in the soil gas BHRA data set for the Operations Area in OU-1.

The preliminary soil gas BHRA data set for the Operations Area in OU-1 is presented in Appendix A, which includes 92 soil gas samples collected at five and 20 ft bgs from 74 locations. Soil gas sample locations in the Operations Area in OU-1 are shown on Figure 4-1. Additional soil gas samples proposed to be collected at 5 and 15 ft bgs from 17 locations within the Operations Area in the *Phase 2 RI Modification No. 11* will be included in the updated BHRA data set of the forthcoming soil gas and groundwater BHRA report for the Operations Area in OU-1.

Groundwater

The shallow groundwater BHRA data set for the Operations Area in OU-1 comprises the analytical results that are representative of current conditions within the Operations Area. Specifically, the data set will include data for volatile compounds from groundwater samples collected at shallow monitoring wells (less than 60 ft bgs) as part of the following groundwater investigations since 2015:

- 2015 Phase 1 RI[11]

[11] Phase 1 RI investigation started in 2014 but the groundwater sampling was conducted in 2015.

- 2017 Phase 2 RI
- 2016-2018 Annual Groundwater Monitoring
- 2017 In-Situ Chromium Treatability Study (baseline only)
- 2018 VER Treatability Study (baseline only)

The preliminary shallow groundwater BHRA data set for the Operations Area in OU-1 is presented in Appendix B, which includes 233 groundwater samples collected from 107 shallow monitoring wells. Shallow groundwater sample locations in the Operations Area in OU-1 are shown on Figure 4-2. Additional groundwater samples collected from shallow monitoring wells within the Operations Area during the most recent investigations (i.e., 2018 Annual Groundwater Monitoring, VER Treatability Study) will be included in the updated BHRA data set of the forthcoming soil gas and groundwater BHRA report for the Operation Area in OU-1 as available.

4.1.2 NERT Off-Site Study Area in OU-2

Soil Gas

The soil gas BHRA data set for the NERT Off-Site Study Area in OU-2 comprises the analytical results that are representative of current conditions within the NERT Off-Site Study Area in OU-2. Specifically, the data set will include data for VOCs from soil gas samples collected at three locations (RISG-1, RISG-2, and RISG-3, as shown on Figure 4-3) at depths of approximately five ft bgs and 15 feet ft bgs as part of the Phase 1 RI, as well as additional soil gas samples proposed to be collected at five and 15 ft bgs at 13 locations in the *Phase 2 RI Modification No. 11* (Ramboll 2018b, these data are currently not available).

The preliminary soil gas BHRA data set for the Off-Site Study Area in OU-2 is presented in Appendix C, which includes seven soil gas samples collected at approximately five and 15 ft bgs from three locations in the Phase 1 RI. Soil gas sample locations in the NERT Off-Site Study Area in OU-2 are shown on Figure 4-3. Additional soil gas samples proposed to be collected at five and 15 ft bgs from 13 locations (Figure 3-1) within the NERT Off-Site Study Area in the *Phase 2 RI Modification No. 11* will be included in the updated BHRA data set of the forthcoming OU-2 soil gas and groundwater BHRA report.

Groundwater

The shallow groundwater BHRA data for the NERT Off-Site Study Area in OU-2 comprises the analytical results that are representative of current conditions within this area. Specifically, the data set will include data for volatile compounds from groundwater samples collected at shallow monitoring wells (less than 60 ft bgs) as part of the following groundwater investigations since 2015:

- 2015 Phase 1 RI[12]
- 2017 Phase 2 RI
- 2016-2018 Annual Groundwater Monitoring

The preliminary shallow groundwater BHRA data for the NERT Off-Site Study Area in OU-2 is presented in Appendix D, which includes 186 groundwater samples collected from 75

[12] Phase 1 RI investigation started in 2014 but the groundwater sampling was conducted in 2015.

shallow monitoring wells. Groundwater sample locations in the NERT Off-Site Study Area in OU-2 are shown on Figure 4-4. Additional groundwater samples collected from shallow monitoring wells within the NERT Off-Site Study Area in OU-2 during the ongoing investigation (i.e., 2018 Annual Groundwater Monitoring) will be included in the updated BHRA data set of the forthcoming OU-2 soil gas and groundwater BHRA report.

4.2 Data Usability Evaluation

The primary objective of the DUE is to identify appropriate data for use in the BHRA. The DUE will be conducted in accordance with NDEP's *Supplemental Guidance for Assessing Data Usability for Environmental Investigations at the Black Mountain Industrial (BMI) Facility in Henderson, NV* (NDEP 2010c), which is based on the USEPA *Guidance for Data Usability in Risk Assessment* (Parts A and B) (USEPA 1992a, b). The USEPA data usability guidance identifies the following data quality criteria for evaluating the usability of site investigation data in the risk assessment process:

- Criterion I – Reports to Risk Assessor;
- Criterion II – Documentation;
- Criterion III – Data Sources;
- Criterion IV – Analytical Methods and Detection Limits;
- Criterion V – Data Review; and
- Criterion VI – Data Quality Indicators.

4.3 Data Analysis

As described in NDEP guidance (NDEP 2010c), the purpose of the data analysis step is to "use simple exploratory data analysis to compare data to the expectations of the CSM, to determine if the data adequately represent the source terms and exposure areas or evaluation areas." The following types of data analyses will be included in the forthcoming soil gas and groundwater BHRA reports:

- Summary statistics for soil gas and shallow groundwater data;
- Spatial distribution of VOC concentrations in soil gas and groundwater;
- Plots for temporal trend of VOC concentrations in groundwater;
- Plots for VOC concentrations in collocated soil gas and groundwater samples; and
- Exploratory data analysis in the context of current and former land use and operations within OU-1 and OU-2 and the CSM.

Summary statistics for the preliminary BHRA data set for the Operations Area in OU-1 are presented in Table 4-1 (soil gas) and Table 4-2 (shallow groundwater). Summary statistics for the preliminary BHRA data set for the NERT Off-Site Study Area in OU-2 are presented in Table 4-3 (soil gas) and Table 4-4 (shallow groundwater). The preliminary summary statistics tables include analytes detected in one or more soil gas or groundwater samples. In developing the preliminary summary statistics, samples with primary and field duplicate results were treated as independent samples, consistent with Option 2 in NDEP guidance (NDEP 2008c). This is considered appropriate because field duplicate samples represent a discrete and unique measurement of soil gas or groundwater chemical conditions proximal to the primary sample (unlike split samples).

The effect of duplicate treatment on the risk results will be discussed in the uncertainty section of the forthcoming soil gas and groundwater BHRA reports.

5. RISK ASSESSMENT METHODOLOGY

The following sections describe the methodology for evaluating potential health risks associated with vapor migration from soil gas and groundwater, which includes the following elements:

- Identification of COPCs;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization

In addition, the approaches for uncertainty analysis and data quality assessment are also discussed.

The soil gas and groundwater BHRAs for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2 will generally use the approach described in the NDEP-approved 2014 BHRA Work Plan, with incorporation of groundwater data as an additional line of evidence for the vapor intrusion risk analysis. The BHRAs will follow the basic procedures outlined in the USEPA's *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual* (USEPA 1989). Other guidance documents consulted in preparing the BHRAs include:

- *Exposure Factors Handbook* (USEPA 2011);
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002a);
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)* (USEPA 2009);
- *Office of Solid Waste and Emergency Response (OSWER) Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (USEPA 2002b);
- *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA 2004);
- *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air* (USEPA 2015);
- *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline* (Interstate Technology & Regulatory Council [ITRC] 2007); and
- *Soil Physical and Chemical Property Measurement and Calculation Guidance, BMI Plant Sites and Common Areas Projects, Henderson, Nevada* (NDEP 2010d).

5.1 Identification of COPCs

All volatile compounds[13] detected in one or more soil gas or groundwater samples in the BHRA data sets described in Section 4 above will be selected as COPCs. The preliminary list of soil gas and groundwater COPCs is presented in Table 5-1.

[13] Volatile compounds are identified using the following criteria consistent with USEPA (2017a): 1) vapor pressure greater than 1 millimeter of mercury (mm Hg) or 2) Henry's Law constant greater than 0.00001 atmosphere-cubic meter per mole (atm-m3/mole).

5.2 Exposure Assessment

The exposure assessment analyzes contaminant releases and the physical setting, identifies exposed populations and exposure pathways, and estimates exposure concentrations and chemical intakes for the identified pathways. The exposure assesment includes the CSM, fate and transport modeling, and exposure assumptions and calculations, as discussed in the following sections.

5.2.1 Conceptual Site Model

To evaluate the human health risks posed by a site, it is necessary to identify the populations that may potentially be exposed to the chemicals present and to determine the pathways by which these exposures may occur. CSMs were developed in order to characterize exposure potential in OU-1 and OU-2. The CSMs outline information relevant to conducting the exposure assessment by 1) evaluating potential chemical sources and releases, 2) identifying populations that could potentially be exposed to chemicals present in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2, and 3) identifying exposure pathways and routes through which human exposure might occur. The CSM can be an important tool in guiding site characterization, evaluating data quality in the context of potential risks to exposure populations, and developing exposure scenarios.

The RI/FS Work Plan identified sources, release mechanisms, exposure media, exposure routes, and potentially exposed populations based on a then current understanding of on-Site and off-Site environmental conditions and considering the NERT Site history. Development of the CSM is an iterative process; the CSM is revised, as appropriate, over the course of an RI based on additional information and understanding gained following review of existing and newly collected data. A preliminary CSM diagram for the NERT Site and downgradient areas was presented as Figure 5-1 of the RI/FS Work Plan (ENVIRON 2014a). In this BHRA Work Plan, the CSMs for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2 have been updated and are presented in Figures 5-1 and 5-2, respectively, and the major elements are discussed below.

<u>CSM for Operations Area in OU-1</u>

As indicated in the CSM (Figure 5-1), chemicals were released from potential on-Site/off-Site sources to surface and subsurface soils through several primary release mechanisms, such as spills and leaks, infiltration and overtopping, and surface water runoff. In addition to the potential primary release mechanisms, secondary/tertiary release mechanisms included wind erosion/mechanical disturbance of surface soil particulates into outdoor air, stormwater runoff from off-Site surface soils to on-Site surface soils, migration of VOCs in the subsurface through the soil column to indoor air, outdoor air, or trench air, and leaching from soils to groundwater. The potentially contaminated exposure media in the Operations Area in OU-1 include air, soil, and groundwater. Potential exposures to surface water (i.e., runoff) by on-Site populations will not be evaluated quantitatively in the BHRA because such exposures would be intermittent and of short duration or regulated under the Occupational Safety and Health Administration (OSHA) program.

The identification of potentially exposed populations and exposure pathways is supported by the CSM. For a complete exposure pathway to exist, all of the following elements must be present (USEPA 1989):

- A source and mechanism for chemical release;
- An environmental transport medium (i.e., air, water, soil);
- A point of potential human contact with the exposure medium; and
- A route of exposure (e.g., inhalation, ingestion, dermal contact).

The current and future land use in the Operations Area of OU-1 is restricted to industrial and/or commercial purposes through a land-use covenant. Accordingly, the potentially exposed on-Site populations to be evaluated in the BHRA for the Operations Area in OU-1 include indoor industrial/commercial workers, outdoor industrial/commercial workers, and short-term construction workers, consistent with USEPA guidance (2002b).

Other potential on-Site populations, such as visitors or trespassers, do not warrant assessment; as discussed by USEPA (2002b), evaluation of exposures to members of the public under a non-residential land-use scenario is generally not warranted, based on the following considerations:

- Public access is generally restricted at industrial sites; and
- While the public may have access to commercial sites, on-site workers have a much higher exposure potential because they spend substantially more time at a site.

This BHRA Work Plan focuses on the vapor intrusion pathways associated with VOCs migrating from soil gas and groundwater. Based on the source and release mechanisms presented in the CSM, the following exposure pathways are identified for quantitative evaluation in the soil gas and groundwater BHRA for the Operations Area in OU-1:

- Indoor commercial/industrial workers
  - *Inhalation of vapors migrating from soil gas/groundwater to indoor air*
- Outdoor commercial/industrial workers
  - *Inhalation of vapors migrating from soil gas/groundwater to outdoor air*
- Construction workers
  - *Inhalation of vapors migrating from soil gas/groundwater to trench air*

To be conservative, construction workers are assumed to be exposed to vapors migrating from soil gas/groundwater while standing in a 10-foot trench in the unsaturated zone, placing them closer to the potential sources. The exposure to VOCs in outdoor air will not be quantitatively evaluated for construction workers and indoor commercial/industrial workers because it is expected to be much lower than the exposure to VOCs in trench air and indoor air.

Complete, direct contact exposure pathways for surface and near surface soils (i.e., ingestion, dermal contact, inhalation of soil particulates) have also been identified in OU-1. Potential human health risks associated with soil pathways will be evaluated in a separate BHRA report for the Operation Area soils, which is currently being prepared and is anticipated to be submitted in early 2019.

Exposure via domestic use of groundwater will not be evaluated because on-Site groundwater is not and will not be used as a domestic water supply. Incidental ingestion of and dermal contact with groundwater during short-term construction activities are not considered complete exposure pathways due to the groundwater depth being greater than 10 ft bgs.

<u>CSM for NERT Off-Site Study Area in OU-2</u>

As indicated in the CSM (Figure 5-2), potential releases from on-Site sources to the NERT Off-Site Study Area in OU-2 is primarily through migration of volatile chemicals present in groundwater to the surface. This soil gas and groundwater BHRA Work Plan for the NERT Off-Site Study Area in OU-2 focuses on the vapor intrusion pathway associated with VOCs migrating from soil gas and groundwater to indoor air, outdoor air, or trench air. Exposure via domestic use of groundwater will not be evaluated because off-Site groundwater is not and will not be used as a domestic water supply. Incidental ingestion of and dermal contact with groundwater during short-term construction activities are not considered complete exposure pathways due to the groundwater depth being greater than 10 ft bgs.

The current and future land use in the NERT Off-Site Study Area in OU-2 is mixed commercial/light industrial and residential use. Accordingly, the potentially exposed off-Site populations identified for the BHRA for the NERT Off-Site Study Area in OU-2 include indoor industrial/commercial workers, outdoor industrial/commercial workers, short-term construction workers, and residents, consistent with USEPA guidance (2002b).

Based on the source and release mechanisms presented in the CSM, the following exposure pathways are identified for quantitative evaluation in the soil gas and groundwater BHRA for the NERT Off-Site Study Area in OU-2:

- Residents
  - *Inhalation of vapors migrating from soil gas/groundwater to indoor air*
- Indoor commercial/industrial workers
  - *Inhalation of vapors migrating from soil gas/groundwater to indoor air*
- Construction workers
  - *Inhalation of vapors migrating from soil gas/groundwater to trench air*

To be conservative, construction workers are assumed to be exposed to vapors migrating from soil gas/groundwater while standing in a 10-foot trench in the unsaturated zone, placing them closer to the potential sources. The exposure to VOCs in outdoor air will not be quantitatively evaluated for construction workers, indoor commercial/industrial workers, and outdoor commercial/industrial workers because it is expected to be much lower than the exposure to VOCs in trench air and indoor air.

5.2.2 Fate and Transport Modeling

The migration of VOCs detected in soil gas (sourcing from soil and groundwater) or groundwater will be quantified in the BHRAs through an intermedia transfer factor. When the transfer factor is multiplied by the source concentration of a chemical in soil gas (in microgram per cubic meter [$\mu g/m^3$]) or groundwater (in microgram per liter [µg/L]), the product is the predicted steady-state concentration in indoor, outdoor, or construction trench air (in $\mu g/m^3$), which represents the exposure point concentration (EPC) in the air to which a receptor (i.e., a member of a potentially exposed population) is exposed over an assumed duration of exposure.

<u>Operations Area in OU-1</u>

For on-Site populations in the Operations Area of OU-1, Ramboll will develop transfer factors for the following scenarios:

- Transport of soil gas from five ft bgs into a commercial/industrial slab-on-grade building;
- Transport of soil gas from 15 ft bgs into a commercial/industrial slab-on-grade building;
- Transport of soil gas from five ft bgs to outdoor air;
- Transport of soil gas from one centimeter (cm) below the base into a 10-foot construction trench;
- Transport of groundwater vapor from 25 ft bgs into a commercial/industrial slab-on-grade building;
- Transport of groundwater vapor from 25 ft bgs to outdoor air; and
- Transport of groundwater vapor from 15 ft bgs into a 10-foot construction trench.

The intermedia transfer factors will be estimated using the screening-level model described by Johnson and Ettinger (1991); this model was developed to predict vapor migration into buildings using a combination of diffusion and advection. Specifically, Version 3.1 of the spreadsheet implementation developed by the USEPA will be used (USEPA 2004).

The calculation of transfer factors will be based on parameters describing the properties of the chemicals evaluated, the vadose zone, the surface barrier, and the air dispersion zone. The physical/chemical properties for the preliminary soil gas and groundwater COPCs that will be used in these calculations are presented in Table 5-2. Based on guidance from USEPA (2018a), only chemicals that easily volatilize will be included in the evaluation of vapor migration. These include chemicals with a Henry's Law constant of greater than 1 x 10^{-5} atm-m^3/mol or a vapor pressure of greater than 1 mm Hg. The source of all physical/chemical properties is noted in Table 5-2. In general, priority is given to the most recent physical/chemical data as well as the most relevant data for a site located in Nevada. As such, the hierarchy for selecting physical/chemical properties is:

1) NDEP values from the basic comparison level (BCL) tables (NDEP 2017a);
2) USEPA values from the regional screening level (RSL) tables (USEPA 2018b);
3) USEPA values from the original Johnson and Ettinger model (USEPA 2004); and
4) USEPA values from EPISuite (2012) combined with using surrogate chemicals for diffusivities in air and water.

As reported in the 2010 Site-Wide Soil Gas HRA (Northgate and Exponent 2010b), soil samples were collected to determine site-specific soil properties representative of the unsaturated zone. Soil samples were collected at 16 locations at depths of 9 to 15 ft bgs (mostly at 10 ft) across the NERT Site to determine volumetric water content, total porosity, dry bulk density, and grain density in accordance with NDEP guidance (NDEP 2010d). The average of the 15 site-specific soil property results measured from 9-10 ft bgs (as shown in Table 5-3) will be used for modeling purposes in the BHRA for the Operations Area in OU-1. One sample collected at a depth of 15 ft bgs will not be included as it represents wetter than average conditions at the NERT Site. Soil sampling locations and boring logs are included in Appendix E.

A review of NERT Site stratigraphy and boring logs indicated that these soil samples collected at 9-10 ft bgs should be representative of the entire Qal stratigraphic unit and it is not expected to be significant variation laterally or with depth in that stratigraphic unit. In general, the Qal extends from the ground surface to the groundwater table over the NERT Site. In places, the groundwater table occurs as much as 10 ft below the base of the Qal in the underlying fine-grained UMCf. For simplicity and to be conservative, the entire vadose zone will be modeled as Qal with no UMCf included. Each soil sample was also plotted on a ternary diagram to determine the soil type for Johnson and Ettinger modeling. The soil samples clustered near the sand to loamy sand border, with the average soil type being loamy sand, which is consistent with the soil types identified in the on-Site soil borings by (ENSR 2005) including poorly sorted gravel, silty gravel, poorly sorted sand, well sorted sand, and silty sand.

Depth to groundwater in OU-1 was determined by evaluating both current and historic groundwater elevations for non-artesianal wells within the Operations Area. Depth to groundwater ranges from approximately 20 to 60 ft bgs, with the majority of the samples between 30 and 50 ft bgs. To be conservative, a depth of groundwater of 25 ft bgs will be selected for modeling in the OU-1 BHRA.

A conservative default commercial/industrial building will be assumed for the indoor air scenario with a building size of 10 meters by 10 meters and a vapor flow rate of five L/minute into the building (USEPA 2004). California's default air exchange rate of one air change per hour for a commercial/industrial building (California Environmental Protection Agency [Cal/EPA] 2011) will be used in the absence of a default value from NDEP or USEPA. A conservative building height of 10 ft will be assumed. The modeling parameters for the Operations Area in OU-1 are presented in Table 5-4.

When modeling the above-ground outdoor air scenario, the site-specific dispersion factor (Q/C) model described in the *Soil Screening Users Guidance* (USEPA 2002b) will be used with a total plume area of 180 acres for the Operations Area in OU-1. For the trench scenario, a box model will be used to simulate dispersion. Trench dimensions of 10 ft deep, 20 ft long, and five ft wide will be assumed. For this box model, the air flow through the trench will be controlled by a site-specific windspeed that is reduced by a factor of 10 to ensure it would be conservative for a trench scenario where the breathing zone may be a few ft bgs. Additionally, soil gas samples will be assumed to be within 1 cm of the base of the trench and VOCs will be emitted from all the trench walls in addition to the base of the trench. To account for the trench air dispersing amongst non-clean plume air, concentrations of trench air will be added to the concentrations of aboveground air to estimate the total exposure for a trench worker.

Benzene is well known to degrade naturally due to aerobic respiration at many sites. Measured concentrations of benzene at shallow depths are consistently lower than would be predicted from deeper sources (soil gas and groundwater) using typical diffusion modeling with no biodegradation, providing evidence for biodegradation at the NERT Site. To account for this, the software bioVapor (American Petroleum Institute [API] 2012) will be used to calculate the relative impact of biodegradation between the samples collected at depth and at the surface for all soil gas and groundwater scenarios. The input parameters for this calculation are also presented in Table 5-4 which are consistent with the input parameters for the rest of the modelling.

NERT Off-Site Study Area in OU-2

For off-Site populations in the NERT Study Area in OU-2, Ramboll will develop transfer factors for the following scenarios:

- Transport of soil gas from five ft bgs into a commercial/industrial slab-on-grade building;
- Transport of soil gas from 15 ft bgs into a commercial/industrial slab-on-grade building;
- Transport of soil gas from five ft bgs into a current/future residential slab-on-grade building;
- Transport of soil gas from 15 ft bgs into a current/future residential slab-on-grade building;
- Transport of soil gas from one centimeter (cm) below the base into a 10-foot construction trench;
- Transport of groundwater vapor from 20 ft bgs into a commercial/industrial slab-on-grade building;
- Transport of groundwater vapor from 20 ft bgs into a current/future residential slab-on-grade building;
- Transport of groundwater vapor from 10 ft bgs into a 10-foot construction trench.

As mentioned previsously, NERT will not evaluate the vapor intrusion pathway within the Eastside Sub-Area since NERT is only responsible for impacts associated with perchlorate and chlorate in groundwater in the Eastside Sub-Area.

The intermedia transfer factors will be estimated using the screening-level model described by Johnson and Ettinger (1991). The calculation of transfer factors will be calculated as discussed for the Operations Area in OU-1.

Currently, only limited soil property data are available for the NERT Off-Site Study Area. In order to perform a more representative site-specific vapor intrusion modeling, soil physical properties, including soil classification (grain size distribution/Atterberg Limits), total organic carbon, bulk density, water content, and total porosity will be collected at 5 ft bgs, 10 ft bgs, and 15 ft bgs at all the 13 locations proposed in the *Phase 2 RI Modification No. 11* (Ramboll 2018b), where the soil properties have not been collected previously[14] in the NERT Off-Study Area in OU-2.

Depth to groundwater in OU-2 was determined by evaluating both current and historic groundwater elevations for non-artesianal shallow wells within the NERT Off-Site Study Area in OU-2. Depth to groundwater ranges from approximately 15 to 70 ft bgs, with the majority of the samples between 25 and 50 ft bgs. To be conservative, a depth of groundwater of 20 ft bgs will be selected for modeling in the OU-2 BHRA.

A conservative default commercial/industrial building will be assumed for indoor air scenario with a building size of 10 meters by 10 meters and a vapor flow rate of five L/minute into the building (USEPA 2004). California’s default air exchange rate of one air change per hour for a

[14] Soil classification (grain size distribution/Atterberg Limits) and total organic carbon have previously been collected at PC-172 (co-located with RISG-4, at 13.5 ft bgs), PC-167 (co-located with RISG-7, at 11.0 ft bgs), and PC-166 (co-located with RISG-9, at 11.5 ft bgs) during the Phase 2 RI.

commercial/industrial building (Cal/EPA 2011) will be used in the absence of a default value from NDEP or USEPA. A conservative building height of 10 ft will be assumed.

A conservative default residential building will be assumed for indoor air scenario with a building size of 10 meters by 10 meters and a vapor flow rate of five L/minute into the building (USEPA 2004). California's default air exchange rate of 1/2 air change per hour and building height of 8 feet for a residential building (Cal/EPA 2011) will be used in the absence of default values from NDEP or USEPA. We will also evaluate the potential for a current residential building and a future residential building built with an engineered fill.

For the trench scenario, the same box model as described in the trench scenario modeling for the Operations Area in OU-1 will be used for evaluating the construction worker exposure to trench air in the NERT Off-Site Study Area in OU-2 as well.

5.2.3 Exposure Assumptions and Calculations

The magnitude of exposure for any given receptor is a function of the amount of chemical in the exposure medium (e.g., air, groundwater, soil), and the frequency, intensity, and duration of contact with that medium. In order to quantify inhalation exposures, the air EPC adjusted by the intake factor, rather than exposure dose, is used as the basis for estimating inhalation risks based on *Risk Assessment Guidance for Superfund, Part F, Supplemental Guidance for Inhalation Risk Assessment* (USEPA 2009).

As shown in Tables 5-5 and 5-6, exposure assumptions recommended by NDEP (2017a) will be used for indoor and outdoor commercial/industrial workers and residents. For the construction workers, exposure assumptions recommended by USEPA (2018a) will be used, except that a utility trench scenario will be evaluated assuming that the construction workers could be exposed to volatile compounds migrating from soil gas and groundwater to air in a construction trench when conducting excavation activities for four hours per day, 30 days per year for one year per NDEP's comment (NDEP 2017b, General Comment #3).

The intake factor for inhalation of volatile compounds migrating from soil gas or groundwater to air will be calculated using the following equation (USEPA 2009):

$$IF_{inh} = \frac{ET \times EF \times ED}{AT \times CF}$$

where:

IF_{inh}	=	Intake Factor for air inhalation (unitless)
ET	=	Exposure Time (hour/day)
EF	=	Exposure Frequency (day/year)
ED	=	Exposure Duration (year)
AT	=	Averaging Time (day)
CF	=	Conversion Factor (hour/day)

For carcinogens, the intake factor averaged over a 70-year lifetime will be used in the risk characterization, while for non-carcinogens, the intake factor averaged over the exposure period will be used (USEPA 1989).

5.3 Toxicity Assessment

The purpose of a toxicity assessment is to present the weight-of-evidence regarding the potential for a chemical to cause adverse effects in exposed individuals, and to quantitatively characterize, where possible, the relationship between exposure to a chemical and the increased likelihood and/or severity of adverse effects (i.e., the dose-response assessment).

Inhalation unit risks (IURs), which are expressed in units of $(\mu g/m^3)^{-1}$, are chemical-specific and experimentally derived potency values that are used to calculate the risk of cancer resulting from inhalation exposure to potentially carcinogenic chemicals. Inhalation reference concentrations (RfCs), which are expressed in units of $\mu g/m^3$, are experimentally derived levels not expected to cause adverse health effects that are used to quantify the extent of toxic effects other than cancer due to inhalation exposure to chemicals.

For soil gas and groundwater COPCs, an initial list of chronic toxicity values will be developed based on the values used by NDEP for the derivation of the 2017 BCLs (NDEP 2017a). For most chemicals in the BCL table, NDEP selected toxicity values from the USEPA's Integrated Risk Information System (IRIS); however, on a case-by-case basis, values provided by other sources, e.g., California Office of Environmental Health Hazard Assessment (OEHHA) Toxicity Criteria Database, were selected over the IRIS values. For chemicals not included in IRIS, NDEP relied on other sources for toxicity values. Ramboll will check the chronic toxicity values from the 2017 BCL table against the identified source to confirm that the most current values are being used.

For COPCs not listed in the 2017 BCL table, the following approach will be used:

- Toxicity values from IRIS will be selected; if not in IRIS, toxicity values from the USEPA RSL table (USEPA 2018b) will be used; and
- For COPCs for which toxicity values are not available from any of the sources listed, Ramboll will use the toxicity values from surrogate chemicals (chemicals with similar chemical structure).

For construction workers who will be assumed to be present at the Site for one year, subchronic toxicity values will be used whenever available for the evaluation of adverse non-cancer effects in accordance with recommendations by USEPA (USEPA 2018a). The general hierarchy of sources used for the subchronic toxicity values are as below:

- USEPA Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV) (USEPA 2018c);
- Agency for Toxic Substances & Disease Registry (ATSDR) Minimal Risk Levels (MRLs) (ATSDR 2017); and
- USEPA's Health Effects Assessment (HEAST) Summary Tables (USEPA 1997).

Route-to-route extrapolation will not be applied, which is consistent with the updated BCL Guidance (NDEP 2017a) and *Risk Assessment Guidance for Superfund, Part F, Supplemental Guidance for Inhalation Risk Assessment* (USEPA 2009).

In addition, for each carcinogenic COPC, the USEPA weight-of-evidence classification will also be identified.

The chronic and subchronic toxicity values for the preliminary COPCs are presented in Table 5-7.

5.4 Risk Characterization

Risk characterization represents the final step in the risk assessment process. In this step, the results of exposure and toxicity assessments are integrated into quantitative or qualitative estimates of potential health risks. In each exposure medium (i.e., soil gas, groundwater), potential excess lifetime cancer risks and non-cancer adverse health effects for each COPC will be characterized separately.

The National Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] § 300) is cited as the basis for the target risk range by NDEP (2017a). According to NDEP (2017a), the acceptability of any calculated incremental cancer risk is generally evaluated relative to the target risk range of 10^{-6} to 10^{-4} described in the NCP. According to NCP and NDEP (2017a), non-carcinogenic chemicals should not be present at levels expected to cause adverse health effects (i.e., a hazard index [HI] greater than one).

It should be noted that the cancer risk and non-cancer hazard to be estimated in the BHRAs do not represent absolute estimates in OU-1 and OU-2, since generic and conservative assumptions will be used, which are likely to overestimate actual exposures and calculated risks. Exceedance of the target cancer risk range of 10^{-6} to 10^{-4} or the target non-cancer HI of one does not indicate that adverse impacts to human health are occurring or will occur, but suggests that further evaluation may be warranted.

5.4.1 Assessment of Cancer Risks

The excess lifetime cancer risk is estimated as the upper-bound incremental probability of an individual developing cancer over a lifetime (i.e., 70 years) as a result of exposure to a potential carcinogen at a given concentration. The equation used to calculate cancer risk due to exposure via inhalation of VOCs migrating from soil gas or groundwater to air is as follows:

$$Cancer\ Risk = EPC_{air} \times IF_{inh} \times IUR$$

where:

EPC_{air} = Exposure Point Concentration in air (µg/m^3)

IF_{inh} = Inhalation Intake Factor (unitless)

IUR = Inhalation Unit Risk (µg/m^3)$^{-1}$

The excess lifetime cancer risk will be calculated for each COPC at each individual soil gas or groundwater sample location, using the air EPC predicted based on the maximum chemical concentration detected in the soil gas or groundwater samples collected at that location. Also, the estimated excess lifetime cancer risk for each COPC will be conservatively summed, regardless of the type of cancer, to estimate the total cancer risk for an exposed individual at each location.

5.4.2 Assessment of Non-Cancer Health Effects

The likelihood of non-cancer adverse effects is quantified by the development of a hazard quotient (HQ). The HQ represents the ratio of the estimated exposure to a non-carcinogen at a given concentration to a value that is believed not to produce non-cancer adverse health effects. The equation used to calculate the non-cancer HQ due to exposure via inhalation of VOCs migrating from soil gas or groundwater is as follows:

$$HQ = \frac{EPC_{air} \times IF_{inh}}{RfC_{inh}}$$

where:

HQ	=	Hazard Quotient
EPC_{air}	=	Exposure Point Concentration in air (µg/m^3)
IF_{inh}	=	Inhalation Intake Factor (unitless)
RfC_{inh}	=	Inhalation Reference Concentration (µg/m^3)

The non-cancer HQ will be calculated for each COPC at each individual soil gas or groundwater sample location, using the air EPC predicted based on the maximum chemical concentration detected in the soil gas or groundwater samples collected at that location. The estimated non-cancer HQ for each COPC will be conservatively summed, regardless of the target organ, to estimate the total non-cancer HI for an exposed individual at each location.

5.5 Uncertainty Analysis

The process of risk assessment has inherent uncertainties associated with the calculations and assumptions used in the BHRAs, resulting from lack of knowledge and variability of site conditions, fate and transport modeling, as well as chemical toxicity and exposure. The approach used in the BHRAs is health-protective and tends to overestimate potential exposure, resulting in estimated cancer risks and non-cancer hazard levels that are likely to overestimate the actual risks or hazards experienced by the potentially exposed populations. These uncertainties are generally difficult to quantify. A qualitative discussion of key uncertainties associated with the available data and the methodology will be presented in the forthcoming soil gas and groundwater BHRAs.

5.6 Data Quality Assessment

Data quality assessment is an analysis that is performed after the risk assessment is complete to determine whether enough data have been collected to support the risk-based decisions that are recommended by the risk assessment. Sample size calculations will be conducted based on the methodology for maximum detected concentrations, which will be conceptualized as a statistical test of the proportion of the soil gas or groundwater samples that are associated with an unacceptable risk.

6. SCHEDULE

It is anticipated that NDEP will approve this Soil Gas and Groundwater BHRA Work Plan for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2 with minimal comments by the end of the first quarter of 2019. The implementation of the soil gas and groundwater BHRAs will begin following NDEP approval of this BHRA Work Plan. It is anticipated that additional soil gas data, for which the sampling plan is described in the *Phase 2 RI Modification No. 11* (Ramboll 2018b), as well as additional groundwater data from the ongoing investigations, will be available prior to the implementation of the soil gas and groundwater BHRAs for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2. The soil gas and groundwater BHRA reports will be prepared separately for the Operations Area in OU-1 and the NERT Off-Site Study Area in OU-2. It is anticipated these reports will be submitted to NDEP in the third quarter 2019.

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TABLES

TABLE 4-1. Preliminary Summary Statistics for VOCs in Soil Gas in the Operations Area of OU-1
Nevada Environmental Response Trust Site
Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
Acetone	μg/m^3	92	91	99	0.0080	0.0080	0.0040	0.41	0.023	0.050	0.080	1.6	SG60
Acrylonitrile	μg/m^3	92	8	8.7	0.00010	0.77	0.00011	0.00034	0.00021	0.00021	0.000089	0.42	SG79
t-Amyl methyl ether	μg/m^3	81	1	1.2	0.000076	0.33	0.00010	0.00010	0.00010	0.00010	--	--	SG46
Benzene	μg/m^3	92	79	86	0.0033	0.065	0.0011	0.16	0.0035	0.014	0.032	2.2	SG51
Benzyl chloride	μg/m^3	92	5	5.4	0.000068	0.15	0.00014	0.00029	0.00017	0.00020	0.000059	0.30	SG33
Bromodichloromethane	μg/m^3	92	62	67	0.00015	0.065	0.00014	0.20	0.0013	0.011	0.032	3.0	SG89
Bromoform	μg/m^3	92	13	14	0.00012	0.77	0.00014	0.14	0.00035	0.017	0.039	2.4	SG89
Bromomethane	μg/m^3	92	18	20	0.00014	0.065	0.000080	0.0018	0.00024	0.00039	0.00043	1.1	SG79
2-Butanone	μg/m^3	92	75	82	0.00080	0.33	0.0020	0.062	0.0062	0.010	0.010	1.0	SG84
tert Butyl alcohol	μg/m^3	92	55	60	0.0030	0.33	0.00020	0.017	0.00060	0.0013	0.0025	1.9	SG66
n-Butylbenzene	μg/m^3	91	46	51	0.00029	0.13	0.00017	0.0030	0.00042	0.00062	0.00059	0.96	SG41
sec-Butylbenzene	μg/m^3	91	15	16	0.000092	0.77	0.000098	0.00093	0.00023	0.00035	0.00030	0.85	SG41
tert-Butylbenzene	μg/m^3	91	4	4.4	0.000077	0.31	0.00035	0.0010	0.00046	0.00056	0.00030	0.53	SG67
Carbon disulfide	μg/m^3	80	54	68	0.000042	0.33	0.00041	0.27	0.0037	0.013	0.038	2.9	SG60
Carbon tetrachloride	μg/m^3	92	86	93	0.0071	0.033	0.00011	18	0.0098	1.1	3.6	3.3	SG29
3-Chloro-1-propene	μg/m^3	91	3	3.3	0.000078	0.15	0.00031	0.0055	0.0010	0.0023	0.0028	1.2	SG40
Chlorobenzene	μg/m^3	92	40	43	0.00015	0.065	0.000093	0.34	0.0011	0.031	0.082	2.7	SG83
Chloroethane	μg/m^3	92	38	41	0.000076	0.065	0.000094	0.10	0.00040	0.017	0.034	1.9	SG53
Chloroform	μg/m^3	92	92	100	--	--	0.00074	160	2.1	18	35	2.0	SG32
Chloromethane	μg/m^3	92	20	22	0.000022	0.15	0.000087	0.027	0.00024	0.0020	0.0061	3.0	SG51
Cumene	μg/m^3	91	29	32	0.00018	0.77	0.000090	0.0097	0.00025	0.00088	0.0019	2.2	SG83
p-Cymene	μg/m^3	80	35	44	0.0015	0.33	0.00013	0.0069	0.00045	0.0013	0.0019	1.5	SG41
Dibromochloromethane	μg/m^3	92	19	21	0.00011	0.15	0.00012	0.16	0.0011	0.014	0.037	2.7	SG89
1,2-Dichlorobenzene	μg/m^3	92	26	28	0.00010	0.065	0.00011	0.052	0.00096	0.0056	0.011	2.0	SG95
1,3-Dichlorobenzene	μg/m^3	92	26	28	0.000097	0.065	0.00012	0.082	0.0012	0.0062	0.016	2.6	SG95
1,4-Dichlorobenzene	μg/m^3	92	74	80	0.00018	0.065	0.00097	0.13	0.012	0.022	0.027	1.2	SG21
Dichlorodifluoromethane	μg/m^3	92	69	75	0.0020	0.33	0.0019	0.051	0.0021	0.0028	0.0059	2.1	SG60
1,1-Dichloroethane	μg/m^3	92	45	49	0.00015	0.065	0.000081	0.29	0.0011	0.032	0.058	1.8	SG66
1,2-Dichloroethane	μg/m^3	92	21	23	0.000078	0.065	0.000080	0.031	0.0037	0.0062	0.0075	1.2	SG57
1,1-Dichloroethene	μg/m^3	92	50	54	0.000040	0.065	0.000074	0.51	0.0032	0.022	0.074	3.4	SG46

TABLE 4-1. Preliminary Summary Statistics for VOCs in Soil Gas in the Operations Area of OU-1
Nevada Environmental Response Trust Site
Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
cis-1,2-Dichloroethene	μg/m^3	92	10	11	0.000068	0.15	0.000084	0.0013	0.00017	0.00032	0.00037	1.2	SG24
trans-1,2-Dichloroethene	μg/m^3	92	4	4.4	0.000064	0.15	0.000085	0.00043	0.00011	0.00018	0.00017	0.91	SG92
1,2-Dichloropropane	μg/m^3	92	25	27	0.000078	0.065	0.000084	0.0026	0.00032	0.00064	0.00072	1.1	SG51
1,4-Dioxane	μg/m^3	92	24	26	0.000093	0.33	0.00014	0.0042	0.00030	0.00070	0.00095	1.3	SG67
Ethanol	μg/m^3	91	76	84	0.17	3.3	0.0014	0.18	0.0053	0.011	0.022	2.0	SG60
Ethyl acetate	μg/m^3	1	1	100	--	--	0.00075	0.00075	0.00075	0.00075	--	--	E-SG-8
Ethyl benzene	μg/m^3	92	59	64	0.00082	0.33	0.00012	0.090	0.0016	0.0079	0.019	2.4	SG41
4-Ethyltoluene	μg/m^3	92	50	54	0.00019	0.33	0.000097	0.021	0.00067	0.0021	0.0044	2.1	SG77
Freon 114	μg/m^3	92	27	29	0.00014	0.33	0.000078	0.00014	0.000093	0.000096	0.000014	0.14	SG46
n-Heptane	μg/m^3	92	38	41	0.000074	0.33	0.00011	0.039	0.00053	0.0036	0.0078	2.2	SG77
Hexachlorobutadiene	μg/m^3	92	43	47	0.00014	0.065	0.00015	0.46	0.0048	0.040	0.091	2.3	SG35
n-Hexane	μg/m^3	1	1	100	--	--	0.00095	0.00095	0.00095	0.00095	--	--	E-SG-8
2-Hexanone	μg/m^3	92	53	58	0.00022	0.33	0.00017	0.0039	0.00061	0.00083	0.00063	0.76	SG41
Methyl tert-butyl ether	μg/m^3	92	10	11	0.000077	0.15	0.000099	0.0010	0.00018	0.00026	0.00027	1.0	SG76
4-Methyl-2-pentanone	μg/m^3	92	52	57	0.00085	0.33	0.00017	0.014	0.00066	0.0019	0.0028	1.5	SG41
Methylene Chloride	μg/m^3	92	81	88	0.000078	0.33	0.000089	0.36	0.0012	0.012	0.042	3.5	SG60
Methylmethacrylate	μg/m^3	91	2	2.2	0.00011	0.77	0.00018	0.00036	0.00027	0.00027	0.00013	0.47	SG41
alpha-Methylstyrene	μg/m^3	91	15	16	0.00011	0.77	0.00011	0.00074	0.00021	0.00030	0.00020	0.69	SG48
Naphthalene	μg/m^3	92	64	70	0.00033	0.13	0.00021	0.073	0.0018	0.0044	0.010	2.3	SG60
n-Octane	μg/m^3	80	37	46	0.000079	0.33	0.00011	1.0	0.0011	0.045	0.17	3.6	SG77
n-Propylbenzene	μg/m^3	91	42	46	0.00017	0.33	0.00011	0.014	0.00046	0.0014	0.0028	2.1	SG77
Styrene	μg/m^3	92	28	30	0.000050	0.77	0.00013	0.0047	0.00026	0.00059	0.00094	1.6	SG48
1,1,2,2-Tetrachloroethane	μg/m^3	92	1	1.1	0.000072	0.15	0.00018	0.00018	0.00018	0.00018	--	--	SG46
Tetrachloroethene	μg/m^3	92	92	100	--	--	0.00050	2.3	0.040	0.11	0.26	2.4	SG35
Toluene	μg/m^3	92	83	90	0.039	0.33	0.00042	0.43	0.0086	0.024	0.059	2.4	SG77
1,1,2-Trichloro-1,2,2-trifluoroethane	μg/m^3	92	53	58	0.00097	0.065	0.00040	0.0019	0.00050	0.00053	0.00020	0.37	SG47
1,2,4-Trichlorobenzene	μg/m^3	92	25	27	0.00012	0.065	0.00012	0.24	0.0031	0.014	0.048	3.3	SG95
1,1,1-Trichloroethane	μg/m^3	92	21	23	0.000092	0.15	0.000087	0.014	0.00053	0.0032	0.0047	1.5	SG66
1,1,2-Trichloroethane	μg/m^3	92	10	11	0.000078	0.065	0.00013	0.0056	0.00082	0.0024	0.0025	1.0	SG53
Trichloroethene	μg/m^3	92	81	88	0.00016	0.065	0.00011	1.7	0.0052	0.068	0.22	3.2	SG47

TABLE 4-1. Preliminary Summary Statistics for VOCs in Soil Gas in the Operations Area of OU-1

Nevada Environmental Response Trust Site

Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
Trichlorofluoromethane	µg/m^3	92	79	86	0.0020	0.033	0.00096	1.7	0.0013	0.14	0.40	2.8	SG61
1,2,4-Trimethylbenzene	µg/m^3	92	59	64	0.00043	0.33	0.00013	0.042	0.0020	0.0045	0.0085	1.9	SG77
1,3,5-Trimethylbenzene	µg/m^3	92	48	52	0.00020	0.33	0.00013	0.022	0.00079	0.0024	0.0046	1.9	SG77
Vinyl acetate	µg/m^3	92	57	62	0.00024	3.3	0.00073	0.029	0.0038	0.0053	0.0051	0.96	SG72
Vinyl chloride	µg/m^3	92	11	12	0.000078	0.065	0.00011	0.0020	0.00050	0.00073	0.00068	0.92	SG51
m,p-Xylene	µg/m^3	91	70	77	0.0052	0.33	0.00025	0.42	0.0054	0.031	0.077	2.5	SG41
o-Xylene	µg/m^3	91	73	80	0.0025	0.33	0.00016	0.12	0.0025	0.010	0.023	2.3	SG41
Xylenes (total)	µg/m^3	1	1	100	--	--	0.0043	0.0043	0.0043	0.0043	--	--	E-SG-8

Notes:

-- = No value

µg/m^3 = microgram per cubic meter

OU = Operable Unit

VOC = Volatile organic compound (as defined by USEPA 2017).

Sources:

USEPA 2017. User's Guide for Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

TABLE 4-2. Preliminary Summary Statistics for VOCs in Shallow Groundwater in the Operations Area of OU-1

Nevada Environmental Response Trust Site

Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
Benzene	µg/L	233	25	11	0.25	13	0.98	12,000	360	1,630	2,880	1.8	M-123
Bromodichloromethane	µg/L	233	46	20	0.25	100	0.26	1.5	0.35	0.46	0.27	0.59	M-36D
Bromoform	µg/L	233	31	13	0.40	160	0.63	3.7	1.3	1.5	0.80	0.52	M-36D
2-Butanone	µg/L	233	1	0.43	2.5	1,000	13	13	13	13	--	--	M-140
Carbon tetrachloride	µg/L	233	85	36	0.25	100	0.25	620	2.0	25	84	3.4	M-123
Chlorobenzene	µg/L	233	33	14	0.25	13	0.34	22,000	510	3,410	5,930	1.7	M-123
Chloroform	µg/L	233	230	99	0.25	6.3	0.35	21,000	140	920	2,860	3.1	M-126
Dibromochloromethane	µg/L	233	4	1.7	0.25	100	0.25	0.81	0.48	0.51	0.27	0.54	M-36D
1,2-Dichlorobenzene	µg/L	233	57	24	0.25	100	0.31	880	1.4	78	207	2.6	M-123
1,3-Dichlorobenzene	µg/L	233	32	14	0.25	100	0.25	44	0.88	6.4	13	2.0	M-123
1,4-Dichlorobenzene	µg/L	233	56	24	0.25	100	0.26	1,800	0.78	130	367	2.8	M-123
1,1-Dichloroethane	µg/L	233	26	11	0.25	100	0.27	44	1.3	5.8	11	1.8	M-5D
1,2-Dichloroethane	µg/L	233	21	9.0	0.25	100	0.27	37	1.2	5.5	9.5	1.7	M-5D
1,1-Dichloroethene	µg/L	233	30	13	0.25	100	0.25	130	1.2	13	33	2.5	M-97
1,3-Dichloropropane	µg/L	233	3	1.3	0.25	100	0.84	0.86	0.85	0.85	0.010	0.012	M-115
1,4-Dioxane	µg/L	217	90	41	0.50	1.0	0.50	22	0.77	1.9	3.4	1.8	MW-16
Hexachlorobutadiene	µg/L	233	5	2.2	0.25	100	0.34	1.1	0.58	0.69	0.34	0.49	M-66
Methyl tert-butyl ether	µg/L	9	1	11	2.5	13	0.86	0.86	0.86	0.86	--	--	CTMW-04S
Methylene Chloride	µg/L	233	25	11	0.88	350	0.88	220	1.9	14	43	3.2	M-123
Tetrachloroethene	µg/L	233	60	26	0.25	100	0.26	98	0.43	3.7	16	4.5	M-123
Toluene	µg/L	233	8	3.4	0.25	100	0.25	0.86	0.53	0.55	0.26	0.47	M-145
1,2,3-Trichlorobenzene	µg/L	233	2	0.86	0.40	160	0.82	0.82	0.82	0.82	0	0	M-22A
1,2,4-Trichlorobenzene	µg/L	233	3	1.3	0.40	160	0.41	0.73	0.48	0.54	0.17	0.31	M-176
Trichloroethene	µg/L	233	79	34	0.25	100	0.26	24	1.8	3.9	5.3	1.4	M-237
Trichlorofluoromethane	µg/L	233	4	1.7	0.25	100	0.32	100	66	58	42	0.73	M-123
1,2,3-Trichloropropane	µg/L	233	188	81	0.0025	25	0.0025	0.57	0.066	0.10	0.11	1.1	M-135

Notes:

-- = not available

OU = Operable Unit

µg/L = microgram per liter

VOC = Volatile organic compound (as defined by USEPA 2017)

Sources:

USEPA 2017. User's Guide for Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

TABLE 4-3. Preliminary Summary Statistics for VOCs in Soil Gas in the NERT Off-Site Study Area of OU-2

Nevada Environmental Response Trust Site

Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
Acetone	ug/m3	18	12	67	7.5	32	18	210	38	62	57	0.91	RISG-2
Acrolein	ug/m3	7	1	14	0.23	0.23	11	11	11	11	--	--	RISG-2
Acrylonitrile	ug/m3	18	6	33	0.61	3.2	0.11	0.86	0.15	0.27	0.29	1.1	RISG-2
Benzene	ug/m3	18	18	100	--	--	1.5	75	3.0	8.3	17	2	RISG-1
Bromodichloromethane	ug/m3	18	16	89	0.011	0.33	0.18	11	1.2	2.9	3.3	1.1	RISG-1
Bromoform	ug/m3	18	3	17	0.22	1.6	0.27	0.99	0.43	0.56	0.38	0.67	SG13
Bromomethane	ug/m3	18	2	11	0.15	0.64	0.088	0.091	0.089	0.089	0.0021	0.024	SG07
2-Butanone	ug/m3	18	13	72	0.85	3.9	5.4	51	13	17	15	0.87	RISG-2
Methyl tert-butyl ether	ug/m3	18	7	39	0.15	0.64	0.33	13	3.7	6.2	5.2	0.83	SG07
n-Butylbenzene	ug/m3	11	11	100	--	--	0.14	1.1	0.50	0.50	0.30	0.60	SG15
sec-Butylbenzene	ug/m3	11	2	18	0.74	3.2	0.15	0.23	0.19	0.19	0.057	0.30	SG07
tert-Butylbenzene	ug/m3	11	1	9.1	0.29	1.3	0.14	0.14	0.14	0.14	--	--	SG12
Carbon disulfide	ug/m3	18	16	89	0.74	0.77	1.3	22	3.7	6.1	5.8	0.96	RISG-1
Carbon tetrachloride	ug/m3	18	18	100	--	--	0.60	390	19	100	140	1.3	RISG-3
3-Chloro-1-propene	ug/m3	11	1	9.1	0.15	0.64	0.19	0.19	0.19	0.19	--	--	SG09
Chlorobenzene	ug/m3	18	10	56	0.15	0.64	0.085	1.8	0.28	0.48	0.52	1.1	SG15
Chloroethane	ug/m3	18	7	39	0.15	0.64	0.14	1.9	0.39	0.78	0.7	0.90	SG09
Chloroform	ug/m3	18	18	100	--	--	34	8900	1200	2800	3000	1.1	RISG-1
Chloromethane	ug/m3	18	6	33	0.12	0.33	0.076	1.6	0.17	0.41	0.59	1.5	RISG-2
Cumene	ug/m3	11	5	45	0.74	3.2	0.088	0.56	0.12	0.26	0.22	0.85	SG14
Cyclohexane	ug/m3	7	1	14	0.38	0.38	9.8	9.8	9.8	9.8	--	--	RISG-2
p-Cymene	ug/m3	11	10	91	0.77	0.77	0.16	12	0.57	2.3	3.7	1.6	SG15
1,2-Dibromo-3-chloropropane	ug/m3	18	1	5.6	0.0056	3.2	0.13	0.13	0.13	0.13	--	--	RISG-3
Dibromochloromethane	ug/m3	18	11	61	0.0048	0.33	0.12	2.1	0.29	0.52	0.57	1.1	RISG-1
1,2-Dibromoethane	ug/m3	18	5	28	0.0037	0.64	0.047	0.11	0.088	0.084	0.023	0.27	RISG-1
1,2-Dichlorobenzene	ug/m3	36	2	5.6	0.15	0.64	3.7	3.7	3.7	3.7	0	0	SG07
1,3-Dichlorobenzene	ug/m3	36	14	39	0.15	0.64	0.098	0.77	0.32	0.34	0.21	0.61	SG15
1,4-Dichlorobenzene	ug/m3	36	24	67	0.62	0.62	0.26	19	0.83	5.0	6.6	1.3	SG13
Dichlorodifluoromethane	ug/m3	18	17	94	0.56	0.56	2.0	5.7	2.3	3.0	1.3	0.44	RISG-3
1,1-Dichloroethane	ug/m3	18	11	61	0.15	0.64	0.079	9.0	3.8	3.7	3.2	0.86	RISG-2
1,2-Dichloroethane	ug/m3	18	7	39	0.15	0.64	0.089	1.1	0.58	0.53	0.36	0.68	RISG-1
1,1-Dichloroethene	ug/m3	18	12	67	0.15	0.64	0.10	170	20	40	52	1.3	RISG-2
cis-1,2-Dichloroethene	ug/m3	18	8	44	0.15	0.64	0.13	11	1.5	2.5	3.6	1.4	RISG-2

TABLE 4-3. Preliminary Summary Statistics for VOCs in Soil Gas in the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
trans-1,2-Dichloroethene	ug/m3	18	4	22	0.15	0.64	0.24	1.1	0.27	0.47	0.42	0.90	RISG-2
1,2-Dichloropropane	ug/m3	18	7	39	0.010	0.64	0.088	1.2	0.59	0.63	0.50	0.78	RISG-1
1,4-Dioxane	ug/m3	18	6	33	0.13	3.2	0.14	0.79	0.21	0.31	0.25	0.81	SG07
Ethanol	ug/m3	18	15	83	8.5	11	2.3	160	12	26	39	1.5	RISG-1
Ethyl acetate	ug/m3	7	2	29	0.36	0.36	7.7	9.4	8.6	8.6	1.2	0.14	RISG-2
Ethyl benzene	ug/m3	18	18	100	--	--	0.10	74	1.2	7.1	17	2.4	RISG-1
4-Ethyltoluene	ug/m3	18	17	94	0.77	0.77	0.11	54	0.78	4.8	13	2.7	RISG-1
Freon 114	ug/m3	18	4	22	0.60	3.2	0.089	0.10	0.10	0.097	0.0055	0.057	SG11
n-Heptane	ug/m3	18	13	72	5.7	5.7	0.11	57	0.58	5.6	16	2.8	RISG-1
Hexachlorobutadiene	ug/m3	36	18	50	0.15	0.17	0.21	11	1.0	3.2	4.1	1.3	SG15
n-Hexane	ug/m3	7	7	100	--	--	1.8	55	3.2	14	20	1.4	RISG-1
2-Hexanone	ug/m3	18	13	72	0.16	0.16	0.32	4.0	0.76	1.6	1.4	0.88	RISG-2
4-Methyl-2-pentanone	ug/m3	18	18	100	--	--	0.15	33	2.3	7.0	9.4	1.3	RISG-1
Methylene Chloride	ug/m3	18	14	78	0.77	3.2	0.23	14	1.9	3.6	4.6	1.3	RISG-3
Methylmethacrylate	ug/m3	18	2	11	0.42	3.2	4.1	5.2	4.7	4.7	0.78	0.17	RISG-3
alpha-Methylstyrene	ug/m3	11	4	36	0.74	3.2	0.39	7.7	0.46	2.2	3.6	1.6	SG12
Naphthalene	ug/m3	36	36	100	--	--	0.42	150	1.4	10	34	3.4	RISG-1
n-Octane	ug/m3	11	9	82	0.77	0.83	0.23	93	1.3	11	31	2.7	SG14
n-Propylbenzene	ug/m3	11	9	82	0.77	3.2	0.084	1.1	0.24	0.39	0.37	0.94	SG14
Styrene	ug/m3	18	10	56	0.21	3.2	0.13	3.3	0.39	0.70	0.94	1.3	RISG-2
tert Butyl alcohol	ug/m3	18	11	61	17	17	0.37	3.2	0.58	0.85	0.83	0.97	SG13
1,1,1,2-Tetrachloroethane	ug/m3	7	2	29	0.0	0.0	0.065	0.084	0.075	0.075	0.013	0.18	RISG-2
Tetrachloroethene	ug/m3	18	18	100	--	--	1.1	11000	14	1100	3100	2.7	RISG-2
Tetrahydrofuran	ug/m3	7	1	14	0.21	0.21	7.6	7.6	7.6	7.6	--	--	RISG-2
Toluene	ug/m3	18	18	100	--	--	0.99	190	7.2	21	44	2.1	RISG-1
1,1,2-Trichloro-1,2,2-trifluoroethane	ug/m3	18	18	100	--	--	0.48	2.1	0.55	0.69	0.38	0.56	RISG-1
1,2,4-Trichlorobenzene	ug/m3	36	8	22	0.15	0.64	0.26	3.7	2.2	2.1	1.7	0.80	RISG-2
1,1,1-Trichloroethane	ug/m3	18	3	17	0.15	0.64	0.10	0.11	0.11	0.11	0.0058	0.054	SG07
1,1,2-Trichloroethane	ug/m3	18	3	17	0.012	0.64	0.20	0.62	0.58	0.47	0.23	0.50	RISG-3
Trichloroethene	ug/m3	18	18	100	--	--	0.96	160	2.8	22	43	1.9	RISG-2
Trichlorofluoromethane	ug/m3	18	18	100	--	--	1.1	7.0	1.6	2.4	1.6	0.68	SG13
1,2,4-Trimethylbenzene	ug/m3	18	18	100	--	--	0.12	240	2.9	19	56	3.0	RISG-1
1,3,5-Trimethylbenzene	ug/m3	18	16	89	0.35	0.77	0.090	81	0.95	7.5	20	2.6	RISG-1

TABLE 4-3. Preliminary Summary Statistics for VOCs in Soil Gas in the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
Vinyl acetate	ug/m3	18	7	39	0.61	32	2.3	19	5.0	6.6	5.7	0.86	RISG-2
m,p-Xylene	ug/m3	11	11	100	--	--	0.29	28	1.9	4.4	8.0	1.80	SG14
o-Xylene	ug/m3	11	11	100	--	--	0.12	8.8	0.89	1.8	2.5	1.4	SG14
Xylenes (total)	ug/m3	7	7	100	--	--	9.6	450	40	97	160	1.6	RISG-1

Notes:

-- = not applicable

μg/m^3 = microgram per cubic meter

OU = Operable Unit

VOC = Volatile organic compound (as defined by USEPA 2017)

Sources:

USEPA 2017. User's Guide for Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

TABLE 4-4. Preliminary Summary Statistics for VOCs in Shallow Groundwater in the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

Analyte	Unit	No. of Samples	No. of Detects	% Detects	Nondetects		Detects						
					Minimum	Maximum	Minimum	Maximum	Median	Mean	Standard Deviation	Coefficient of Variation	Location of Maximum
Benzene	ug/L	157	5	3.2	0.25	2.5	0.28	34	26	17	16	0.92	PC-194
Bromodichloromethane	ug/L	157	12	7.6	0.25	2.5	0.26	2.0	0.43	0.74	0.69	0.92	PC-187
Bromoform	ug/L	157	10	6.4	0.37	4.0	0.40	7.7	0.85	2.4	2.8	1.2	PC-187
tert-Butylbenzene	ug/L	157	1	0.64	0.25	2.5	0.34	0.34	0.34	0.34	--	--	PC-166
Carbon tetrachloride	ug/L	157	73	47	0.25	0.50	0.32	13	1.6	2.5	2.6	1.0	PC-188
Chlorobenzene	ug/L	157	30	19	0.25	2.5	0.29	54	2.0	6.9	11	1.7	PC-166
Chloroform	ug/L	168	158	94	0.25	0.25	0.25	1,000	16	120	200	1.6	PC-67
Dibromochloromethane	ug/L	157	3	1.9	0.25	2.5	1.2	1.3	1.3	1.3	0.058	0.046	PC-187
1,2-Dichlorobenzene	ug/L	314	126	40	0.25	2.5	0.27	16	3.1	4.2	3.8	0.89	PC-166
1,3-Dichlorobenzene	ug/L	314	102	32	0.23	2.5	0.25	3.0	1.5	1.4	0.73	0.53	PC-186
1,4-Dichlorobenzene	ug/L	314	112	36	0.25	2.5	0.25	23	5.1	6.2	5.4	0.87	PC-166
1,1-Dichloroethane	ug/L	157	47	30	0.25	2.5	0.32	3.5	1.5	1.5	0.71	0.47	PC-18
1,2-Dichloroethane	ug/L	157	13	8.3	0.25	2.5	0.35	0.54	0.42	0.44	0.063	0.14	PC-31
1,1-Dichloroethene	ug/L	157	19	12	0.25	2.5	0.29	2.7	1.1	1.2	0.67	0.55	PC-175
1,4-Dioxane	ug/L	125	74	59	0.50	0.50	0.50	4.7	1.1	1.2	0.70	0.57	PC-21A
Methylene Chloride	ug/L	157	17	11	0.88	4.4	1.0	25	3.5	4.9	5.7	1.2	PC-67
Tetrachloroethene	ug/L	157	82	52	0.25	1.3	0.25	56	1.0	3.2	7.2	2.3	PC-21A
Toluene	ug/L	157	10	6.4	0.25	2.5	0.25	1.4	0.42	0.50	0.33	0.65	PC-193
Total THM	ug/L	18	18	100	--	--	1.8	850	38	200	280	1.4	PC-67
1,2,3-Trichlorobenzene	ug/L	157	30	19	0.40	4.0	0.41	2.3	0.82	0.98	0.52	0.53	PC-50
1,2,4-Trichlorobenzene	ug/L	314	74	24	0.40	4.0	0.43	14	6.4	6.4	3.0	0.47	PC-31
Trichloroethene	ug/L	157	90	57	0.25	2.5	0.27	2.7	0.54	0.83	0.68	0.81	PC-166
1,2,3-Trichloropropane	ug/L	175	95	54	0.0025	0.56	0.0025	0.39	0.061	0.10	0.11	1.1	PC-37

Notes:

-- = not applicable

µg/L = microgram per liter

OU = Operable Unit

THM = Trihalomethanes

VOC = Volatile organic compound (as defined by USEPA 2017)

Sources:

USEPA 2017. User's Guide for Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

TABLE 5-1. Preliminary Soil Gas and Shallow Groundwater COPCs in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

COPC [1]	OU-1		OU-2	
	Soil Gas	Groundwater	Soil Gas	Groundwater
Acetone	X		X	
Acrolein			X	
Acrylonitrile	X		X	
t-Amyl methyl ether	X			
Benzene	X	X	X	X
Benzyl chloride	X			
Bromodichloromethane	X	X	X	X
Bromoform	X	X		X
Bromomethane	X			
2-Butanone	X	X	X	
tert Butyl alcohol	X			
n-Butylbenzene	X			
sec-Butylbenzene	X			
tert-Butylbenzene	X			X
Carbon disulfide	X		X	
Carbon tetrachloride	X	X	X	X
3-Chloro-1-propene	X			
Chlorobenzene	X	X	X	X
Chloroethane	X			X
Chloroform	X	X	X	X
Chloromethane	X		X	
Cumene	X			
Cyclohexane			X	
p-Cymene	X			
1,2-Dibromo-3-chloropropane			X	
Dibromochloromethane	X	X	X	
1,2-Dibromoethane			X	
1,2-Dichlorobenzene	X	X		X
1,3-Dichlorobenzene	X	X		X
1,4-Dichlorobenzene	X	X	X	X
Dichlorodifluoromethane	X		X	
1,1-Dichloroethane	X	X	X	X
1,2-Dichloroethane	X	X	X	X
1,1-Dichloroethene	X	X	X	X
cis-1,2-Dichloroethene	X		X	
trans-1,2-Dichloroethene	X		X	
1,2-Dichloropropane	X		X	
1,3-Dichloropropane		X		
1,4-Dioxane	X	X		X
Ethanol	X		X	
Ethyl acetate	X		X	
Ethyl benzene	X		X	

TABLE 5-1. Preliminary Soil Gas and Shallow Groundwater COPCs in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

COPC [1]	OU-1		OU-2	
	Soil Gas	Groundwater	Soil Gas	Groundwater
4-Ethyltoluene	X		X	
Freon 114	X			
Hexachlorobutadiene	X	X	X	
n-Heptane	X		X	
n-Hexane	X		X	
2-Hexanone	X		X	
Methyl tert-butyl ether	X	X		
4-Methyl-2-pentanone	X		X	
Methylene Chloride	X	X	X	X
Methylmethacrylate	X		X	
alpha-Methylstyrene	X			
Naphthalene	X		X	
n-Octane	X			
n-Propylbenzene	X			
Styrene	X		X	
1,1,1,2-Tetrachloroethane			X	
1,1,2,2-Tetrachloroethane	X			
Tetrachloroethene	X	X	X	X
Toluene	X	X	X	X
1,1,2-Trichloro-1,2,2-trifluoroethane	X		X	
1,2,3-Trichlorobenzene		X		X
1,2,4-Trichlorobenzene	X	X	X	X
1,1,1-Trichloroethane	X			
1,1,2-Trichloroethane	X		X	
Trichloroethene	X	X	X	X
Trichlorofluoromethane	X	X	X	
1,2,3-Trichloropropane		X		X
1,2,4-Trimethylbenzene	X		X	
1,3,5-Trimethylbenzene	X		X	
Vinyl acetate	X		X	
Vinyl chloride	X			
m,p-Xylene	X			
o-Xylene	X			
Xylenes (total)	X		X	

Notes:

COPC = Chemical of Potential Concern

OU = Operable Unit

USEPA = United States Environmental Protection Agency

[1] Volatile organic compound as defined by USEPA (2017).

Source:

USEPA 2017. User's Guide for Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

TABLE 5-2. Physical/Chemical Properties for Preliminary Soil Gas and Shallow Groundwater COPCs in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

COPC [1]	Molecular Weight MW (g/mol)	Organic Carbon Partition Coefficient, K_{oc} (cm^3/g)	Diffusivity in Air, D_a (cm^2/s)	Diffusivity in Water, D_w (cm^2/s)	Pure Component Water Solubility, S (mg/L)	Henry's Law Constant at 25° C H ($atm\text{-}m^3/mol$)	Normal Boiling Point, T_B (°K)	Critical Temperature, T_C (°K)	Enthalpy of Vaporization at the Normal Boiling Point, ΔHv,b (cal/mol)	Source
Acetone	58.00	5.75E-01	1.24E-01	1.14E-05	1.00E+06	3.88E-05	329.20	508.10	6955.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Acrolein	56.00	2.12E+01	1.05E-01	1.22E-05	2.10E+05	1.20E-04	325.60	506.00	6730.77	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Acrylonitrile	53.00	8.50E-01	1.08E-01	1.34E-05	7.90E+04	8.84E-05	350.30	519.00	7786.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
t-Amyl methyl ether	102.18	2.27E+01	6.50E-02	7.80E-06	2.64E+03	1.32E-03	--	--	--	EPISuite (USEPA 2012) + diisopropyl ether for diffusivities
Benzene	78.10	6.20E+01	8.80E-02	9.80E-06	1.75E+03	5.55E-03	353.24	562.16	7342.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Benzyl chloride	127.00	5.00E+01	6.66E-02	7.80E-06	3.30E+03	5.06E-05	--	--	--	NDEP (2017)
Bromodichloromethane	164.00	1.00E+02	2.98E-02	1.06E-05	6.74E+03	1.60E-03	363.15	585.85	7800.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Bromoform	252.73	3.18E+01	3.57E-02	1.04E-05	3.10E+03	5.35E-04	422.35	696.00	9479.00	USEPA (2017a) + USEPA (2004) for Tb, Tc, and ΔH
Bromomethane	94.95	9.00E+00	7.28E-02	1.21E-05	1.52E+04	6.24E-03	276.71	467.00	5714.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
2-Butanone	72.00	4.50E+00	8.95E-02	9.80E-06	2.68E+05	2.74E-05	352.50	536.78	7480.70	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
tert Butyl alcohol	74.12	2.92E+00	9.00E-02	1.00E-05	1.81E+05	9.05E-06	--	--	--	NDEP (2017)
n-Butylbenzene	134.22	2.83E+03	7.50E-02	7.80E-06	1.38E+01	1.31E-02	456.46	660.50	9289.93	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
sec-Butylbenzene	134.22	2.15E+03	7.50E-02	7.80E-06	1.70E+01	1.87E-02	446.50	679.00	88730.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
tert-Butylbenzene	134.22	2.15E+03	7.50E-02	7.80E-06	3.00E+01	1.26E-02	--	--	--	NDEP (2017)
Carbon disulfide	76.00	4.57E+01	1.04E-01	1.00E-05	1.19E+03	3.03E-02	319.00	552.00	6391.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Carbon tetrachloride	154.00	1.52E+02	7.80E-02	8.80E-06	7.93E+02	3.04E-02	349.90	556.60	7127.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
3-Chloro-1-propene	77.00	4.38E+01	9.40E-02	1.10E-05	3.37E+03	1.10E-02	--	--	--	NDEP (2017)
Chlorobenzene	113.00	2.24E+02	7.30E-02	8.70E-06	4.72E+02	3.70E-03	404.87	632.40	8410.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Chloroethane	65.00	1.47E+01	1.04E-01	1.15E-05	5.70E+03	1.10E-02	285.30	460.40	5879.40	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Chloroform	119.00	5.30E+01	1.04E-01	1.00E-05	7.92E+03	3.67E-03	334.32	536.40	6988.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Chloromethane	51.00	3.50E+01	1.09E-01	6.50E-06	8.20E+03	2.40E-02	249.00	416.25	5114.60	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Cumene	120.00	2.20E+02	7.50E-02	7.10E-06	6.10E+01	1.20E+00	425.56	631.10	10335.30	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Cyclohexane	84.00	1.60E+02	8.00E-02	9.00E-06	5.50E+01	1.98E-01				NDEP
p-Cymene	134.00	2.20E+02	7.50E-02	7.10E-06	6.10E+01	1.20E+00	--	--	--	NDEP (2017)
1,2-Dibromo-3-chloropropane	236.33	1.70E+02	8.00E-02	8.00E-06	1.23E+03	1.50E-04				USEPA (2017a)
Dibromochloromethane	208.28	6.31E+01	1.96E-02	1.05E-05	2.70E+03	8.50E-04	416.14	678.20	5900.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,2-Dibromoethane	188.00	2.81E+01	7.33E-02	8.06E-06	3.40E+03	3.20E-04	404.60	583.00	8310.03	NDEP + USEPA 2004 for Tb, Tc, ΔH
1,2-Dichlorobenzene	147.00	3.79E+02	6.90E-02	7.90E-06	1.56E+02	1.90E-03	453.57	705.00	9700.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,3-Dichlorobenzene	147.00	3.79E+02	6.90E-02	7.90E-06	1.56E+02	1.90E-03	446.00	684.00	9230.18	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,4-Dichlorobenzene	147.00	6.16E+02	6.90E-02	7.90E-06	7.38E+01	2.43E-03	447.21	684.75	9271.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Dichlorodifluoromethane	120.92	5.80E+01	8.00E-02	1.05E-05	2.80E+02	1.00E-01	243.20	384.95	9421.36	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,1-Dichloroethane	99.00	5.30E+01	7.42E-02	1.05E-05	5.06E+03	5.62E-03	330.55	523.00	6895.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,2-Dichloroethane	99.00	3.80E+01	1.04E-01	9.90E-06	8.52E+03	9.79E-04	356.65	561.00	7643.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,1-Dichloroethene	97.00	6.50E+01	9.00E-02	1.04E-05	2.25E+03	2.61E-02	304.75	576.05	6247.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
cis-1,2-Dichloroethene	97.00	3.55E+01	7.36E-02	1.13E-05	3.50E+03	4.08E-03	333.65	544.00	7192.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv

TABLE 5-2. Physical/Chemical Properties for Preliminary Soil Gas and Shallow Groundwater COPCs in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

COPC [1]	Molecular Weight MW (g/mol)	Organic Carbon Partition Coefficient, K_{oc} (cm^3/g)	Diffusivity in Air, D_a (cm^2/s)	Diffusivity in Water, D_w (cm^2/s)	Pure Component Water Solubility, S (mg/L)	Henry's Law Constant at 25° C H ($atm\text{-}m^3/mol$)	Normal Boiling Point, T_B (°K)	Critical Temperature, T_C (°K)	Enthalpy of Vaporization at the Normal Boiling Point, ΔHv,b (cal/mol)	Source
trans-1,2-Dichloroethene	97.00	3.80E+01	7.07E-02	1.19E-05	6.30E+03	9.38E-03	320.85	516.50	6717.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,2-Dichloropropane	113.00	4.70E+01	7.82E-02	8.73E-06	2.80E+03	2.80E-03	369.52	572.00	7590.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,3-Dichloropropane	113.00	4.70E+01	7.82E-02	8.73E-06	2.80E+03	2.80E-03	--	--	--	NDEP (2017)
1,4-Dioxane	88.11	2.63E+00	8.74E-02	1.05E-05	1.00E+06	4.80E-06	--	--	--	USEPA (2017a)
Ethanol	46.00	1.00E+00	1.24E-01	1.37E-05	1.00E+06	5.00E-06	--	--	--	NDEP (2017)
Ethyl acetate	88.00	5.94E+01	7.32E-02	9.66E-06	8.00E+04	1.40E-04	--	--	--	NDEP (2017)
Ethyl benzene	106.20	2.04E+02	7.50E-02	7.80E-06	1.69E+02	7.88E-03	409.34	617.20	8501.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
4-Ethyltoluene	120.19	2.20E+02	7.50E-02	7.10E-06	6.10E+01	1.20E+00	--	--	--	NDEP (2017)
Freon 114	170.92	1.97E+02	7.80E-02	8.20E-06	4.31E+01	1.51E+00	--	--	--	EPISuite (USEPA 2012) + 1,1,2-Trichloro-1,2,2-trifluoroethane for diffusivities
Hexachlorobutadiene	260.76	8.45E+02	2.67E-02	7.03E-06	3.20E+00	1.03E-02	486.15	738.00	10206.00	USEPA (2017a) + USEPA (2004) for Tb, Tc, and ΔH
n-Heptane	100.00	8.20E+03	6.16E-02	6.45E-06	3.40E+00	2.00E+00	--	--	--	NDEP (2017)
n-Hexane	86.00	8.90E+02	2.00E-01	7.77E-06	1.80E+01	1.22E-01	341.70	508.00	6895.15	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
2-Hexanone	100.16	1.50E+01	7.00E-02	8.40E-06	1.72E+04	9.32E-05	--	--	--	NDEP (2017)
Methyl tert-butyl ether	85.00	6.00E+00	8.00E-02	1.00E-05	1.50E+05	5.90E-04	328.30	497.10	6677.66	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
4-Methyl-2-pentanone	100.00	1.34E+02	7.50E-02	7.80E-06	1.90E+04	1.40E-04	389.50	571.00	8243.11	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Methylene Chloride	85.00	1.00E+01	1.01E-01	1.17E-05	1.32E+04	2.19E-03	313.00	510.00	6706.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Methylmethacrylate	100.00	1.31E+01	7.70E-02	8.60E-06	1.50E+04	3.40E-04	373.50	567.00	8974.90	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
alpha-Methylstyrene	118.00	3.60E+02	7.12E-02	8.00E-06	3.00E+02	2.30E-03	--	--	--	NDEP (2017)
Naphthalene	128.16	1.19E+03	5.90E-02	7.50E-06	3.10E+01	4.83E-04	491.14	748.40	10373.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
n-Octane	114.00	1.60E+04	7.09E-02	7.34E-06	6.60E-01	3.20E+00	--	--	--	NDEP (2017)
n-Propylbenzene	120.00	2.83E+03	7.50E-02	7.80E-06	1.38E+01	1.31E-02	432.20	630.00	9123.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Styrene	104.20	9.12E+02	7.10E-02	8.00E-06	3.10E+02	2.75E-03	418.31	636.00	8737.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,1,1,2-Tetrachloroethane	168.00	7.90E+01	7.10E-02	7.90E-06	2.97E+03	3.45E-04	403.50	624.00	9768.28	NDEP + USEPA 2004 for Tb, Tc, ΔH
1,1,2,2-Tetrachloroethane	168.00	7.90E+01	7.10E-02	7.90E-06	2.97E+03	3.45E-04	419.60	661.15	8996.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Tetrachloroethene	165.83	2.65E+02	7.20E-02	8.20E-06	2.00E+02	1.84E-02	394.40	620.20	8288.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Toluene	92.00	1.40E+02	8.70E-02	8.60E-06	5.26E+02	6.64E-03	383.78	591.79	7930.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,1,2-Trichloro-1,2,2-trifluoroethane	187.38	1.60E+02	2.88E-02	8.07E-06	1.10E+03	5.21E-01	320.70	487.30	6462.56	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,2,3-Trichlorobenzene	181.45	1.38E+03	3.95E-02	8.38E-06	1.80E+01	1.25E-03	--	--	--	USEPA (2017a)
1,2,4-Trichlorobenzene	181.00	1.66E+03	3.00E-02	8.23E-06	3.00E+02	1.42E-03	486.15	725.00	10471.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,1,1-Trichloroethane	133.00	1.35E+02	7.80E-02	8.80E-06	1.33E+03	1.72E-02	347.24	545.00	7136.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,1,2-Trichloroethane	133.00	7.50E+01	7.80E-02	8.80E-06	4.42E+03	9.13E-04	386.15	602.00	8322.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Trichloroethene	131.00	9.43E+01	7.90E-02	9.10E-06	1.10E+03	1.03E-02	360.36	544.20	7505.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Trichlorofluoromethane	137.40	1.60E+02	8.70E-02	1.30E-05	1.10E+03	9.70E-02	296.70	471.00	5998.90	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,2,3-Trichloropropane	147.43	5.10E+01	7.10E-02	7.90E-06	2.70E+03	2.80E-02	430.00	652.00	9171.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
1,2,4-Trimethylbenzene	120.19	3.72E+03	7.50E-02	7.10E-06	2.55E-01	5.70E-03	442.30	649.17	9368.80	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv

TABLE 5-2. Physical/Chemical Properties for Preliminary Soil Gas and Shallow Groundwater COPCs in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2
Nevada Environmental Response Trust Site
Henderson, Nevada

COPC [1]	Molecular Weight MW (g/mol)	Organic Carbon Partition Coefficient, K_{oc} (cm^3/g)	Diffusivity in Air, D_a (cm^2/s)	Diffusivity in Water, D_w (cm^2/s)	Pure Component Water Solubility, S (mg/L)	Henry's Law Constant at 25° C H ($atm\text{-}m^3/mol$)	Normal Boiling Point, T_B (°K)	Critical Temperature, T_C (°K)	Enthalpy of Vaporization at the Normal Boiling Point, ΔHv,b (cal/mol)	Source
1,3,5-Trimethylbenzene	120.19	8.19E+02	7.50E-02	7.10E-06	5.00E+01	7.71E-03	437.89	637.25	9321.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Vinyl acetate	86.00	5.25E+00	8.50E-02	9.20E-06	2.00E+04	5.11E-04	345.65	519.13	7800.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Vinyl chloride	63.00	1.86E+01	1.06E-01	1.23E-06	2.76E+03	2.70E-02	259.25	432.00	5250.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
m,p-Xylene	106.17	3.89E+02	7.69E-02	8.44E-06	1.85E+02	7.64E-03	--	--	--	USEPA 2004
o-Xylene	106.20	2.41E+02	8.70E-02	1.00E-05	1.78E+02	5.19E-03	417.60	630.30	8661.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv
Xylenes (total)	106.20	1.96E+02	7.00E-02	7.80E-06	1.61E+02	7.34E-03	411.52	616.20	8525.00	NDEP (2017) + USEPA (2004) for T_B, T_C, ΔHv

Notes:

-- = Not available
$atm\text{-}m^3/mol$ = atmosphere-cubic meter per mole
cal/mol = calorie per mole
cm^3/g = cubic centimeter per gram
cm^2/s = square centimeter per second
g/mol = gram per mole
°K = degrees Kelvin
mg/L = milligram per liter
COPC = Chemical of potential concern
EPISuite = Estimation Programs Interface Suite
NDEP = Nevada Division of Environmental Protection
OU = Operable unit
USEPA = United States Environmental Protection Agency

[1] Volatile compounds defined by USEPA (2017b) as chemicals with vapor pressure greater than 1 millimeter (mm) Hg or Henry's Law constant greater than 0.00001 $atm\text{-}m^3/mole$.

Sources:

NDEP. 2017. User's Guide and Background Technical Document for NDEP Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas. December 2008, Revision 14, July.
USEPA. 2004. User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings Office of Emergency and Remedial Response. February.
USEPA. 2012. Estimation Programs Interface Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.
USEPA. 2017a. Regional Screening Levels Table. November.
USEPA. 2017b. Regional Screening Levels User's Guide. November.

TABLE 5-3. Soil Properties Data for the Operations Area of OU-1

Nevada Environmental Response Trust Site

Henderson, Nevada

Sample ID [1]	Depth (ft)	Volumetric Water Content [2]	Dry Bulk Density [3] (g/cm^3)	Grain Density [4] (g/cm^3)	Soil Total Porosity [5] (g/cm^3)	Soil Type
SA56-10BSPLP	10	0.134	1.689	2.719	0.379	Loamy Sand
RSAM3-10BSPLP	10	0.145	1.593	2.674	0.404	Loamy Sand
SA166-10BSPLP	10	0.100	1.721	2.681	0.358	Loamy Sand
SA182-10BSPLP	10	0.182	1.740	2.601	0.331	Sandy Loam
RSAJ3-10BSPLP	10	0.154	1.770	2.682	0.340	Loamy Sand
RSAI7-10B	10	0.138	1.661	2.682	0.381	Sand
SA34-10BSPLP	10	0.169	1.738	2.696	0.355	Loamy Sand
SA52-15BSPLP [6]	15	0.239	1.405	2.710	0.481	Sand
RSAQ8-10BSPLP	10	0.148	1.697	2.695	0.370	Sand
RSAN8-10BSPLP	10	0.189	1.679	2.683	0.374	Loamy Sand
RSAQ4-10BSPLP	10	0.141	1.841	2.705	0.319	Sand
SA148-10BSPLP	10	0.119	1.762	2.732	0.355	Sand
SA30-9BSPLP	9	0.160	1.805	2.711	0.334	Sand
SA128-10BSPLP	10	0.156	1.654	2.654	0.377	Loamy Sand
SA102-10BSPLP	10	0.135	1.769	2.696	0.344	Sand
SA64-10BSPLP	10	0.148	1.717	2.651	0.352	Sand
Mean	9.93	0.148	1.722	2.684	0.358	Loamy Sand
Mininum	9	0.100	1.593	2.601	0.319	NA
Maximum	10	0.189	1.841	2.732	0.404	NA
Median	10	0.148	1.721	2.683	0.355	NA

Notes:

ft = feet

g/cm^3 = grams per cubic centimeter

ASTM = American Society for Testing and Materials

NA = not applicable

OU = Operable unit

[1] The soil properties were reported in Northgate and Exponent (2010).

[2] As measured according to ASTM D 2216 and converted from mass-based water moisture to volumetric water content.

[3] As measured according to ASTM D 2937.

[4] As measured according to ASTM D 854.

[5] Calculated from dry bulk density and grain density.

[6] Sample not included in the evaluation.

Source:

Northgate and Expoent. 2010. Site-Wide Soil Gas Human Health Risk Assessment, Tronox LLC, Henderson, Nevada, November 22.

TABLE 5-4. Modeling Parameters for the Operations Area of OU-1
Nevada Environmental Response Trust Site
Henderson, Nevada

Parameter	Value	Units	Notes
Source/Receptor Parameters - Indoor and Outdoor Scenarios			
Depth to groundwater	25	feet	Site-specific estimate
Soil gas sampling depth	5	feet	Site-specific estimated based on sampling depth
	15	feet	
Soil temperature at source	17	Celsius	Site-specific measurement
Soil Parameters			
USDA soil type	Loamy Sand	--	Site-specific estimate based on soil boring logs and site measurements. See text for further discussion.
Bulk density	1.722	g/cm^3	Site-specific measurement
Total porosity	0.358	unitless	Site-specific measurement
Water-filled porosity	0.148	unitless	Site-specific measurement
Parameters used for benzene degradation			
Fraction organic carbon	0.006	unitless	Default value (USEPA 2002)
Minimum oxygen content for aerobic respiration	1	%	Default value (API 2012)
First order biodegradation rate for benzene	0.79	1/hour	Default value (API 2012)
Building Foundation Parameters			
Depth to Bottom of Foundation, Slab-on-grade	15	cm	Default value (Cal/EPA 2011)
Foundation crack ratio	0.005	unitless	Default value (Cal/EPA 2011)
Average vapor flow rate into building	5	$L/min/m^2$	Default value (USEPA 2004)
Foundation thickness	10	cm	Default value (Cal/EPA 2011)
Air Dispersion Parameters			
Commercial Indoor Air Scenario			
Air exchange rate	1	1/hour	Default value for commercial buildings (Cal/EPA 2011)
Length of building	1000	cm	Default value for commercial buildings (USEPA 2004)
Width of building	1000	cm	Default value for commercial buildings (USEPA 2004)
Mixing height of building, Slab-on-grade	305	cm	Engineering estimate.
Commercial Outdoor Air Scenario			
Site specific dispersion factor (Q/C):	33.79	g/m^2-s per kg/m^3	Based on a plume area of 180 acres in OU-1 Operations Area
Source/Receptor Parameters -10 foot Construction Trench Scenario			
Depth to groundwater	15	feet	Site-specific estimate
Soil gas sampling depth	1	cm	Site-specific estimate for depth between trench and soil gas sample
Length of construction trench	609.6	cm	Assumed (20 feet)
Width of construction trench	152	cm	Assumed (5 feet)
Depth of construction trench	10	feet	Assumed
Windspeed	0.41	m/s	Conservative Estimate (1/10 of site-specific windspeed)
Site specific dispersion factor (Q/C_{vol})	34.17	g/m^2-s per kg/m^3	Site-specific estimate based on box model.

Notes:
-- =Not applicable
cm = centimeter
g/cm^3 = gram per cubic centimeter
g/m^2-s per kg/m^3 = (gram per square meter-second) per (kilogram per cubic meter)
$L/min/m^2$ = liter per minute per 100 square meter

API = American Petroleum Institute
Cal/EPA = California Environmental Protection Agency
OU = Operable unit
USDA = United States Department of Agriculture
USEPA = United States Environmental Protection Agency

Sources:

API. 2012. BIOVAPOR – A 1-D Vapor Intrusion Model with Oxygen-Limited Aerobic Biodegradation. Version 2.1. November

CalEPA. 2011. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance). Final. Department of Toxic Substances Control. October.

USEPA. 2002. Supplemental Guidance for Developing. Soil Screening Levels for Superfund Sites. December

USEPA. 2004. User’s Guide for Evaluating Subsurface Vapor Intrusion Into Buildings Office of Emergency and Remedial Response. February.

TABLE 5-5. Exposure Assumptions for Workers in the Operations Area of OU-1 and the NERT Off-Site Study Area of OU-2

Nevada Environmental Response Trust Site

Henderson, Nevada

Exposure Factors	Units	Symbol	Indoor Commercial/ Industrial Worker		Outdoor Commercial/ Industrial Worker		Construction Worker	
			Value	Source	Value	Source	Value	Source
Population-Specific Exposure Assumptions								
Exposure Time	hours/day	ET	8	NDEP 2017a	8	NDEP 2017a	4	VDEQ 2016
Exposure Frequency	days/year	EF	250	NDEP 2017a	225	NDEP 2017a	30	[1]
Exposure Duration	years	ED	25	NDEP 2017a	25	NDEP 2017a	1	USEPA 2017
Averaging Time for Cancinogens	days	AT_c	25,550	NDEP 2017a	25,550	NDEP 2017a	25,550	USEPA 2017
Averaging Time for Noncarcinogens	days	AT_{nc}	9,125	NDEP 2017a	9,125	NDEP 2017a	365	USEPA 2017
Inhalation of Vapor Migrating from Soil Gas or Groundwater to Air								
Conversion Factor	hour/day	CF	24	--	24	--	24	--
Intake Factor for Vapor Inhalation, cancer	unitless	$IF_{vapor.inh\_c}$	8.2E-02	USEPA 2009	7.3E-02	USEPA 2009	2.0E-04	USEPA 2009
Intake Factor for Vapor Inhalation, noncancer	unitless	$IF_{vapor.inh\_nc}$	2.3E-01	USEPA 2009	2.1E-01	USEPA 2009	1.4E-02	USEPA 2009

Notes:

-- = Not applicable

NDEP = Nevada Divisoin of Environmental Protection

OU = Operable unit

USEPA = United States Environmental Protection Agency

VDEQ = Virginia Department of Environmental Quality

[1] Recommended exposure frequency in NDEP's January 12, 2017 comment letter (NDEP 2017b).

Sources:

NDEP. 2017a. User's Guide and Background Technical Document for NDEP Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas. December 2008, Revision 14, July.

NDEP. 2017b. Response to: Soil Gas Investigation and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 1. January 12.

VDEQ. 2016. Virginia Unified Risk Assessment Model - VURAM User's Guide. Appendix 3.

USEPA. 2009. Risk Assessment Guidance for Superfund. Vol. 1: Part F, Supplemental Guidance for Inhalation Risk Assessment. Final. January.

USEPA 2017. User's Guide for Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

TABLE 5-6. Exposure Assumptions for Residents in the NERT Off-Site Study Area of OU-2

Nevada Environmental Response Trust Site

Henderson, Nevada

Exposure Factors	Units	Symbol	Residents	
			Value	Source
Population-Specific Exposure Assumptions				
Exposure Time	hours/day	ET	24	NDEP 2017
Exposure Frequency	days/year	EF	350	NDEP 2017
Exposure Duration	years	ED	26	NDEP 2017
Averaging Time for Cancinogens	days	AT_c	25,550	NDEP 2017
Averaging Time for Noncarcinogens	days	AT_{nc}	9,490	NDEP 2017
Inhalation of Vapor Migrating from Soil Gas or Groundwater to Air				
Conversion Factor	hour/day	CF	24	--
Intake Factor for Vapor Inhalation, cancer	unitless	$IF_{vapor.inh\_c}$	3.6E-01	USEPA 2009
Intake Factor for Vapor Inhalation, noncancer	unitless	$IF_{vapor.inh\_nc}$	9.6E-01	USEPA 2009

<u>Notes:</u>

-- = Not applicable

NDEP = Nevada Divisoin of Environmental Protection

OU = Operable unit

USEPA = United States Environmental Protection Agency

<u>Sources:</u>

NDEP. 2017. User's Guide and Background Technical Document for NDEP Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas. December 2008, Revision 14, July.

USEPA. 2009. Risk Assessment Guidance for Superfund. Vol. 1: Part F, Supplemental Guidance for Inhalation Risk Assessment. Final. January.

TABLE 5-7. Chronic and Subchronic Inhalation Toxicity Criteria for Preliminary Soil Gas and Shallow Groundwater COPCs
Nevada Environmental Response Trust Site
Henderson, Nevada

Chemical	Inhalation Unit Risk $(\mu g/m^3)^{-1}$		USEPA Carcinogen Classification	Inhalation Chronic RfC $(\mu g/m^3)$		Inhalation Subchronic RfC $(\mu g/m^3)$	
Acetone	--	--	D	31,000	ATSDR 2017	30,869	ATSDR 2017
Acrolein	--	--	--	0.020	IRIS	0.092	ATSDR 2017
Acrylonitrile	0.000068	IRIS	B1	2	IRIS	2	IRIS [1]
t-Amyl methyl ether	--	--	--	3,000	IRIS [2]	2,523	ATSDR 2017 [2]
Benzene	0.0000078	IRIS	A	30	IRIS	80	PPRTV
Benzyl chloride	0.000049	Cal/EPA 2018	B2	1	PPRTV	4	PPRTV
Bromodichloromethane	0.000037	Cal/EPA 2018	B2	600	IRIS [3]	20	PPRTV
Bromoform	0.0000011	IRIS	B2	--	--	--	--
Bromomethane	--	--	D	5	IRIS	100	PPRTV
2-Butanone	--	--	D	5,000	IRIS	5,000	IRIS [1]
tert Butyl alcohol	--	--	--	30,000	PPRTV [4]	30,000	PPRTV [4]
n-Butylbenzene	--	--	--	400	IRIS [5]	90	HEAST [5]
sec-Butylbenzene	--	--	--	400	IRIS [5]	90	HEAST [5]
tert-Butylbenzene	--	--	--	400	IRIS [5]	90	HEAST [5]
Carbon disulfide	--	--	--	700	IRIS	700	HEAST
Carbon tetrachloride	0.000006	IRIS	B1	100	IRIS	189	ATSDR 2017
3-Chloro-1-propene	0.000006	Cal/EPA 2018	C	1	IRIS	10	HEAST
Chlorobenzene	--	--	D	50	PPRTV	500	PPRTV
Chloroethane	--	--	--	10,000	IRIS	4,000	PPRTV
Chloroform	0.000023	IRIS	B2	98	ATSDR 2017	244	ATSDR 2017
Chloromethane	--	--	D	90	IRIS	3,000	PPRTV
Cumene	--	--	D	400	IRIS	90	HEAST
Cyclohexane	--	--	--	6,000	IRIS	18,000	PPRTV
p-Cymene	--	--	--	400	IRIS [5]	90	HEAST [5]
1,2-Dibromo-3-chloropropane	0.006	PPRTV	--	0.2	IRIS	2	PPRTV
Dibromochloromethane	--	--	C	--	--	--	--
1,2-Dibromoethane	0.0006	IRIS	--	9	IRIS	9	IRIS [1]
1,2-Dichlorobenzene	--	--	D	200	HEAST	2,000	HEAST
1,3-Dichlorobenzene	--	--	D	200	HEAST [6]	2,000	HEAST [6]
1,4-Dichlorobenzene	0.000011	Cal/EPA 2018	C	800	IRIS	1,202	ATSDR 2017
Dichlorodifluoromethane	--	--	--	100	PPRTV Appendix	1,000	PPRTV
1,1-Dichloroethane	0.0000016	Cal/EPA 2018	C	--	--	5,000	HEAST
1,2-Dichloroethane	0.000026	IRIS	B2	7	PPRTV 2017	70	PPRTV
1,1-Dichloroethene	--	--	C	200	IRIS	79	ATSDR 2017
cis-1,2-Dichloroethene	--	--	D	--	--	793	ATSDR 2017 [7]
trans-1,2-Dichloroethene	--	--	D	--	--	793	ATSDR 2017

TABLE 5-7. Chronic and Subchronic Inhalation Toxicity Criteria for Preliminary Soil Gas and Shallow Groundwater COPCs
Nevada Environmental Response Trust Site
Henderson, Nevada

Chemical	Inhalation Unit Risk $(\mu g/m^3)^{-1}$		USEPA Carcinogen Classification	Inhalation Chronic RfC $(\mu g/m^3)$		Inhalation Subchronic RfC $(\mu g/m^3)$	
1,2-Dichloropropane	0.00001	Cal/EPA 2018	B2	4	IRIS	4	PPRTV
1,3-Dichloropropane	--	--	--	4	IRIS [8]	4	PPRTV [8]
1,4-Dioxane	0.000005	IRIS	B1	30	IRIS	720	ATSDR 2017
Ethanol	--	--	--	100,000	NDEP 2017	100,000	NDEP 2017 [1]
Ethyl acetate	--	--	--	70	PPRTV	700	PPRTV
Ethyl benzene	0.0000025	Cal/EPA 2018	D	1,000	IRIS	9,000	PPRTV
4-Ethyltoluene	--	--	--	400	IRIS [5]	90	HEAST [5]
Freon 114	--	--	--	30,000	HEAST [9]	50,000	PPRTV [9]
Hexachlorobutadiene	0.000022	IRIS	C	--	--	--	--
n-Heptane	--	--	D	7,000	NDEP 2017	4,000	PPRTV
n-Hexane	--	--	D	700	IRIS	2,000	PPRTV
2-Hexanone	--	--	D	30	IRIS	30	IRIS [1]
Methyl tert-butyl ether	0.00000026	Cal/EPA 2018	--	3,000	IRIS	2,523	ATSDR 2017
4-Methyl-2-pentanone	--	--	D	3,000	IRIS	800	HEAST
Methylene Chloride	0.00000001	IRIS	B1	600	IRIS	1,042	ATSDR 2017
Methylmethacrylate	--	--	E	700	IRIS	700	IRIS [1]
alpha-Methylstyrene	--	--	--	1,000	IRIS [10]	3,000	HEAST [10]
Naphthalene	0.000034	Cal/EPA 2018	C	3	IRIS	3	IRIS [1]
n-Octane	--	--	--	--	--	--	--
n-Propylbenzene	--	--	--	1,000	PPRTV Appendix	1,000	PPRTV Appendix
Styrene	--	--	--	1,000	IRIS	3,000	HEAST
1,1,1,2-Tetrachloroethane	0.0000074	IRIS	C	--	--	--	--
1,1,2,2-Tetrachloroethane	0.000058	Cal/EPA 2018	B1	--	--	--	--
Tetrachloroethene	0.00000026	IRIS	B1	40	IRIS	41	ATSDR 2017
Toluene	--	--	D	5,000	IRIS	5,000	PPRTV
1,1,2-Trichloro-1,2,2-trifluoroethane	--	--	--	30,000	HEAST	50,000	PPRTV
1,2,3-Trichlorobenzene	--	--	--	--	--	--	--
1,2,4-Trichlorobenzene	--	--	D	2	PPRTV 2017	20	PPRTV
1,1,1-Trichloroethane	--	--	D	5,000	IRIS	3,818	ATSDR 2017
1,1,2-Trichloroethane	0.000016	IRIS	C	0.2	PPRTV Appendix	2	PPRTV Appendix
Trichloroethene	0.0000041	IRIS	A	2	IRIS	2.1	ATSDR 2017
Trichlorofluoromethane	--	--	--	--	--	1,000	PPRTV
1,2,3-Trichloropropane	--	--	B1	0.3	IRIS	0.3	IRIS [1]
1,2,4-Trimethylbenzene	--	--	D	60	IRIS	200	IRIS
1,3,5-Trimethylbenzene	--	--	D	60	IRIS [11]	200	IRIS
Vinyl acetate	--	--	--	200	IRIS	35	ATSDR 2017

TABLE 5-7. Chronic and Subchronic Inhalation Toxicity Criteria for Preliminary Soil Gas and Shallow Groundwater COPCs
Nevada Environmental Response Trust Site
Henderson, Nevada

Chemical	Inhalation Unit Risk $(\mu g/m^3)^{-1}$		USEPA Carcinogen Classification	Inhalation Chronic RfC $(\mu g/m^3)$		Inhalation Subchronic RfC $(\mu g/m^3)$	
Vinyl chloride	0.0000044	IRIS	A	100	IRIS	77	ATSDR 2017
m,p-Xylene	--	--	D	100	IRIS [12]	400	PPRTV [12]
o-Xylene	--	--	D	100	IRIS [12]	400	PPRTV [12]
Xylenes (total)	--	--	D	100	IRIS	400	PPRTV

Notes:
-- = Not available
$\mu g/m^3$ = microgram per cubic meter
ATSDR = Agency for Toxic Substances and Disease Registry
Cal/EPA = California Environmental Protection Agency
COPC = Chemical of potential concern
HEAST = Health Effects Assessment Summary Tables (USEPA 1997)
IRIS = Integrated Risk Information System (USEPA 2018a)
NDEP = Nevada Department of Environmental Protection
PPRTV = Provisional Peer Reviewed Toxicity Values for Superfund (USEPA 2018b)
RfC = Reference concentration
USEPA = United States Environmental Protection Agency

USEPA categorizes chemicals into Groups A, B, C, D, and E carcinogens (USEPA 2014, 2018a):
A: Human Carcinogen
B: Probable Human Carcinogen, including B1 (limited evidence from human epidemiological studies) and B2 (inadequate or no evidence from epidemiological studies)
C: Possible Human Carcinogen
D: Not Classifiable as to Human Carcinogenicity
E: Evidence of Noncarcinogenicity for Humans

[1] Chronic RfC was used as a surrogate.
[2] Methyl tert-butyl ether was used as a surrogate.
[3] Dichloromethane was used as a surrogate.
[4] sec-Butyl alcohol was used as a surrogate.
[5] Cumene was used as a surrogate.
[6] 1,2-Dichlorobenzene was used as a surrogate.
[7] trans-1,2-Dichloroethene was used as a surrogate.
[8] 1,2-Dichloropropane was used as a surrogate.
[9] 1,1,2-Trichloro-1,2,2-trifluoroethane was used as a surrogate.
[10] Styrene was used as a surrogate.
[11] 1,2,4-Trimethylbenzene was used as a surrogate.
[12] Xylenes (total) was used as a surrogate.

Sources:
ATSDR. 2017. Minimal Risk Levels. June.
Cal/EPA. 2018. Toxicity Criteria Database. Available online at https://data.ca.gov/dataset/toxicity-criteria-database. Accessed on March 23, 2018.
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USEPA. 1997. Health Effects Assessment Summary Tables (HEAST). EPA 540-R-97-036. Office of Solid Waste and Emergency Response. Washington, D.C. July.
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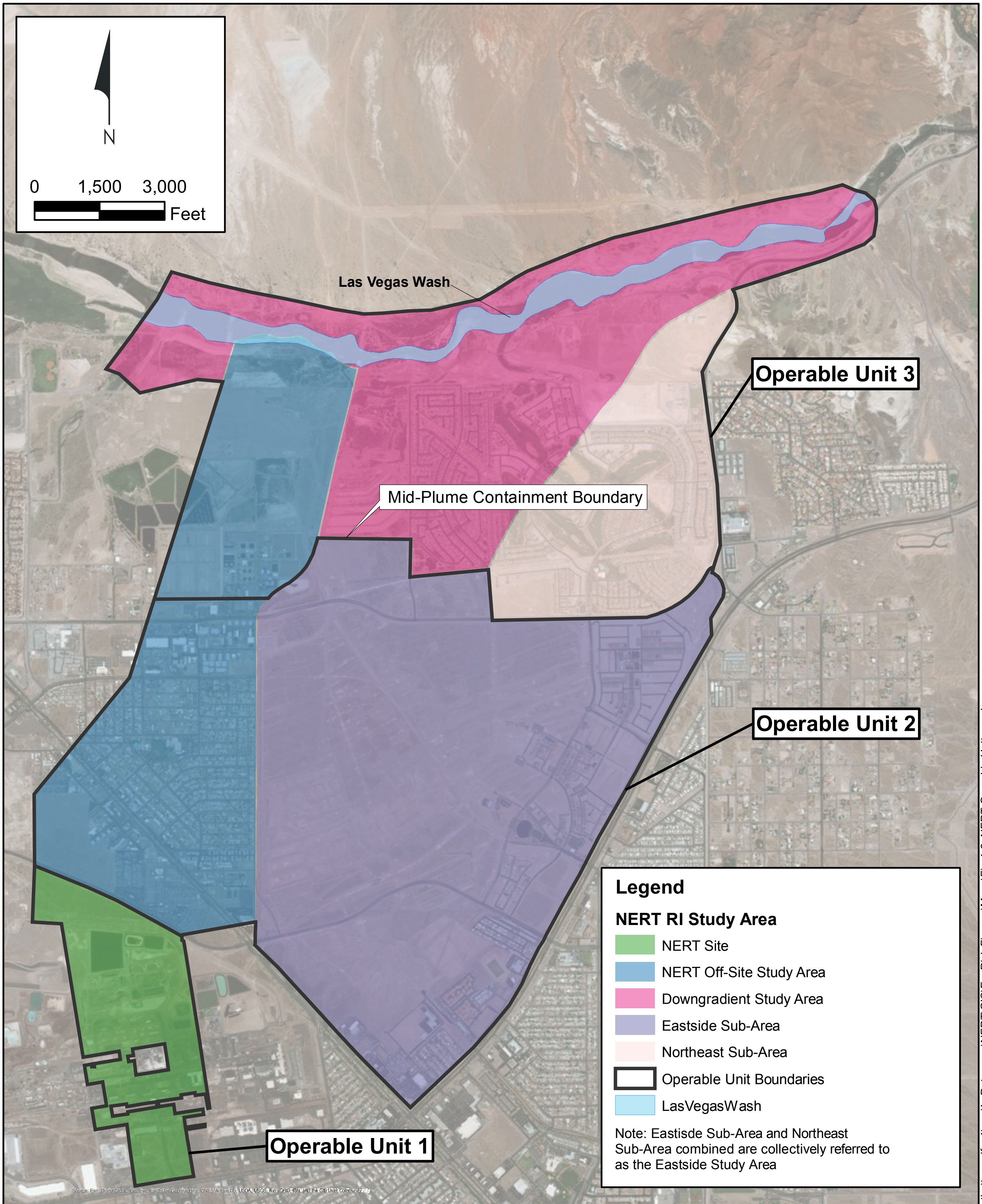
USEPA. 2018a. Integreated Risk Information System (IRIS). Available online at https://www.epa.gov/iris. Accessed on March 23, 2018.
USEPA. 2018b. Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV). Available online at https://hhpprtv.ornl.gov/. Accessed on March 23, 2018.

FIGURES



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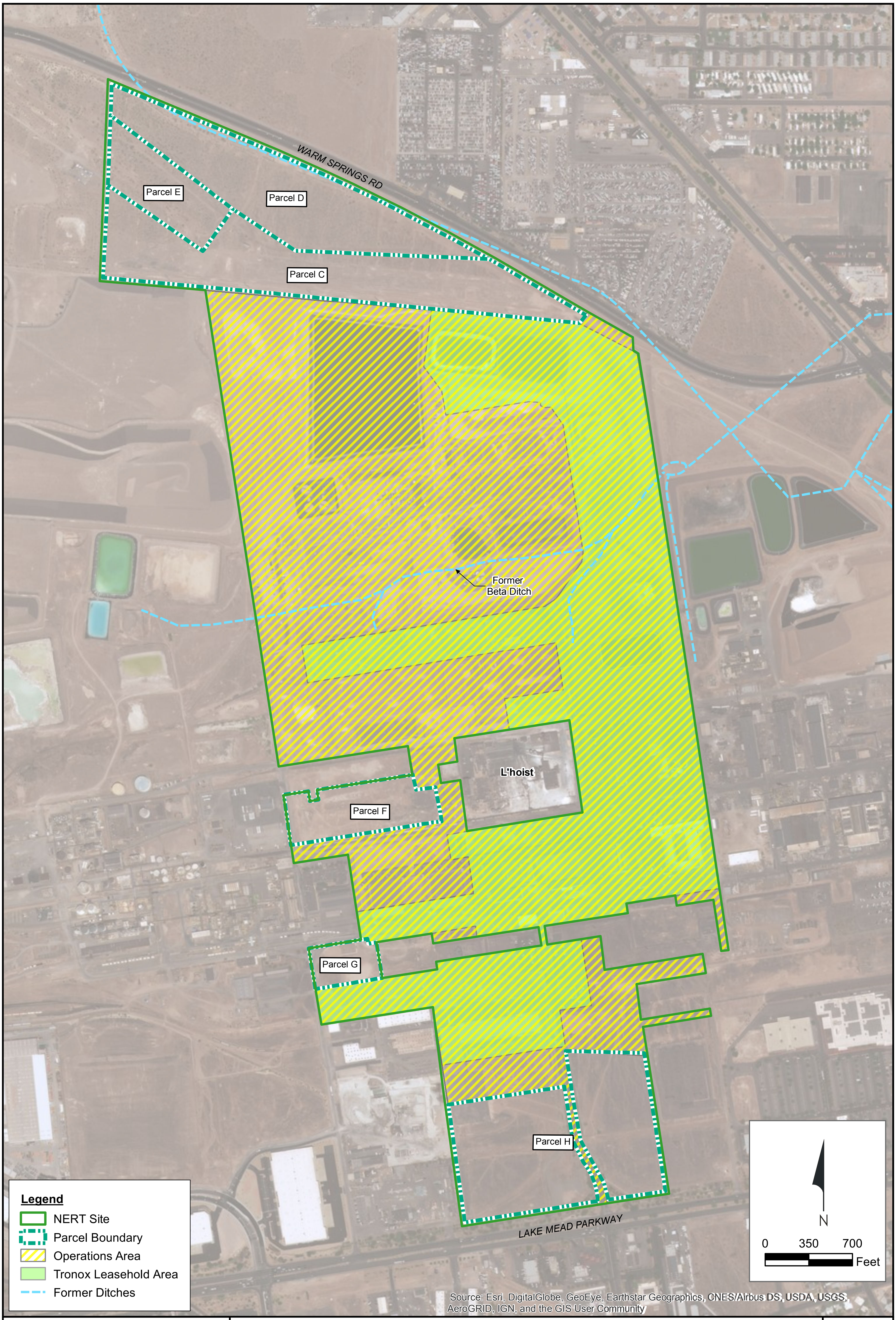
RAMBOLL

Site Location and Operable Unit Map

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
1-1

Drafter: RS Date: 5/30/2018 Contract Number: 169000 6943 Approved by: Revised:



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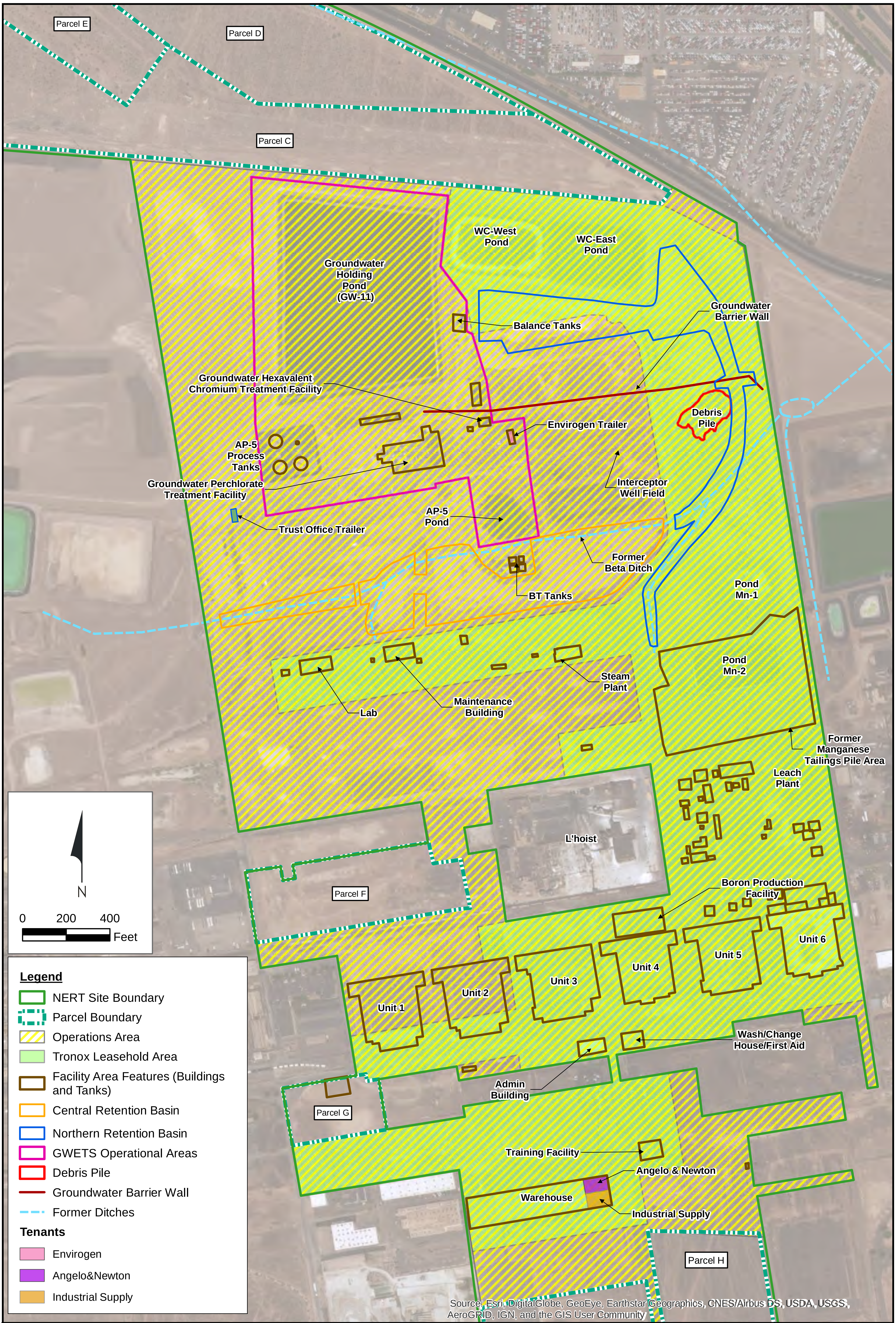
Layout of Operable Unit 1
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **1-2**

Drafter: RS | Date: 5/1/2018 | Contract Number: 169000 6943-017 | Approved by: | Revised:



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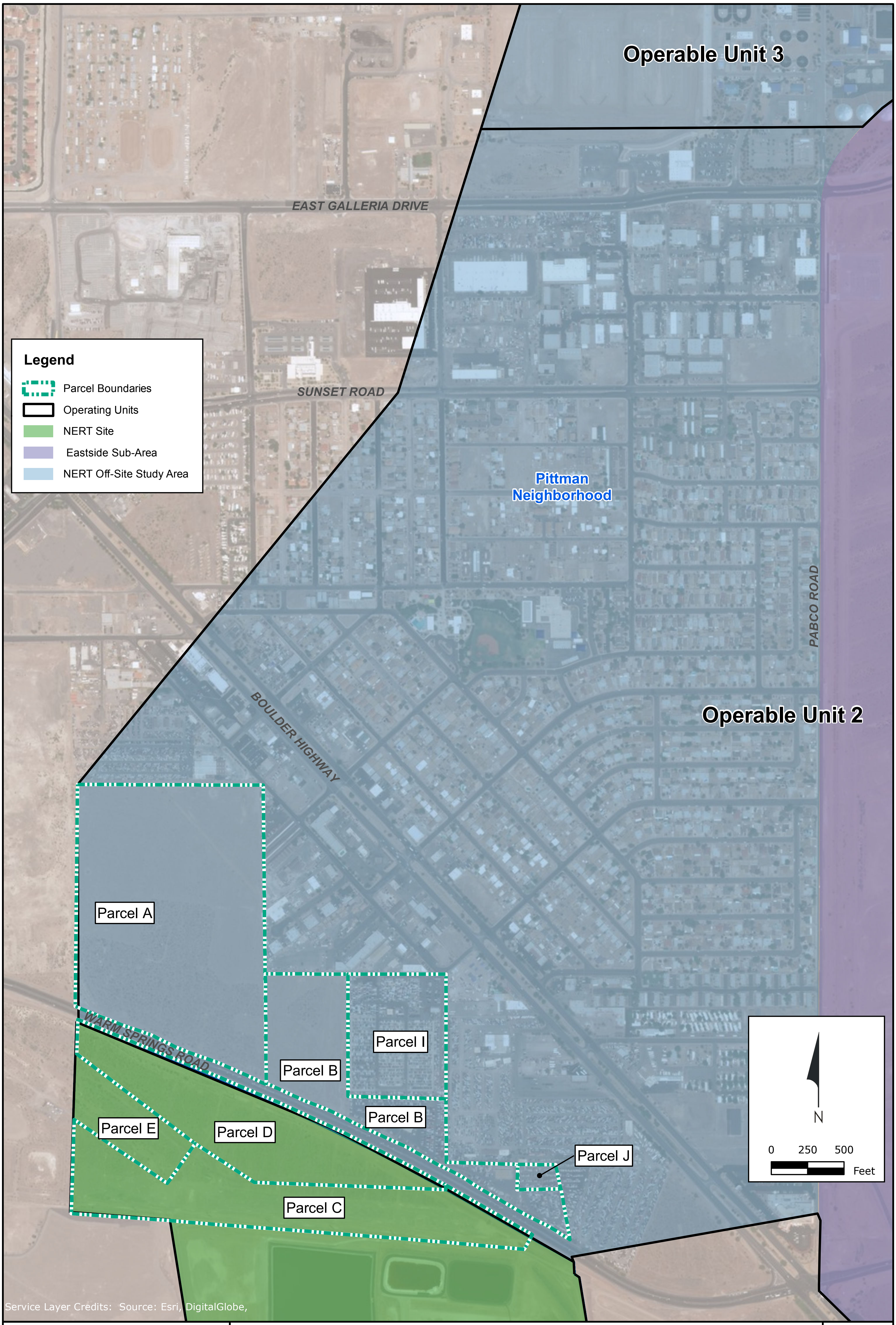
Operations Area Features
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **1-3**

Drafter: RS | Date: 6/11/2018 | Contract Number: 169000 6943-017 | Approved by: | Revised:

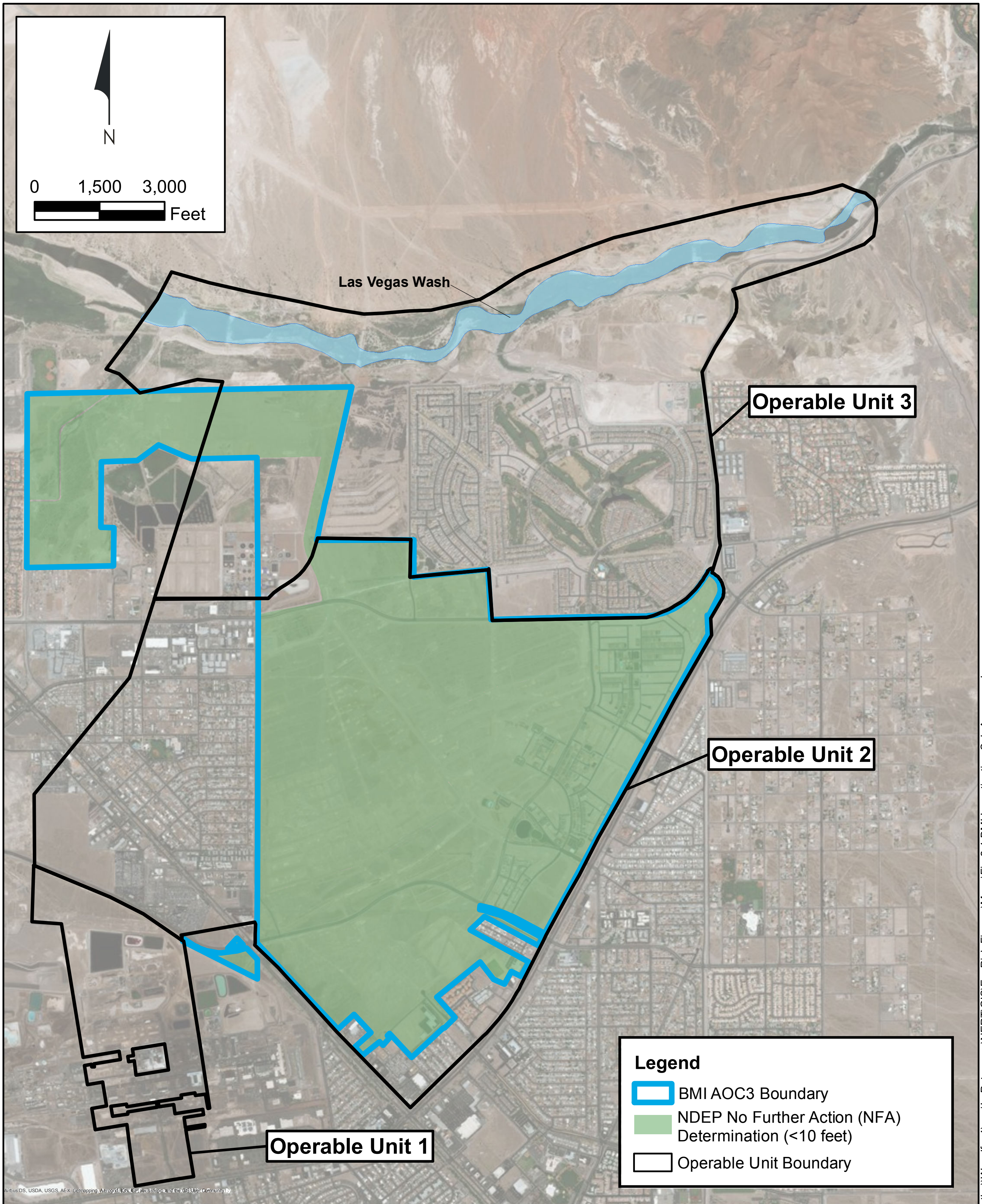


RAMBOLL

Layout of the NERT Off-Site Study Area in Operable Unit 2
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
1-4

Drafter: AR/RS | Date: 5/15/2018 | Contract Number: 169000 6943-017 | Approved by: | Revised:



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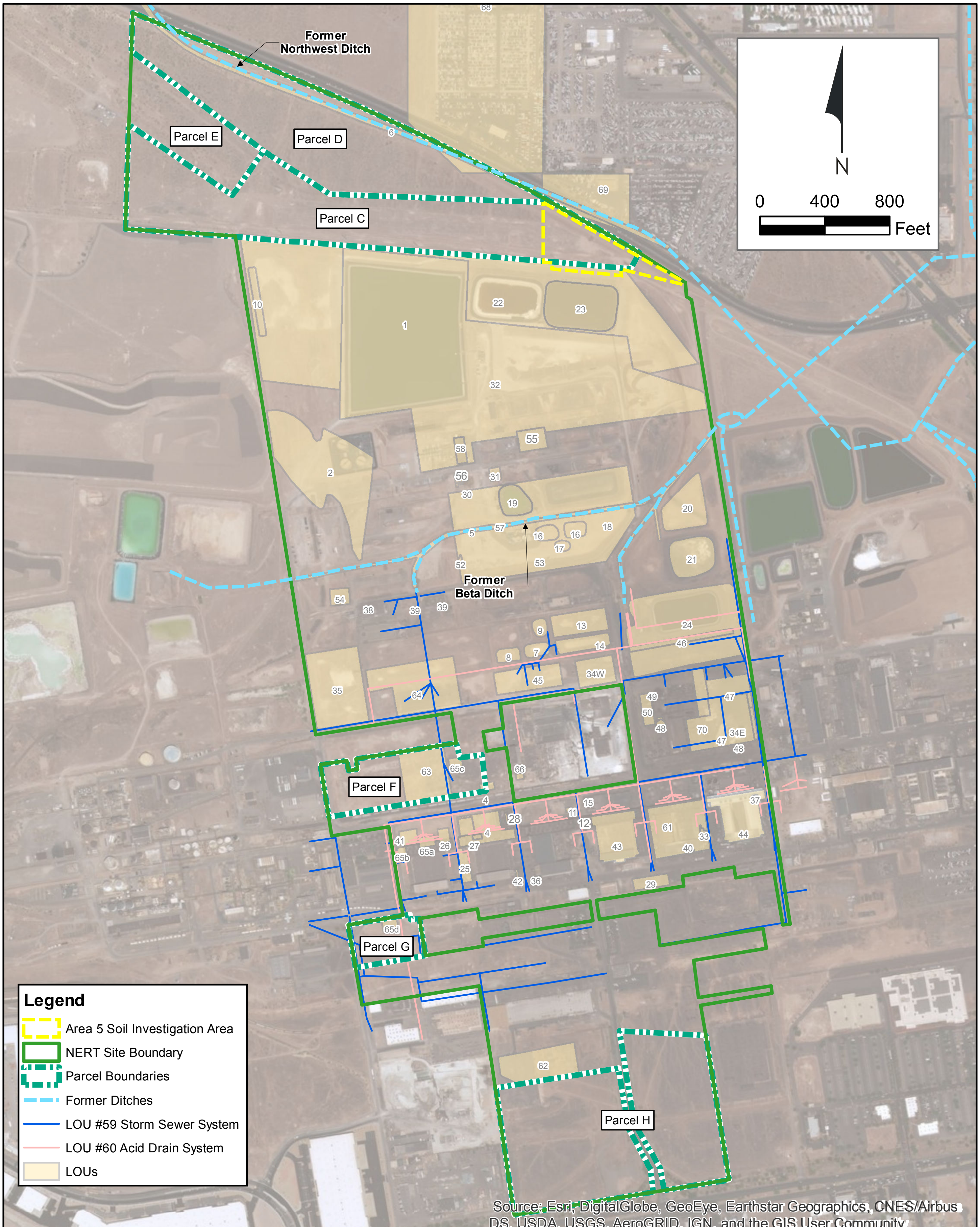
BMI Investigation No Further Action Determination Areas

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **1-5**

Drafter: RS | Date: 5/9/2018 | Contract Number: 169000 6943 | Approved by: | Revised:



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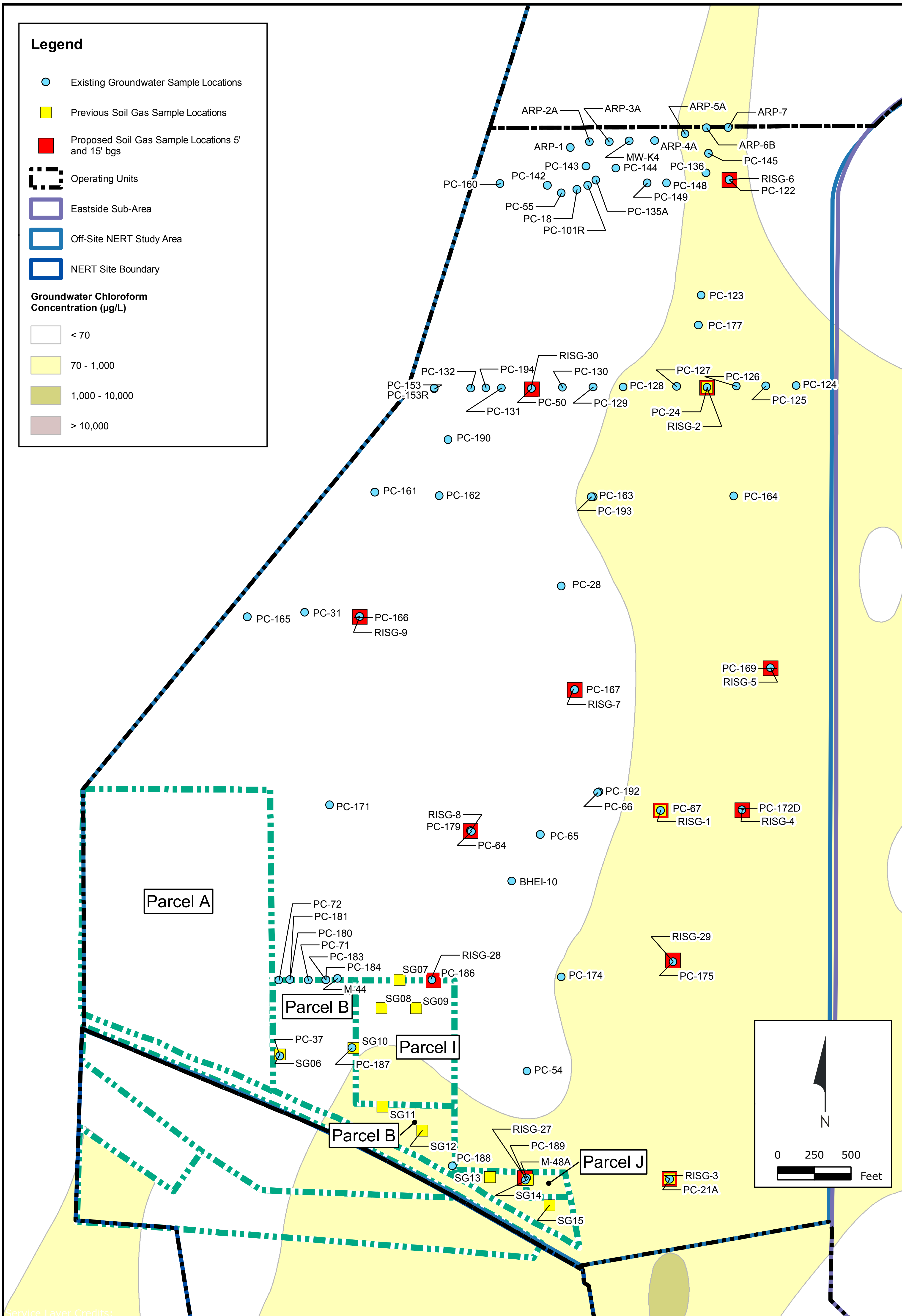
Letter of Understanding (LOU) Map
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
2-1

Drafter: RS | Date: 5/15/2018 | Contract Number: 169000 6943-017 | Approved by: | Revised:



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RAMBOLL

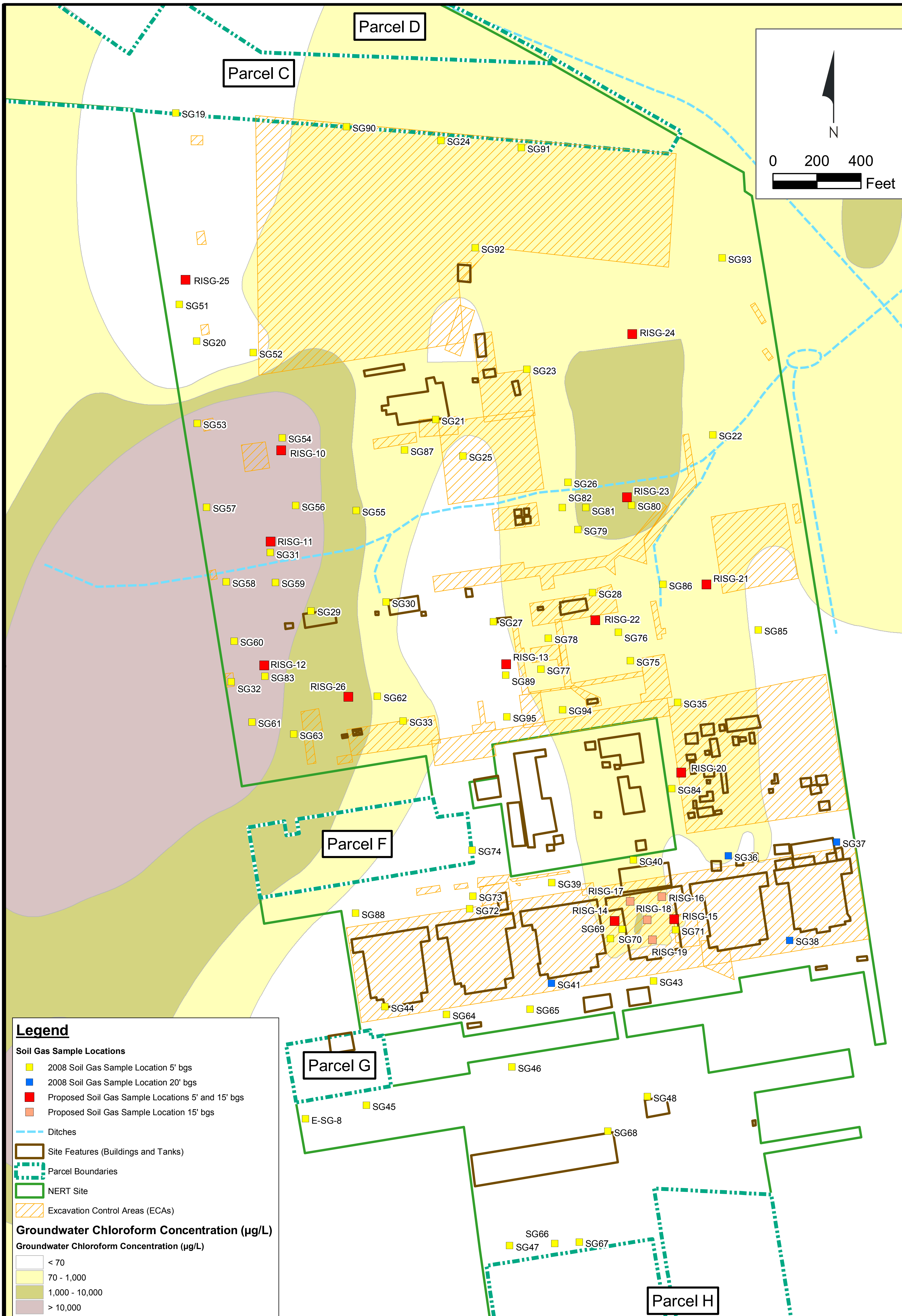
Proposed Soil Gas Sample Locations in the NERT Off-Site Study Area of OU-2 (Chloroform Plume as Depicted in 2017)

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure

3-1

Drafter: RS | Date: 6/19/2018 | Contract Number: 169 000 6943-012 | Approved by: | Revised:



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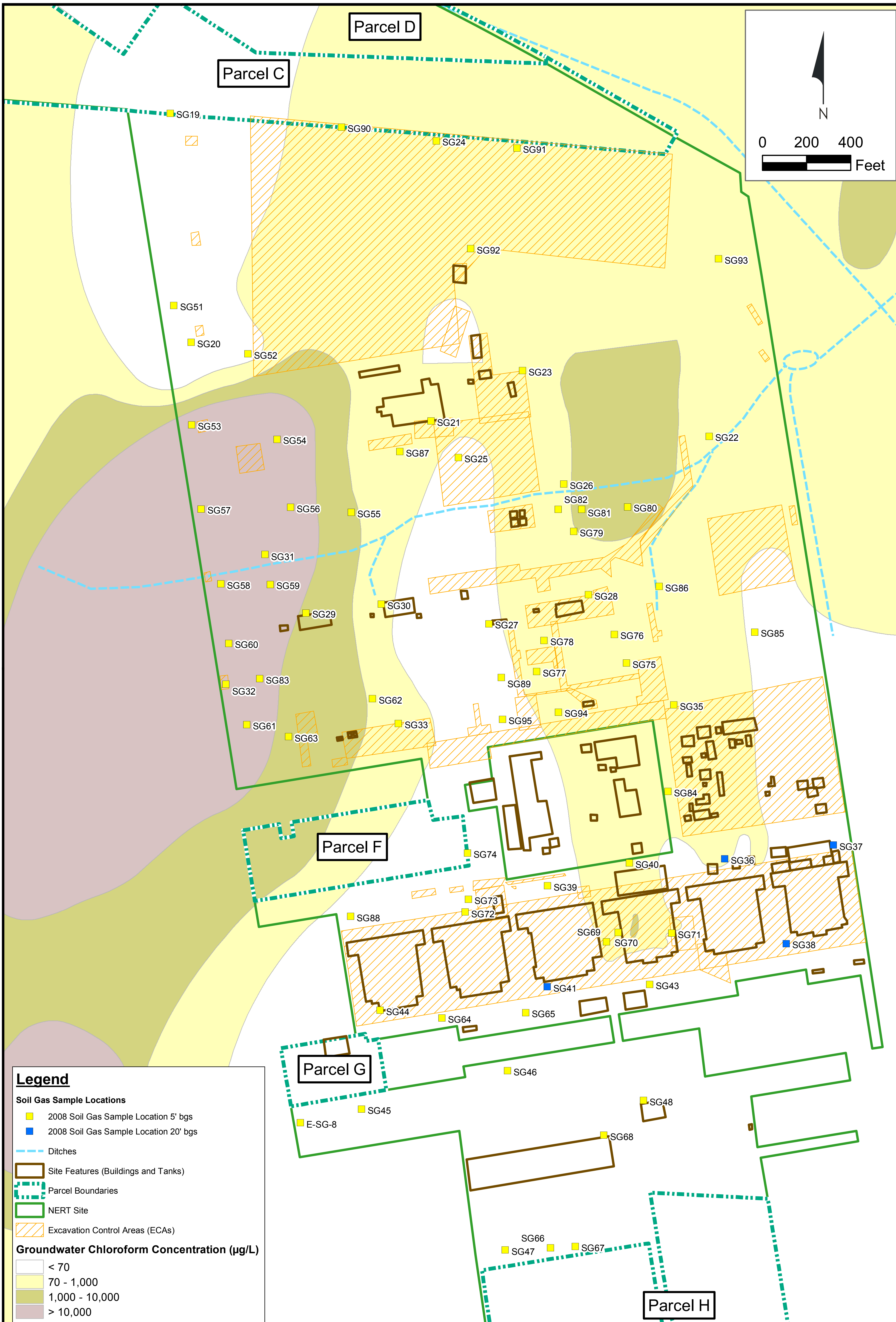
Proposed Soil Gas Sample Locations in OU-1
(Chloroform Plume as Depicted in 2017)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
3-2

Drafter: RS | Date: 6/19/2018 | Contract Number: 169 000 6943-012 | Approved by: | Revised:



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Existing Soil Gas Sample Locations in the Operations Area of OU-1 (Chloroform Plume as Depicted in 2017)

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **4-1**

Drafter: RS | Date: 5/1/2018 | Contract Number: 169000 6943-017 | Approved by: | Revised:

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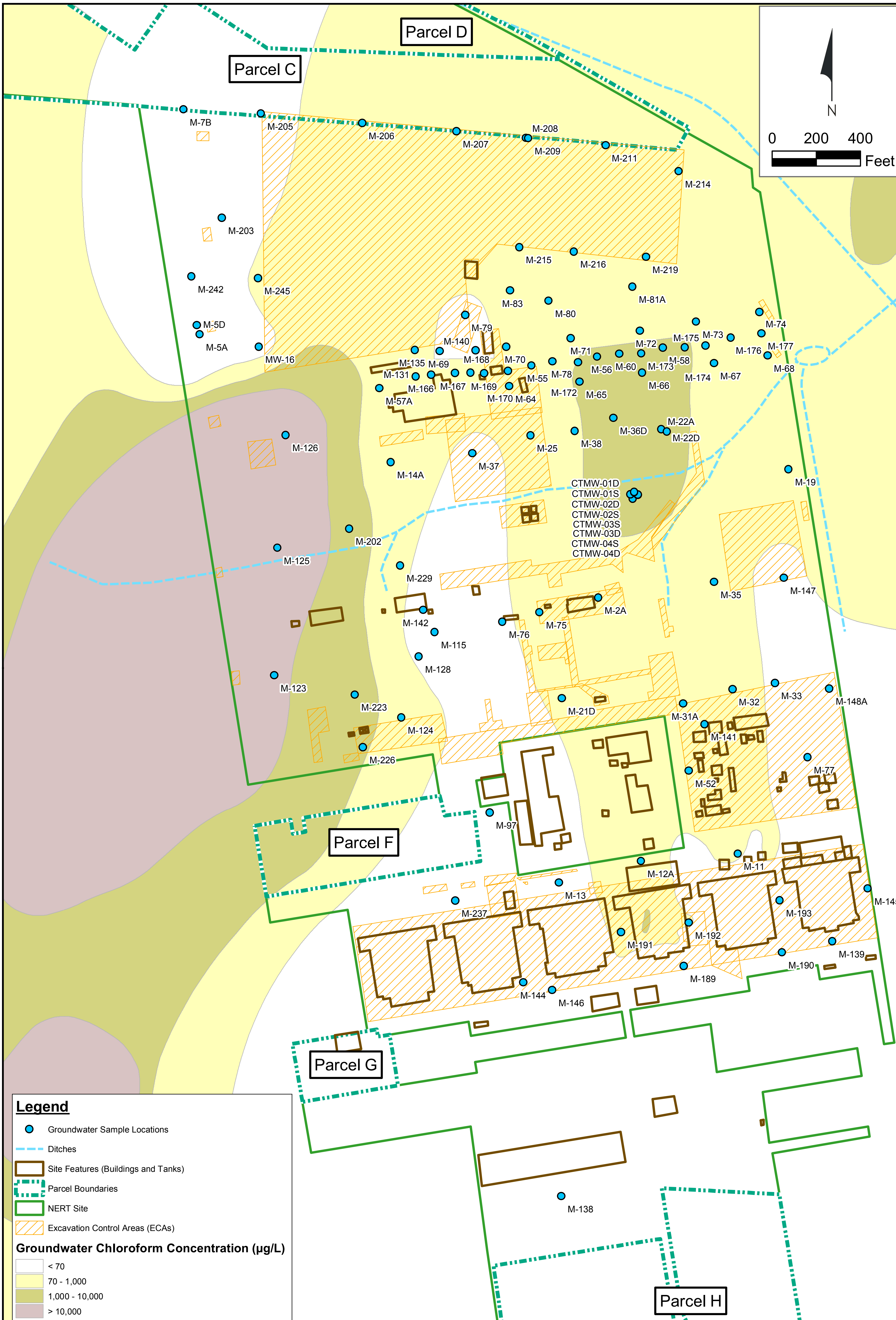

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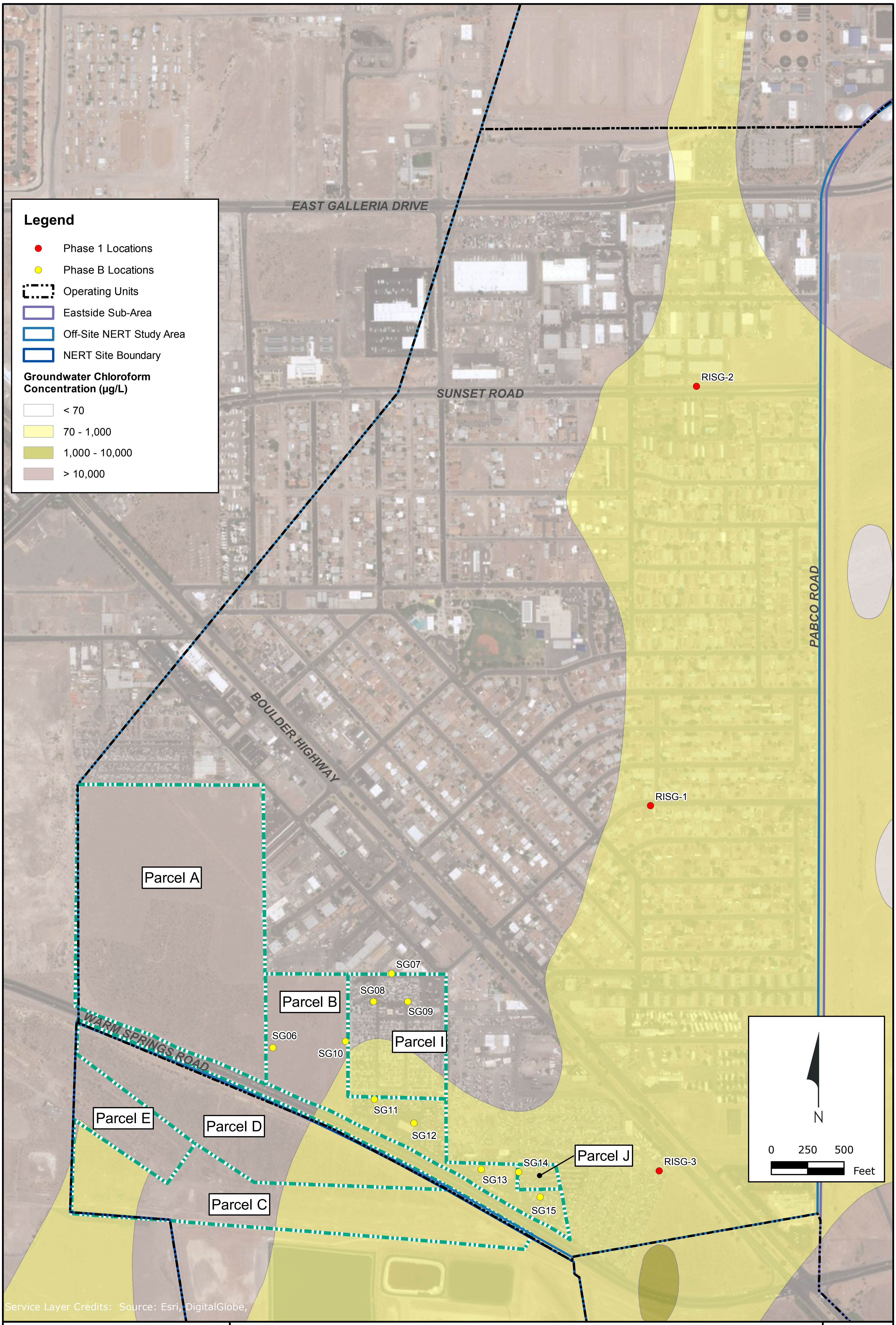
RAMBOLL

Existing Shallow Groundwater Sample Locations in the Operations Area of OU-1 (Chloroform Plume as Depicted in 2017)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-2

Drafter: RS	Date: 5/1/2018	Contract Number: 169000 6943-017	Approved by:	Revised:



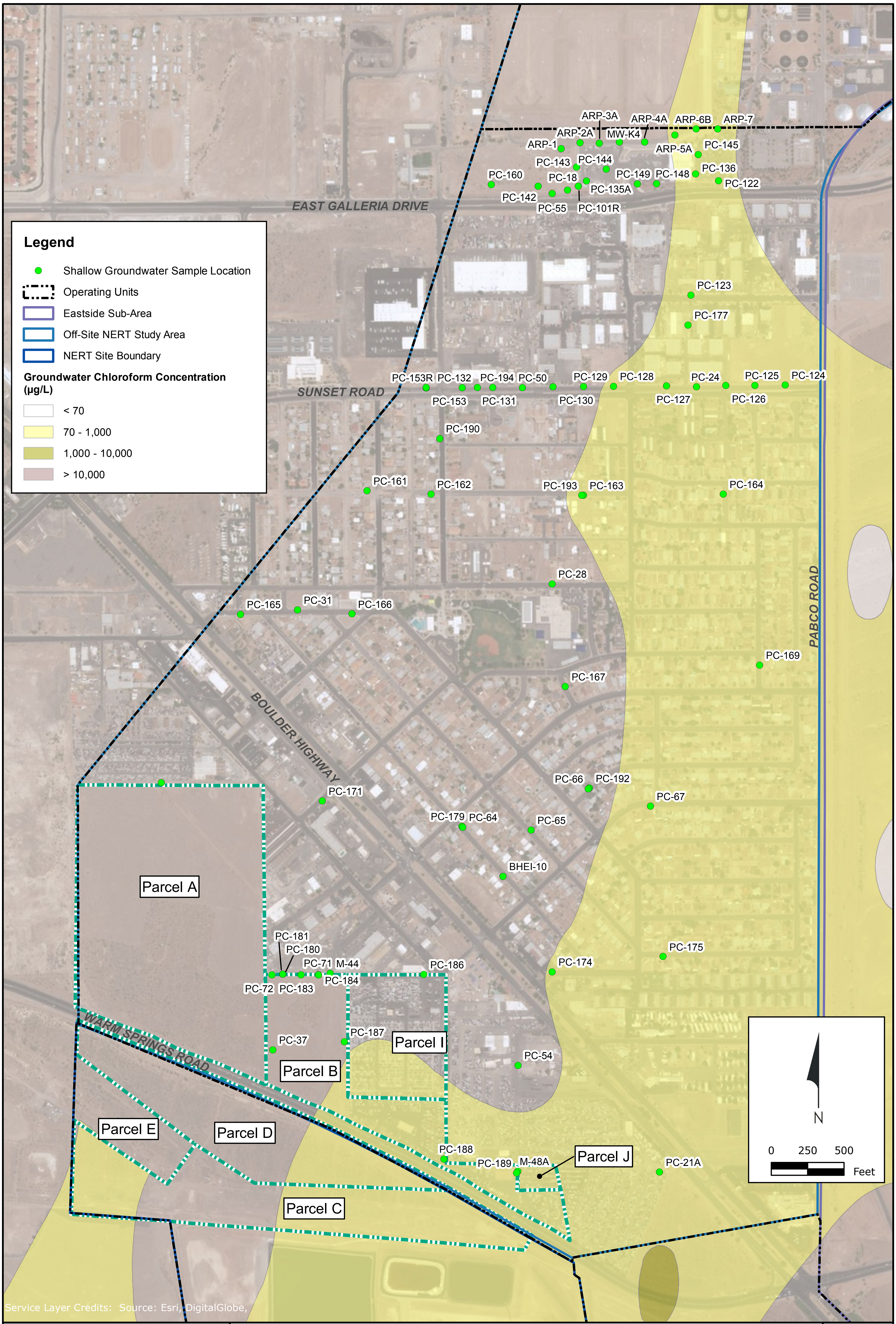
RAMBOLL

Existing Soil Gas Sample Locations in the NERT Off-Site Study Area of OU-2 (Chloroform Plume as Depicted in 2017)

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **4-3**

Drafter: RS | Date: 6/11/2018 | Contract Number: 169000 6943-017 | Approved by: | Revised:



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Existing Shallow Groundwater Sample Locations in the NERT Off-Site Study Area of OU-2(Chloroform Plume as Depicted in 2017)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-4

Drafter: RS	Date: 6/11/2018	Contract Number: 169000 6943-017	Approved by:	Revised:

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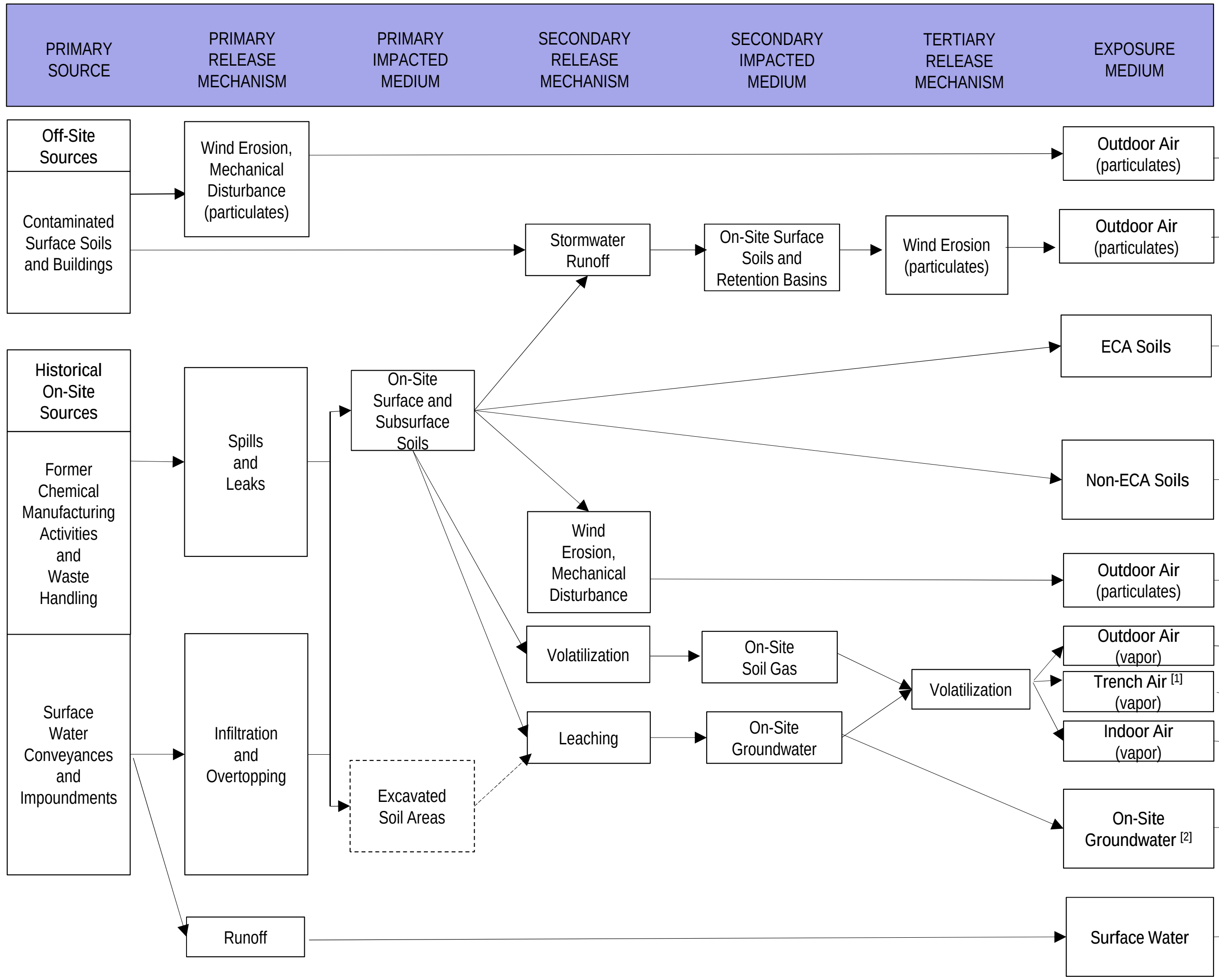

Exposure Medium	Exposure Route	On-Site Receptor: Short-Term Construction Worker	Outdoor Commercial/ Industrial Worker	Indoor Commercial/ Industrial Worker	Visitor/ Trespasser
Outdoor Air (particulates) (off-site sources)	Inhalation [3] [4]	(✓)	(✓)	(✓)	⊙
Outdoor Air (particulates) (wind erosion)	Inhalation [3] [4]	✓	✓	✓	⊙
ECA Soils	Ingestion [3]	SMP	SMP	SMP	⊙
	Dermal	SMP	SMP	inc	⊙
	External Gamma [5]	SMP	SMP	SMP	⊙
Non-ECA Soils	Ingestion [3]	✓	✓	✓	⊙
	Dermal	✓	✓	inc	⊙
	External Gamma [5]	✓	✓	✓	⊙
Outdoor Air (particulates)	Inhalation [3] [4]	✓	✓	✓	⊙
Outdoor Air (vapor)	Inhalation	◎	✓	◎	⊙
Trench Air [1] (vapor)	Inhalation	✓	inc	inc	⊙
Indoor Air (vapor)	Inhalation	inc	inc	✓	⊙
On-Site Groundwater [2]	Ingestion	inc	inc	inc	inc
	Dermal	inc	inc	inc	inc
Surface Water	Ingestion	●	●	inc	⊙
	Dermal	●	●	inc	⊙

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Conceptual Site Model for OU-1 Operations Area

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-1**

Drafter: EL Date: 4/13/18 Contract Number: 169 000 6943-017 Approved by: Revised:

Notes:

BHRA Baseline health risk assessment
ECA Excavation control area
NDEP Nevada Division of Environmental Protection
OSHA Occupational Safety and Health Administration
OU Operable unit
VOC Volatile organic compound

[1] To be conservative, construction workers are assumed to be exposed to vapors migrating from soil gas/groundwater while standing in a 10-foot trench in the unsaturated zone, placing them closer to the potential sources.

[2] Exposure via domestic use of groundwater is not evaluated because on-site groundwater is not and will not be used as a source of drinking water. Incidental ingestion of and dermal contact with groundwater by on-site construction workers are considered to be incomplete exposure pathways because depth to groundwater is >10 feet below ground surface.

[3] Includes radionuclide exposures, if applicable.

[4] Includes asbestos exposures.

[5] Only radionuclide exposures, if applicable.

Key:

inc Incomplete exposure pathway

SMP Site Management Plan -- potential exposures via direct-contact pathways will be managed through the SMP.

✓ Complete exposure pathway; evaluated quantitatively in the BHRA.

(✓) Complete exposure pathway. Ramboll understands that exposures of on-site receptors to airborne releases from neighboring properties would be evaluated in the risk assessments being prepared for those properties, under the oversight of NDEP. This pathway will be discussed quantitatively in the OU-1 soil BHRA using the results of risk assessments prepared by the neighboring properties, or qualitatively, if risk assessments are not available.

◎ The exposure to VOCs in outdoor air is not quantitatively evaluated for construction workers and indoor commercial/industrial workers because it is expected to be much lower than the exposure to VOCs in trench air and indoor air.

○ For on-site receptors, potentially complete, but insignificant exposure pathway; not evaluated quantitatively because such exposures would be intermittent and of short duration or regulated under OSHA.

⊙ Potentially complete exposure pathway; not evaluated quantitatively because public access is generally restricted at industrial sites and potential exposures of a visitor/trespasser would be less than exposures of an on-site worker; the visitor/trespasser will be discussed qualitatively.

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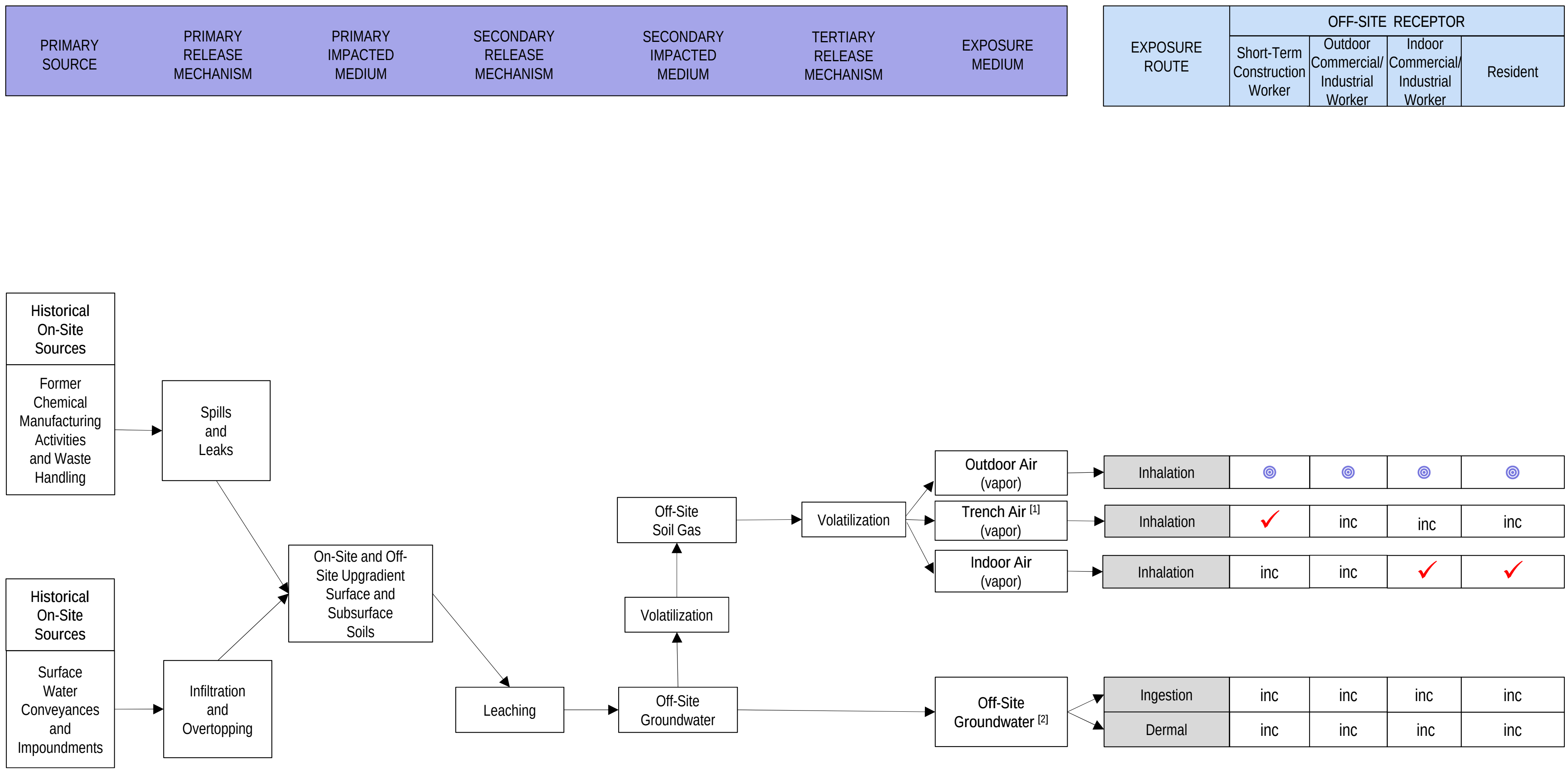
Conceptual Site Model for OU-1 Operations Area
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5-1

Drafter: EL Date: 4/13/18 Contract Number: 169 000 6943-017 Approved by: Revised:



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Conceptual Site Model for the NERT Off-Site Study Area in OU-2

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-2**

Drafter: PW | Date: 4/20/18 | Contract Number: 169 000 6943-017 | Approved by: | Revised:

Notes:

BHRA	Baseline health risk assessment
OU	Operable unit
VOC	Volatile organic compound
[1]	To be conservative, construction workers are assumed to be exposed to vapors migrating from soil gas/groundwater while standing in a 10-foot trench in the unsaturated zone, placing them closer to the potential sources.
[2]	Exposure via domestic use of groundwater is not evaluated because off-site groundwater is not and will not be used as a source of drinking water. Incidental ingestion of and dermal contact with groundwater by off-site construction workers are considered to be incomplete exposure pathways because depth to groundwater is >10 feet below ground surface.

Key:

inc	Incomplete exposure pathway
✓	Complete exposure pathway; evaluated quantitatively in the BHRA.
◎	The exposure to VOCs in outdoor air is not quantitatively evaluated for construction workers, indoor commercial/industrial workers, outdoor workers, or residents because it is expected to be much lower than the exposure to VOCs in trench air or indoor air.

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RAMBOLL

Conceptual Site Model for the NERT Off-Site Study Area in OU-2
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-2**

Drafter: PW Date: 4/20/18 Contract Number: 169 000 6943-017 Approved by: Revised:

APPENDIX A
OU-1 OPERATIONS AREA SOIL GAS BHRA DATA SET (CD)

APPENDIX B
OU-1 OPERATIONS AREA SHALLOW GROUNDWATER BHRA DATA SET (CD)

APPENDIX C
OU-2 NERT OFF-SITE STUDY AREA SOIL GAS BHRA DATA SET (CD)

APPENDIX D
OU-2 NERT OFF-SITE STUDY AREA SHALLOW GROUNDWATER BHRA DATA SET (CD)

APPENDIX E
OU-1 OPERATIONS AREA SOIL PROPERTY SAMPLING LOCATIONS AND BORING LOGS (CD)