Remedial Investigation and Feasibility Study Work Plan Revision 1

Nevada Environmental Response Trust Site; Henderson, Nevada

Prepared for:
Nevada Environmental Response Trust

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Remedial Investigation and Feasibility Study Work Plan, Revision 1

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

Nevada Environmental Response Trust (NERT) 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

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Date: 1/9/14

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Nevada Environmental Response Trust
(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.

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Acronyms and Abbreviations

AECOM	AECOM, Inc.
AL	Action Levels
AMPAC	American Pacific Corporation
AOC	Administrative Order on Consent
AP	ammonium perchlorate
AP&CC	American Potash and Chemical Company
ARAR	applicable or relevant and appropriate requirements
AWF	Athens Road Well Field
BCL	basic comparison level
bgs	below ground surface
BHRA	baseline health risk assessment
BHC	benzene hexachloride (also known as hexachlorocyclohexane)
BMI	Black Mountain Industrial
BRC	Basic Remediation Company
Broadbent	Broadbent & Associates, Inc.
CAA	Clean Air Act
CAMU	Corrective Action Management Unit
CCAQR	Clark County Air Quality Regulations
CEM	Certified Environmental Manager
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIC	Community Involvement Coordinator
CIP	Community Involvement Plan
CO	Carbon monoxide
COH	City of Henderson
COPC	chemical of potential concern
CSTR	Continuously-Stirred Tank Reactors
CSM	conceptual site model
CWA	Clean Water Act
CZE	Capture Zone Evaluation
DAF	dilution attenuation factor
DBSA	Daniel B. Stephens & Associates, Inc

DDT	dichlorodiphenyltrichloroethane
DNAPLs	Dense Non-Aqueous Phase Liquids
DPE	Dual-Phase Extraction
DQO	data quality objective
DRO	diesel range organics
DTSC	Department of Toxic Substances Control
DVSR	Data Validation Summary Report
EC	electrical conductivity
ECA	Excavation Control Areas
EDDs	electronic data deliverables
ENSR	ENSR Corporation
Envirogen	Envirogen Technologies, Inc.
ENVIRON	ENVIRON International Corporation
ESTCP	Environmental Security and Technology Certification Program
Facility Area	The Site, excluding Parcels C, D, F, G, and H
FBR	Fluidized-Bed Reactor
FRTR	Federal Remediation Technology Roundtable
ft^3	cubic feet
ft/ft	feet per foot
ft/yr	feet per year
FS	Feasibility Study
GAC	Granular Activated Carbon
G&M	Geraghty & Miller, Inc
gpd/ft^2	gallons per day per square foot
gpm	gallons per minute
GRA	general response actions
GRO	gasoline range organics
GWETS	Groundwater Extraction and Treatment System
GWRTAC	Ground-Water Remediation Technologies Analysis Center
GWTP	Groundwater Treatment Plant
H+A	Hargis & Associates
HASP	Health and Safety Plan

HCB	hexachlorobenzene
HI	hazard index
HRA	health risk assessment
H2S	hydrogen sulfide
Integral	Integral Consulting Inc.
ISCO	In-Situ Chemical Oxidation (ISCO)
ISCR	In-Situ Chemical Reduction (ISCR)
ITRC	Interstate Technology & Regulatory Council
IWF	Interceptor Well Field
IX	ion exchange
KMCC	Kerr-McGee Chemical Corporation
LBCLs	Leaching-based Basic Comparison Levels
lbs	pounds
LOU	Letter of Understanding
LSSL	Leaching-Based, Site-Specific Levels
MCL	maximum contaminant level
MGD	million gallons per day
µg/L	micrograms per liter (parts per billion)
mg/L	milligrams per liter (parts per million)
MPE	Multi-Phase Extraction
mph	miles per hour
NAC	Nevada Administrative Code
NAPL	non-aqueous phase liquid
NCP	National Contingency Plan
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust
NFA	No Further Action
Northgate	Northgate Environmental Management, Inc.
No_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRS	Nevada Revised Statute
OCHs	organochlorine herbicides

OCPs	organochlorine pesticides
O&M	operations and maintenance
OPA	Oil Pollution Act
OPPs	organophosphate pesticides
ORO	oil range organics
OSHA	Occupational Safety and Health Administration
OSSM	Olin Chlor-Alkali/Stauffer/Syngenta/Montrose (formerly POSSM)
PAHs	polycyclic aromatic hydrocarbons
Pb	Lead
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene (also referred to as perchloroethene)
PEL	permissible exposure limits
PEPCON	Pacific Engineering and Production Company of Nevada (former)
POTWs	Publicly Owned Treatment Works
PM_{10}	particulate matter
PRB	permeable reactive barrier
QA	quality assurance
QAAP	Quality Assurance Project Plan
Qal	Quaternary alluvium
QC	quality control
RAAs	remedial action alternatives (RAAs)
RAO	remedial action objective
RAW	removal action work plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RIB	Rapid Infiltration Basin
RSLs	Regional Screening Levels
RZ	remediation zone
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
Site	Nevada Environmental Response Trust (NERT) Site
SMP	Site Management Plan

SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure
SRC	Site-related chemical
SRG	soil remediation goal
SVE	Soil Vapor Extraction
SVOCs	semivolatile organic compounds
SWF	Seep Well Field
SWMU	solid waste management unit
TBC	to-be-considered
TCE	trichloroethene
TDS	total dissolved solids
TEFs	toxicity equivalent factors
TEQ	toxic equivalents
TIMET	Titanium Metals Corporation
TOC	Total Organic Carbon
TPH	total petroleum hydrocarbons
TLP	Threshold Limit Values
Tronox	Tronox LLC
Trust	Nevada Environmental Response Trust
TSCA	Toxic Substances Control Act
UIC	Underground Injection Control
UMCf	Upper Muddy Creek Formation
UMCf-cg1	Upper Muddy Creek Formation, first coarse-grained facies
UMCf-cg2	Upper Muddy Creek Formation, second coarse-grained facies
UMCf-fg1	Upper Muddy Creek Formation, first fine-grained facies
UMCf-fg2	Upper Muddy Creek Formation, second fine-grained facies
USEPA	U.S. Environmental Protection Agency
VOCs	volatile organic compounds
WAPA	Western Area Power Administration
WBZ	water-bearing zone
WECCO	Western Electrochemical Company
Work Plan	Remedial Investigation and Feasibility Study Work Plan

xMCf	Transitional Muddy Creek Formation
yd^3	cubic yard

Executive Summary

This document comprises a work plan for a Remedial Investigation/Feasibility Study (RI/FS) at the Nevada Environmental Response Trust ("Trust") Site, located within the Black Mountain Industrial (BMI) Complex in unincorporated Clark County and surrounded by the City of Henderson, Nevada. This Work Plan has been prepared in accordance with the Interim Consent Agreement between the Nevada Division of Environmental Protection (NDEP) and the Trust, effective February 14, 2011, and is consistent with applicable U.S. Environmental Protection Agency (USEPA) RI/FS guidance (USEPA 1988), which states that the overall purpose of the RI/FS process is "to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site."

Background

The Site has been the location of industrial operations since 1942 when it was developed by the U.S. government as a magnesium plant to support World War II operations. Following the war, the Site continued to be used for industrial activities, including production of perchlorates, boron, and manganese compounds. Former industrial and waste management activities conducted at the Site, as well as those conducted at adjacent properties, resulted in contamination of environmental media, including soil, groundwater, and surface water. Tronox LLC (Tronox) leases a portion of the Site from the Trust, on which it operates a manufacturing facility producing manganese dioxide, batteries, and boron products. The northwestern portion of the Site contains groundwater treatment facilities, including a chromium groundwater treatment plant, a fluidized-bed reactor (FBR) process for perchlorate treatment, and a lined pond (GW-11) that receives extracted groundwater from one on-site and two off-site extraction well fields. In addition, a drainage ditch known as the Beta Ditch, traverses the Site from west to east and was historically used to convey storm water and process wastewater from the Site and neighboring facilities.

Removal Actions

The Site has been the subject of numerous investigations and removal actions beginning in 1979. The first investigation involved the installation of nine monitoring wells that identified elevated chromium concentrations in groundwater underlying the Site. In 1986-87, additional monitoring wells and 11 on-site extraction wells (known as the Interceptor Well Field [IWF]) were installed along with an on-site chromium treatment facility (the Groundwater Treatment Plant or "GWTP"). The IWF, which still operates at the Site in an expanded configuration, is located in the central portion of the property, approximately 2,400 feet north and downgradient of the central process area of the Site. Additional extraction wells were installed in the 1990s and early 2000s to increase groundwater capture at the IWF. In addition, a bentonite-slurry barrier wall (the "barrier wall") was installed on the downgradient side of the IWF in 2001.

In 1997, elevated concentrations of perchlorate were detected in the Colorado River, which was ultimately traced to groundwater plumes originating at the Site and another ammonium perchlorate manufacturing facility in Henderson. As an interim measure to address the perchlorate plume, a shallow water bearing zone (WBZ) extraction well was installed at Athens Road (approximately 8,200 feet north of the barrier wall and the IWF) in 1998. Groundwater from this well and the IWF was routed to an on-site holding pond, the GW-11 Pond which was constructed in late 1998, until the current perchlorate treatment system could be implemented.

In Spring 1999, hydrologists with the Southern Nevada Water Authority discovered an approximately 400 gpm seep discharging into Las Vegas Wash that contained over 100 mg/L of perchlorate. In 1999, a seep capture sump and temporary single-use resin ion exchange (IX) system were installed near the Las Vegas Wash to capture and treat the water discharging from the seep. In 2001, the Seep Well Field (SWF) was initially constructed near the seep with four extraction wells. Pumping from these wells began in July 2002 and the extracted groundwater was treated by a temporary IX system near the wash and later also by a second temporary single-use resin IX system located at the Site. Five additional extraction wells were installed in February 2003 and an additional extraction well was installed in December 2004 to complete the SWF. The 10 extraction wells in the SWF are situated over the deepest part of an alluvial channel, near the Las Vegas Wash.

To further address the perchlorate plume, in 2002, the Athens Well Field (AWF) was constructed, located approximately 8,200 feet north (downgradient) of the IWF and approximately 4,500 feet south (upgradient) of the SWF. The AWF was initially constructed as a series of 15 groundwater extraction wells screened in Quaternary alluvium (Qal) at eight locations[1] that span across two alluvial paleochannels located on either side of an Upper Muddy Creek Formation (UMCf) ridge. Another extraction well was added to the AWF in 2006.

The original IX treatment systems eventually proved to be unworkable and were abandoned in favor of a biological treatment system employing FBR technology in 2004 (ENSR 2005). An additional reactor was added to the FBR system in 2006 to manage the decommissioning of an on-site pond (AP-5) that contained high concentrations of perchlorate.

Interim Soil Removal Actions

Interim soil removal actions were conducted in response to NDEP's 2009 order to remove all impacted soil from the Site by the end of 2010 to minimize potential health risks associated with the continued presence of contaminated soil (NDEP 2009g). The main contaminated portions of the Site were divided into five separate remediation zones based on geographic groupings of elevated detections of contaminants and conceptual site model (CSM) considerations (Northgate Environmental Management, Inc. [Northgate] 2010g). For applicable remediation zones, the general removal action strategy consisted of excavation of soils within designated polygons, sampling of discolored soil, removal of discolored soil if above site-specific soil remediation goals (SRGs) or otherwise deemed appropriate to remove, and designation of Excavation Control Areas (ECAs) for inaccessible areas, including areas with chemicals of potential concern (COPCs) and/or discolored soil left in place. The removal activities and post-removal conditions at the Site are described in detail in the *Revised Interim Soil Removal Action Completion Report* (ENVIRON International Corporation [ENVIRON] 2012e), submitted to NDEP on September 28, 2012 and approved by NDEP on December 17, 2012 (NDEP 2012c).

[1] The AWF wells are paired, with the well pairs acting in concert with one well pumping while the adjacent well (the so called "buddy" well) is used to measure water levels and monitor the effect of pumping on the aquifer.

<u>*Soil Gas Health Risk Assessment*</u>

Soil gas sampling results were evaluated and eight volatile organic compounds (VOCs) were retained as COPCs for quantitative evaluation in the draft *Site-wide Soil Gas Health Risk Assessment* (Soil Gas HRA) (Northgate 2010r). For the Soil Gas HRA (Northgate 2010r), the migration of COPCs in soil gas from the subsurface to indoor air was estimated using modeling.

<u>*Groundwater Removal Actions*</u>

Current operations at the Site include the continued operation of an on-site Groundwater Extraction and Treatment System (GWETS) that acts to remove hexavalent chromium and perchlorate from shallow groundwater beneath the Site and at downgradient locations along the existing contaminant plume. The GWETS has been in operation since 2006 and operates by capturing groundwater from three extraction well fields (the IWF, AWF, and SWF) and treating the captured groundwater via aboveground treatment facilities for subsequent discharge at the Las Vegas Wash. Perchlorate in extracted groundwater is treated in the on-site FBR process using ethanol as a carbon source. Chromium in extracted groundwater is treated via chemical reduction and precipitation using ferrous sulfate. The IWF currently consists of 23 active extraction wells located immediately upgradient (south) of the vertical barrier wall. The AWF currently consists of seven active extraction wells screened in the alluvium that span approximately 1,200 feet across two alluvial paleochannels. The SWF consists of 10 wells screened across the full thickness of the Quaternary alluvium at the deepest portion of an alluvial channel just south of the Las Vegas Wash. The two off-site well fields, the AWF and the SWF, are served by three lift stations that convey the captured groundwater to the aboveground treatment portions of the GWETS via underground pipelines.

The GWETS has been effective at removing and treating significant amounts of perchlorate and chromium in on-site and off-site groundwater. From July 2002 through June 2012, an estimated 3,093 tons of perchlorate and 19 tons of chromium have been removed and treated by the GWETS. Potential gaps in plume capture have been observed as evidenced by elevated concentrations (primarily perchlorate, but also chromium) at the ends of the IWF and downgradient of the AWF. To address potential gaps in capture and to increase the overall effectiveness of the existing GWETS, the Trust will conduct a GWETS Optimization Project (ENVIRON 2013c) that was approved by NDEP on December 3, 2013 (NDEP 2013e). As part of the GWETS Optimization Project, nine currently idle extraction wells will be activated, and the existing groundwater flow model will be refined and updated in order to estimate capture zones and perform other analyses to support the optimization of the GWETS extraction rates. The model will continue to be refined as part of the RI/FS.

<u>*Groundwater Monitoring Program*</u>

The current GWETS groundwater monitoring program consists of approximately 1,800 water level measurements and over 1,000 groundwater samples collected from groundwater wells each year. Samples are collected on monthly, quarterly, and annual schedules in accordance with monitoring requirements outlined in previous Consent Orders and an Administrative Order on Consent (AOC) and through subsequent regulatory correspondence. In an effort to improve and streamline the groundwater monitoring program, a long-term monitoring optimization study is planned and will be presented as part of the RI Report.

A work plan to characterize and remove the residual solids remaining in an on-site lined surface impoundment (the AP-5 pond) at the Site (ENVIRON 2012d) was approved by NDEP on February 4, 2013 (NDEP 2013a).

Initial Site Evaluation

Consistent with the RI/FS guidance (USEPA 1988), the initial site evaluation includes a detailed evaluation of historical information regarding the Site, including data generated from the numerous investigations previously conducted at the Site. The initial site evaluation: (1) summarizes the CSM, (2) identifies the preliminary remedial action objectives (RAOs) and applicable or relevant and appropriate requirements (ARARs), (3) describes the development of general response actions and screening of remedial technologies and process options, and (4) describes additional areas that require investigation to determine the nature and extent of COPCs at the Site.

Conceptual Site Model

The CSM for this Work Plan (see Section 5.1) is developed based on a current understanding of on-site and off-site environmental conditions that affect the Facility Area, which is comprised of the 265-acre portion of the Site excluding Parcels C, D, F, G, and H. This preliminary identification of sources, release mechanisms, exposure media, exposure routes, and receptors is based on a current understanding of on-site and off-site environmental conditions. As part of the CSM, potential contaminant sources and release mechanisms were identified and reviewed. NDEP has identified 70 source areas which include areas that are currently used for chemical production, areas that are no longer active, and/or areas where near surface soil contamination has previously been addressed. These current or former source areas include, but are not limited to:

- Unit buildings 1 through 6;
- Surface water impoundments (over 15 former and current surface water impoundments were identified as LOUs);
- Former and current surface and subsurface water conveyances (e.g., the Beta Ditch, Beta Ditch Extension, Northwest Ditch, drainage systems, sewers, piping);
- Leach Plant area;
- Acid drain system;
- Agricultural division plant;
- Ammonium perchlorate plant and associated buildings;
- Materials and product handling and storage areas;
- Waste handling and storage areas;
- Manganese tailings area;
- Stock pile areas; and
- Former hazardous waste landfill (LOU 10) and other hazardous waste storage areas.

Historical releases from potential source areas have been documented or inferred from field investigations that have identified chemically impacted on-site soils, soil gas, and groundwater.

Neighboring properties include the Olin property to the west of the Site, the unlined BMI landfill that received wastes from a number of operating entities, the Lhoist property that is surrounded by the Site on three sides and that contributed to flows to the Beta Ditch prior to 1979, and the Titanium Metals Corporation (TIMET) property to the east of the Site. These adjacent neighboring properties are considered potential former and/or current off-site sources of contaminants to Site groundwater, particularly from the west; surface soils and surface water (from off-site storm water entering the Site); and air (airborne particulates released from contaminated surface soils and buildings on these adjacent properties).

Considering the existing investigation results, completed removal action, and Site Management Plan (SMP) controls in place at the Facility Area, surface and near surface soils[2] were placed into one of four categories to inform the CSM, as well as identify data gaps and exposure pathways for evaluation in the RI and baseline health risk assessment (BHRA) to be conducted as part of the RI/FS. The four categories are identified as follows:

- Category 1 - Soils in ECAs
- Category 2 - Soil Remediation Goals [SRGs] Not Exceeded, Not in ECA
- Category 3 - SRGs Exceeded, Not in ECA
- Category 4 - Inadequate Characterization, Not in ECA.

The soil category classifications will be utilized, along with worker activity patterns, for the identification of exposure units in the upcoming BHRA Work Plan, to be submitted to NDEP in February 2014. The approach for identifying soil COPCs for evaluating risk to human health will be identified in the BHRA Work Plan. Based on our review of the data, soil COPCs will include chemicals (both inorganic and organic), asbestos, and radionuclides.

The potentially contaminated exposure media at the Facility Area and nearby vicinity include ambient and indoor air, soil, surface water, and groundwater. Consistent with the NDEP-approved 2010 HRA Work Plan (Northgate 2010d), current and future on-site receptors identified for evaluation in the BHRA include long-term indoor workers, long-term outdoor commercial or industrial workers, and short-term construction workers. Currently, over 100 full-time workers are employed at the Tronox facility and approximately seven workers are employed at the GWETS.

As part of this RI/FS Work Plan, ENVIRON conducted an updated screening of vadose zone soil concentrations against NDEP Leaching-based Basic Comparison Levels (LBCLs) or similar screening levels using a soil dataset that has been revised to incorporate changes resulting from the interim soil removal action. Preliminary leaching-based soil COPCs were selected using a frequency of detection approach and a complete list of COPCs based on leaching to groundwater was developed (Section 5.1.4.1). In addition to perchlorate and chromium, the list

[2] Defined as 0-10 feet below the "new" ground surface. The "new" ground surface refers to the soil surface following excavation, backfilling, and grading associated with the 2011 interim soil removal action (ENVIRON 2012e).

includes specific metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins/furans, organic acids, radionuclides, total petroleum hydrocarbons (TPH), and various general chemistry parameters. As part of the RI, ENVIRON will review available soil data to evaluate whether any revisions to this list are necessary.

Perchlorate and chromium are the primary Site-related chemicals detected in soil at the Site and in groundwater beneath and downgradient of the Site. Although there is no reported use of chloroform at the Site, chloroform is also detected in groundwater at the Site, at neighboring properties, and in downgradient areas. In addition to perchlorate and chromium, the groundwater CSM includes the transport of volatile chemicals present in the vadose zone to groundwater by infiltration and vapor-phase diffusion. In general, infiltration at the Site is limited due to portions of the Site being paved and the arid climate. However, sufficient water could be generated to mobilize Site-related chemicals during certain events including rainstorms of sufficient quantity and duration, utility pipeline leaks or breaks, or leaks from surface impoundments. Transport by diffusion can also occur if the vadose zone soils remain dry, which could result in transport of volatile chemicals in the vapor phase downward to the water table.

In addition to perchlorate and chromium, ENVIRON developed a list of other COPCs in groundwater that exceed screening criteria, based on analysis of data from several investigations performed since 2006, including the Phase A and Phase B investigations and others. COPCs in groundwater were selected using a frequency of detection approach and a complete list of COPCs in groundwater was developed (Section 5.1.4.2). In addition to perchlorate and chromium, COPCs in groundwater include specific metals, VOCs, pesticides, radionuclides, SVOCs, and general chemistry parameters. As part of the RI, available groundwater data will be reviewed to evaluate whether any revisions to the preliminary groundwater COPCs are necessary.

Remedial Action Objectives and Remedial Alternatives Evaluation

Preliminary RAOs and ARARs have been developed for use and further evaluation during the RI/FS. Short-term RAOs are anticipated to be met in less than 5 years and include: 1) mitigation of the discharge of COPCs originating at the Site to the Las Vegas Wash, 2) optimization of the current GWETS operation to ensure that maximum capture efficiency is being achieved for each of the three extraction well fields, and 3) prevention of human exposure to COPCs in soil that would pose an unacceptable health risk to on-site and off-site receptors. Long-term RAOs are those that address a longer time frame (i.e., greater than 5 years). These include: 1) downgradient aquifer restoration, 2) mitigation of the migration of COPCs from the Site to the area downgradient of the northern Site property boundary, and 3) mitigation of significant leaching of perchlorate and other Site COPCs from vadose zone soils to underlying groundwater.

Based on the identified ARARs and preliminary RAOs identified for the Site, general response actions (GRAs) have been developed (Section 5.3.1), and a comprehensive list of potentially applicable remedial technologies and process options has been compiled (Section 5.3.2). The technologies and process options have been evaluated and screened in this Work Plan resulting in the retention of implementable technologies that can be used in the development of remedial action alternatives (RAAs). Of the 119 discrete process options that were initially identified, 62 process options were screened out from further consideration on the basis of effectiveness, implementability, and cost. A total of 57 process options were retained from the screening process for remedial alternative development. The remedial technologies and process options will be further evaluated in the feasibility study (FS).

Based on the initial screening, the following general preliminary remedial action alternatives (RAA) have been identified as potentially practicable alternatives to address the COPCs in soil and groundwater at the Site: 1) no further action; 2) enhancement of groundwater containment, recovery, and aboveground treatment via upgrades to the existing GWETS; 3) enhancement of groundwater containment, recovery, and aboveground treatment via upgrades to the existing GWETS and on-site source control; and 4) enhanced groundwater containment and extraction at the IWF and AWF with in-situ treatment downgradient of the AWF. The preliminary RAAs are not meant to be comprehensive and specific with respect to retained process options. Rather, these RAAs represent general conceptual approaches that would address the primary COPCs and RAOs for the Site. Further analysis and screening conducted during the implementation of the RI are expected to identify numerous potentially applicable process options that can be evaluated for each of the preliminary RAAs identified. Treatability studies will also be used to evaluate certain remedial technologies for which additional information regarding their feasibility/performance under site-specific conditions is necessary. Treatability studies evaluating a permeable reactive barrier (PRB) and in-situ soil flushing have been proposed. Additional treatability studies may be identified as further information is developed during the RI/FS.

Data Gaps to be Evaluated in the RI

For the RI/FS, additional areas have been identified that require investigation to determine the nature and extent of COPCs in soil and groundwater at the Site. Many of these areas were previously identified by NDEP as areas requiring further study. For purposes of additional soil characterization, four main areas have been identified for collection of additional physical and chemical data from both shallow and deep soils. These areas include the AP-5 Pond area, the debris pile, soil in the area between the debris pile and AP-5 Pond, and the area west of Pond Mn-1. Also, additional data are needed to evaluate the Category 1 soil areas with limited soil characterization due to access constraints (e.g., soils beneath Unit buildings). These additional data needs will be addressed by the installation of shallow groundwater monitoring wells with soil samples collected continuously during drilling. Five monitoring wells are proposed in the area of the Unit Buildings 4, 5, and 6. In addition, directional drilling may be employed where feasible in order to obtain soil samples from beneath certain operating areas of the Site where high perchlorate concentrations are present in shallow wells. Soil and groundwater samples will be analyzed for COPCs in groundwater. Additional data review and groundwater investigations are also proposed to address the following data gaps: determination of background COPC concentrations, revision of the preliminary list of COPCs, COPC impact in the Middle Water-Bearing Zone/Muddy Creek Formation, the magnitude and extent of trespassing chemicals, the lateral and vertical extents of the downgradient plume, chloroform within the downgradient plume, and stream-aquifer interaction with the Las Vegas Wash. These data gaps will be addressed as part of the RI/FS.

RI/FS Tasks and Schedule

As specified within the RI/FS framework identified in USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988), the following tasks will be conducted as part of this RI/FS:

- Task 1: Project Planning;
- Task 2: Community Relations;
- Task 3: Groundwater Modeling;
- Task 4: Field Investigation;
- Task 5: Sample Analysis and Data Verification and Validation;
- Task 6: Data Evaluation;
- Task 7: Risk Assessment;
- Task 8: Treatability Studies;
- Task 9: Remedial Investigation Report;
- Task 10: Remedial Alternatives Development;
- Task 11: Detailed Analysis of Alternatives; and
- Task 12: Feasibility Study Report.

Further details regarding the scope of each of these tasks are provided in Section 6 of this Work Plan. This RI/FS Work Plan is being submitted to NDEP in January 2014, and follows the recent submittal in December 2013 of a Community Involvement Plan (CIP) (ENVIRON 2013g) and two treatability study work plans (ENVIRON 2013e,f). A Sampling and Analysis Plan (SAP), which will contain field sampling plans, a Quality Assurance Project Plan (QAPP) and a health and safety plan (HASP), for the data gap field investigation will be submitted to NDEP in late January 2014. A BHRA Work Plan will be submitted to NDEP in February 2014. It is anticipated that these documents will be approved by NDEP by May 2014. Field investigations to address data gaps, as outlined in the SAP, are anticipated to be performed between June and November 2014, after which the BHRA will be performed from approximately January to July 2015. The soil flushing and permeable reactive barrier (PRB) treatability studies will be implemented concurrent with the data gap field investigation and continuing into 2015. The RI and BHRA reports are anticipated to be prepared from February to July 2015, followed by completion of the treatability studies in mid 2015 to early 2016 and preparation of the FS report in 2016. The anticipated RI/FS project schedule is provided in Section 7.2.

1.0 Introduction

In accordance with the Interim Consent Agreement between the Nevada Division of Environmental Protection (NDEP) and the Nevada Environmental Response Trust ("Trust"), effective February 14, 2011, ENVIRON International Corporation (ENVIRON) submits this Remedial Investigation (RI) and Feasibility Study (FS) Work Plan, Revision 1 (Work Plan) to the NDEP on behalf of the Trust. A prior RI/FS Work Plan was submitted to NDEP on December 17, 2012. Comments on the work plan were provided by NDEP to the Trust on June 27, 2013. On behalf of the Trust, ENVIRON provided a response to NDEP comments on October 4, 2013. On November 18, 2013, NDEP provided four comments based on their review of the October 4, 2013 response to comments document. As requested in NDEP's November 18, 2013 letter, a tabular summary providing revised annotated responses to NDEP's June 27, 2013 and November 18, 2013 comments is provided in Appendix A.

The Site comprises approximately 346 acres[3] located within the Black Mountain Industrial (BMI) Complex in unincorporated Clark County and is surrounded by the City of Henderson, Nevada (Figure 1-1). The property comprising the Site has a long, complex ownership and operational history, as summarized in Section 2. The Site has been the location of industrial operations since 1942 when it was developed by the U.S. government as a magnesium plant to support World War II operations. Following the war, the 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 Site, as well as those conducted at adjacent properties, resulted in contamination of environmental media at the Site, including soil, groundwater, and surface water.

Tronox LLC (Tronox) most recently owned and operated the Site until February 14, 2011, on which date the Trust took title to the Site in conjunction with the settlement of Tronox's bankruptcy proceeding. Tronox currently leases a portion of the Site from the Trust, on which it continues to operate its chemical manufacturing business. The exclusive purpose and functions of the Trust include (among others): "(i) own the (Site) for purposes of implementing the Settlement Agreement[4], (ii) carry out administrative and property management functions related to the (Site), (iii) manage and/or fund implementation of Environmental Actions for the Henderson Legacy Conditions (as defined in the Settlement Agreement) that are approved by (NDEP)."

The Site has been the subject of extensive environmental investigations and removal actions since the 1970s. The on-site Hazardous Waste Landfill was closed and capped in 1985. A groundwater treatment system for removal of hexavalent chromium from groundwater was constructed in 1987. In 1994, NDEP identified 69 Letter of Understanding Potential Source

[3] Following the sale of Parcels A and B in December 2013 to TRECO, LLC, the Site comprises approximately 346 acres.

[4] Settlement Agreement shall mean that certain Consent Decree and Environmental Settlement Agreement, effective February 14, 2011, filed in the *Tronox Incorporated, et al.* Bankruptcy Case No. 09-10156 (ALG).

Areas (NDEP 1994) (referred to in this and other reports as LOUs[5]). In 1997, perchlorate, later shown to originate, in part, from the Site, was detected in Las Vegas Wash and the Colorado River (NDEP 2011a), and in 1999, an additional groundwater treatment system for removal of perchlorate was constructed. At the end of 2010, Tronox excavated and disposed of the waste material from the onsite landfill. In 2010 and 2011, over 500,000 cubic yards (yd^3) of impacted soils and tailings were removed from the Site and disposed of at an off-site location.

Investigation and cleanup activities at the Site are being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and the Interim Consent Agreement[6] between NDEP and the Trust. In accordance with CERCLA, a Remedial Investigation/Feasibility Study (RI/FS) is being conducted to investigate the nature and extent of contamination at the Site and downgradient plume (Figure 1-2) and to develop remedial action alternatives, as appropriate. As stated in RI/FS guidance (U.S. Environmental Protection Agency [USEPA] 1988), the overall purpose of the RI/FS process is "to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site."

This Work Plan identifies additional activities within the RI/FS process that are proposed to address remaining contamination at the Site. The overall format of the Work Plan follows that recommended in USEPA guidance (USEPA 1988) for conducting an RI/FS, as follows:

- Section 1 presents a brief introduction, identifying the purpose of the RI/FS and the contents of this report.
- Section 2 presents background information about the Site including descriptions of the ownership and operational history, physical setting, climate, and geology and hydrogeology.
- Section 3 summarizes regulatory actions and historical and recent field investigations of soil, soil gas, indoor air, and groundwater.
- Section 4 summarizes interim removal actions conducted to date and risk assessments evaluating the potential adverse effects associated with exposures to chemicals in soils, indoor air, and groundwater.
- Section 5 presents the Initial Site Evaluation, which includes (1) a preliminary conceptual site model (CSM), (2) a preliminary identification of regulatory requirements and remedial action objectives (RAOs), (3) a screening of remedial technologies and process options, and (4) a preliminary identification of data gaps.
- Section 6 outlines RI/FS tasks described in USEPA guidance (USEPA 1988) and discusses the planned activities for each of these tasks.

[5] Appendix B includes a figure showing the locations of all LOUs (Figure B-1) and a comprehensive table (Table B-1) listing the LOUs, LOU name, and the soil and soil gas work plans and investigations conducted for the individual LOUs through October 2013.
[6] Interim Consent Agreement, effective February 14, 2011.

- Section 7 describes the project management structure and proposed schedule for completion of the RI/FS.
- Section 8 lists the references cited in this report.

Appendices to this Work Plan provide detailed analyses or supplementary information, as follows:

- Appendix A Response to NDEP Comments on the RI/FS Work Plan
- Appendix B Summary of Historical LOU Soil and Soil Gas Investigations
- Appendix C Soil Remediation Goals for the 2011 Interim Soil Removal Action
- Appendix D Background Data Set for Soils

2.0 Site Background

2.1 Operational History

The Site is located within the BMI[7] Complex, which consists of several facilities owned and operated by a number of chemical companies (Figure 2-1). The BMI Complex was first developed in 1942 by the U.S. government as a magnesium plant for World War II operations. Later, a part of the BMI Complex that would ultimately become the Site was leased by Western Electrochemical Company (WECCO). WECCO produced manganese dioxide, sodium chlorate, sodium perchlorate, and other perchlorates. WECCO also produced ammonium perchlorate (a powerful oxidizer) for the Navy during the early 1950s using a plant that was constructed on the Site by the Navy. WECCO merged with American Potash and Chemical Company (AP&CC) in 1956, and continued production of ammonium perchlorate for the Navy. In 1967, Kerr-McGee Chemical Corporation (KMCC) purchased AP&CC. KMCC began production of boron chemicals in the early 1970s. The production processes included elemental boron, boron trichloride (a colorless gas used as a reagent in organic synthesis), and boron tribromide (a colorless fuming liquid used in a variety of applications). The production of boron tribromide was discontinued in 1994, and the production of sodium chlorate and ammonium perchlorate was discontinued in 1997 and 1998, respectively. Perchlorate was reclaimed at the Site using existing equipment until early 2002.

In 2006, Tronox took ownership of the facility formerly operated by KMCC on the Site and operated it to produce electrolytic manganese dioxide for use in the manufacture of alkaline batteries; elemental boron for use as a component of automotive airbag igniters; and boron trichloride for use in the pharmaceutical and semiconductor industries and in the manufacture of high-strength boron fibers for products that include sporting equipment and aircraft parts. In 2009, Tronox filed for Chapter 11 bankruptcy. As previously noted in Section 1, the Trust took title to the Site on February 14, 2011, as a result of the settlement of Tronox's bankruptcy proceeding. Tronox currently has a long-term lease for approximately 114 acres of the Site (ENVIRON 2013d), where it continues its manufacturing operations (identified on Figure 2-2 as "Tronox-Leased Area").

2.2 Site Description

The Site is located approximately 13 miles southeast of the city of Las Vegas and is located in an area of unincorporated Clark County, Nevada, that is surrounded by the City of Henderson (Figure 1-1). It covers approximately 346 acres[8], and lies in Sections 12 and 13 of Township 22 S, Range 62 E (Figure 2-2).

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[7] The acronym "BMI" has been applied to several entities over the years. From 1941 until 1951 it referred to Basic Magnesium Incorporated; in 1951, a syndicate of tenants formed under the name of Basic Management, Inc. to provide utilities and other services at the complex; the group has also been known as Basic Metals, Inc., and at the present is called the Black Mountain Industrial complex.

[8] Previous documents have identified an area of approximately 450 acres. Following the sale of Parcels I and J and a part of Parcel B in 2008, the Site comprised approximately 410 acres. Following the sale of Parcel A and the remaining portion of Parcel B in December 2013, the Site currently comprises approximately 346 acres.

The Site is located in an industrial land use area. The nearest residential areas are located just north (across North Boulder Highway) and south (across Lake Mead Parkway) of the Site (Figure 2-1). The Site is generally rectangular, but certain interior portions of the rectangle are owned and operated by other companies, specifically, Lhoist, Western Area Power Administration (WAPA), BMI, and Titanium Metals Corporation (TIMET). Facilities on the exterior borders of the Site are TIMET to the east, and Olin Chlor-Alkali to the west (formerly known as [1] Pioneer Americas LLC, which includes former Stauffer and Montrose Sites; [2] Olin Chlor-Alkali/Stauffer/Syngenta/Montrose [OSSM]; and [3] Pioneer/Olin Chlor-Alkali/Stauffer/Syngenta/ Montrose [POSSM]). Olin Chlor-Alkali is hereafter referred to as the Olin property. Certain remediation system components jointly operated by Olin Chlor-Alkali, Stauffer, Syngenta, and Montrose are referred to as being operated by OSSM. BMI is located mainly to the east of the Site, although a BMI-owned Corrective Action Management Unit (CAMU) is located immediately to the west. A summary of the neighboring properties, the ditches and other conveyances that are located on these properties, and their former property names are provided in Table 2-1. Areas referred to as Parcels A, B, I, and J, which were formerly part of the Site, were sold in 2008 and 2013, and now represent neighboring properties to the north (Figure 2-3).

An area within the northwestern portion of the Site consists of groundwater treatment facilities, which are operated on behalf of the Trust by an outside contractor, Envirogen Technologies, Inc. (Envirogen)[9]. Three lined ponds on the Site (known as WC-West, WC-East, and Mn-2 receive process-related wastewater discharges from ongoing Tronox facility operations, and an additional lined pond (known as GW-11) receives extracted groundwater from remediation activities. The Site is traversed (from west to east) by a drainage ditch known as the Beta Ditch that historically conveyed liquid wastes from the Site and from neighboring facilities located to the west. The Beta Ditch, which no longer discharges off-site to the east, has been re-graded, channelized, and now includes a retention basin as described in detail in Section 2.6. The west end of the Beta Ditch at the Site continues to receive storm water drainage from the neighboring property to the west. These Site features are shown in Figure 2-3.

The major buildings on the Site include Units 1 through 6, which are aligned in a row extending in a west-east direction across the southern portion of the Site (Figure 2-3). These buildings were constructed during World War II for magnesium production. Unit buildings 3 through 6 and the southern portions of Unit buildings 1 and 2 are within the boundaries of the Tronox-leased area. Tronox uses Units 5 and 6 for production of manganese dioxide; Unit 5 is also used for storage. Units 1, 2, and most of Unit 4 are no longer used and have been partially demolished. The remaining portion of Unit 4 has been retrofitted to house an advanced battery manufacturing process that started up in 2012. Tronox currently uses Unit 3 for office and storage activities. In addition, Tronox produces boron products within a Boron Plant to the north of Unit 4, and manganese sulfate solution (for use in the manganese dioxide production process) is produced within a Leach Plant north of Units 5 and 6. Other buildings present at the Site include an administration building, a change house, a laboratory building, a maintenance shop, a steam plant, and various storage buildings (Figure 2-3). The Site is crossed by asphalt

[9] Envirogen is referred to elsewhere in this report as the GWETS Contractor.

and concrete roads, dirt roads, active utility lines, a gaseous chlorine line, and railroad spurs. An extensive network of active and inactive underground utility lines is present under the roads and open areas at the Site.

In addition to the Tronox and Envirogen operations at the Site, Tronox has three subtenants within the Tronox-leased area, which provide various services to Tronox and other local businesses (Table 2-2). The locations of the tenant operations are shown in Figure 2-4. The Tronox subtenant operations are briefly described below:

- Industrial Supply: provides tools and supplies for manufacturing, construction, and utilities.
- Angelo & Newton: provides technical and managerial consulting services, specializing in chemical process plant safety compliance, regulatory compliance, and battery and energy systems.
- Pronto Constructors: provides construction services.

Within the boundaries of the Site, and as shown on Figure 2-3, are Parcels C, D, E, F, G, and H. The Parcels are at the edges of the Site, to the north, west, and south. Parcel E contains a portion of the OSSM groundwater treatment system. As noted above, Parcels I and J (and the eastern portion of Parcel B) were sold to Rolly Properties LLC (Parcels B and I) and Robert and Sandra Ellis (Parcels B and J) in 2008, and Parcel A and the remaining portion of Parcel B were sold to Treco in December 2013; these areas are no longer a part of the Site. Environmental investigations for all remaining Parcels except Parcel E (i.e., Parcels C, D, F, G, and H) have generally been conducted separate from investigations at other portions of the Site.[10] The field investigation work for these Parcels has been completed, and the health risk assessments and decision documents are in progress or completed, depending on the parcel. For these reasons, with the exception of Parcel E, the parcels are not included in this Work Plan and are not a part of the Site RI/FS process.

2.3 Physical Setting

Elevations across the Site range from 1,677 to 1,873 feet above mean sea level. The land surface across the Site generally slopes toward the north at a gradient of approximately 0.02 feet per foot (ft/ft). The developed portions of the Site have been modified by grading to accommodate building foundations, surface impoundments, and access roads. Further modifications to the Site were made as part of the Interim Soil Removal Action (ENVIRON 2012e) in which soils were typically excavated to depths of up to 10 ft below ground surface (bgs). In some cases, depths were extended to greater than 10 ft to remove discolored soils. Not all excavations were completely backfilled following excavation, resulting in some areas with depressions with 3:1 side slopes. Off-site to the north, the topographic surface continues at approximately the same gradient to approximately Sunset Road, at which point it flattens to a gradient of approximately 0.01 ft/ft to the Las Vegas Wash (ENSR 2005).

[10] The remaining portion of the Site excluding Parcels C, D, F, G, and H is herein after referred to as the "Facility Area."

2.4 Climate

The climate of the 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. 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 rainfalls over a smaller area for a short duration. These 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 9 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%. The mean annual evaporation from lake and reservoir surfaces ranges from 60 to 82 inches per year (KMCC 1985).

2.5 Geology and Hydrogeology

The following subsections describe the regional geology, local geology, and local hydrogeology.

2.5.1 Regional Geology

The Site is located within the 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 Frenchman and Sunrise Mountains to the east; by the McCullough Range and River Mountains to the south and southeast; and 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 2007c).

In the Las Vegas Valley, eroded Tertiary and Quaternary sedimentary and volcanic rocks comprise the unconsolidated basin deposits, which can be up to 13,000 feet thick (ENSR 2007c). The valley floor consists of fluvial, paludal (swamp), playa, and lacustrine deposits surrounded by more steeply sloping alluvial fan aprons derived from erosion of the surrounding mountains. Generally, the deposits grade finer with increasing distance from their source and with decreasing elevation. The structure within the Quaternary and Tertiary-aged basin fill is characterized by a series of generally north-south trending fault scarps.

2.5.2 Local Geology

The local geology and hydrogeology are defined by data collected from more than 1,100 borings and wells that have been installed in the area. The following descriptions are summarized from the CSM report (ENSR 2005).

Alluvium. The Site is located on Quaternary alluvial deposits (Qal) that slope north toward Las Vegas Wash. The alluvium consists of a reddish-brown heterogeneous mixture of well-graded sand and gravel with lesser amounts of silt, clay, and caliche. Clasts within the alluvium are primarily composed of volcanic material. Boulders and cobbles are common. Due to the mode of deposition, no distinct beds or units are continuous over the area.

A major feature of the alluvial deposits is the stream-deposited sands and gravels that were laid down within paleochannels eroded into the surface of the Muddy Creek Formation during infrequent flood runoff periods. These deposits vary in thickness and are narrow and generally linear. These generally uniform sand and gravel deposits exhibit higher permeability than the adjacent, well-graded deposits. In general, these paleochannels trend northeastward.

The thickness of the alluvial deposits ranges from less than 1 foot to more than 50 feet beneath the Site. Soil types identified in on-site soil borings include poorly sorted gravel, silty gravel, poorly sorted sand, well sorted sand, and silty sand. The thickness of the alluvium, as well as the top of the underlying Muddy Creek Formation, was mapped to locate these paleochannels.

Transitional (or reworked) Muddy Creek Formation. Where present, Transitional Muddy Creek Formation (xMCf) is encountered at the base of the alluvium. The Transitional Muddy Creek Formation consists of reworked sediments derived from the Muddy Creek Formation, which is described below. Therefore, the xMCf appears similar to the Muddy Creek Formation, but it consists of reworked, less consolidated and indurated sediments.

Muddy Creek Formation. The Upper Muddy Creek Formation (UMCf) of Pleistocene age occurs in the 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 Site, the Muddy Creek Formation is composed of at least two thicker units of fine-grained sediments of clay and silt (the first and second fine-grained facies) interbedded with at least two thinner units of coarse-grained sediments of sand, silt, and gravel (the first and second coarse-grained facies). Except for the southernmost 1,000 feet adjacent to Lake Mead Parkway, the first fine-grained facies (UMCf-fg1) separates the first coarse-grained facies (UMCf-cg1) from the overlying Quaternary alluvium at the Site. Within the southern 1,000 feet of the Site, the Muddy Creek Formation's UMCf-fg1 pinches out along a roughly west-northwesterly trending line. South of this line, the UMCf-cg1 directly underlies the Quaternary alluvium.

The Muddy Creek Formation represents deposition in an alluvial apron environment from the Spring Mountains to the west, grading into fluvial, paludal (swamp), playa, and lacustrine environments further out into the valley center. On the Site, the Muddy Creek does not crop out but instead subcrops beneath a veneer of Quaternary alluvium.

In on-site borings, the contact between the Quaternary alluvium and the Muddy Creek Formation (UMCf-fg1) is typically marked by the appearance of a well-compacted, moderate brown silt-to-sandy silt or stiff clay-to-sandy clay, whereas near the Las Vegas Wash, the contact is marked by gray-green to yellow-green gypsiferous clays and silts.

2.5.3 Local Hydrogeology

Background information is described in detail in the 2005 CSM report (ENSR 2005). Depth to groundwater ranges from about 27 to 80 ft bgs and is generally deepest in the southernmost portion of the Site, becoming shallower as it approaches the Las Vegas Wash to the north. A potentiometric surface map depicting shallow groundwater elevations during the May-June 2012 timeframe is presented on Plate 2 (ENVIRON 2012c). The groundwater gradient averages 0.015 to 0.02 ft/ft south of the Athens Road well field (AWF), flattening to 0.007 to 0.010 ft/ft north of the well field (Northgate Environmental Management, Inc. [Northgate] 2010m). The groundwater flow direction at the Site is generally north to north-northwesterly, whereas north of the Site the direction changes slightly to the north-northeast. This generally uniform flow pattern may be modified locally by subsurface alluvial channels cut into the underlying UMCf, the on-site bentonite-slurry groundwater barrier wall, on- and off-site artificial groundwater highs or "mounds" created around the on-site recharge trenches (not currently in use) and City of Henderson Water Reclamation Facility Bird Viewing Preserve Ponds, and by depressions created by the groundwater extraction wells at the three groundwater extraction well fields (Northgate 2010m).

NDEP has defined three water-bearing zones (WBZs) that are of interest in the BMI Complex: the Shallow WBZ, which is defined by the first occurrence of groundwater in either the Qal, xMCf, or the UMCf where the xMCf is missing, is unconfined to partially confined, and is considered the "water table aquifer"; the Middle WBZ, which extends from approximately 90 to 300 ft bgs; and the Deep WBZ, which is defined as the contiguous WBZ that is generally encountered between 300 to 400 ft bgs (NDEP 2009a). Environmental investigations at the Site have primarily focused on the Shallow WBZ, although recent investigations (Northgate 2010f, 2010i) have included a number of Middle WBZ wells to improve vertical delineation of hydrogeology and chemical constituent distribution. Plates 1a, 1b, and 1c show the locations of all former and current groundwater monitoring wells in the Shallow WBZ, Middle WBZ, and Deep WBZ, respectively.

At the Site, the Shallow WBZ is comprised of the saturated portions of the alluvium and the uppermost portion of the UMCf to depths of approximately 90 ft bgs. Beneath the northern portion of the Site, the first groundwater encountered occurs within the alluvium at depths of 30 ft bgs or more, and shallows northward, occurring near the ground surface at Las Vegas Wash. In the alluvial aquifer, groundwater flows towards the north-northeast with minor variations, generally mimicking the slope of the ground surface. The results of a 1998 pump test in the Athens Road area indicate a permeability of 50 gallons per day per square foot (gpd/ft^2), a transmissivity of 1,300 gpd/ft, and a groundwater velocity of 220 feet per year (ft/yr) for groundwater in the alluvial aquifer (KMCC 1998b). However, significantly higher groundwater velocities, ranging from approximately 600 to 2,500 ft/yr, have been calculated based on alluvial well pumping and slug tests (KMCC 1998b), and a groundwater velocity of over 12,000 ft/yr was reported based on a tracer test conducted in the alluvial channel between the Athens Road area and the Las Vegas Wash (Errol Montgomery and Associates 2000).

Beneath the central portion of the Site, groundwater is first encountered within the Shallow Zone in the UMCf-fg1, and can be more than 50 ft bgs, as documented in historic water level measurements. South of where UMCf-fg1 pinches out, beneath the southern portion of the Site, the first groundwater encountered occurs within the UMCf-cg1 and can be more than 70 ft bgs as documented in historical water level measurements from well M-103 and further confirmed from water level measurements from wells M-120 and M-121, which were installed as part of the upgradient investigation (ENSR 2007d). The gradient of the potentiometric surface in both UMCf-fg1 and UMCf-cg1 (south of where UMCf-fg1 pinches out) mimics the ground surface and the flow direction is to the north-northeast with minor variations. Both the horizontal and vertical hydraulic conductivities of the UMCf are one or more magnitudes of order less than those of the Qal (ENSR 2005).

Investigations of the Middle WBZ at the Site and surrounding sites indicate, with a few exceptions, a vertically upward gradient between the Middle and Shallow Zones that generally increases with depth. At the Site, the sediments within the Middle WBZ consist predominantly of the UMCf-fg1. The UMCf-cg2 occurs below the fine-grained unit at the base of the Middle WBZ, roughly between approximate depths of 280-300 ft bgs. The UMCf-cg2 unit has been defined below the western portion of the Site by six deep wells (TR-1, TR-5, TR-7, TR-9, TR-11, TR-12). The UMCf-cg2 unit is confined, as indicated by artesian groundwater elevations consistently measured in these wells.

Based on previous reports, there are no water supply wells reported within four miles of the Site that extract water from the regional Las Vegas Valley “shallow aquifer” (ENSR 2005). Businesses and residences located within or downgradient of the BMI Complex are connected to a municipal water supply. Under state policy, if there is a municipal connection at the property, the well should be plugged and abandoned unless there is a non-revocable permit associated with the well. The Nevada Division of Water Resources is the agency responsible for this enforcement.

According to information provided by NDEP, in 2007 NDEP conducted a survey of all identified owners of wells located downgradient of the BMI Complex. All owners responded that they had no information on any well that may have existed on their property except for two owners who could not be reached for follow up. The possible presence of wells on these two properties has not been verified. Based on information provided by NDEP, one well was identified by the Southern Nevada Water Authority at a business property near Boulder Highway northwest of the Site in September 2013. The agencies are evaluating follow up actions including possible referral to the Nevada Division of Water Resources for enforcement.

2.6 Surface Water

The Site is located in a very arid region with few natural surface water bodies; however, surface water is present at the Site, primarily in surface water impoundments receiving process wastewater. Surface water is also present following storm events. During the 2011 interim soil removal action, the Facility Area[11] was graded such that storm water would be retained on the Site. Due to existing roads, utility berms, and other site features, many areas at the Site have inward grades which keep storm water from flowing out of the Facility Area. Based on the surface areas and soil types, significant ponding is not expected to occur in these areas outside

[11] The term “Facility Area” represents the portion of the Site excluding Parcels C, D, F, G, and H.

of major storm events. In addition, two main designated retention basins and a drainage channel were constructed within the Facility Area, as shown on Figure 2-3, and described below:

- Central Retention Basin: Surface runoff from off-site areas and water collected in the majority of the storm sewer network within the Tronox-leased area is directed to the Central Retention Basin. Storm water also enters the Site from the west through surface flow, which is collected in an on-site conveyance trench that flows into the Central Retention Basin. This area has a design capacity of approximately 1,295,470 ft^3 (RCI Engineering 2010).

- Northern Retention Basin: Surface runoff from north of the former Beta Ditch is directed to the Northern Retention Basin. This basin also accepts overflow from the Central Retention Basin during major storm events through a channel constructed along the eastern side of the Site. This area has a design capacity of approximately 1,219,680 ft^3 of water (RCI Engineering 2010).

- Drainage Channel: A storm water conveyance channel is located east/northeast of the Central Retention Basin and conveys storm water from the Central Retention Basin (if necessary) and the eastern portion of the Site to the Northern Retention Basin.

Additionally, drainage and diversion structures have been constructed throughout and along the perimeters of the BMI Complex to channel surface water flow (ENSR 2005) as shown on Figure 2-1. The west end of the former Beta Ditch at the Site continues to receive storm water drainage from the neighboring property to the west during major storm events.

Surface water in the Downgradient Plume Area occurs infrequently as storm runoff in shallow washes and flows to the north toward Las Vegas Wash. Las Vegas Wash is a tributary to Lake Mead and it is the only channel through which the valley's excess water flows to the lake. Lake Mead is a major reservoir on the Colorado River.

3.0 Regulatory Actions and Site Investigations

The Site has been the subject of numerous regulatory actions and environmental investigations since the early 1970s. The soil and groundwater investigations conducted through 2005 served as the basis of the first comprehensive CSM developed for the Site in 2005 by ENSR (ENSR 2005). A brief chronological summary of investigations conducted prior to 2005 is presented in Section 3.1.

Since development of the CSM in 2005 (ENSR 2005), additional investigations and interim removal actions have been conducted. For soil, soil gas, and groundwater, these investigations included primarily the Phase A and Phase B Source Area Investigations. These investigations (described in Section 3.2) and the interim soil removal action (described in Section 4) serve as the primary basis for the updated CSM presented in Section 5 of this report.

3.1 Overview of Regulatory Actions and Environmental Investigations: 1970 - 2005

This section provides a brief chronological summary of investigations conducted through 2005.

During the 1970s, the USEPA, the State of Nevada, and Clark County investigated potential environmental impacts from the BMI company operations, including atmospheric emissions, groundwater and surface water discharges, and soil impacts (ENSR 2007c).

Between 1971 and 1976, KMCC modified its manufacturing processes and constructed lined surface impoundments to recycle and evaporate industrial wastewater in response to the 1972 Federal Water Pollution Control Act (the Clean Water Act [CWA]). Ponds P-1 and Old P-2 were constructed in May through September 1972 for management of potassium-bearing process fluids. Pond S-1 was completed in October 1974 for management of chlorate process liquids. Ponds AP-1, AP-2, and AP-3 were completed by May 8, 1974 for management of ammonium perchlorate liquids, and Pond C-1 was completed by December 1974 for management of nonhazardous wastes including cooling tower liquids (Kleinfelder 1993). The facility achieved zero-discharge status in 1976 regarding industrial wastewater management, and in February 1977, KMCC obtained a National Pollutant Discharge Elimination System (NPDES) permit under the CWA authorizing up to 4 million gallons per day (MGD) discharge of non-contact cooling water to Las Vegas Wash. In 1980, the USEPA requested specific information from the BMI companies regarding their manufacturing and waste management practices by issuing a CWA Section 308 letter.

In July 1981, KMCC initiated a groundwater investigation to comply with federal Resource Conservation and Recovery Act (RCRA) standards for monitoring two existing on-site impoundments (Ponds S-1 and P-1). In December 1983, NDEP requested that KMCC investigate the extent of chromium impact in groundwater beneath the Site. Forty groundwater monitoring wells were installed and, in July 1985, KMCC submitted to NDEP a hydrogeological investigation report delineating a chromium plume within the “near surface groundwater” (KMCC 1985). A Consent Order between KMCC and NDEP was signed in September 1986 (NDEP 1986) that stipulated additional characterization and implementation of corrective action to address chromium in groundwater. Remediation of hexavalent chromium in groundwater began in mid-1987 when four extraction wells (or "interceptor" wells) were installed downgradient of the Ammonium Perchlorate (AP) Plant. The extracted water was pumped to a chromium treatment facility where hexavalent chromium was reduced to trivalent chromium that was then precipitated and removed. Treated water was subsequently reinjected at a series of recharge trenches downgradient of the interceptor well field (IWF).

In April 1991, KMCC was one of six past or present entities that had conducted business within the BMI Complex that entered into a Consent Agreement with NDEP (NDEP 1991) to conduct environmental studies to assess site-specific environmental conditions at individual company sites, the BMI Common Areas, and any off-site waste management areas that were the result of past and present industrial operations and waste disposal practices.

In April 1993, and in compliance with the 1991 Consent Agreement, KMCC submitted a Phase I Environmental Conditions Assessment report to NDEP (Kleinfelder 1993). The purpose of the report was to identify and document site-specific environmental impacts resulting from past or present industrial activities. The Phase I Environmental Conditions Assessment included a comprehensive assessment of the geologic and hydrologic setting, as well as historical manufacturing activities. The Environmental Conditions Assessment identified 31 solid waste management units (SWMUs), 20 areas of known or suspected releases or spills, and 14 miscellaneous areas where Site activities may have impacted the environment.

In 1994, NDEP issued a Letter of Understanding (LOU) to KMCC identifying 69 potential source areas or "items of interest" (LOU-1 through LOU-69) and specifying the level of environmental investigation to be conducted by KMCC (NDEP 1994). Subsequent to the issuance of the LOU, an additional potential source area, the former U.S. Vanadium site, was identified during planning for the Phase B 2008 investigation (NDEP 2011a). Although not formally designated as an LOU, the U.S. Vanadium site is hereafter referred to as LOU-70. A detailed discussion of the specific areas or items of interest identified in the LOUs, lists of the products made, years of production, and approximate waste volumes for WECCO, AP&CC, and Tronox, and actions taken for each LOU study item is presented in the 2005 CSM (ENSR 2005). The 70 LOUs are listed in Table B-1 of Appendix B to this Work Plan and the LOU locations are shown on Figure B-1.

In 1996, KMCC and the other parties at the BMI Complex entered into a Consent Agreement with NDEP to perform a Phase II Environmental Conditions Assessment and to conduct Remedial Alternative Studies (RAS), Interim Measures, or Additional Work (NDEP 1996). KMCC collected additional data in 1996 and 1997 as part of a Phase II Environmental Conditions Assessment (ENSR 1997) that addressed 12 LOUs identified for additional soil and groundwater characterization in the Phase II Work Plan (KMCC 1997).

In late 1997, perchlorate contamination was discovered in Las Vegas Wash and determined to have originated from the KMCC and former Pacific Engineering and Production Company of Nevada (PEPCON) facilities (NDEP 2011a). KMCC undertook a characterization study to identify the subsurface pathway(s) and characterize perchlorate concentrations in shallow groundwater downgradient of the Site to the Athens Road area in Henderson (about one-mile south of Las Vegas Wash) (KMCC 1997). KMCC installed extraction wells in the Athens Road area in September 1998 to remove perchlorate-bearing shallow groundwater (KMCC 1998a).

By late 1999, a water collection system and temporary ion exchange (IX) treatment process for perchlorate removal was installed at the Las Vegas Wash and began operating as a result of a 1999 Consent Agreement between KMCC and NDEP which defined initial removal requirements (NDEP 1999). Additional interceptor wells were installed in 1998 and early 1999 for continued capture of on-site groundwater for removal of hexavalent chromium (ENSR 2005). These interceptor wells, in combination with the interceptor wells installed in 1987 as a result of the 1986 Consent Order, continued to capture on-site groundwater for removal of hexavalent chromium; however, instead of re-injecting the treated groundwater, the treated water was impounded in a lined pond (GW-11, constructed in late 1998) and held for additional treatment for perchlorate.[12] Untreated Lake Mead water was reinjected into the groundwater system via the recharge trenches (NDEP 2011a).

Between 1999 and 2001, KMCC conducted a supplemental Phase II Environmental Conditions Assessment, the results of which were submitted to NDEP in April 2001 (ENSR 2001). In comments on the Supplemental Phase II Environmental Conditions Assessment report on February 11, 2004, NDEP (2004) required additional work to investigate and characterize the Site. Specifically, NDEP emphasized the importance of developing a CSM to identify all Site-related chemicals (SRCs), data gaps, and delineate the extent of groundwater contamination.

In 2001, an Administrative Order on Consent (AOC) (NDEP 2001) defined additional removal requirements that included a low-permeability barrier wall with an upgradient collection (interceptor) well field, the construction of the Athens Road groundwater collection well field, the construction of the seep area collection well field, and the development of a treatment process that removes chromium and perchlorate from the collected water and then discharges the water within limits set forth in an existing NPDES permit. The effectiveness of these systems at removing contaminant mass, reducing groundwater concentrations, and reducing contaminant mass flux into Las Vegas Wash is presented in annual and semi-annual monitoring reports (e.g., ENVIRON 2013b).

In response to this order, KMCC constructed a groundwater barrier wall along the downgradient side of the interceptor well line and installed additional groundwater extraction wells along the Athens Road Area and in the seep well field (SWF) area to enhance the recovery of perchlorate-contaminated groundwater. KMCC also constructed a biological fluidized-bed reactor (FBR) treatment system designed to remove perchlorate from recovered groundwater.

In 2005, an AOC (NDEP 2005) between NDEP and KMCC established a compliance schedule for treatment of the perchlorate residues of Pond AP-5 designed to reduce the amount of perchlorate in groundwater and surface water reaching the Las Vegas Wash and Lake Mead.

[12] NDEP (2011a) and other historical documents refer to GW-11 as an 11-acre pond. Recent review of available design drawings and topographic maps indicates the pond is approximately 14.8 acres at the top of the liner, and approximately 10.4 acres at the toe of the berm at the bottom of the pond.

Additionally, in 2005 as a follow up to the Phase I and Phase II activities completed by KMCC, a CSM report was prepared for the Site that integrated information from the soil and groundwater investigations conducted to date to document information on Site-specific sources, release mechanisms, transport pathways, exposure routes, and potential receptors (ENSR 2005). The 70 LOUs were subdivided into common potential contaminant groups for discussion. For reference, Appendix B includes a figure showing the locations of all LOUs (Figure B-1) and a comprehensive table (Table B-1) listing the LOUs, LOU name, and the soil and soil gas work plans and investigations and HRAs conducted for the individual LOUs through October 2013.

The 2005 CSM identified several data gaps related to soil characterization, including:

- Identification of background concentrations of metals and other naturally occurring chemicals of potential concern (COPCs) in the local area.
- Identification of other COPCs.
- Evaluation of historic data for usability for risk assessment purposes.
- Preparation of a risk assessment to evaluate risks posed by the Site to human receptors.

3.2 Regulatory Actions and Investigations: 2005 to Present

Site investigations conducted since completion of the 2005 CSM have included the Phase A and Phase B Source Area Investigations (Phase A and Phase B investigations) to further characterize soil, groundwater, and soil gas across the Site as described in the following sections. An indoor air study was also conducted at the operating Tronox facility to evaluate uncertainties in vapor intrusion models used in a soil gas health risk assessment.

3.2.1 Soil

The objectives of the Phase A and B investigations were to refine the 2005 CSM, further characterize site conditions, and provide data for future risk assessments. To identify and characterize the distribution of SRCs in soils, the investigation focused on soil conditions associated with the 192 SRCs identified in the 2005 CSM report and their suspected source areas. A total of 127 soil samples were collected from 27 suspected source area locations in November and December of 2007. The sample locations were selected based on results from past site investigations (ENSR 2005), information on chemical use at the Site, and the 70 LOU study areas identified by NDEP in 1994. In addition to the 192 SRCs previously identified, 44 additional parameters were analyzed and reported by the laboratory.

During the Phase A investigation, soil samples were collected at depths of 0.5 to 1 ft, and at 10-ft intervals thereafter, until groundwater was encountered (ENSR 2006). The samples were analyzed for metals; volatile organic compounds (VOCs), including fuel oxygenates; semivolatile organic compounds (SVOCs); polychlorinated biphenyls (PCBs); dioxins and furans; total petroleum hydrocarbons (TPH as gasoline, diesel, and oil range organics [GRO, DRO, and ORO]); organochlorine herbicides (OCHs); organochlorine pesticides (OCPs); and organophosphate pesticides (OPPs). In addition, analyses were conducted for radionuclides, asbestos (surface soil samples only), and wet chemistry constituents. Not all samples were analyzed for all analytes, and at some locations, samples were collected at more frequent depth intervals. In addition, samples were collected from the manganese ore and tailings stockpile for analysis of metals and radionuclides, and two near surface (1.5 to 3 ft bgs) soil samples were collected and analyzed for physical and geotechnical parameters.

The objective of the Phase B investigation was to further characterize and evaluate the LOUs in the Facility Area and their potential impact on soil conditions across the Facility Area, based on the results of the Phase A investigation. For the Phase B investigation, the Facility Area was subdivided into four areas for investigation activities: Areas I, II, III, and IV. Table B.1 (Appendix B) identifies the LOUs within the four investigation areas. Separate work plans describing the Area-specific scope of work were prepared as follows: Area I Work Plan (ENSR 2008b, approved by NDEP on May 6, 2008); Area II Work Plan (ENSR 2008c, approved by NDEP on July 21, 2008); Area III Work Plan (ENSR 2008e, approved by NDEP on July 21, 2008); and Area IV Work Plan (ENSR 2008d, approved by NDEP on June 18, 2008). In addition, a revised investigation work plan was prepared that was applicable to the four Investigation Areas (AECOM, Inc. [AECOM] 2008, approved by NDEP on January 16, 2009).

During the Phase B investigation, samples were collected at initial soil depths of 0.5 and 10 ft bgs, the capillary fringe, and the midpoint between the capillary fringe and 10 ft bgs, without exceeding 20 ft between each vertical sample (AECOM 2008). Judgmental samples were collected at 0.5 ft and 10 ft bgs in locations where certain surface features were noted, including minor stains or above ground pipelines.

The number of soil borings and samples varied across the investigation areas, as follows:

- **Area I:** 6,493 environmental samples and 1,369 field quality control (QC) samples were collected from 65 borings (Northgate 2010a).
- **Area II:** 7,697 environmental and 1,719 field QC samples were collected from 86 borings (Northgate 2010b).
- **Area III:** 2,990 environmental and 676 field QC samples were collected from 33 borings (Northgate 2010c).
- **Area IV:** 5,999 environmental and 1,266 field QC samples were collected from 54 borings (Northgate 2010e).

During the Phase B investigation, soil samples were analyzed for the following analytical groups and analytes: metals, VOCs, SVOCs, organic acids, PCBs and PCB congeners, dioxin/furans, OCPs, OPPs, TPH, chlorate, perchlorate, cyanide, hexavalent chromium, formaldehyde, and radionuclides. In addition, based on the findings of the Phase A investigation, samples were collected from 0 to 2 inches bgs and analyzed for asbestos fibers, and samples collected from 0 to 0.5 ft bgs were analyzed for dioxin/furans. Samples for wet chemistry and geotechnical parameters were also collected (Northgate 2010a,b,c,e).

Supplemental sampling of shallow soils was conducted in December 2009 in accordance with two Tronox memoranda, Scope for Additional Sampling of Area I and Area II (approved by NDEP on November 24, 2009 and December 14, 2009, respectively). A total of 129 soil samples were collected at Phase B locations where contaminants exceeded Nevada Basic

Comparison Levels (BCLs) to provide information for remediation planning and supplement post-excavation confirmation sampling (Neptune and Company 2010).

The results of the Phase A and B investigations identified a number of constituents within the upper 10 ft of soil with reported concentrations in excess of NDEP worker BCLs or modified risk-based goals (as agreed upon by NDEP), which are collectively referred to as "soil remediation goals" (SRGs). These constituents included metals; SVOCs, including hexachlorobenzene (HCB); PCBs; OCPs; dioxin toxic equivalents (TEQs), asbestos, and perchlorate.

Interim soil removal actions were conducted in Areas I through IV based on the results of the Phase A and B investigations, as described in Section 4. The SRGs utilized during the interim soil removal actions are described and listed Appendix C.

3.2.2 Soil Gas

The Phase B soil gas investigation involved collection of 75 soil gas samples across the Facility Area in May 2008. Details of the soil gas sampling are provided in the *Phase B Source Area Investigation Soil Gas Survey Work Plan* (Soil Gas Work Plan; ENSR 2008a, approved by NDEP in March 2008) and summarized in the draft *Site-wide Soil Gas Health Risk Assessment* (Soil Gas HRA) (Northgate 2010r). Soil gas sample locations were based on the following: (1) results of the Phase A investigation (ENSR 2007c), which identified the presence of several VOCs in soil and/or groundwater samples collected at the Site; (2) historic soil and groundwater data collected during prior investigations; and (3) an assessment of former chemical usage at the individual LOUs (18 LOUs were identified as potential sources of VOCs or in areas where VOCs had been detected in soil or groundwater)[13].

The objective of the soil gas survey was to evaluate the nature and extent of VOCs in soil gas in potential VOC source areas. From a review of historic information and Phase A investigation results, the following areas were identified in the Soil Gas Work Plan as potential sources of VOCs or areas where VOCs were detected in soil and/or groundwater (ENSR 2008a):

- 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)
- 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)

[13] A plume sourced at a neighboring property and carrying VOCs, non-aqueous phase liquid (NAPL), and other contaminants enters the site along the western boundary. The NAPL and COPCs in the dissolved phase are expected to affect soil gas. This area was not adequately sampled during the 2008 soil gas investigation. Additional soil gas samples were collected in this area, as described in *Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G and H, Revision 0* (ENVIRON 2013a).

- 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 seventy-five soil gas samples were collected throughout the Facility Area, with one of these samples collected in Parcel E. Samples were collected at 5 ft bgs, with the exception of 4 samples collected in the vicinity of Unit 3, Unit 5, and Unit 6 at 20 ft bgs (SG-36, SG-37, SG-38, and SG-41) (Northgate 2010r). In a July 18, 2007 conference call (NDEP 2007a), 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 ENSR's *Phase B Source Area Investigation – Soil Gas Survey 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 2010r). 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 (ENSR 2008a); and SG-37 and SG-38, near areas with relatively lower chloroform concentrations in groundwater (ENSR 2008a).

Results of the investigation indicated that chloroform, trichloroethene (TCE), chlorobenzene, carbon tetrachloride, and trichlorofluoromethane were detected at elevated concentrations in soil gas beneath the Site. Elevated concentrations of VOCs in soil gas appeared to be localized within specific areas, such as the western area, Unit 4, the Old P-3 Pond, Pond S-1, the former truck emptying/dumping site, the ammonium perchlorate laboratory building and former satellite accumulation point, and the former State Industries catch basin. Analytical results for samples collected during the soil gas survey were presented in a DVSR (ENSR 2008g) that was submitted to NDEP on October 13, 2008 and approved by NDEP on October 20, 2008.

The draft Soil Gas Health Risk Assessment (HRA) is summarized in Section 4.2.

3.2.3 Indoor Air

To assess the potential uncertainty associated with use of vapor intrusion models in the draft Soil Gas HRA, an indoor air quality study was conducted at the operating Tronox facility in 2010. The first round of indoor and outdoor air samples were collected at several locations throughout the facility in May 2010 (Northgate 2010o) and analyzed for chloroform, carbon tetrachloride, and TCE. The sampling results were presented in the *Spring 2010 Indoor Air Quality Sampling and Analysis Report* (Northgate 2010o, approved by NDEP on November 1, 2010). Chloroform and carbon tetrachloride were detected in all but one indoor air sample and all outdoor air samples. TCE was detected in all indoor air samples and some outdoor air samples; however, the detection limits in the outdoor samples were elevated due to sampling conditions (Northgate 2010o).

A second round of indoor and outdoor air sampling was performed in December 2010. The objective of the additional round of sampling was to identify the seasonal meteorological variations and the potential difference in the building operations and activities, and to collect additional data to supplement the indoor air modeling efforts and the uncertainty evaluation in the draft Soil Gas HRA. The sampling results were presented in the *December 2010 Indoor Air Quality Sampling and Analysis Report* (Northgate 2011a, approved by NDEP on March 21, 2011). A total of 32 indoor and 18 outdoor air samples were collected at the Tronox facility in Spring and December 2010. The samples were analyzed for three target analytes: chloroform, carbon tetrachloride, and TCE. Chloroform was detected in all but one indoor air sample and in all outdoor air samples, and carbon tetrachloride was detected in all but one indoor and one outdoor air sample. TCE was detected in approximately 80 percent of the samples. Northgate (2011a) reported that the maximum and mean indoor concentrations of the target analytes were significantly below their respective occupational exposure levels (specifically, Threshold Limit Values [TLVs]), and that mean indoor air concentrations were below risk-based commercial air concentrations corresponding to a 1×10^{-5} risk level. (It is noted that the NDEP point of departure for exposure to chemicals in indoor air resulting from Site-related releases is 1×10^{-6}.)

The results of the December 2010 indoor and outdoor air monitoring indicated that in general, the indoor chloroform concentrations were higher than ambient levels. However, based on the draft Soil Gas HRA, the modeled soil gas and groundwater chloroform concentrations do not entirely explain the measured indoor air concentrations, as the measured chloroform results are generally higher than the modeled values. Northgate (2011a) reported that the measured chloroform concentrations were below occupational levels and below the 1×10^{-5} risk level. (The NDEP point of departure for risk due to soil gas is 1×10^{-6}.)

3.2.4 Groundwater

As previously described for soils, in 2005, as a follow up to the Phase I and Phase II activities completed by KMCC, a CSM Report was prepared for the Site that integrated information from the soil and groundwater investigations conducted to date to document information on site-specific sources, release mechanisms, transport pathways, exposure routes, and potential receptors (ENSR 2005).

As described in the 2005 CSM, based on the results of the groundwater investigations conducted during the 1980s, the initial focus of the on-site groundwater remediation was containment and treatment of hexavalent chromium in shallow groundwater. Remediation of hexavalent chromium began in mid-1987, when four extraction wells were installed downgradient of the ammonium perchlorate plant.

In mid-1997, analytical methods were developed to detect low perchlorate concentrations (down to 0.004 milligrams per liter (parts per million) [mg/L]) and governmental and regulatory concern increased regarding health hazards of perchlorate in drinking water. Perchlorate was subsequently discovered in the Colorado River and traced upstream to Henderson and the location of two ammonium perchlorate manufacturing facilities, one of which was the Site. The other facility (American Pacific Corporation [AMPAC], formerly Pacific Engineering and Production Company of Nevada [PEPCON]) is located approximately 1.5 miles southwest of the Site.

In late 1997, KMCC undertook a perchlorate characterization study to determine the subsurface pathway(s) and the perchlorate concentrations in shallow groundwater downgradient from the Site to its discharge in Las Vegas Wash. Between March and June 1998, soil borings and monitoring wells were drilled and installed and the subsurface data was mapped and analyzed. The investigation results were presented in the Phase II Perchlorate Investigation Report (KMCC 1998a).

An outcome of this groundwater investigation report indicated that the perchlorate was generally confined to a Quaternary-age alluvial channel eroded into the underlying sediments. Subsurface mapping demonstrated that the deepest and best defined section of the channel lay beneath the Pittman Lateral (Athens Road) area, about one mile south of Las Vegas Wash. The north-trending perchlorate plume is displaced eastward from the main alluvial channel just north of the Site by a high total dissolved solids (TDS) plume that converges from the west and preferentially occupies the western part of the channel. The perchlorate plume eventually begins to merge and mix with the higher TDS plume at, and downgradient from, the Pittman Lateral. The Phase II investigation results provided the basis for installation of the first extraction well (PC-70) at the AWF in September 1998.

In the spring of 1999, hydrologists with the Southern Nevada Water Authority discovered a perchlorate-impacted seep on-trend with the buried alluvial channel, discharging into Las Vegas Wash. At the time of discovery, the seep was flowing at about 400 gallons per minute (gpm) and contained over 100 mg/L perchlorate. This led to another phase of off-site monitoring well installation, sampling, and groundwater characterization between March and September 2000. These results were presented in the *Seep Area Groundwater Characterization Report* (KMCC 2001). The report documented that groundwater was traveling at an average of 35 feet per day between Athens Road (now Galleria Drive) and the seep; that there were no other major downgradient sources of perchlorate along Las Vegas Wash; and that the entire saturated thickness of the alluvial channel contained perchlorate at varying concentrations.

Between 2001 and 2004, the SWF and the AWF were installed to mitigate perchlorate impacts. The on-site IWF was expanded in between 1998 and 2003 to include additional extraction wells to further address perchlorate and chromium impacts. In 2001, it was modified further by the addition of a groundwater barrier wall. The barrier wall was constructed along the downgradient side of the interceptor well line to a depth of 60 ft bgs.

The 2005 CSM identified several data gaps related to groundwater characterization, including:

- Background concentrations of metals and other naturally occurring COPCs in the local area.
- Configuration of the fine-grained facies of the Muddy Creek formation.
- Identification of other COPCs.
- Historic data need to be evaluated for their usability for human health and ecological risk assessment purposes.
- Risk assessment to evaluate risks posed by the Site to human and ecological receptors.

Investigations conducted since 2005 have addressed some of the identified data gaps related to groundwater characterization, as described below.

2006/2007 – Upgradient Investigation Results (ENSR). In March 2006, soil borings were drilled at six locations in the southern (upgradient) portion of the Site. Four of the borings were completed as 2-inch diameter monitoring wells (M-117, M-118, M-120, and M-121). The first saturated unit in this portion of the Site is the upper coarse-grained facies of the Muddy Creek Formation (UMCf-cg1). Wells M-120 and M-121 are about 100 feet deep and monitor the UMCf-cg1. Wells M-117 and M-118 are about 150 feet deep and monitor the lower fine-grained facies of the Muddy Creek Formation (UMCf-fg2). Groundwater samples were collected from the four new wells and six existing wells. The samples were analyzed for perchlorate, metals, VOCs including fuel oxygenates, TPH, pH, electrical conductivity (EC), alkalinity, carbonate, bicarbonate, water chemistry ions, and radionuclides. As part of the upgradient investigation, a comparison was performed to evaluate whether two sampling methods would yield significantly different analytical results. Two sets of groundwater samples were collected from nine of the wells, the first using bailers and the second using micro-purge sampling pumps. In general, the results yielded mixed results for metals and wet chemistry parameters. The results varied more for less soluble constituents than for the more highly soluble constituents.

In the wells sampled for this upgradient investigation, chromium was detected at concentrations up to 0.054 mg/L. None of the chromium detections were above the maximum contaminant level (MCL) for chromium of 0.1 mg/L. In shallow groundwater wells M-120 and M-121 at the southern (upgradient) Site boundary, perchlorate was detected at concentrations of 0.55 mg/L and 2 mg/L, respectively. These results indicate that perchlorate is migrating onto the Site from upgradient locations.

Soil samples collected during this investigation were analyzed for a broad suite of SRCs. The validated data were compared statistically to the City of Henderson (COH) and Basic Remediation Company (BRC)/TIMET background data (BRC/TIMET 2007) to assess whether they represented similar populations and could be combined for subsequent analyses. The statistical comparisons indicated that for arsenic and iron, the COH data set could be combined with the Site upgradient area data from depths of 20 feet or less. For calcium and lead, the BRC/TIMET data set could be combined with the Site upgradient area data from depths of 20 feet or less. For the radionuclides thorium-228, thorium-230, and uranium-235, the COH data set could be combined with the Site upgradient area data from depths up to 5 feet. For uranium-238, the BRC/TIMET data set could be combined with the Site upgradient area data from depths up to 5 feet. All other chemicals represented different populations and should not be combined for subsequent analyses (BRC/TIMET 2007).

2007-2009 – Phase A and Phase B Investigations. In conjunction with the soil samples collected during the Phase A and Phase B investigations described in Section 3.2.1, one-time groundwater samples were collected from many of the deeper soil borings. In addition, groundwater samples were collected from new and existing monitoring wells during several sampling events.

The objectives of the Phase A groundwater investigation were to (1) characterize SRCs in groundwater at 27 suspected source areas at the Site and (2) characterize groundwater chemistry upgradient and downgradient of the Site (ENSR 2006). As part of the Phase A investigation, groundwater samples were collected from 20 shallow groundwater monitoring wells and one groundwater interceptor well (I-AR), and groundwater grab samples were collected from open boreholes at 6 locations where nearby wells either did not exist or were not functional. The wells were sampled in November/December 2006 using micro-purge/low-flow sampling techniques. All groundwater samples were analyzed for inorganic compounds (metals and cyanide), fuel alcohols, OCPs, PCBs, radionuclides, OPPs, OCHs, VOCs and SVOCs. Of the 210 SRCs analyzed, 125 SRCs were not detected (ENSR 2007c).

The same 20 monitoring wells plus well M-98 were sampled again in May 2007 to assess the potential for analytical bias of metals and radionuclides in groundwater results based on high turbidity levels associated with sampling methodology. An addendum to the Phase A Work Plan was submitted on May 1, 2007 (ENSR 2007a, approved by NDEP the same day) to evaluate potential analytical bias in the results reported for metals and radionuclides for the November/December 2006 sampling. On two sampling events conducted in May 2007, three samples were collected from each of the 21 monitoring wells to assess the effect of turbidity on groundwater results for metals and radionuclides. Two unfiltered samples were collected from each well using two different low-flow rates to evaluate the effect of pump rates on turbidity levels, and a third sample was collected and field filtered to provide a baseline from which comparisons between filtered and unfiltered analytical results could be made (ENSR 2007a). Based on an evaluation of the results, and as reported in the NDEP approved Phase A investigation report, ENSR (2007c) concluded that analytical results appropriate for evaluation of metals and radionuclides in groundwater include the following:

- Unfiltered low-flow samples collected in May 2007.
- Filtered grab samples collected during the November/December 2006 sampling.
- For hexavalent chromium, results from all samples could be used (the analytical method employed for this constituent was essentially a filtered method).
- Analytical results for metals and radionuclides from the unfiltered water samples collected during the November/December 2006 sampling event were found to be biased high due to elevated turbidity levels and should be excluded (ENSR 2007c).

Fourteen new on-site monitoring wells were installed during the Phase B investigation and an extensive focused sampling program was conducted. As described in Section 3.2.1, Phase B work plans were developed for each of the four investigation areas (i.e., Areas I, II, III, and IV). The objective of the groundwater portion of the Phase B investigation was to characterize the presence of SRCs in specific LOU source areas. The locations of the new monitoring wells were selected to allow for further delineation of SRCs detected in Phase A investigation grab samples (ENSR 2007c).

Samples were collected from 109 existing and new groundwater monitoring wells in Areas I, II, III, and IV, and wells north (downgradient), east, and west of Area I. The groundwater samples were collected and analyzed in accordance with the *Revised Phase B Investigation Work Plan*

(AECOM 2008) and the *Revised Phase B Quality Assurance Project Plan* (AECOM-Northgate 2009). Samples were analyzed for metals, VOCs, SVOCs, PCBs, OCPs, OPPs, organic acids, perchlorate, hexavalent chromium, and total cyanide. In addition, analyses were conducted for radionuclides and wet chemistry constituents. Not all wells were sampled for all analytes. The Phase B sampling investigation resulted in 2,817 groundwater analyses and 746 field QC sample analyses. The validated data from this extensive groundwater sampling program is available for use in the RI to identify the COPCs in groundwater that will be evaluated further during the RI/FS process.

2008-2010 – Investigations in Support of Capture Zone Evaluations. In order to support an evaluation of the capture zones of the three well fields, field work consisting of well installation, geotechnical sampling, and well testing was performed in early 2008. A capture zone evaluation was submitted as Appendix B of the 2008 Annual Remedial Performance Report (ENSR 2008f). Additional drilling of two soil borings and completion of one recovery well (I-AB) at the west end of the barrier wall was proposed, and was completed in mid-2009. In response to NDEP comments, eight deeper UMCf monitoring wells were installed in September and October 2009 to evaluate the vertical extent of contaminant plumes and vertical head differences. The data collected from the new wells was incorporated into an interim evaluation of the capture zones established by operation of the IWF and the AWF (Northgate 2010f).

As proposed in the *Capture Zone Evaluation Work Plan* prepared by Northgate (2010i, approved by NDEP on May 24, 2010), an additional 41 new monitoring and recovery wells and 8 replacement monitoring wells were installed at the IWF and AWF during April-July 2010. Based on the new data and in response to NDEP comments, the *Capture Zone Evaluation (CZE) Report* provided an evaluation of the capture zones of all three well fields (Northgate 2010s). In Appendix E of the *CZE Report*, Northgate described a numerical groundwater flow model that was developed for use in evaluating capture zones. Although the *CZE Report* itself has not been approved by NDEP, this initial groundwater model was approved by NDEP on April 4, 2013 for use in capture zone evaluation.

As part of the 2013 Groundwater Extraction and Treatment System (GWETS) Optimization Project, which is described in more detail in Section 4.3.3, the initial groundwater model will be updated and revised and used to estimate capture zones and perform other analyses to support the optimization of the existing groundwater extraction system.

4.0 Interim Removal Actions and Health Risk Assessments

Sections 4.1 and 4.2 describe soil removal actions and HRAs conducted at the Facility Area. Section 4.3 describes on-site and downgradient groundwater removal actions performed previously and currently in place. Section 4.4 describes the current groundwater monitoring program.

Since the Trust assumed ownership of the Site in February 2011, all analytical data collected by ENVIRON and used for data analysis and decision making (except for FBR influent and effluent monitoring data) were validated in accordance with NDEP's data validation requirements at the time. This data includes monitoring well data, extraction well data, and soil data contained in a relational database maintained by ENVIRON. In addition, data compiled from NDEP's regional database[14] collected by neighboring properties has been used for analyzing off-site areas and historical data. It is our understanding that data from NDEP's regional database were validated according to NDEP guidance current at the time of sampling.

4.1 Interim Soil Removal Actions and Health Risk Assessments at the Facility Area

As previously described in Section 3.2.1, the results of the Phase A and B source investigations identified a number of constituents within the upper 10 ft of soil in excess of SRGs. On December 14, 2009, NDEP issued to Tronox a Finding of Alleged Violation and Order requiring Tronox to comply with the obligations pertaining to the Henderson facility under the various Consent Agreements previously issued for the Site, and setting forth a specified schedule for compliance (the "2009 Division Order") (NDEP 2009g). At a meeting on February 22, 2010, NDEP and Tronox discussed the conceptual scope and implementation of a soil remediation program to comply with the 2009 Division Order requiring the removal of all impacted soil from the Site by the end of 2010 to minimize potential health risks associated with the continued presence of contaminated soil. A detailed scope of work for the soil removal was presented in the *Removal Action Work Plan for Phase B Soil Remediation of Remediation Zones RZ-B through RZ-E* (the "RAW") (Northgate 2010j, approved by NDEP on August 20, 2010).

For purposes of soil excavation activities, the main contaminated portions of the Site were divided into five separate remediation zones (RZs) roughly based on geographic groupings of elevated detections of contaminants and CSM considerations (Northgate 2010g). The RZs are listed below:

- RZ-A: the area on the southern portion of the Site
- RZ-B: the area around the Units
- RZ-C: the ammonium perchlorate production area, Koch Materials area, pond and diesel storage tank area, and manganese tailings area
- RZ-D: the former Trade Effluent ponds and ammonium perchlorate pad/drum recycling area (including the former hazardous waste landfill)

[14] The NDEP regional database is available at: http://ndep.neptuneinc.org/ndep_gisdt/home/index.xml.

- RZ-E: the Beta Ditch

For RZ-A, the results of a soil HRA (Northgate 2010k, approved by NDEP on August 20, 2010) indicated that exposures to residual chemicals in the upper 10 ft of soil in RZ-A were below NDEP's point of departure for noncancer effects (hazard index [HI] of 1) and cancer risks (1×10^{-6}) for indoor commercial workers, outdoor commercial/industrial workers, and construction workers. The upper-bound estimated risks for death from lung cancer or mesothelioma for asbestos exposures to outdoor commercial/industrial workers were less than or equal to 1×10^{-6} for chrysotile and amphibole fibers. The best estimate and upper-bound estimates for asbestos exposures to construction workers were less than or equal to 1×10^{-6} for chrysotile fibers and ranged from zero to 6×10^{-5} for amphibole fibers. Since the risks estimated from asbestos exposures were evaluated based on constant lifetime exposures, not short-term exposures such as construction activities, the results indicate that exposures to asbestos in soil should not result in unacceptable risks for the aforementioned receptors. Based on HRA results, RZ-A was not included in the removal program (Northgate 2010k).

For RZ-B through RZ-E, Voronoi/Thiessen polygons were generated for each RZ to define areas with SRG exceedances (Northgate 2010j). The general remediation strategy consisted of excavation of soils within designated polygons, sampling of discolored soil, removal of discolored soil if above SRGs or otherwise deemed appropriate to remove, and designation of Excavation Control Areas (ECAs) for inaccessible areas, including areas with COPCs and/or discolored soil left in place.

To further define the polygons of areas identified for excavation, pre-confirmation sampling was conducted in Spring 2010 in accordance with a pre-confirmation sampling work plan (Northgate 2010g, approved by NDEP on March 30, 2010). Two types of borings were advanced during the pre-confirmation sampling program, including (1) 84 borings at existing locations (adjacent to Phase A and B sampling locations) and (2) 91 borings at new locations. Data from "existing locations" were used to establish polygon depths, while data from "new locations" were used to define the horizontal extent and vertical delineation of excavation of near-surface soils (0 to 10 ft bgs). Results from the Phase A, Phase B, and pre-confirmation sampling events are presented in Appendix A of the Excavation Plans for Phase B Soil Remediation for each RZ (RZ-B, Northgate 2010l; RZ-C, Northgate 2010n; RZ-D, Northgate 2010p; and RZ-E, Northgate 2010q).

Discolored soil was encountered in various locations during removal activities. Based on the location of the discolored soil, available nearby analytical results, the anticipated extent of discolored soil, and the excavation activities currently in progress, some areas of discolored soil were removed. Other areas of discolored soil were sampled and evaluated to determine if the soil should be removed or left in place in accordance with the *Work Plan for Evaluation of Discolored Soil and Confirmation Soil Sampling in Visually-Impacted Areas* (ENVIRON 2011b, approved by NDEP on May 12, 2011). Following the removal of discolored soil, confirmation soil samples were collected to verify that remaining COPC soil concentrations were below SRGs. If the analytical results indicated that concentrations were above SRGs, additional soil was typically removed and additional confirmation soil sampling performed.

As presented in Northgate's Manganese Tailings Removal Technical Memorandum (Northgate 2012) approved by NDEP February 21, 2013, the manganese tailings pile area removal actions were initiated on April 29, 2010 and completed on July 19, 2010. The manganese tailings pile area, located north of the Manganese Leach Plant and south of Mn-1 Pond (Figure 2-3), is approximately 8.6 acres in size and was used from 1975 through 2004 for the disposal of manganese tailings from the leach plant process which included the leach beds (the historic manganese tails). This material is a non-hazardous solid waste product generated in the production of electrolytic-grade manganese dioxide. Manganese tailings material from all locations at the Site were consolidated to this location and covered with soil sometime prior to 1985. The tailings pile was periodically graded to maintain the desired shape and drainage. Since 2004, manganese tailings from the Tronox operations (current tailings production) have been shipped to an appropriate off-site landfill.

A total of 284,232 tons of tailings and minor debris were removed from the manganese tailings pile. In accordance with a request by the NDEP, a confirmation sampling program was implemented subsequent to tailings removal. Based on the results of the confirmation sampling program, additional shallow soil excavation was conducted concurrent with Phase B soil remediation in accordance with the *Removal Action Work Plan* (Northgate 2010j), and the *Revised Excavation Plan for Phase B Soil Remediation of RZ-C Addendum to the Remedial Action Work Plan* (Northgate 2010n). The post-confirmation sampling excavation was conducted to address soil that contained concentrations of manganese, arsenic, cobalt, and/or asbestos that exceeded screening criteria.

The removal activities and post-removal conditions at the Site are described in detail in the *Revised Interim Soil Removal Action Completion Report* (ENVIRON 2012e), submitted to NDEP on September 28, 2012 and approved by NDEP on December 17, 2012 (NDEP 2012c). Post-removal soil conditions are described in Section 5.1.3.

4.2 Site-wide Health Risk Assessment for Soil Gas

The soil gas sampling results and data usability evaluation were also presented in the draft Soil Gas HRA (Northgate 2010r). The objective of the draft Soil Gas HRA was to evaluate the potential for adverse health impacts associated with potential exposure by future indoor commercial workers to chemicals in soil gas that may migrate to indoor and outdoor air. As described in the draft Soil Gas HRA, 65 of the 71 VOCs analyzed were detected in one or more samples during the Phase B soil gas survey. Based on a multi-step COPC selection process, including toxicity screen evaluation, frequency of detection, and CSM considerations, eight VOCs (benzene, bromodichloromethane, carbon tetrachloride, chloroform, hexachlorobutadiene, naphthalene, tetrachloroethene [PCE], and TCE) detected in soil gas were retained as COPCs for quantitative evaluation in the HRA.

For the HRA, the migration of COPCs in soil gas from the subsurface to indoor air was estimated using the USEPA vapor intrusion model (2004a) based on Johnson and Ettinger (1991). Cancer risks and hazard indices were quantified on a sample-by-sample basis. Non-cancer hazard indices associated with inhalation of vapors in indoor and outdoor air and theoretical excess cancer risks associated with inhalation of vapors in outdoor air were below NDEP's point of departure for indoor and outdoor commercial workers. Theoretical excess cancer risks associated with inhalation of vapors in indoor air under hypothetical future site conditions range from 2×10^{-9} (SG94, located in RZ-C) to 1×10^{-4} (SG32, also located in RZ-C). The results of the draft Soil Gas HRA indicate that at most locations evaluated, chloroform contributes up to 99% of the overall cancer risk from inhalation of vapors in indoor air, with carbon tetrachloride the only other VOC for which a cancer risk was above 1×10^{-5}. None of the other COPCs had cancer risk estimates greater than 1×10^{-6} (Northgate 2010r). NDEP has not reviewed or approved the Soil Gas HRA.

4.3 Interim Groundwater Removal Actions

The following subsections describe on-site and downgradient groundwater removal actions performed previously (Section 4.3.1) and those that are currently in place (Section 4.3.2).

4.3.1 Historical Groundwater Removal Actions

Groundwater remediation has been conducted at the Site dating back to the mid-1980s. This subsection summarizes historical groundwater removal actions conducted at the Site to address chromium (Section 4.3.1.1) and perchlorate (Section 4.3.1.2).

4.3.1.1 Chromium Removal and the Interceptor Well Field

A groundwater investigation was initiated by KMCC in July 1981 to comply with federal RCRA standards associated with certain on-site impoundments. This investigation involved the installation of nine monitoring wells and identified elevated chromium concentrations in groundwater underlying the Site. In 1986, KMCC and NDEP entered into a Consent Order, which required additional groundwater characterization activities and the implementation of removal activities to address elevated concentrations of chromium in groundwater (NDEP 1986). Pursuant to the Consent Order, KMCC installed an additional 43 monitoring wells and a groundwater interceptor well field (the IWF) consisting of 11 groundwater extraction wells (I-A[15] through I-K) in the shallow WBZ in late 1986 (ENSR 2005).

The 11 extraction wells initially were capable of producing a cumulative extraction rate of approximately 100 gpm; however, this level of extraction was not sustainable over the long term (see additional discussion below). The extracted groundwater was conveyed to a chromium treatment facility (called the Groundwater Treatment Plant or “GWTP”), constructed in 1986-87 along with the IWF, where hexavalent chromium was electrolytically reduced to trivalent chromium and then co-precipitated with iron oxide. The treated water was subsequently re-injected through two parallel recharge trenches located approximately 250 feet downgradient (north) of the IWF line of wells. The IWF, which still operates at the Site in an expanded configuration, is located in the central portion of the Site, approximately 2,400 feet north and downgradient of the central process area of the Site. From initiation of removal activities through 1993, the IWF and GWTP had captured and treated over 200 million gallons of groundwater and removed an estimated 8,500 pounds of chromium from the environment (ENSR 2005).

[15] Interceptor well I-A has since been plugged and abandoned.

Over the course of the next several years, additional groundwater monitoring wells were installed to evaluate the effectiveness of the IWF, GWTP and recharge trenches. Between 1986 and 1993 approximately 47 additional monitoring wells were installed at the Site. All of these wells were installed in the Shallow WBZ, some being entirely screened within the Qal, some being screened within the transition to the UMCf, and some entirely within the UMCf.

Evaluations of Site conditions in 1991 and 1993 concluded that the extensive dewatering of the Qal in the vicinity of the IWF and the localized groundwater flow in discrete channels in the UMCf were contributing to a decline in recovery volumes (ENSR 2005). Based on these findings, KMCC installed four additional extraction wells in 1993 (I-L, I-M, I-N, and I-O) to improve capture in the discrete channel flow areas. Over the next several years, additional extraction wells were installed as part of continued efforts to increase groundwater capture at the IWF. Two extraction wells (I-P and I-Q) were installed in 1998; five more wells (I-R, I-S, I-T, I-U, and I-V) were installed in early 1999; and a large diameter well (I-AR) located upgradient of the IWF was installed in April 2000. To further enhance groundwater capture, a bentonite-slurry barrier wall (the “barrier wall”) was installed on the downgradient side of the IWF in 2001. The barrier wall, which is still in place, is approximately 1,600 feet in length and 60 feet deep and constructed to tie vertically into the uppermost 30 feet of the UMCf. By November 2001, cumulative extraction from the IWF had increased from approximately 23 gpm to over 50 gpm.

4.3.1.2 Perchlorate Removal and the Athens Road and Seep Well Fields

In 1997, elevated concentrations of perchlorate were detected in the Colorado River, the source of which was ultimately traced to the Site and another ammonium perchlorate manufacturing facility in Henderson. Groundwater perchlorate investigations completed in 1997 and 1998 identified perchlorate concentrations ranging from 1,500 mg/L at the northern Site boundary to around 100 mg/L between the City of Henderson former Rapid Infiltration Basins (RIBs) and the Las Vegas Wash (ENSR 2005). The investigations concluded that Quaternary-age alluvial channels eroded into the underlying sediments were significant transport pathways for downgradient perchlorate migration. Subsurface mapping indicated that the deepest and best defined section of the channel believed primarily responsible for transport of perchlorate from the Site lay beneath the Pittman Lateral area at Athens Road (now Galleria Drive) about one mile south of Las Vegas Wash (ENSR 2005). As an interim measure to address the perchlorate plume, a Shallow WBZ extraction well (PC-70) was installed at Athens Road (approximately 8,200 feet north of the barrier wall and the IWF) in September 1998. Groundwater extracted from this extraction well, as well as groundwater extracted from the IWF, was routed to the GW-11 Pond, which commenced operation in late 1998. The extracted groundwater was held in GW-11 until the current perchlorate treatment system could be implemented.

In Spring 1999, hydrologists with the Southern Nevada Water Authority discovered an approximately 400 gpm seep discharging into Las Vegas Wash that contained over 100 mg/L of perchlorate. Following investigation of this seep, KMCC entered into a Consent Agreement with NDEP (dated July 26, 1999) to initiate removal measures to intercept and treat the seep discharge. Later in 1999, a seep capture sump and temporary single-use resin ion exchange (IX) system were installed near the Las Vegas Wash to capture and treat the water discharged from the seep. After additional investigation of the seep was completed, in 2001 KMCC constructed four extraction wells in the seep vicinity (PC-99R2, PC-99R3, PC-115, and PC-

116)[16], from which extracted groundwater was treated by the temporary IX system near the wash and later also by a second temporary single-use resin IX system located on-site. The pumping from these additional wells began in July 2002.

Another AOC, entered into by KMCC and NDEP on October 8, 2001, further defined removal requirements necessary to address the perchlorate contamination. Pursuant to this AOC, KMCC commenced construction of the existing off-site AWF, the off-site SWF, and an on-site perchlorate treatment system.

The AWF was initially constructed as a series of 15 groundwater extraction wells screened in the Qal at seven paired well locations (with one standalone well) that span approximately 1,200 feet across two alluvial paleochannels located on either side of an UMCf ridge. Construction of the AWF was completed in March 2002[17] and continuous pumping began in mid-October of that year. The well pairs act in concert with one well pumping while the adjacent well (the so called "buddy" well) is used to measure water levels and monitor the effect of pumping on the aquifer. In September 2006, another standalone well screened deeper into the alluvial channel on the east side of the AWF, ART-9, began full-time operation replacing ART-6A after groundwater elevations at the AWF dropped below a level where ART-6/6A could be effective.

The SWF is located approximately 4,500 feet north (downgradient) of the AWF near the Las Vegas Wash. As discussed above, when pumping began in July 2002, the SWF consisted of four extraction wells situated over the deepest part of the alluvial channel and a seep capture sump. Five additional wells (PC-117 to PC-121) were installed in February 2003 and an additional well (PC-133) was installed in December 2004 to complete the SWF.

With regard to the perchlorate treatment system, KMCC initially designed and constructed an 825 gpm regenerable resin IX (ISEP®/catalytic destruction process) treatment plant. Due to difficulties in commissioning the regenerable resin IX system, a temporary single-use resin IX system was placed in service on-site to supplement the seep area temporary IX system (ENSR 2005). The permanent on-site ISEP/catalytic destruction process treatment system eventually proved to be unworkable and was abandoned in favor of a biological treatment system employing FBR technology (ENSR 2005). Construction of a 1,000 gpm (peak flow) biological treatment plant was completed in early 2004. Optimization of the plant operations continued into the fourth quarter of 2004. The temporary IX system at Las Vegas Wash near the SWF was shut down in June 2004 and the on-site temporary IX system was shut down in the first quarter of 2004.

Pursuant to the April 12, 2005 AOC, an additional reactor was added to the FBR system in 2006 to manage the decommissioning of an on-site impoundment, the AP-5 pond, which contained

[16] PC-99R2 (a 6-inch diameter well) and PC-99R3 (an 8-inch diameter well) were combined into one extraction well. PC-115 and PC-116 (6-inch diameter wells) were subsequently replaced by PC-115R and PC-116R (8-inch diameter wells) to improve performance.

[17] Eight extraction wells (ART-1 through ART-8) were completed between October 2001 and January 2002 allowing pumping to begin from these wells in March 2002. Seven additional extraction wells (ART-1A, 2A, 3A, 4A, 6A, 7A, and 8A) were installed in February through March 2003. ART-5 does not have a buddy well.

high concentrations of perchlorate. In August 2006, pumping of AP-5 pond water to the on-site treatment system commenced as part of the decommissioning process. After initial dewatering of the AP-5 pond, stabilized Lake Mead water was periodically pumped to the pond to solubilize residual ammonium perchlorate in the pond solids. The last of these transfers occurred in December 2012. The resulting water was discharged to the treatment plant in batches via the GW-11 pond. Since the AP-5 pond pumping operation began in 2006, an estimated 1,176 tons of perchlorate were removed from the AP-5 pond and treated on-site.[18]

Since the discovery of perchlorate in on-site and downgradient groundwater in 1997-1998 to the full-scale treatment of perchlorate via the biological perchlorate reduction FBR plant in 2005, over 220 additional groundwater monitoring wells have been installed on-site and at downgradient locations by KMCC. Some of these groundwater wells, as well as those previously installed as part of the various chromium investigations, have been plugged and abandoned; however, the majority of wells remain part of the active groundwater monitoring well network for use in evaluating the performance of the groundwater removal actions. The current groundwater monitoring program utilizing these wells, and others installed after 2005, is discussed in Section 4.4.

4.3.2 Current Groundwater Removal Actions

Current operations at the Site include the continued operation of an on-site GWETS that removes hexavalent chromium and perchlorate from shallow groundwater beneath the Site and at downgradient locations along the existing contaminant plume. This section describes the current system (Section 4.3.2.1) and discusses its performance (Section 4.3.2.2).

4.3.2.1 Description of the Current Groundwater Extraction and Treatment System

The GWETS has been in place in essentially its current configuration since 2006. The GWETS operates by capturing groundwater from three extraction well fields and treating the captured groundwater via aboveground treatment facilities for subsequent discharge at the Las Vegas Wash. Perchlorate in extracted groundwater is treated in the on-site FBR process using ethanol as a carbon source. Chromium in extracted groundwater is treated via chemical reduction and precipitation using ferrous sulfate. A process flow diagram for the GWETS is included as Figure 4-1, and a location map covering the area from the Site to the Las Vegas Wash showing the primary components of the GWETS is included as Figure 4-2. Design specifications for the various pipelines and pumps used within the GWETS, including all extraction well pumps, are presented in Tables 4-1 and 4-2, respectively.

Groundwater is captured from a system of extraction wells installed into the Shallow WBZ at three strategic locations described previously in Section 4.3.1: (1) on-site at the IWF; (2) approximately 8,200 feet downgradient of the IWF at the AWF; and (3) approximately 4,500

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[18] The estimate of perchlorate removed from AP-5 was calculated from monthly flow volumes to GW-11 from AP-5 and perchlorate data provided by Veolia Water North America (Veolia), for the period from September 2006 to June 2011. Data from GW-11 was used since it has received the water pumped from AP-5. Based on the monthly flow and concentration data, the mass of perchlorate was calculated for each month and was summed to obtain the estimate of 1,176 tons. A previous estimate of perchlorate removal from AP-5 found that a total of 1,295 tons were removed between 2006 and 2012 (Tronox 2010). This estimate was prepared by Northgate on behalf of Tronox and also reportedly used flow and concentration data, although the exact methodology is not known.

feet beyond the AWF near the Las Vegas Wash at the SWF. The locations of the three well fields are shown on Figure 4-2 in relation to other GWETS features.

The IWF currently consists of 23 active extraction wells[19] located immediately upgradient (south) of the vertical barrier wall constructed in 2001. The IWF pumps at a cumulative extraction rate of between 60 and 73 gpm (ENVIRON 2012c) and captures the highest concentrations of both chromium and perchlorate (as compared with the downgradient well fields). From May 2011 through June 2012, chromium concentrations in the IWF pumping wells ranged from 0.16 to 31 mg/L, while perchlorate concentrations ranged from 96 to 2,300 mg/L during this same time period (ENVIRON 2012c). The highest concentrations of chromium observed are in the middle of the IWF well line around I-T (28-31 mg/L during quarterly sampling from May 2011 through June 2012) and decrease to below 1.0 mg/L at the western end of the IWF and to 1.3 mg/L at I-K at the eastern end of the IWF over this same time period. Higher perchlorate concentrations are observed in two areas of the IWF: on the western side of the IWF around I-AR (2,100-2,300 mg/L during quarterly sampling from May 2011 through June 2012) and on the eastern side around I-U (1,600-1,900 mg/L over the same time period).

The AWF currently consists of 7 active extraction wells[20] screened in the alluvium that span approximately 1,200 feet across two alluvial paleochannels located on either side of an UMCf ridge. The AWF cumulatively pumps at a rate of between approximately 250 and 273 gpm (ENVIRON 2012c) and captures chromium and perchlorate at concentrations significantly lower than those observed at the IWF. From May 2011 through June 2012, chromium concentrations in the AWF pumping wells have ranged from below laboratory quantitation limits (0.00088-0.0020 mg/L) to 1.5 mg/L, while perchlorate concentrations have ranged from 1.3 to 420 mg/L during this same time period (ENVIRON 2012c). The highest concentrations of chromium are at the east side of the AWF well line around ART-9 (1.2-1.5 mg/L during quarterly sampling from May 2011 through June 2012) and decrease to below laboratory quantitation limits (0.00088-0.0020 mg/L) at the eastern end of the AWF at ART-1. Higher perchlorate concentrations are observed in two areas of the AWF: on the western side of the AWF around ART-4 (330-420 mg/L during monthly sampling from May 2011 through June 2012) and on the eastern side around ART-9 (300-330 mg/L during the same time period). The locations of ART-4 and ART-9 correspond with two alluvial sub-channels that intersect the AWF. It is believed that these channels represent primary transport pathways for contaminated groundwater from the Site.

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[19] Seven additional extraction wells (I-AA, I-AB, I-AC, I-AD, I-W, I-X, and I-Y) were installed between December 2007 and June 2010 and connected to the IWF in 2010-2011; however, extraction from these wells has not commenced. The 2012 Annual Remedial Performance Report presented an evaluation of these new extraction wells and proposed a plan to operate these new wells (ENVIRON 2012c). Startup of these wells is being performed under the 2013 GWETS Optimization Project, as described in Section 4.3.3.

[20] In June/July 2010, additional groundwater wells were installed in the AWF including four large diameter monitoring wells that could be used as additional extraction wells (ART-7B, PC-148, PC-149, and PC-150). The 2012 Annual Remedial Performance Report presented an evaluation of these new wells and proposed a plan to operate them as extraction wells (ENVIRON 2012c). Startup of two of these wells (ART-7B and PC-150) is being performed under the 2013 GWETS Optimization Project, as described in Section 4.3.3.

The SWF consists of 10 wells[21] screened across the full thickness of the Qal at the deepest portion of an alluvial channel just south of the Las Vegas Wash. The SWF cumulatively pumps at a rate of between approximately 510 and 622 gpm (ENVIRON 2012c). Chromium concentrations in the SWF pumping wells are below laboratory quantitation limits (0.00088-0.0020 mg/L). Perchlorate concentrations in the SWF pumping wells from May 2011 through June 2012 ranged from 0.31 to 14 mg/L (ENVIRON 2012c). The highest perchlorate concentrations are generally observed in PC-99R2/R3 in the center of the SWF.

The two off-site well fields, the AWF and the SWF, are served by three lift stations that convey the captured groundwater to the aboveground treatment portions of the GWETS via underground pipelines. The locations of these lift stations and pipelines are shown on Figure 4-2. Lift Station 1, located at the Las Vegas Wash, conveys groundwater extracted by the SWF to Lift Station 2 located on Pabco Road just south of Galleria Drive (formerly Athens Road). Lift Station 3, located within the AWF well line along Galleria Drive, conveys groundwater extracted by the AWF to Lift Station 2. Lift Station 2 pumps the combined flows from Lift Stations 1 and 3 to the on-site equalization area for treatment. A small ferrous sulfate drip system is located at the AWF lift station (Lift Station 3) to treat the lower concentrations of chromium present in groundwater extracted by the AWF. Because the concentrations of total chromium within extraction wells at the SWF are well below the GWETS effluent discharge limitation of 0.1 mg/L (7-day average), groundwater extracted from the SWF is not treated specifically to remove chromium. However, based on FBR influent and effluent monitoring data some incidental chromium removal is achieved in the FBRs (ENVIRON 2013b).

The aboveground treatment system consists of two series-linked systems: (1) a hexavalent chromium treatment system that treats extracted groundwater from the IWF using ferrous sulfate to reduce hexavalent chromium to trivalent chromium, which is then removed from solution via chemical precipitation, and (2) the FBR process that treats extracted groundwater from the IWF, AWF, and SWF.[22] Effluent from the chromium treatment system, historically referred to as the GWTP, is pumped to an equalization area where it is combined with water from the off-site well fields. The current configuration of the GWTP has a reported design maximum capacity of 75 gpm at a maximum hexavalent chromium concentration of 15 mg/L. According to original design drawings, the FBR design hydraulic flow is 1,000 gpm (at a contaminant loading of 1,893 equivalent pounds per day).[23]

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[21] Two of the extraction wells at the SWF (PC-99R2 and 99R3) are connected and operate as one combined extraction well and are also sampled as one.

[22] The FBRs are part of a biological treatment system that includes five 33,000-gallon primary reactors, four 28,800-gallon secondary reactors, and ancillary systems. See Figure 4-1 for a process flow diagram. For brevity, the system as a whole is often referred to as the “FBRs” or the “FBR Plant”.

[23] Equivalent pounds per day is calculated with the following formula:
Equivalent Load (lbs/day) = [(0.90 x NO3-N) + (0.17 x Cl03) + (0.18 x Cl04)] x Q x 1440 x 8.34 / 1,000,000

Where:
NO3-N = Nitrate-nitrogen concentration, (mg/L as N)
Cl03 = Chlorate concentration, (mg/L)
Cl04 = Perchlorate concentration, (mg/L)
Q = Influent flow (gpm)

From the equalization tanks, the blended water flows through activated carbon beds to remove organic compounds before being filtered and pumped to the FBRs for removal of perchlorate, chlorate, and nitrate.[24] Chromium that is precipitated out of solution from the AWF (via the ferrous sulfate drip in Lift Station 3) is retained in activated carbon beds and subsequently backwashed into the GW-11 pond using stabilized Lake Mead water. During backwash events, the carbon remains in the vessels and is reused until the absorptive capacity of the carbon is ultimately spent. The effluent from the FBRs is discharged to an outfall located at the Las Vegas Wash via an underground pipeline. Solids from the GWTP and the FBRs are conditioned and dewatered prior to being disposed off-site. An approximately 15-acre double-lined pond, referred to as GW-11, holds off-specification effluent and feed bypass during treatment system maintenance.[25] The maximum operating capacity of the GW-11 pond is approximately 62.4 million gallons (Mgal) with an allowed three feet of freeboard, corresponding to a maximum operating water elevation of 1,747 feet above mean sea level (amsl). As of October 20, 2013, the current water elevation in GW-11 is 1743.85 amsl, corresponding to a water volume of approximately 48.2 Mgal. A perchlorate concentration of 24 mg/L was detected in the most recent sample collected from GW-11 (December 2, 2013). GW-11 has been sampled on a monthly basis since May 2013. Perchlorate concentrations in GW-11 have varied between 24 mg/L and 190 mg/L during this period.

There are some former components of the GWETS that are no longer operating. Groundwater recharge trenches formerly located downgradient (north) of the IWF and barrier wall were originally installed to receive extracted and treated groundwater, but have been used in the recent past to inject stabilized Lake Mead water into the subsurface to replace water extracted by the IWF. Reinjection ceased in September 2010, when the recharge trenches were partially removed to accommodate soil excavation activities at the Site. Also, a seep capture sump located north of the SWF was formerly used to capture groundwater before it surfaced and flowed to the Las Vegas Wash; however, the seep has not flowed since April 2007.

4.3.2.2 Performance of the Current Groundwater Extraction and Treatment System

The GWETS has been effective at removing and treating large amounts of perchlorate and chromium in on-site and off-site groundwater. From July 2002[26] through June 2012 the estimate of perchlorate mass removed and treated by the GWETS is approximately 6,185,000 pounds (approximately 3,093 tons). The current estimate of chromium mass removed and treated during this same time period is approximately 38,000 pounds (approximately 19 tons).

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[24] Envirogen anticipates utilizing the GW-11 pond as an equalization basin and is currently in the process of making the required modifications.

[25] The GW-11 pond has been referred to in historical documents as being approximately 11 acres in size. Recent review of available design drawings and topographic maps indicates the pond is approximately 14.8 acres at the top of the liner, and approximately 10.4 acres at the toe of the berm at the bottom of the pond.

[26] July 2002 was used as the start date for this performance evaluation since the extraction before this time was limited. This date corresponds to the time period when the AWF and SWF well fields were being installed and downgradient extraction from these well fields began.

Figures 4-3 and 4-4 present estimated monthly mass removals based on well extraction rates and individual well concentrations from July 2002 through June 2012 for perchlorate and chromium, respectively. This represents the time period where all three of the well fields were operating; however, as discussed in previous sections, the well fields have been expanded significantly during this time.

As shown in Figure 4-3, system-wide perchlorate mass removals have declined since the middle of 2003 primarily due to the sharp decline in perchlorate mass removal at the SWF. The decreased mass removal rates from the SWF result from decreased concentrations of perchlorate at the Las Vegas Wash, which is likely due to operation of the upgradient extraction well fields. In contrast, the perchlorate mass removals at the IWF and AWF have only marginally decreased during this time period.

Since July 2002, the maximum monthly perchlorate mass removal occurred in June 2003 when a total of approximately 76,300 pounds were removed and treated. At this time the percentages of perchlorate mass removal attributed to the IWF, AWF, and SWF were 39, 36, and 25 percent, respectively. Since then, the perchlorate mass removed from the SWF has diminished significantly. Recently, in June 2012, the total monthly perchlorate mass removal was 37,600 pounds with the IWF and AWF accounting for 51 and 45 percent, respectively, while the SWF accounted for only 3 percent.

As shown on Figure 4-4, the IWF is responsible for the majority of chromium mass removal with the AWF responsible for a significantly smaller amount. As mentioned above, because concentrations of chromium at the SWF are consistently below laboratory quantitation limits (0.00088-0.0020 mg/L), the chromium mass removal at the SWF is negligible, and therefore, is not shown on Figure 4-4. The figure shows that chromium mass removal at the IWF has been decreasing since around the end of 2008, while chromium mass removal from the AWF has been slowly increasing during this same period. In fact, chromium mass removed at the AWF has slowly, but steadily increased since the end of 2003. This increase of chromium mass removal at the AWF is also evident in Figure 4-5, which presents a side-by-side comparison of extraction rates and chromium and perchlorate mass removal estimates for each of the three well fields.

Since July 2002, the maximum monthly chromium mass removal occurred in January 2005 when a total of approximately 366 pounds were removed and treated. At this time the percentages of chromium mass removal attributed to the IWF and AWF were 96 and 4 percent, respectively. Recently, in June 2012 the total monthly chromium mass removal was 243 pounds with the IWF and AWF accounting for 84 and 16 percent, respectively,

Figure 4-5 illustrates the relative efficiencies of the three extraction well fields based on the amount of perchlorate and chromium mass removed and the overall extraction rates. Figure 4-5 illustrates that although the IWF has a relatively low overall extraction rate, it is responsible for the majority of chromium removal and about half of the perchlorate removal of the entire GWETS. The AWF is responsible for a relatively small amount of chromium removal and slightly less than half of the perchlorate removal. The SWF has by far the highest extraction rate, but negligible chromium removal and a relatively small percentage of the overall perchlorate removal (three percent in June 2012).

Estimates of perchlorate mass remaining in the subsurface were originally presented within an attachment to the 2013 annual performance report (ENVIRON 2013b). Three different methodologies (kriging, spline, and contour interpolation) were used to generate a range of estimated masses for the years 2012, 2006, and 2002 as summarized in Table 4-3. For 2012, estimated perchlorate mass remaining within the plume boundary ranged between 2,674 and 3,728 metric tons. In 2006, the remaining perchlorate mass was estimated between 3,724 to 4,199 metric tons. In 2002, the mass was estimated between 5,514 to 6,893 metric tons.

Although mass removal is an important measure of performance, the degree that the GWETS captures Site contaminants, thereby mitigating migration of contaminants downgradient, is the ultimate measure of effectiveness. Northgate conducted a capture zone evaluation (CZE) to evaluate the efficacy of the GWETS in 2010. In conjunction with the CZE, a calibrated groundwater flow model was developed for the Site and additional monitoring and potential extraction wells were installed (Northgate 2010f and 2010s). The groundwater flow model was approved by NDEP on April 4, 2013. The model will be updated and refined as described in Section 4.3.3.2 and then used to further evaluate the performance of the GWETS.

As discussed in the 2012 annual performance report (ENVIRON 2012c), potential gaps in plume capture have been observed as evidenced by elevated concentrations (primarily of perchlorate, but also chromium) at the ends of the IWF and downgradient of the AWF. The gaps are generally consistent with capture gaps identified in the 2010 CZE Report, and therefore, some of the potential new extraction wells installed previously could be utilized to enhance capture in these areas. The 2013 GWETS Optimization Project, described in the next section, was developed to address these capture zone gaps.

4.3.3 2013 GWETS Optimization Project

As discussed above, potential gaps in plume capture have been observed as evidenced by elevated concentrations (primarily of perchlorate, but also chromium) at the ends of the IWF and downgradient of the AWF. The 2013 GWETS Optimization Project is designed to address potential gaps in plume capture that have been observed as evidenced by elevated concentrations (primarily perchlorate, but also chromium) at the ends of the IWF and downgradient of the AWF, as well as to increase the overall effectiveness of the existing GWETS. A revised work plan describing the project (ENVIRON 2013c) was submitted to NDEP on November 22, 2013, and approved by NDEP on December 3, 2013 (NDEP 2013e). The primary goal of the 2013 GWETS Optimization Project is to optimize mass removal rates and capture zones of the three well fields comprising the GWETS.

To support the optimization, the following work will be performed in 2014:

- Test and activate nine currently idle extraction wells located in the IWF and AWF,
- Perform additional well testing to further characterize hydraulic properties of the major geologic units at the IWF and AWF,
- Characterize the stream-aquifer interaction at the SWF, and

- Update and refine the existing groundwater model.

Following completion of these tasks, extraction rates at each of the three well fields will be optimized using the results of data analysis and groundwater modeling. Detailed information is provided in the 2013 GWETS Optimization Project Work Plan (ENVIRON 2013c).

4.3.3.1 Performance Metrics

As described in the work plan, the optimization of the GWETS will be informed by the analysis of several performance metrics. The performance metrics include the metrics requested by NDEP, as well as additional metrics identified by ENVIRON that are consistent with the objectives of the 2013 GWETS Optimization Project and future optimization efforts.

The metrics include those identified in the October 10, 2013 letter from NDEP commenting on the 2013 Annual Remedial Performance Report (ENVIRON 2013b) as outlined below:

- The concentrations at which NERT is achieving 90% and 99% capture of perchlorate and chromium;
- Monthly perchlorate and chromium mass removal rates from the IWF, AWF, and SWF;
- Perchlorate and chromium capture efficiency of IWF, AWF, and SWF;
- Perchlorate and chromium plume mass estimates; and
- Mass loading of perchlorate and chromium in the Las Vegas Wash at Northshore Road.

Additional metrics identified by ENVIRON include the following:

- The amount of surface water from Las Vegas Wash and the COH Birding Ponds that is being extracted by the SWF;
- The fraction of mass loading in Las Vegas Wash at Northshore Road that originates from the NERT Site; and
- The environmental footprint of the GWETS with a focus on energy use.

A description of ENVIRON's proposed approach for determining the performance metrics is as follows:

- In order to calculate several of the metrics, study area boundaries must be defined. For this purpose, ENVIRON will use the plume mass estimate boundaries presented in Appendix A of the recent Annual Remedial Performance Report (ENVIRON 2013b).
- The total mass flux within the study area being transported by groundwater flow across hypothetical east-west lines passing through the IWF, AWF, and SWF will be estimated using modeled groundwater flow rates and interpolated concentrations.
- The fraction of the total mass flux being captured by the IWF, AWF, and SWF will be estimated using capture zones from the groundwater model. Capture efficiency is the ratio of captured mass flux to total mass flux.

- Target capture zones that represent 90% and 99% capture efficiency will be shown on a figure and compared to the actual capture zones achieved by well fields as estimated by the groundwater model.
- Future estimates of perchlorate and chromium plume mass will follow the general approach used in the recent Annual Remedial Performance Report (ENVIRON 2013b).
- Mass loading at Northshore Road will be calculated as the product of the flow rate at the Northshore Road stream gage and perchlorate concentrations measured in Las Vegas Wash near the stream gage.

A presentation of the draft metrics was provided to NDEP on October 31, 2013. No comments were received from NDEP on this deliverable. These metrics will be used during the optimization of the GWETS and incorporated into future deliverables such as the Annual and Semi-Annual Remedial Performance Reports as well as the RI/FS. The evaluation of GWETS performance using the metrics will be consistent with the USEPA guidance on evaluating capture zones for groundwater pump and treat systems (USEPA 2008).

4.3.3.2 Groundwater Modeling

As part of the 2013 GWETS Optimization Project, the existing groundwater flow model will be refined and updated. The updated and refined model will be used to estimate capture zones and perform other analyses to support the optimization of the GWETS extraction rates. The model will continue to be refined as part of the RI/FS, as described in Section 6.3.

The existing model was developed by Northgate and documented in the Capture Zone Evaluation Report (Northgate 2010s). On April 4, 2013, the groundwater model was approved by NDEP for use in capture zone evaluation. The current model is a steady-state model calibrated to Site conditions existing during 2008/2009. In order to optimize the current GWETS, the model will be updated to current conditions and refined to better represent groundwater flow in the vicinity of the three extraction well fields. The model update and refinement will be performed in two phases as described below.

Phase I. The model will be updated to reflect the current configuration and pumping and injection rates of the GWETS, AMPAC, and OSSM remediation systems. A regional water balance will be prepared in order to confirm that the model is generally consistent with observed conditions. An initial evaluation of the stream-aquifer interaction in the vicinity of the SWF will also be conducted. This updated version of the model and the stream-aquifer interaction evaluation will be used to support the development of performance metrics described in Section 4.3.3.1.

Phase II. The model will be refined in order to incorporate the results of aquifer testing performed as part of the 2013 GWETS Optimization Project, the regional water balance, and the study of stream-aquifer interaction. As part of this phase, the model boundary conditions and hydraulic properties will be recalibrated to more accurately represent groundwater flow and evaluate the effectiveness of the GWETS. The updated and refined model will then be used to evaluate the performance of alternative extraction rates at the three well fields. Optimum extraction rates using the identified performance metrics will be identified and recommended for future implementation.

4.3.3.3 Future Work

Currently, there are certain limitations to operation of the existing GWETS that may require upgrades if expansion of the groundwater extraction network is deemed necessary. The treatment system is operating near its design average annual hydraulic loading of 950 gpm at the FBRs (the design 30-day average maximum flow is 1,000 gpm). The GWTP is operating near its current operational maximum hydraulic loading of 75 gpm (including 8-10 gpm of required recycle). Lift Station 3, which conveys extracted water from the AWF to Lift Station 2, is pumping at close to its maximum sustainable flow of 290 gpm. The pumping at Lift Station 2, which conveys water from the SWF and the AWF to the on-site treatment plant is also limited — it has a maximum sustainable flow of 900 gpm — but since Lift Station 2 is downstream of Lift Station 3, it is not directly limiting the flow from the AWF. A full evaluation of the GWETS, including the issues noted above, will be performed as part of the RI/FS.

4.4 Groundwater Monitoring Program

Pursuant to the aforementioned NDEP Orders, KMCC and then Tronox conducted groundwater monitoring and remediation system monitoring. In conjunction with the settlement of Tronox's bankruptcy proceeding, the Trust took title to the Site and the GWETS and continued the GWETS monitoring program.

The GWETS monitoring program consists of about 8,000 analyses per year including various and wide-ranging analytical methods from samples collected from the treatment processes, as well as from groundwater wells. Performance and compliance samples are collected and analyzed throughout the year including during weekly, bi-weekly, monthly, quarterly, and annual sampling events. However, the remainder of this section focuses on the groundwater monitoring program that is used to evaluate the overall effectiveness of the GWETS rather than monitoring related to permit compliance.

Currently, approximately 1,800 water level measurements and over 1,000 groundwater samples are collected from groundwater wells each year as part of the remediation monitoring program. Samples are collected on monthly, quarterly, and annual schedules in accordance with monitoring requirements outlined in the previous Consent Orders and AOC and through subsequent regulatory correspondence. One monitoring well, M-10, is sampled on a quarterly basis in compliance with the Site's NPDES permit. The wells sampled as part of the monitoring program are shown on Figure 4-6. The current monitoring program is summarized in Table 4-4 and as follows (numbers referenced are from the 2011 monitoring year, but will vary slightly due to well access and status):

- **Monthly Sampling** – On a monthly basis, groundwater samples and water level measurements are collected from most active monitoring wells in the AWF, SWF, and within the plume between these two well fields. Samples are analyzed for perchlorate and TDS.[27] Data are used to calculate the mass of perchlorate removed by the well fields and to provide groundwater level and quality data in the northern portion of the plume downgradient of the AWF. Water level measurements only are collected monthly from the IWF extraction wells and approximately 45 monitoring wells located within or adjacent to the NERT facilities to characterize the groundwater levels and flow directions.

- **Quarterly Sampling** – Expanded monitoring events are conducted in the first, third, and fourth quarters and consist of collecting 138 groundwater samples and 163 water level measurements (inclusive of monthly monitoring activities described above). Groundwater samples are collected from wells screened in the Shallow WBZ located throughout the plume. Samples are analyzed for perchlorate, chromium, TDS, and pH. A small subset of wells is also sampled for hexavalent chromium for compliance with the Site's Underground Injection Control (UIC) permit #UNEV94218. One monitoring well, M-10, is sampled on a quarterly basis in compliance with the Site's NPDES permit.
- **Annual Sampling** – Annually, a comprehensive monitoring event is conducted in the second quarter, and consists of 262 groundwater samples and 294 water level measurements collected from wells screened in the Shallow, Middle, and Deep WBZs. These wells include 29 wells that are owned by entities other than NERT including the City of Henderson, BMI, Olin, TIMET, and others. In addition to the analytes above, a subset of wells are analyzed for chlorate and nitrate.

Initially, separate quarterly progress reports were submitted for the chromium and perchlorate removal programs. In 2006, reporting for the two programs was combined, and since then the monitoring reports have been submitted semi-annually. The current semi-annual reports consist of text, tables, and figures documenting the status of remediation efforts, with appendices containing laboratory data reports, data validation reports, field documentation, and electronic data deliverables. An annual report submitted following the comprehensive second quarter monitoring event also includes a potentiometric surface map for the plume area and isoconcentration maps for the monitored constituents.

As described in Section 3, numerous groundwater investigations were conducted dating back to the early 1980s to characterize potential impacts to groundwater primarily related to chromium, and later, perchlorate. These investigations involved the installation of borings and groundwater wells to investigate specific data gaps; however, a systematic and critical evaluation of the groundwater monitoring network does not appear to have ever been performed. According to the NDEP's All Wells Database for the BMI Complex (September 2012 version) over 700 borings have been installed at the Site and downgradient of the Site by KMCC/Tronox including 390 that were constructed as groundwater wells. Of these 390 wells, it appears 103 were plugged and abandoned leaving 287 active wells at the Site. As noted above, most of these wells, and an additional 27 wells owned by others, are currently gauged and/or sampled as part of the groundwater monitoring program. In an effort to improve and streamline the groundwater

[27] Chromium and pH are analyzed on a quarterly and annual basis and are not regularly analyzed as part of the monthly sampling events.

monitoring program, a long-term monitoring optimization study is planned and will be presented as part of the RI Report.

4.4.1 AP-5 Pond Solids Characterization and Disposal

A work plan to characterize and remove the residual solids remaining in an on-site lined surface impoundment (the AP-5 pond) at the Site (ENVIRON 2012d) was submitted to NDEP on September 28, 2012 and approved by NDEP on February 4, 2013. The objective of this work plan is to methodically and efficiently characterize the solids to facilitate proper handling, management, and disposal.

This plan was prepared in response to NDEP's approval letter dated June 28, 2012 to implement a *Proposal to Discontinue Treatment of AP-5 Pond Water at NERT Facility*, dated March 30, 2012 (ENVIRON 2012a). The proposal recommended implementation of the following four steps:

1. Permanently close the valve that allows flow of Lake Mead water into the AP-5 pond.
2. Pump all remaining water present in the AP-5 pond to the GW-11 pond and from there to the on-site groundwater treatment plant.
3. Characterize residual solids in the AP-5 pond for off-site disposal.
4. Remove residual solids from the AP-5 pond for disposal at an appropriately permitted off-site disposal facility.

To date, step one has been implemented and step two has been completed to the extent possible utilizing the existing AP-5 pond pumping system. Additional dewatering is not expected to be necessary prior to the removal of the residual solids, however a limited volume of liquid may remain following removal of the residual solids due to the need for moisture conditioning during removal activities. Moisture conditioning is utilized to reduce potential dust exposure and to mitigate oxidizing or ignition potential of the material while in the pond at the Site. Any liquid remaining in the pond after removal of the residual solids will be pumped or otherwise safely transported to the GW-11 Pond for eventual treatment in the GWETS.

Characterization of the solids in the AP-5 pond (step three) is currently in progress. Data collected from characterization sampling will inform removal and disposal methods to be implemented during step four.

Once steps one through four are completed, all subsequent decommissioning work regarding the AP-5 pond (e.g., liner removal, underlying soil sampling, remediation as necessary) will be undertaken as part of the RI/FS.

5.0 Initial Site Evaluation

Consistent with RI/FS guidance (USEPA 1988), the initial site evaluation: (1) summarizes the CSM, (2) identifies the preliminary RAOs and applicable or relevant and appropriate requirements (ARARs), (3) describes the development of general response actions and screening of remedial technologies and process options, and (4) describes additional areas that require investigation to determine the nature and extent of COPCs in groundwater and soil at the Site.

Since the Trust assumed ownership of the Site in February 2011, all analytical data collected by ENVIRON and used for data analysis and decision making (except for FBR influent and effluent monitoring data) were validated in accordance with NDEP's data validation requirements current at the time of sampling. This data includes monitoring well data, extraction well data, and soil data contained in a relational database maintained by ENVIRON. In addition, data compiled from NDEP's regional database[28] collected by neighboring properties has been used for analyzing off-site areas and historical data. It is our understanding that data from NDEP's regional database were validated according to NDEP guidance current at the time of sampling.

5.1 Conceptual Site Model

This preliminary identification of sources, release mechanisms, exposure media, exposure routes, and receptors is based on a current understanding of on-site and off-site environmental conditions. The CSM will be revised, as appropriate, based on further evaluation of available on-site and off-site characterization data and additional environmental data collected during the RI.

The CSM for this RI/FS Work Plan is developed for the Facility Area. Information from the parcel investigations will be reviewed and considered within the context of an evaluation of the nature and extent of historical soil and groundwater contamination, but the baseline health risk assessment (BHRA) will not include the evaluation of health risks for Parcels C, D, F, G, or H. As noted in Section 2.2, the parcels have generally been evaluated on a separate timeframe from that of the Facility Area and are not included in the RI/FS process.

A comprehensive *Environmental Conditions Assessment* report was prepared for the Site in 1993 (Kleinfelder 1993). The report provided detailed summaries of processes and operations conducted during the periods of operation by the U.S. government and subsequent occupants of the Site and identified locations of former operations and associated support structures. Based on information from historical investigations and the 1993 *Environmental Conditions Assessment*, NDEP identified 70 LOUs as potential source areas (or areas requiring additional information, either in the form of further historical research or additional field sampling) in 1994 (NDEP 1994).

The 2005 CSM (ENSR 2005) presented detailed information on the LOU source areas identified by NDEP, including information on products made, years of production, and approximate waste volumes and actions taken to date. Available analytical results for each LOU were summarized

[28] The NDEP regional database is available at: http://ndep.neptuneinc.org/ndep_gisdt/home/index.xml.

and SRCs were identified based on a review of the activities and/or processes associated with each LOU. Potential contaminant migration pathways and receptors were also described. The 70 LOUs are listed in Table B-1 of Appendix B and the LOU locations are shown on Figure B-1.[29]

Since 2005, the Site has been the subject of additional field investigations and interim removal actions have been implemented. For Facility Area soils, the investigations and interim removal actions included mainly the Phase A and Phase B Source Area Investigations and soil removal actions in RZ-B through RZ-E, as described in Sections 3 and 4 of this Work Plan and tabulated in Table B-1 of Appendix B. The design of the Phase A and Phase B investigations was based on knowledge of historical Site operations (including consideration of all NDEP-identified LOUs), and all work plans were reviewed and approved by NDEP. This resulting data set was then used to inform the soil interim removal action (completed in 2011) during which over 500,000 yd^3 of soil were removed from the Site.

Based on the Phase A, Phase B, and other historical data, an HRA was completed for soils in RZ-A (Northgate 2010k). As summarized in Section 4.1, estimated cancer risks and noncancer hazards for RZ-A soils were less than NDEP's point of departure and these soils were not included in the removal program (Northgate 2010k). As a result of this finding, soils were not removed from RZ-A, and the RZ-A soil data set has been used as a background data set for soils in the remaining RZs, as directed by NDEP in August 2010 (NDEP 2010b).

The following sections provide an updated CSM based on current conditions at the Site, incorporating information from the recent investigations, removal actions, and HRAs. Background information described in Section 2 of this Work Plan — site history, physical setting and climate, geology, and hydrogeology — was taken into consideration in the development of the CSM. Information from previous sections of this report is summarized below, as appropriate, for clarity in the development of the CSM. A schematic of the CSM is shown on Figure 5-1.

5.1.1 Potential Contaminant Sources and Release Mechanisms

The 5,000-acre BMI Complex (of which the Facility Area comprises 265 acres) has been used for industrial activities since 1942, when the complex was sited and operated for the U.S. government as a wartime magnesium production plant (Kleinfelder 1993). During the period of government operations, the magnesium production operations consisted of the following major facilities, some of which were located on the area that is now the Site:

- A brine purification facility that dissolved solar salt and removed calcium, potassium, strontium, sulfate, and bicarbonate impurities via a precipitation and filtering process.
- A chloralkali plant to produce sodium hydroxide and chlorine gas from the electrolysis of purified sodium chloride brine.

[29] Additional information for the LOUs can be found in "LOU Packets," provided on a compact disc accompanying the *Site Management Plan (SMP)* (ENVIRON 2013d, 2012b).

- A plant that created pellets of magnesium oxide and a carbon source.
- Ten identical, large buildings (Units 1 through 10), each of which contained chlorinators (furnaces) that created molten magnesium chloride by reacting the magnesium oxide/carbon pellets with chlorine gas at high temperature and banks of electrolytic cells that produced magnesium metal by electrochemical reduction of the molten magnesium chloride.
- An extensive system of surface impoundments that were used to receive process effluent for evaporative disposal. This system originally included the Trade Effluent Ponds, and later included the Upper and Lower BMI Ponds, and the associated Alpha, Beta, and Northwest Ditches used to transport effluent to the Ponds. Additionally, storm water and waste water originating from the former Stauffer and Montrose operations areas were diverted from the Lower to the Upper Ponds through the Beta Ditch Extension, which extends onto the Site and connects with the Beta Ditch.
- Associated support buildings for the storage and transport of raw materials and the purification and processing of magnesium metal into ingots.

During the period of government operations, extensive volumes of liquid wastes were discharged to four unlined Trade Effluent Settling Ponds (Figure 5-2)[30]. These liquids were generally composed of acid effluent and waste caustic liquor containing high levels of TDS, dissolved metals, and to a lesser degree, chlorinated organic compounds (Kleinfelder 1993). Solid materials were placed in an open area south of the Trade Effluent Settling Ponds and north of the caustic settling ponds (Kleinfelder 1993). Waste water originating from the various production processes was discharged to a storm sewer system that emptied into unlined drainage ditches (e.g., the Alpha, Beta, and Northwest Ditches). The unlined drainage ditches routed waste water to a system of unlined ponds currently referred to as the Upper and Lower BMI ponds. The unlined surface conveyances and subsurface piping served to move waste water and chemicals across the BMI Complex (with the potential for releases to soil) and impoundments allowed process effluents to infiltrate into soil and to groundwater in areas throughout the BMI Complex. Additionally, storm water and waste water originating from the former Stauffer and Montrose operations areas were diverted from the Lower to the Upper Ponds through the Beta Ditch Extension (BRC 2007).

Following the end of magnesium production in 1944, the BMI Complex was subdivided into three primary production areas. Features located on what is now the Site include (Kleinfelder 1993):

- Six metal process Unit buildings (Units 1 through 6) and the attached chlorination buildings, rectifier buildings, motor generator buildings, and bridges.
- A flux plant.
- Peat storage areas.

[30] Figure 5-2 identifies former and current surface water impoundments and conveyances located on the Site. The Alpha Ditch and Upper and Lower BMI Ponds, mentioned in this paragraph, were not located on the area currently occupied by the Site.

- An area with a salt storage building, pulverizer building, tunnel kiln building, rotary kiln building, pellet storage building, and magnesite silos.
- Various other buildings and open storage areas.
- An area occupied by approximately two and one-fifth of the original four Trade Effluent Ponds (Figure 5-2) that were used for management of liquid waste generated by the U.S. government operations.
- The Beta Ditch (specifically, the section crossing the Site), the Beta Ditch Extension, and the Northwest Ditch.
- As described previously in Section 2, chemical manufacturing operations have continued at the Site since 1945, including production of chlorate and perchlorate compounds, boron and boron-related compounds, and refined manganese oxide.

5.1.1.1 Source Areas

The 70 source areas identified by NDEP include areas that are currently used for chemical production (e.g., some Unit buildings), areas that are no longer active, and/or where near surface soil contamination has been addressed (e.g., former surface water impoundments that have been closed). These current or former source areas include, but are not limited to:

- Unit buildings 1 through 6
- Surface water impoundments (over 15 former and current surface water impoundments were identified as LOUs)
- Former and current surface and subsurface water conveyances (e.g., the Beta Ditch, Beta Ditch Extension, Northwest Ditch, drainage systems, sewers, piping)
- Leach Plant area
- Acid drain system
- Agricultural division plant
- Ammonium perchlorate plant and associated buildings
- Materials and product handling and storage areas
- Waste handling and storage areas
- Manganese tailings area
- Stock pile areas
- Former hazardous waste landfill (LOU 10) and other hazardous waste storage areas

Historical releases from potential source areas have been documented or inferred from field investigations that have identified chemically impacted on-site soils, soil gas, and groundwater.

Specific examples of reported releases include process chemicals leaking to soil through cracks in the basements of Units 4 and 5 (LOUs 43 and 61) and the basement of Unit 6 (LOU 44). The concrete basements served as sumps to collect process liquor, spillage, and wash water. Removal activities were undertaken in the Unit 6 basement in 1987 to remove the cracked concrete floor, followed by recontouring of the underlying soil and installation of a liner system. Other process leaks and spills (associated with the Unit buildings) to soils have been documented. The Unit process effluents contained high levels of TDS, perchlorate, and to a lesser degree, hexavalent chromium (Kleinfelder 1993).

From 1945 until the mid-1970s, process effluents from the chlorate, perchlorate, and boron-related production processes were sent to the unlined Upper and Lower BMI Ponds via the Beta Ditch (LOU 5) and manganese-related wastes were disposed of in on-site leach beds (LOU 24). In addition, other BMI companies used these same ditches for conveying wastes, providing an historical source of contaminants (from neighboring properties) unrelated to former Site operations to be present in Site environmental media. In the early 1970s, under the federal NPDES program, the industries at the BMI Complex curtailed waste discharges to the Upper and Lower BMI Ponds. KMCC achieved zero-discharge status in 1976, at which time process effluents were sent to on-site, lined surface impoundments. Over time, several of these lined surface impoundments reported known releases and liner failures; these early impoundments were eventually replaced with more effective double-lined systems.

Investigations of areas potentially impacted as a result of former tenant operations were addressed through NDEP's identification of LOUs and the Phase A and B investigations conducted at the LOUs. RI/FS planning will take into consideration the presence of current tenants (as described in Section 2.2); soil investigations conducted to date have been impeded by current building footprints and associated infrastructure, leaving data gaps in the investigation. Tenant buildings and associated infrastructure will also be considered in evaluating possible remedial alternatives. In conducting any remedial action, potential exposures/risks associated with the inhalation pathway (and any other relevant pathways) for tenants (and off-site receptors) will be considered.

5.1.1.2 Neighboring Properties

The Olin property to the west of the Site (formerly referred to as POSSM, Figure 2-1) occupies the location of the former BMI Complex chloralkali production facility. Post-1945 process activities on the property included operation of a chloralkali facility to produce chlorine gas, hydrochloric acid, and sodium hydroxide. In 1947, additional manufacturing facilities were constructed to produce pesticides and chlorinated organic compounds. Production of pesticides and organic compounds ceased in 1983, and production facilities were demolished and removed from the Olin property in 1984. Operation of the chloralkali facility is ongoing (Integral Consulting Inc. [Integral] 2009). Over time, extensive volumes of process effluents and solid wastes were disposed of in unlined ponds and buried on the Olin property. These wastes contained high levels of TDS, chlorinated organic compounds, and extensive amounts of phosphoric acid. Prior to 1976, certain process effluents were routed to the Upper and Lower BMI Ponds. These waste streams included large volumes of sulfuric and hydrochloric acid, as well as sulfonated metabolites of dichlorodiphenyltrichloroethane (DDT) (Hargis & Associates [H+A] 2008). The unlined Beta Ditch transported contaminants from these western properties through the Site. Also to the west is the BMI CAMU (Figure 2-1). Both the Olin and BMI properties have been the subject of extensive environmental investigations, which have documented significant chemical impact to environmental media at the properties. It is noted that significant volumes of organochlorine pesticide and asbestos wastes were disposed of at what is now the Olin property.

The BMI landfill (also referred to as the BMI dump) is located within the BMI CAMU area in the western portion of the BMI Complex in an area formerly used as a Trade Effluent pond; the landfill began operating in 1942. The BMI landfill is unlined and consists of a northern and southern lobe, referred to as the North Landfill Lobe and the South Landfill Lobe, as shown on Figure 2-1. The North Landfill Lobe occupies a 51.7-acre rectangular-shaped area of land from the northern boundary of the CAMU Area south to approximately the northern edge of the Slit Trench Area (Daniel B. Stevens & Associates, Inc. [DBSA] 2007). The South Landfill Lobe occupies an 8.2-acre polygonal-shaped area that abuts the eastern boundary of the CAMU area in the southern portion of the property.

A number of different operating companies, including KMCC, sent solid and liquid wastes to the BMI landfill. KMCC sent primarily the following types of wastes: housekeeping wastes (e.g., paper, cartons, bags, pallets, drums, and plastics), asbestos-containing material, elemental carbon powder (from boron operations), filter cake from the sodium chlorate operations, and dried residues from the cleaning of Ponds P-1 and AP-2 (ENVIRON 2011a). Other materials disposed of in the North Landfill Lobe included: DDT paper bag packaging, carbon tetrachloride liquid waste, high paraffin fuel oil, polychlorinated benzene still bottom residues, and chlorine liquefaction sludge (DBSA 2007). Prior to 1970, solid wastes were reportedly periodically disposed of in the BMI North Landfill Lobe and burned (Geraghty & Miller, Inc. [G&M] 1993, as cited by DBSA 2007). BRC has estimated that the North and South Landfill Lobes received between 500,000 and 1,000,000 cubic yards of materials from 1942 until 1980. From 1972 to 1979, KMCC used the BMI landfill for disposal of certain boron compound wastes and from 1975 to 1980, for disposal of chlorate wastes. In 1979, the boron compound wastes were disposed of off-site (Kleinfelder 1993). Between 1980 (when the BMI landfill closed) and 1983, the chlorate wastes were disposed of at an on-site hazardous waste landfill (LOU 10, subsequently closed). Between 1967 and 1975, manganese dioxide wastes were disposed of through on-site leach beds; subsequently, these wastes were disposed of at an on-site nonhazardous waste pile and more recently, off-site. It is believed that the South Landfill Lobe received similar wastes during similar time frames as the North Landfill Lobe, except there were no effluent ponds located in the footprint of the South Landfill Lobe nor was the waste burned (DBSA 2007).

In February 1980, the BMI landfill was closed and capped (BRC 2012b and Weston 1993, as cited by BRC 2007). Historical manufacturing operations in the production areas upgradient of the BMI Landfill have significantly impacted groundwater quality in the vicinity of the CAMU area, as well as further downgradient (DBSA 2007). More recently, BRC covered and capped buried waste in the North and South Landfill Lobes, and surface liquids were removed from ditches to reduce the potential for chemical leachate in the CAMU area to migrate to and impact groundwater (DBSA 2007 and BRC 2012a). Due to the direction of groundwater flow in the region (generally north to northeasterly), a groundwater contaminant plume has migrated onto the Site from the Olin property. Contaminants include VOCs, non-aqueous phase liquid (NAPL), and pesticides. The responsible parties for this plume are currently operating a groundwater treatment system and performing groundwater monitoring under NDEP oversight (ENVIRON 2011a).

The Lhoist property (formerly Chemstar, a lime producer) is surrounded by the Site on three sides. Lhoist operations contributed to flows to the Beta Ditch prior to 1979. Lime production processes encompass mining and rock preparation, calcining to convert carbonate rock to calcium and/or magnesium oxides (quicklime), and hydrating the quicklime to hydroxides. The storm sewer system historically conveyed effluent from the Lhoist, Stauffer, and TIMET properties (Kleinfelder 1993).

The TIMET property to the east of the Site includes four former BMI process units (Units 7 through 10) and refinery buildings. Activities conducted on what is now the TIMET site from 1951 to present included production of magnesium ingot, titanium tetrachloride, titanium sponge, and titanium ingot (TIMET 2007). From 1951 until 1972, TIMET disposed of its caustic waste, leach liquor, and other process waste streams to the Upper BMI Ponds via the Beta Ditch. From 1970 to 1971, Stauffer and Montrose conveyed storm water and wastewaters from the Lower to the Upper BMI Ponds via the Beta Ditch Extension (BRC 2007). Additionally the Northwest Ditch (LOU 6), which originates near the Beta Ditch and crosses the northern portion of the Site (Kleinfelder 1993), received and conveyed process waste streams from the BMI Complex facilities to the BMI Common Area and was identified under the Phases I and II BMI Common Area Consent Agreement as a BMI Common Areas issue (ENSR 2005, Broadbent & Associates, Inc. [Broadbent] 2011). From 1976 to 1982, TIMET built 31 lined surface impoundments on top of the southwestern portion of the Upper Ponds where its process waste streams were discharged. Several of the lined ponds reported liner failures and were upgraded to double-lined systems. In 2005, a water conservation facility went online and discharge to the ponds ceased. The TIMET process waste streams contained high levels of TDS and dissolved metal chlorides (LAW Engineering 1993).

These adjacent neighboring properties are considered potential former and/or current “off-site” sources of contaminants to Site groundwater (as noted above), particularly from the west; surface soils and surface water (from off-site storm water entering the Site); and air (airborne particulates released from contaminated surface soils and buildings on these adjacent properties).

5.1.2 Release Mechanisms and Potential Migration Pathways

Environmental media at the Site, including air, soil, soil gas, surface water, and groundwater, have been impacted, as shown through a review of historical records or confirmed through field investigations. The fate and transport of Site contaminants released from on-site (and off-site) sources was assessed to identify the environmental media potentially impacted by releases. The primary historical and/or current release mechanisms and impacted environmental media at the Site are identified as follows:

- Wind dispersal of fugitive dust from contaminated surface soils.
- Following precipitation events, contaminants adsorbed to surface soils and sediments can be transported via surface water to other on-site soils and on-site surface

impoundments. (As discussed in Section 2.6, the Site has been graded to retain surface water runoff in order to minimize transport of contaminants to off-site areas.)

- Overflow of surface impoundments.
- Leaching from surface impoundments and surface and subsurface conveyances through subsurface soils to groundwater.
- Leaching from contaminated surface and near surface soils to deep soils and migration to groundwater.
- Migration of VOCs from subsurface sources (groundwater or soil) through the vadose zone to ambient or indoor air.
- For NAPL (a trespassing contaminant), formation of smear zones due to fluctuations in the water table and subsequent migration of the more volatile constituents through the vadose zone to ambient or indoor air.
- Surfacing of groundwater or groundwater discharges to drainages or lakes, such as Las Vegas Wash or Lake Mead.

5.1.3 Categorization of Soils

As described in Section 4.1, an interim soil removal action was completed for the Facility Area (RZs B through E) in November 2011, in which accessible soils with COPC concentrations greater than worker SRGs were removed. Inaccessible soils (with COPC concentrations greater than SRGs) and incompletely characterized soils (due to access issues) were assigned to one of 38 ECAs established following the remediation program (7 in RZ-B, 18 in RZ-C, 10 in RZ-D, and 3 in RZ-E).

Considering the investigations, removal action, and Site Management Plan (SMP) controls in place at the Facility Area, surface and near surface soils (0-10 ft below the "new" ground surface[31]) were placed into one of four categories to help inform the CSM, as well as identify data gaps and exposure pathways for evaluation in the RI and BHRA. The four categories are identified as follows:

- **Category 1 (Soils in ECAs)**: Includes all soils in ECAs. Due to access or other constraints that precluded soil excavation, soils in ECAs with COPC concentrations exceeding SRGs were left in place. ECAs also include 0 to 10 ft bgs soils that have not been fully characterized due to access or other restrictions. Soils in approximately 85 acres of the Facility Area (total area of 265 acres) are identified as ECAs (ENVIRON 2013d).

  Deeper Category 1 soils (greater than 10 ft bgs) with no or limited sampling data due to access constraints (e.g., soils beneath Unit buildings or active ponds), are being evaluated to identify data gaps and strategies for sampling, containment, and/or remediation as described in Section 5.4.

[31] The "new" ground surface refers to the soil surface following excavation, backfilling, and grading associated with the 2011 interim soil removal action (ENVIRON 2012e). In Sections 5 and 6, the 0 to 10 ft depth interval refers to the post-excavation soil horizon unless otherwise stated.

- **Category 2 (SRGs Not Exceeded, Not in ECA)**: Includes soils with COPC concentrations less than SRGs within the 0-10 ft post-excavation depth interval. These soils are in areas that (1) were not identified for remediation because COPC concentrations were less than SRGs based on results of the Phase A and Phase B source investigations (or other historical investigations) or (2) were remediated and soils exceeding SRGs in the 0-10 ft depth interval were removed, either in 2011 during the interim soil removal action or during other removal actions (e.g., closure of surface water impoundments). In addition, RZ-A soils for which cancer risks are less than 1×10^{-6} and hazard indices are less than 1 (as estimated in the NDEP-approved 2010 HRA [Northgate 2010d]) are included as Category 2 soils. Category 2 soils comprise approximately 163 acres within the Facility Area. No additional sampling is proposed within the 0-10 ft depth interval for Category 2 soils.
- **Category 3 (SRGs Exceeded, Not in ECA)**: Includes soils with COPC concentrations greater than SRGs within the 0-10 ft post-excavation depth interval that are not in ECAs. Category 3 soils comprise approximately 8 acres.

  Category 3 soils were identified during a comprehensive review of residual soil concentrations following completion of the 2011 interim soil removal action (ENVIRON 2012e, approved by NDEP on December 17, 2012). The 12 areas identified as Category 3 soils are shown on Figure 5-3 (numbers 1-12)[32] and information about each area is provided in Table 5-1, including sample location, sample depth interval, chemicals exceeding their respective SRG, detected concentrations, and SRGs. The chemicals detected in one or more of these areas at concentrations above their respective SRG are arsenic, perchlorate, dioxin TEQs, benzo(a)pyrene TEQs, and hexachlorobenzene.

  Soils in Category 3 areas are being evaluated to identify data gaps, although in general, it is anticipated that sufficient post-remediation samples are available to evaluate potential risks to human health associated with exposures to soils in these areas.
- **Category 4 (Inadequate Characterization, Not in ECA)**: Includes soils that are inadequately characterized that are not in ECAs. One of the Category 4 areas — the debris pile — has been identified for further evaluation (shown on Figures 2-2 and 5-3). Materials in the debris pile (e.g., concrete) have not been characterized and soils have not been sampled; sampling in this area is identified as a data gap in Section 5.4. The debris pile covers approximately 10 acres.

The approach for identifying soil COPCs (for evaluating risk to human health) will be identified in the ENVIRON BHRA Work Plan currently in preparation. Based on our review of the data, soil COPCs will include chemicals (both inorganic and organic), asbestos, and radionuclides. The BHRA Work Plan will also describe the approach for dividing the Facility Area into exposure units. The primary factors that will be considered in the identification of exposure units include soil category (as defined above) and worker activity patterns. Section 5.1.5 identifies the

[32] The BHRA Work Plan (ENVIRON 2014, in preparation) may propose incorporating some Category 3 areas into ECAs (i.e., into existing Category 1 areas), and it is possible that additional areas will be identified and classified as Category 3 soils, as soil concentrations are compared to current (updated) BCLs.

receptors and exposure pathways that will be evaluated in the BHRA and Section 6.7 provides additional information on the BHRA task.

The 2011 interim soil removal action addressed mainly soils in the 0 to 10 ft pre-excavation horizon (with some exceptions, as noted above). The primary concern with contamination in deeper soils (greater than 10 ft bgs) is the potential for leaching to groundwater, as discussed in the following section.

5.1.4 Summary of the Groundwater CSM

The 2005 CSM presented a CSM for groundwater based on data collected at the Site and Site vicinity since 1986 (ENSR 2005). An updated version of a generalized conceptual diagram of potential contaminant source areas, contaminant pathways, and potential receptors is presented on Figure 5-4.

As noted in the 2005 CSM, vadose zone transport of non-volatile chemicals is a function of having the necessary chemical environment and sufficient infiltration to mobilize the chemical through the unsaturated zone to underlying groundwater. Portions of the Site are paved or covered, which prevents infiltration of water. Given the arid climate and the current physical condition of the Site, there are only a few specific occurrences that can generate sufficient water to mobilize Site-related chemicals that are present in the subsurface following the remediation of impacted soils in the upper surface and near surface (typically, 0-10 feet). These occurrences can include a rainstorm of sufficient quantity and duration to saturate the soil beyond its field capacity; a water supply pipeline break that discharges water to a specific area which then infiltrates to groundwater; or developing a leak in or beneath a synthetically lined pond that releases sufficient water to reach the water table (ENSR 2005).

Volatile chemicals present in the vadose zone can also be transported to groundwater by vapor-phase diffusion, in addition to being transported by infiltration. If infiltration is limited, vadose zone soils will remain generally dry, which will allow diffusion of volatile chemicals in the vapor phase downward to the water table. Volatile chemicals that are soluble will dissolve in groundwater and may be transported downgradient through groundwater transport.

5.1.4.1 Leaching-Based Soil COPCs

Perchlorate and chromium are the primary chemicals present in soil that may impact groundwater. An initial screening of chemicals present in on-site soils (RZ-A through RZ-E) for leaching potential was presented in the *Revised Technical Memorandum: Calculation of Leaching-Based, Site-Specific Levels (LSSLs) for the Soil-to-Groundwater Pathway using NDEP Guidance* by Northgate (2011b) dated May 9, 2011. This document has not been approved by NDEP. This initial screening was conducted prior to the soil removal action, so the screening included soil results from locations that were excavated as part of the soil removal action and did not include soil results from confirmation samples collected as part of the removal action. Therefore, the initial screening by Northgate will not be revised and resubmitted to NDEP, nor will it be used in future evaluations.

As part of this RI/FS Work Plan, ENVIRON conducted an updated screening of vadose zone soil concentrations against NDEP Leaching-based Basic Comparison Levels (LBCLs) or similar screening levels using a soil dataset that has been revised to incorporate changes resulting from the interim soil removal action. The revised leaching-based screening was conducted on all vadose zone soil samples collected within the alluvium in the Facility Area since 2006 that were not excavated. For this screening, a default dilution attenuation factor (DAF) of 1 was used. If warranted, ENVIRON may in the future calculate site-specific screening levels or perform unsaturated zone transport modeling to further refine the list of soil COPCs that may pose a leaching concern.

ENVIRON used the most recent version of the LBCLs from August 2013 for non-radionuclides (NDEP 2013d) and from February 2009 for radionuclides (NDEP 2009b). For chemicals detected in soil that do not have a LBCL, screening criteria were based on the USEPA Regional Screening Levels (RSLs) for groundwater protection (USEPA 2013a), with the MCL-based screening levels selected over the risk-based screening levels, if available. For the seven Aroclors and 12 dioxin-like co-planer PCB congeners, individual risk-based screening levels in the USEPA RSL table were used; for all other individual or mixtures of PCBs, MCL-based screening levels for low-risk PCBs were used. For radionuclides without NDEP LBCLs, screening criteria were based on USEPA screening levels (USEPA 2000b). Finally, for chemicals with no published NDEP or USEPA screening levels, a generic LBCL was calculated using the approach presented in NDEP guidance (NDEP 2013d).

Leaching-based soil COPCs were selected as follows. For chemicals with a site-wide detection frequency in soil greater than 5%, the chemical was considered a COPC if there was at least one detected concentration exceeding the screening level. For chemicals with a detection frequency between 0 and 5%, the chemical was considered a COPC if the maximum concentration was greater than a factor of 20 over the screening level or if the number of samples exceeding the screening level was greater than 10. Chemicals with no screening levels were retained as COPCs. The 16 dioxin and furan congeners other than 2,3,7,8-tetrachlorodibenzo-p-dioxin with toxicity equivalent factors (TEFs) defined by the World Health Organization (Van den Berg et al. 2006) were retained as COPCs in this initial screening, but will be evaluated further in the future. Consistent with USEPA guidance, the essential nutrients calcium, potassium, and sodium were not included as COPCs.

In the following list of COPCs in soil, an asterisk indicates that no comparison screening criterion was available:

Preliminary Contaminants of Potential Concern (COPCs) in Soil Based on Leaching to Groundwater		
Chlorates	Perchlorate	Chlorate
Metals	Aluminum Antimony Arsenic Barium Boron Cadmium Chromium Cobalt Copper Iron Lead Magnesium Manganese	Mercury Molybdenum Nickel Niobium Palladium* Selenium Silver Strontium Thallium Tungsten Zinc Zirconium
VOCs	Benzene 2-Butanone Carbon Tetrachloride Chlorobenzene Chloroform 1,2-Dichlorobenzene 1,4-Dichlorobenzene 1,2-Dichloroethane 1,1-Dichloroethene	1,1-Dichloropropene* 1,4-Dioxane Ethyl tert-butyl ether* Methylene Chloride Tetrachloroethene 1,2,3-Trichlorobenzene Trichloroethene 1,2,3-Trichloropropane 1,2,4-Trimethylbenzene
SVOCs	Dimethylphthalate* Formaldehyde 1-Methylnaphthalene	2-Methylnaphthalene Octachlorostyrene*
Organophosphorus Pesticides	Dimethoate	Stirphos*
Organochlorine Pesticides	alpha-BHC beta-BHC gamma-BHC 2,4'-DDE* 4,4'-DDE 4,4'-DDT	Dieldrin Endosulfan I* Endosulfan Sulfate* Endrin Ketone* Hexachlorobenzene

Preliminary Contaminants of Potential Concern (COPCs) in Soil Based on Leaching to Groundwater		
Polycyclic Aromatic Hydrocarbons (PAHs)	Acenaphthylene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene	Benzo(g,h,i)perylene* Indeno(1,2,3-cd)pyrene Phenanthrene
Polychlorinated Biphenyls (PCBs)	Aroclor-1260 PCB-081 PCB-118 PCB-126	PCB-169 PCB-209 Total PCBs
Dioxins/Furans	2,3,7,8-tetrachlorodibenzo-p-dioxin Other 16 congeners with TEFs*	
Organic Acids	Phthalic Acid*	
Radionuclides	Radium-226 Radium-228 Thorium-228 Thorium-230 Thorium-232	Uranium-234 Uranium-235 Uranium-238 Uranium
Total Petroleum Hydrocarbons (TPH)	TPH-diesel* TPH-gasoline*	TPH-oil*
General Chemistry	Ammonia* Bromide* Carbonate* Chloride* Chlorine Nitrate	Nitrite* Phosphorus (total) Ortho-Phosphate* Silicon* Sulfate* Sulfur*

For metals and radionuclides, the Site soil concentrations will be compared to background datasets to determine whether the concentrations found on-site are consistent with background. The background comparisons will be done using the background datasets described in Appendix D and consistent with the statistical approach presented in NDEP guidance (NDEP 2009f). As part of the RI, ENVIRON will review available soil data to evaluate whether any revisions to this list are necessary.

5.1.4.2 Groundwater COPCs

Perchlorate and chromium are the primary Site-related chemicals detected in groundwater downgradient of the Site. Although there is no reported use of chloroform at the Site, chloroform is also detected in groundwater at the Site, at neighboring properties, and in downgradient areas. ENVIRON developed a list of other COPCs in groundwater that exceed screening criteria. Groundwater screening criteria were selected according to the following hierarchy: 1) primary MCLs, 2) residential water BCLs (NDEP 2013d), 3) tap water RSLs (USEPA 2013a), 4) secondary MCLs, and 5) risk-based target activities for thorium isotopes from NDEP (2009b) and uranium isotopes from USEPA (2013b).

The screening for groundwater COPCs was based on analysis of data from the Phase A investigation (low-flow samples only) conducted in May 2007 (ENSR 2007a,c), Phase B investigations conducted from 2008 to 2009 (Northgate 2010h), the Upgradient Investigation (ENSR 2007d), the Capture Zone Evaluation data gaps investigation conducted in September 2010 (Northgate 2010s), and other groundwater sampling data collected since 2006. The analysis was limited to unfiltered samples for this initial screening. Groundwater samples were analyzed for metals, VOCs, SVOCs, pesticides, herbicides, dioxins, furans, radionuclides, organic acids, and other general chemistry parameters.

Groundwater COPCs were defined as follows. For chemicals with a site-wide detection frequency in groundwater greater than 5%, the chemical was considered a COPC if there was at least one detected concentration exceeded the screening level. For chemicals with a detection frequency between 0 and 5%, the chemical was considered a COPC if the maximum concentration was greater than a factor of 20 over the screening level or if the number of samples exceeding the screening level was greater than 10. If no screening criterion was available, the chemical was retained as a COPC in this initial screening, but will be evaluated further in the future. Consistent with USEPA guidance, the essential nutrients calcium, potassium, and sodium were not included as COPCs. Also in a future evaluation during the RI, metals, radionuclides, and TDS concentrations in groundwater will be compared to background concentrations to determine whether they are statistically different.

In the following list of COPCs in groundwater, an asterisk indicates that no comparison screening criterion was available:

Preliminary Contaminants of Potential Concern (COPCs) in Groundwater		
Chlorates	Perchlorate	Chlorate
Metals	Aluminum Arsenic Boron Chromium VI Chromium (total) Cobalt	Iron Lead Magnesium Manganese Strontium Tungsten
VOCs	Benzene Bromodichloromethane Bromoform 1,2-Dichlorobenzene 1,4-Dichlorobenzene 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethene 1,4-Dioxane	Carbon Tetrachloride Chlorobenzene Chloroform Chloromethane Dibromochloromethane Methylene Chloride Tetrachloroethene Trichloroethene 1,2,3-Trichloropropane
Organochlorine Pesticides	alpha-BHC	Heptachlor epoxide
Radionuclides	Radium-226 and -228 Thorium-228 Thorium-230	Thorium-232 Uranium-238 Uranium
SVOCs	bis(2-Ethylhexyl)phthalate	
General Chemistry	Ammonia Bromide* Chloride Cyanide (total) Nitrate	Nitrite Phosphorus (total) Sulfate Total Dissolved Solids
Organic Acids	4-Chlorobenzenesulfonic acid	

As part of the RI, ENVIRON will review available groundwater data to evaluate whether any revisions to this list are necessary.

5.1.5 Land Use, Exposed Populations, and Exposure Pathways

The following sections identify current and future land use at the Site and potentially exposed populations. Potential exposure pathways for evaluation in the BHRA are discussed.

5.1.5.1 Land Use and Exposed Populations

The Site is situated within an area zoned for industrial use and as discussed previously, Tronox currently has a long-term lease for approximately 114 acres of the Site where it conducts its manufacturing operations. Parcels C, D, F, G, and H (not evaluated as part of the RI/FS process, as discussed in Section 2.2) are currently subject to an option to purchase by a third party. Parcel E (part of the Facility Area) contains a portion of the OSSM groundwater treatment system.

Surrounding land use is predominantly industrial. The nearest residential developments are located north and south of the Site, with residential developments to the east and west located at a greater distance. Given the highly industrialized nature of the 5,000-acre BMI Complex (which includes the Facility Area and adjacent facilities), and the long-term lease with Tronox, future use of the Facility Area is expected to remain industrial.

Potentially exposed populations (receptors) were identified considering current and expected future land use. Consistent with the NDEP-approved 2010 HRA Work Plan (Northgate 2010d), current and future on-site receptors identified for evaluation in the BHRA include long-term indoor workers, long-term outdoor commercial or industrial workers, and short-term construction workers. Currently, over 100 full-time workers are employed at the Tronox facility and approximately 7 workers are employed at the GWETS.

Other potential on-site receptors include visitors and trespassers. However, as discussed in USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002), evaluation of exposures to members of the public entering an operating facility is generally not warranted for two reasons: (1) public access is restricted or controlled at industrial sites, and (2) while the public may have access to a property, exposures of an on-site worker would be much higher than those of a visitor because workers spend substantially more time at a site. Accordingly, on-site visitors and trespassers will not be quantitatively evaluated in the risk assessment. These receptors were also excluded in the NDEP-approved 2010 HRA Work Plan (Northgate 2010d). Potential off-site receptors include workers, residents, and recreational users.

5.1.5.2 Exposure Media and Pathways

The potentially contaminated exposure media at the Facility Area and nearby vicinity include ambient and indoor air, soil, surface water, and groundwater. Potentially complete exposure pathways for each on-site and off-site receptor and exposure medium are discussed in the following sections and identified on the preliminary CSM diagram (Figure 5-1) and in Tables 5-2a and 5-2b.

The Facility Area will be divided into subareas (exposure units) in the BHRA Work Plan. The exposure units will be identified considering current and anticipated future land use and the soil category (i.e., Category 1, 2, 3, or 4 soils). The BHRA Work Plan will also include preliminary summary statistics for the post-removal data set for the Facility Area as a whole and by exposure unit. Applicable elements from the 2010 HRA Work Plan will be incorporated and the general risk assessment methodology, including exposure equations, toxicity values, and risk equations, presented in the NDEP-approved 2010 HRA Work Plan (Northgate 2010d), will be adopted in the BHRA.

Air. Chemicals detected in soil or soil gas can be transported into air through two primary mechanisms. Soil-bound chemicals can be released to air if impacted surface soils are subjected to wind erosion and/or mechanical disturbance. Volatile chemicals in soil gas can migrate through the unsaturated zone to ambient and indoor air.

- For on-site receptors, potential exposure pathways include inhalation of airborne particulates in ambient and indoor air and inhalation of VOCs in ambient and indoor air, with inhalation of VOCs in indoor air higher than those estimated for ambient air. If the cancer risk is greater than 1×10^{-6} or the HI is greater than 1 for the indoor air pathway, the potential risks to on-site outdoor workers will also be quantified. In the absence of monitoring data following soil removal activities in the Facility Area, potential airborne concentrations of COPCs resulting from Site releases will be modeled.[33] The specific models to be used will be identified in the BHRA work plan. Inhalation pathways (airborne particulates and the vapor intrusion pathway) will be evaluated for all soil categories except Category 2 soils (i.e., soils for which COPC concentrations are less than BCLs). Potential exposures of current tenants will be considered in evaluating this pathway.
- For off-site receptors, inhalation exposures to airborne particulates or VOCs released from the Facility Area would be substantially lower than the exposures of on-site outdoor workers. These pathways will be evaluated if cancer risks for on-site receptors exceed 1×10^{-6} or the HI is greater than one. However, the vapor intrusion pathway for VOCs in the downgradient plume is considered a potentially complete exposure pathway for off-site receptors (indoor worker and residents). The importance of this pathway and need for quantitative assessment is under evaluation. The evaluation will consider the effectiveness of the current groundwater mitigation systems, depth of groundwater in the downgradient area, and contaminant (VOC) concentrations in downgradient groundwater.

Soil. Individuals may ingest soil inadvertently, by transfer of soil on fingers to the mouth, for example. Individuals may also be exposed to COPCs in soil through dermal contact and external gamma radiation.

- For on-site receptors, three complete exposure pathways for outdoor workers will be evaluated: (1) incidental ingestion of soil, (2) dermal contact with soil, and (3) external gamma exposure from radionuclides in soil. For the indoor worker, only the soil ingestion pathway will be evaluated quantitatively. Although the dermal pathway is considered complete for the indoor worker, exposures for this pathway would be negligible relative to the ingestion pathways; consistent with USEPA guidance (USEPA 2002) and the NDEP-approved HRA work plan (Northgate 2010d), this pathway

[33] As noted in response-to-comment #41a (see Appendix A), ENVIRON's review of an ambient air data set collected by BMI and provided to ENVIRON by NDEP indicates that the data are not representative of current conditions at the NERT site. For this reason, ambient air concentrations will be modeled.

will not be evaluated quantitatively. Inhalation of airborne soil particulates and VOCs released from soil was discussed above in the “Air” exposure medium section.

- For the ingestion, dermal contact, and external gamma exposure pathways, exposures will be evaluated for Category 3 and 4 soils. For Category 1 soils, exposures for direct contact pathways (soil ingestion and dermal contact) will be managed through the SMP (ENVIRON 2013d). The ingestion and dermal contact pathways for Category 2 soils, for which COPC concentrations are less than SRGs, will not be evaluated quantitatively.
- For off-site receptors, deposition of airborne particulates released from the Site is a potential transport mechanism. However, potential exposures of off-site receptors to deposited particulates would be negligible.

Surface Water. As previously discussed in Section 2.6, the Site is located in a very arid region with few natural surface water bodies; however, surface water is present at the Site, primarily in surface water impoundments receiving process wastewater. Surface water is also present following storm events, during which COPCs in contaminated surface soils can dissolve. Based on the surface grade and soil types, significant ponding is not expected to occur outside of major storm events.

- For on-site receptors, exposures of outdoor workers to COPCs in storm water runoff during the few yearly precipitation events would be insignificant and worker maintenance activities at the surface water impoundments and associated conveyances would be covered under regulations put forward by the Occupational Safety and Health Administration (OSHA). Based on these considerations, potential worker exposures to surface water are not identified for quantitative evaluation.

- For off-site receptors, exposure to SRCs in surface water represents a potentially complete exposure pathway. As discussed in Section 3.2.4, impacted groundwater discharges to surface water at Las Vegas Wash, which empties into Lake Mead. Lake Mead is the source of approximately 90 percent of the drinking water in Southern Nevada (Las Vegas Water District 2012). Further, Lake Mead and the downstream Colorado River serve as municipal and agricultural water sources for areas of California, Arizona, and Mexico. The existing GWETS was designed to mitigate this exposure pathway and the three extraction well fields in the system have reduced the amount of perchlorate entering Las Vegas Wash by approximately 90 percent (Las Vegas Water District 2012). Nevertheless, exposures to SRCs present in Las Vegas Wash and Lake Mead represent potentially complete exposure pathways for off-site recreational users and residents serviced by the Las Vegas Water District, as well as recreational users and residents in California, Arizona, and Mexico served by Lake Mead and the Colorado River.

Groundwater. Businesses and residences located within or downgradient of the BMI Complex are connected to a municipal water supply. NDEP has conducted a survey of identified private well owners in the area downgradient of the BMI Complex to confirm that the wells are no longer present, and none were identified. NDEP is coordinating with the Southern Nevada Water Authority to investigate the status of a private well identified at a business property within the municipal hookup area in September 2013. 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. The only potential for direct contact with groundwater is associated with intrusive subsurface activities.

- For on-site receptors, direct contact with groundwater (i.e., incidental ingestion or dermal contact) during construction activities is considered to be an incomplete exposure pathway. Depth to groundwater ranges from about 27 to 80 ft bgs, deeper than excavations typically associated with construction activities. Further, potential exposures of workers (e.g., construction or utility workers) associated with activities at depths greater than 10 ft bgs are managed through the SMP (ENVIRON 2013d). Specifically, the SMP presents risk management measures and procedures to be implemented during construction to mitigate potential risks to human health and the environment from potential exposure to COPCs, and to manage soil and groundwater during construction activities.

  Potential exposures of current and future indoor receptors will be evaluated for the vapor intrusion pathway (with groundwater as the source of VOCs) for all areas of the Site where data indicate that groundwater is contaminated with VOCs. If risks or HIs exceed 10^{-6} or 1, respectively, for the on-site indoor commercial/industrial worker, then potential risks to on-site outdoor commercial/industrial workers will also be quantified.

- For off-site receptors, although depth to groundwater can be less than 20 ft in the downgradient area, potential exposures of construction workers to groundwater are considered negligible. Direct contact with groundwater (incidental ingestion or dermal contact) would be intermittent and standard engineering controls such as dewatering of excavations, minimize worker exposures. Indirect pathways (specifically, the vapor intrusion pathway) will be evaluated in off-site areas with site-related VOC concentrations greater than screening levels.

5.2 Remedial Action Objectives and ARARs

RAOs are media-specific (e.g., soil or groundwater) objectives designed to protect human health and the environment from releases and exposures to hazardous substances. RAOs incorporate information regarding the specific setting, COPCs, potential future uses of the Site, and human health and ecological risk-based criteria. The RAOs reflect a preference for permanent solutions, incorporating approaches, where feasible and appropriate, that will reliably reduce contaminant toxicity, mobility, or volume.

Applicable or relevant and appropriate requirements (ARARs) are considered during the development of RAOs. Applicable requirements are those federal and state cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site. If a requirement is not applicable, it may still be relevant and appropriate. A relevant and appropriate requirement addresses problems or situations that are substantially similar to those encountered at a similar site.

5.2.1 Identification and Selection of Applicable or Relevant and Appropriate Requirements

It is not unusual that multiple federal and/or state requirements are initially identified as being relevant, even though the requirements address similar issues or circumstances. USEPA ARAR guidance provides for screening of the "relevant" requirements to determine which requirements are "appropriate" and hence, an ARAR. "Relevant" requirements would not be considered "appropriate" when:

- "...another requirement is available that more fully matches the circumstances at the site," or
- "...another requirement is available that has been designed to apply to that specific situation, reflecting an explicit decision about the requirements appropriate to that situation."

For a state requirement to qualify as an ARAR, it must be promulgated, legally enforceable, more stringent than any corresponding federal requirement, consistently applied, and identified in a timely manner.

ARARs fall into one of three identified categories: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs are health- or risk-based numerical limitations or standards that apply to site-specific conditions. Location-specific ARARs are restraints placed on activities conducted in a specific location. Action-specific ARARs are technology- or activity-based requirements or limitations on actions taken with respect to hazardous waste or site remediation activities.

In addition to chemical-, location-, and action-specific ARARs, advisories, criteria, and guidance developed by USEPA or other federal or state agencies may, as appropriate, be considered in developing remediation alternatives. These criteria are referred to as "to-be-considered" (TBC) criteria.

5.2.1.1 Potential Chemical-Specific ARARs and TBC Criteria

As discussed in the July 2011 NDEP Action Memorandum, federal chemical-specific ARARs determined to be practicable for the Site are as follows:

- Safe Drinking Water Act (SDWA) under 40 CFR 142;
- Toxic Substances Control Act (TSCA); and
- OSHA Standard 29 CFR 1910 Subpart Z (Toxic and Hazardous Substances). Subpart Z provides permissible exposure limits (PELs), communication guidelines, and chemical specific information for hazardous substances.

State chemical-specific ARARs determined to be applicable for the Site are as follows:

- Nevada Administrative Code (NAC) 445A.200 - 201 (Las Vegas Wash Beneficial Use Standards for Confluence of Las Vegas Wash with Lake Mead to Telephone Line Road); and

- NAC 445A.121 - 122, and 445A.1236 (Standards for Water Quality).

The following federal chemical-specific TBC criteria were identified for perchlorate in groundwater:

- “Interim Drinking Water Health Advisory for Perchlorate” prepared by USEPA Office of Science and Technology, Office of Water, EPA 822-R-08-025 dated December 2008 (USEPA 2008); and,
- “Revised Assessment Guidance for Perchlorate”, Memorandum prepared by USEPA Office of Solid Waste and Emergency Response dated January 8, 2009 (USEPA 2009a).

The following state chemical-specific TBC criteria were identified for groundwater, soil, and surface water at the Site. These values are generally risk-based concentrations that are to be used as guidelines for preliminary screening evaluations:

- Under NAC 445A.226 – 22755, Action Levels (ALs) for contaminated sites are derived. BCLs are risk-based media concentrations for use in an initial screening evaluation to assist in risk assessment components such as the evaluation of data usability, determination of extent of contamination, identification of COPCs, and identification of preliminary remediation goals. The BCL values are derived as specified in NAC 445A.2272 and using equations from USEPA guidance, USEPA toxicity criteria, and USEPA exposure factors.

5.2.1.2 Potential Location-Specific ARARs

Location-specific ARARs are restraints placed on activities to be conducted in specific locations. Types of location-specific ARARs include requirements restricting actions or protecting floodplains, wetlands, historic places, archeological sites, and sensitive ecosystems. Potential federal location-specific ARARs at the Site are:

- Clean Water Act (CWA) 40 CFR 131, 404 and 33 CFR Part 330 (Dredge and Fill Material Discharge into Waterways);
- Federal Migratory Bird Treaty Act (Federal Protection of Migratory Birds);
- Federal Endangered Species Act of 1973 (Conservation of Threatened and Endangered Plants and Animals and the Habitats); and
- The National Historic Preservation Act of 1966, as amended in 2006, 16 U.S.C. 470 (NHPA) 36 CFR 65, 68, and 800 (Standards for the Designation, Treatment, and Protection of Historic Properties). These codes are applicable if a portion of the Site is deemed to be a “historic property.”

Potential State location-specific ARARs at the Site are:

- Nevada Revised Statute (NRS) 535 (Dams and Other Obstructions); and
- NAC 534 (Underground Water and Wells).

5.2.1.3 Potential Action-Specific ARARs

Action-specific ARARs are technology- or activity-based requirements or standards that apply to specific remedial activities conducted as part of a selected remedy. Potential federal action-specific ARARs are:

- Resource Conservation and Recovery Act (RCRA), as amended by the 1984 Hazardous Solid Waste Amendments:
  - 42 USC Chapter 82 Section 6901 - 6991 (Solid Waste Disposal);
  - 40 CFR 261 (Identification and Listing of Hazardous Waste);
  - 40 CFR 262 (Standards Applicable to Generators of Hazardous Waste); and
  - 40 CFR 263 (Standards Applicable to Transporters of Hazardous Waste).
- National Pollution Discharge Elimination System (NPDES) Permits issued under the CWA 40 CFR 122-125 (Discharge of Treated Groundwater to Surface Water);
- National Pretreatment Standards for Discharges to Public Owned Treatment Works (POTWs) under the CWA 40 CFR 403 (Discharge of Wastewater and Treated Groundwater to Sewers);
- CWA and Oil Pollution Act (OPA) 40 CFR 112 (Oil Pollution Prevention):
  - 40 CFR 112 Subpart A (General Applicability and Requirements);
  - 40 CFR 112.8 (Spill Prevention, Control, and Countermeasure (SPCC) Plan Requirements for Onshore Facilities); and
  - 40 CFR 112 Subpart D (Response Requirements).
- SDWA 40 CFR 144 (Groundwater Injection);
- Clean Air Act (CAA) 40 CFR 51 (New Source Review/Prevention of Significant Deterioration Rules for Nonfugitive Major Emission Sources);
- CAA 40 CFR 61 (National Emission Standards for the Hazardous Air Pollutants);
- Hazardous Materials Transportation Act 40 CFR 171-178 (Transportation of Hazardous Materials);
- Federal Hazardous Materials Transportation Law (49 U.S.C. 5101 et seq.) 49 CFR 171 and 172 (General Information, Regulations, Definitions, Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans); and
- OSHA 29 CFR 1910.20 (Worker Training for Remediation Activities at Hazardous Waste Remediation Sites).

Potential State action-specific ARARs are:

- NAC 459.970 - 9729 (Certification of Certain Consultants and Contractors);
- NAC 445A.121 - 122, and 445A.1236 (Standards for Water Quality);

- NAC 445A.228 - 263 (Discharge Permits);
- NAC 444.965 - 976 (Disposal of Asbestos);
- NAC 445A.810 - 925 (Underground Injection Control);
- NRS 533.437 - 4377 (Groundwater Appropriations — Environmental Permits);
- Clark County Air Quality Regulations (CCAQRs) Section 12.0 - 12.13 (Stationary Source Permitting). CCAQRs require permits for source facilities based on emission rates of the following: particulate matter (PM_{10}), carbon monoxide (CO), VOCs, nitrogen oxides (NO_x), sulfur dioxide (SO_2), Lead (Pb), total reduced sulfur, and hydrogen sulfide (H_2S);
- CCAQR Section 26 (Emission of Visible Air Contaminants);
- CCAQR Section 40 (Prohibitions of Nuisance Conditions);
- CCAQR Sections 41 and 90 - 93 (Fugitive Dust);
- CCAQR Section 45 (Idling of Diesel Powered Motor Vehicles);
- CCAQR Sections 50 and 51 (Storage and Loading of Petroleum Products); and
- CCAQR Section 94 (Permitting and Dust Control for Construction Activities). Requires permits for construction activities including, but not limited to, soil excavation, grading, and mechanized trenching.

5.2.2 Potential RAOs for the Site

For consistency with the National Oil and Hazardous Substances Contingency Plan (NCP, 40 CFR 300), RAOs proposed for the Site must be technically feasible and comply with ARARs (40 CFR 300.430). As discussed above and in the NDEP Action Memorandum dated July 21, 2011 (NDEP 2011a), the primary chemical-specific ARARs that apply to groundwater at the Site include:

- SDWA USEPA Maximum Contaminant Levels (MCLs) under 40 CFR 142;
- Nevada Water Quality Standards under NAC 445A.200 - 201 which include Las Vegas Wash Beneficial Use Standards for Confluence of Las Vegas Wash with Lake Mead to Telephone Line Road.

In addition, TBC criteria would include the BCLs discussed above. With respect to perchlorate, the TBC criteria include the Nevada Interim Action Level (AL) for perchlorate in drinking water of 18 µg/L (NDEP 2011a,b) and the Interim Drinking Water Health Advisory and federal PRG of 15 µg/L (USEPA 2008 and USEPA 2009a).

The proposed RAOs for groundwater have been selected to incorporate the following chemical-specific ARARs/TBCs:

- Perchlorate: Because there are no chemical-specific ARARs for perchlorate, the most applicable and relevant TBC for perchlorate that is protective of human health is the Interim Drinking Water Health Advisory and federal PRG of 15 µg/L (USEPA 2008 and

USEPA 2009a), chosen over the Nevada Interim AL of 18 µg/L since it is the lower of the two values.

- Other Site COPCs: The most prevalent COPC detected in groundwater at the Site other than perchlorate is chromium. The chemical-specific ARAR for chromium is the federal MCL of 100 µg/L, which the State of Nevada has adopted by reference (NAC 445A). For other Site COPCs, the chemical-specific ARARs/TBCs discussed above will be evaluated based on the results of a site-specific risk assessment and incorporated into the Site FS.

5.2.2.1 Short-Term Remedial Action Objectives

Short-term RAOs for the Site are those RAOs that are projected to be met in less than 5 years at the Site.

- **Off-Site Groundwater and Las Vegas Wash:** To meet the primary CERCLA objective of being protective of human health and the environment, discharge of COPCs originating at the Site to the Las Vegas Wash will be mitigated to help achieve chemical-specific ARARs/TBCs within the Wash. This RAO is currently being achieved, in part, and (in the short-term) will be met via continued operation of the SWF, the AWF, and the IWF and Barrier Wall System. RAOs associated with on-site soils and groundwater (described below) will be consistent with meeting this objective in the long-term.

- **Optimization/Enhancement of Groundwater Extraction and Treatment System:** Consistent with the short-term RAO regarding off-site groundwater and Las Vegas Wash (described above), the current groundwater extraction and treatment system will be investigated with the objective of optimizing operation and enhancing performance of the system, including pumping at all three extraction well fields. The current system has been effective in reducing the concentrations of perchlorate in Las Vegas Wash. In 2011, annual average perchlorate concentrations in Las Vegas Wash were 14.8 µg/L at Pabco Road and 44.8 µg/L at Northshore Road (USBOR 2012). In Lake Mead, perchlorate concentrations in 2011 at site CR 346.4 were generally below 3 µg/L (LVWCC 2013). The optimization program will investigate current groundwater pumping schemes and the system configuration to ensure that maximum capture efficiency is being achieved at each of the three extraction well fields and to evaluate whether alternatives could be used to enhance such efficiency and improve cost-effectiveness.

- **Shallow Soil:** Prevent human exposure to COPCs in soil that would pose an unacceptable health risk to on-site and off-site receptors under current and future land uses.

5.2.2.2 Long-Term Remedial Action Objectives

Long-term RAOs for the Site are those RAOs that will focus on achieving restoration of downgradient groundwater over a long time frame (i.e., greater than 5 years).

- **Downgradient Aquifer Restoration:** The overall RAO for groundwater downgradient of the Site is to restore the alluvial aquifer and UMCf to meet ARARs/TBCs. This RAO will be achieved incrementally by first focusing on the control of off-site migration of COPCs at the downgradient boundary of the Site (see below).

- **On-Site Groundwater Control:** To achieve the overall long-term RAO of downgradient aquifer restoration, the migration of COPCs present in groundwater at the Site will be mitigated. Specifically, groundwater immediately downgradient of the northern property boundary of the Site will meet ARARs/TBCs likely through a combination of the implementation of on-site vadose zone source control and the implementation (as required) of barrier groundwater control options (e.g., extraction, hydrogeologic barriers, or in-situ treatment).

- **Vadose Zone Source Control:** To be consistent with the preference for permanent remedies, incorporating approaches that will reliably reduce contaminant toxicity, mobility, or volume through treatment, this RAO will address the mitigation of significant leaching of perchlorate and other Site COPCs from vadose zone soils to underlying groundwater. In addition, vadose zone source control will also reduce direct contact with COPCs present in soil. The effectiveness and implementability of this RAO could be limited by the presence of existing operating units at the Site and therefore, will be evaluated in conjunction with on-site groundwater control alternatives to ensure that ARARs/TBCs will be achieved at the downgradient Site boundary. It is also anticipated that additional areas of vadose zone source control will be identified in the future as Site operations and Unit buildings are altered and/or decommissioned.

5.3 Development of General Response Actions and Screening of Remedial Technologies and Process Options

Under USEPA RI/FS guidance (USEPA 1988), a preliminary range of remedial action alternatives and associated technologies should be identified. This identification is not meant to be a detailed investigation of alternatives. Rather, it is intended to be a more general classification of potential remedial actions based upon the RAOs. To accomplish this, as described in this section, general response actions (GRAs) were developed for the Site. Following the identification of GRAs, and in accordance with USEPA RI/FS guidance, remedial technologies and process options were identified and initially screened. Following the initial screen, the process options retained for further analysis were further evaluated and screened. Process options were eliminated from further consideration if other process options within the same technology type offer significant relative advantages. The purpose of this screening step is to minimize the number of process options that must be considered in the development of alternatives without limiting the flexibility of the remedial design.

5.3.1 General Response Actions

GRAs are media-specific actions that satisfy RAOs that have been developed for the Site. The GRAs that have been developed for groundwater and associated source areas at the Site are summarized below.

- **No Further Action (NFA).** Evaluation of a “no action” alternative, or a no further action alternative if removal or remedial actions have already been implemented, is required under the NCP (40 CFR §300.430). For this GRA, it is assumed that no further removal or remedial actions, other than those removal actions that have already been implemented at the Site, would be performed.

- **Institutional Controls.** Institutional controls are legal or physical means to prevent potential exposures to COPCs by limiting the use of contaminated property (e.g., limiting groundwater use).
- **Groundwater Monitoring.** Impacted groundwater may be monitored on a periodic basis to ensure that chemical concentrations do not increase such that there is an unacceptable risk to human health or the environment.
- **Monitored Natural Attenuation.** Monitored natural attenuation relies on natural processes to achieve site-specific remedial objectives and routine monitoring to measure progress toward those objectives. The “natural attenuation processes” include physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentrations of contaminants in groundwater.
- **Containment Actions.** These response actions reduce the mobility of COPCs, eliminate exposure pathways, and prevent the migration and transport of COPCs to unaffected media.
- **Groundwater Extraction.** These response actions provide for extracting groundwater prior to ex-situ treatment.
- **Ex-Situ Groundwater Treatment Actions.** These response actions provide for treatment of extracted groundwater prior to discharge/disposal.
- **Excavation.** These response actions provide for excavation of source areas, prior to ex-situ treatment or disposal.
- **Ex-Situ Source Area Treatment Actions.** These response actions provide for treatment of excavated source area soils.
- **In-Situ Groundwater Treatment Actions.** These response actions reduce the mobility of COPCs, eliminate exposure pathways and prevent the migration and transport of COPCs to unaffected media.
- **In-Situ Source Area Treatment Actions.** These response actions are intended to reduce the concentrations of COPCs within vadose zone source areas in order to reduce the toxicity, mobility, or volume of contamination and also to aid in the attainment of RAOs at downgradient locations.
- **Discharge of Water from Ex-Situ Groundwater Treatment Actions.** These response actions provide for the disposal of treated liquids resulting from groundwater extraction and treatment operations.
- **Ex-Situ Vapor/Air Emissions Treatment Actions.** These response actions provide for the ex-situ treatment of vapors or other air emissions resulting from other in-situ or ex-situ treatment operations.

5.3.2 Initial Screening of Remedial Technologies and Process Options

A list of potentially applicable technology types and process options has been identified, evaluated, and screened for each GRA that has been developed for the Site. The term "technology types" refers to general categories of remedial technologies, and the term "process options" refers to specific processes within each of the technology types. The technology types and process options that have been considered and evaluated in this section are based upon ENVIRON's experience at similar sites and readily available technical information from government, industry, and academia including the following sources:

- Department of Toxic Substances Control (DTSC), 2004. Perchlorate Contamination Treatment Alternatives. January.
- Evanko, C.R. and Dzombak, D.A., 1997. Technology Evaluation Report TE-97-01: Remediation of Metals-Contaminated Soils and Groundwater. Ground-Water Remediation Technologies Analysis Center (GWRTAC). October.
- Federal Remediation Technology Roundtable (FRTR). 2012. www.frtr.gov.
- Interstate Technology & Regulatory Council (ITRC), 2000. Technology Overview: Dense Non-Aqueous Phase Liquids (DNAPLs): Review of Emerging Characterization and Remediation. Interstate Technology & Regulatory Council. June.
- ITRC, 2007. Remediation Technologies for Perchlorate Contamination in Water and Soil. PERC-2. Interstate Technology & Regulatory Council, Perchlorate Team. www.itrcweb.org.
- Sale, T. and Newell, C., 2011. A Guide for Selecting Remedies for Subsurface Releases of Chlorinated Solvents, U.S. Department of Defense, Environmental Security and Technology Certification Program (ESTCP) Project ER-200530. March.
- Urbansky, E. T, 1998. Perchlorate chemistry: implications for analysis and remediation. Bioremediation Journal 2, 81–95.
- USEPA, 1986. Grouting Techniques in Bottom Sealing of Hazardous Waste Sites. (EPA/600/2-86/020).
- USEPA, 1997. Engineering Bulletin: Technology Alternatives for the Remediation of Soils Contaminated with As, Cd, Cr, Hg, and Pb. (EPA/540/S-97/500). August.
- USEPA, 2000a. In-Situ Treatment of Soil and Groundwater Contaminated with Chromium, Technical Resource Guide. (EPA/625/R-00/005). October.
- USEPA, 2004b. In-Situ Thermal Treatment of Chlorinated Solvents: Fundamentals and Field Applications. (EPA/542/R-04/010). March.
- USEPA, 2004c. DNAPL Remediation: Selected Projects Approaching Regulatory Closure. (EPA 542-R-04-016). December.
- USEPA, 2005. Perchlorate Treatment Technology Update, Federal Facilities Forum Issue Paper. (EPA/542/R-05/015). May.
- USEPA, 2009b. DNAPL Remediation: Selected Projects Where Regulatory Closure Goals Have Been Achieved. (EPA 542/R-09/008). August.

- USEPA, 2012. Contaminated Site Clean-up Information Website. http://www.clu-in.org/.

According to USEPA guidance (USEPA 1988), technology types and process options are screened to retain implementable technologies that can be used in the development of remedial alternatives. During this initial screening step, process options are eliminated from further consideration on the basis of technical implementability (either as a stand-alone remedy or as a component of an overall remedial option). Readily available data concerning Site characteristics and chemical distributions are used to screen out technologies and process options that cannot be effectively implemented at the Site.

Because the Site covers a relatively large area, consists of variable geological features, and contains a number of different classes of contaminants, the relatively broad spectrum of technologies evaluated herein was required to fully evaluate technologies with potential applicability at the Site.

The results of the initial screening of remedial technologies and process options for the Site are summarized in Table 5-3. Table 5-3 lists GRAs, remedial technologies and process options that were considered during the initial screening process, descriptions of process options, and screening comments that support conclusions concerning the technical implementability of the various process options. Process options that were retained for secondary screening are shaded, while process options that were eliminated from further consideration are unshaded.

A total of 119 discrete process options were included in the initial screening matrix for the Site. Of these, 10 process options were eliminated from further consideration based on a lack of technical implementability, leaving 109 process options that were retained for further analysis.

5.3.3 Secondary Screening of Process Options

During this stage of the screening process, the process options that were retained within the initial screening process were further evaluated and screened on the basis of effectiveness, implementability, and relative cost.

5.3.3.1 Process Option Screening Criteria

As noted above, process options were screened in this step on the basis of effectiveness, implementability, and cost. These screening criteria are discussed below.

- **Effectiveness**: The effectiveness of process options that are considered to be technically implementable is evaluated relative to other processes within the same technology type. This evaluation focuses upon: (1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs; (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the Site.

- **Implementability**: Implementability encompasses both the technical and administrative feasibility of implementing a process option. Since technical implementability is used as a screening criterion during initial screening to eliminate technology types and process options, this secondary screening process places more emphasis on the institutional aspects of implementability such as the ability to obtain necessary permits, the availability of treatment, storage, and disposal facilities, and the availability of equipment and skilled workers necessary to implement the process option.

- **Cost:** At this early stage in the RI/FS process, relative capital and operations and maintenance (O&M) costs are qualitatively compared using engineering judgment. Each process is evaluated as to whether costs are high, moderate, or low relative to other process options in the same technology type. Life cycle costs have been considered, though not explicitly, in the relative cost comparisons in the initial screening process.

5.3.3.2 Preliminary Selection of Feasible Technologies

Results of secondary screening of process options on the basis of effectiveness, implementability, and cost are summarized in Table 5-4. Of the 109 process options that were retained for further evaluation after the initial screening step, an additional 46 process options were screened out from further consideration in this step. A total of 63 process options were retained from the secondary screening process for remedial alternative development. A general summary of the process options retained for further analysis in the RI/FS is provided below.

No Further Action

This option is required under the NCP for comparison purposes. This option stipulates that no actions are to be taken beyond the previous and current interim removal actions described in Section 4 of this Work Plan, including the interim soil removal actions and health risk assessments described in Sections 4.1 and 4.2, the historical and current groundwater removal actions described in Section 4.3 (i.e., the construction and operation of the GWETS), and the groundwater monitoring described in Section 4.4.

Management Options

Management options include those which limit exposures to COPCs through the use of institutional controls and other administrative instruments implemented at the Site. Examples of management options that have been retained for further evaluation include the following:

- Groundwater Use Restrictions;
- Site Access Restrictions;
- SMP to manage risk to Site occupants and workers by identifying remaining COPCs left in place and the appropriate risk management measures to follow when encountering/ disturbing media containing COPCs;
- Legal Restrictions to Land Use; and
- Deed Restrictions.

Monitoring Options

Monitoring options include those to limit exposures to COPCs through the methodic and routine observation, measurement, and/or sample collection/analysis of environmental media. Monitoring options are used to ensure that levels of COPCs do not exceed certain health or environmental standards and to alert site managers to changing conditions that may lead to such an exceedance in the future, so that preventative measures can be implemented. In the case of monitored natural attenuation, monitoring is used to measure the progress of natural processes to reduce the mass, mobility, and/or toxicity of COPCs. Examples of monitoring options that have been retained for further evaluation include the following:

- Groundwater Sampling and Monitoring; and
- Monitored Natural Attenuation of Groundwater.

Source Control Options

Source control options include those which restrict or mitigate the transport of COPCs from source areas to downgradient groundwater and off-site receptors. Contaminant discharge from sources can be reduced via containment and/or depletion. Some process options can perform both functions depending on how they are implemented (e.g., groundwater extraction). Examples of source control options employing a containment approach that have been retained for further evaluation include the following:

- Groundwater Extraction/Hydraulic Containment (including applicable ex-situ groundwater treatment options);
- Slurry Walls;
- Single-Layer Synthetic Membrane Cap;
- Multi-Layered Cap System; and
- Asphalt/Concrete Paving.

Examples of source control options employing a source depletion approach that have been retained for further evaluation include the following:

- Groundwater Extraction (including applicable ex-situ groundwater treatment options);
- Soil Flushing;
- Soil Excavation;
- Enhanced Reductive Bioremediation;
- In-Situ Chemical Reduction (ISCR);
- In-Situ Chemical Oxidation (ISCO);
- Soil Vapor Extraction (SVE) (including applicable ex-situ vapor treatment options);
- Dual-Phase Extraction (DPE) (including applicable ex-situ vapor and groundwater treatment options);
- Multi-Phase Extraction (MPE) (including applicable ex-situ vapor, groundwater, and DNAPL treatment options);
- Air Sparging (including applicable ex-situ vapor treatment options); and

- In-Situ Well Stripping (including applicable ex-situ vapor treatment options).

Downgradient Plume Options

Downgradient plume options include those which restrict or mitigate the transport of off-site COPCs to further downgradient groundwater and off-site receptors. Ultimately, in keeping with the long-term RAOs, the downgradient plume options are those capable of also restoring off-site groundwater in the alluvial aquifer and UMCf to meet ARARs/TBCs. Examples of downgradient plume options that have been retained for further evaluation include the following:

- Groundwater Extraction (including applicable ex-situ groundwater treatment options);
- ISCR;
- Enhanced Reductive Bioremediation – Mobile Amendments;
- Enhanced Reductive Bioremediation – Fixed Biobarriers; and
- Slurry Walls or Other Containment Options.

In-Situ Process Enhancement Options

In-situ process enhancement options include those which can enhance the performance of the source control and downgradient plume options. These options can be employed within low-permeability formations to enhance either the yield of groundwater and/or vapor extraction process options or increase distribution of substrates or other subsurface amendments for enhancing the performance or longevity of in-situ biological/chemical options. Examples of in-situ process enhancement options that have been retained for further evaluation include the following:

- Pneumatic Fracturing;
- Hydraulic Fracturing;
- Funnel and Gate;
- Directional Wells;
- Soil Flooding; and
- Bioremediation.

Ex-Situ Groundwater Treatment

Ex-situ groundwater treatment options include those which can reduce the mass, mobility, and/or toxicity of COPCs in extracted groundwater from on-site and off-site groundwater extraction facilities. Examples of ex-situ groundwater treatment options that have been retained for further evaluation include the following:

- Air Stripping;
- Liquid-Phase Carbon Adsorption Using Granular Activated Carbon (GAC);
- Chemical Oxidation;
- Chemical Precipitation;

- Coagulation/Flocculation;
- IX Using Single-Use Resins;
- Anaerobic FBRs; and
- Anaerobic Continuously-Stirred Tank Reactors (CSTRs).

Discharge Options

Discharge options include those allowing discharge of extracted groundwater. Examples of discharge options that have been retained for further evaluation include the following:

- Surface Water Discharge;
- Sewer Discharge;
- Water Reuse;
- Subsurface Water Discharge;
- Pittman Bypass Pipeline; and
- Zero Discharge (i.e., enhanced evaporation mechanisms).

Ex-Situ Vapor/Air Emissions Treatment

Ex-Situ vapor/air emissions treatment options include those which remove COPCs from vapor or air emissions resulting from other process options. Examples of ex-situ vapor/air emissions options that have been retained for further evaluation include the following:

- Vapor Phase Carbon Adsorption;
- Advanced Oxidation;
- Catalytic Oxidation;
- Thermal Oxidation; and
- Biofiltration.

Following completion of site characterization, risk assessment, and treatability study tasks in the RI/FS, the above process options will be evaluated to determine their applicability in relevant regions of the Site. Following this evaluation, the process options will be assembled into several remedial alternatives for further evaluation in the FS.

5.3.4 Preliminary Remedial Action Alternatives

From the preliminary screening evaluation, a number of practicable remedial technologies and process options to address the COPCs in soil and groundwater at the Site were retained based on readily available Site information and professional experience. From this list of retained technologies and process options, the following preliminary remedial action alternatives (RAAs) were developed for further evaluation. ENVIRON notes that the RAAs presented here are not meant to be comprehensive and specific with respect to the retained process options to be evaluated in each. Rather, we have identified conceptual RAAs that would address the primary COPCs and RAOs identified for the Site. It is anticipated that numerous variations on each conceptual RAA identified below will be included for analysis in the FS. As information is obtained in the RI to address data gaps, additional RAAs may be identified and included in future analyses. Short-term and long-term RAOs, which must be technically feasible and comply with ARARs, will be used to evaluate the acceptability of each of RAA. Alternatives that meet both short-term and long-term RAOs will be ranked higher than RAAs that meet only short-term or long-term RAOs. The criteria used to evaluate RAAs are discussed in more detail in Section 6.11.

The conceptual remedial alternatives developed from the preliminary screening include:

RAA-1 – No Further Action

The No Further Action alternative involves no remedial actions beyond the interim measures currently in place, and represents a baseline for comparison of the remaining remedial alternatives. The No Further Action alternative is not expected to meet RAOs defined for the Site.

RAA-2 – Enhancement of Groundwater Containment, Recovery, and Aboveground Treatment via Upgrades to the Existing GWETS

This alternative would include use of the existing GWETS as a primary component for both on-site containment of COPCs and for downgradient groundwater restoration. Enhancements to the existing GWETS would likely be required to meet RAOs and could include the installation of additional extraction wells to improve horizontal and vertical capture. Groundwater modeling would be used to optimize groundwater extraction using the new wells. Upgrades to the treatment system could be necessary to handle increased hydraulic and/or mass loading. Groundwater treatment process options and discharge options retained in the screening process described above would be considered for this purpose.

RAA-3 – Enhancement of Groundwater Containment, Recovery, and Aboveground Treatment via Upgrades to the Existing GWETS and On-site Source Control

This alternative would employ the same upgrades to the existing GWETS identified in RAA-2 and also examine the potential effectiveness of employing source control alternatives to mitigate the migration of COPCs from on-site vadose zone source area soils to groundwater. The methods of source control could include containment and/or source depletion options. Source control process options to be examined in this alternative would include capping, soil flushing, and in-situ treatment options. Treatability/pilot testing of soil flushing, which appears to be particularly promising as a source control option for perchlorate based on preliminary screening, has been proposed in a work plan submitted to NDEP on December 27, 2013 (ENVIRON 2013f).

RAA-4 – Enhanced Groundwater Containment and Extraction at the IWF and AWF with In-Situ Treatment Downgradient of the AWF

This alternative would employ some of the same upgrades to the existing GWETS identified in RAA-2 or RAA-3 with the implementation of an in-situ treatment (e.g., enhanced bioremediation via a permeable reactive barrier) downgradient of the AWF. Depending on the demonstrated effectiveness of the in-situ treatment system, this alternative could ultimately include reducing (or eliminating) the operation of the SWF. Treatability/pilot testing of enhanced in-situ bioremediation has been proposed in a work plan submitted to NDEP on December 27, 2013 (ENVIRON 2013e).

5.4 Data Gaps

As discussed in Section 3, the Site has been the subject of numerous regulatory actions and environmental investigations since the early 1970s. The soil and groundwater investigations conducted through 2005 served as the basis of the first comprehensive CSM developed for the Site in 2005 (ENSR 2005). Since then, additional soil and groundwater investigations and interim removal actions (described in Section 4) have been conducted. For the RI/FS, additional areas have been identified that require investigation to determine the nature and extent of COPCs in soil and groundwater at the Site. Many of these areas were previously identified by NDEP as areas requiring further study.

5.4.1 Soil

The purpose of soil investigations conducted during the RI phase is to complete characterization activities (i.e., to address data gaps) at the Facility Area and ensure that adequate data is available to: (1) conduct the BHRA, (2) identify and evaluate potential sources of COPCs in groundwater, and (3) support the development and evaluation of remedial alternatives.

All analytical results for soil samples in areas not removed during the interim soil removal action and that remain representative of current conditions at the Facility Area are being reviewed for usability in the BHRA. For many analytes, the post-remediation data set for 0-10 ft depth interval includes results at over 500 sampling locations, although for other analytes (particularly those not expected to be Site related) the analytical data set is much more limited. The ongoing data gap evaluation considers spatial coverage for the preliminary list of soil COPCs and the exposure units that will be identified in the BHRA work plan (see Section 6.7 for additional information on preparation of the BHRA work plan). For the evaluation of potential groundwater sources, the analytical results from both shallow and deep soils are being reviewed for spatial coverage, considering the current understanding of groundwater contamination.

5.4.1.1 Soil Data Gaps

Several data gaps have been identified based on the review of the post-removal soil data set completed to date. As shown on Figure 5-5a, additional physical and chemical data are needed in both shallow and deep soils in at least four main areas.

These areas, and the general nature of the investigation in each area, can be described as follows:

- **Pond AP-5.** Relatively high concentrations of perchlorate and chromium have been detected in groundwater in the AP-5 pond area. NDEP previously identified Pond AP-5 as a potential source of metals, hexavalent chromium, perchlorate, chlorate, and ammonium (NDEP 2011a). As discussed in Section 4.4.1, draining and removal of residual solids from the pond has been proposed to NDEP. Following draining and residual solids removal, approximately 6 to 8 soil borings are anticipated to be installed in the area of the former Pond AP-5. The exact number and location of these borings will be identified in a forthcoming Sampling and Analysis Plan (SAP) following analysis of data quality objectives (DQOs) and a field survey of the area to identify potential physical obstructions.

- **Debris pile.** Data are needed to evaluate the nature of the debris in the debris pile and the chemical and physical characteristics of the soil within and below the debris pile, as well as soil to the area south of the debris pile. NDEP has previously requested that this area be investigated during the RI. It is anticipated that three exploratory trenches will be constructed through the debris pile to observe the materials in the debris pile. Visual evidence of subsurface soil and debris along with field instrument readings will be used during exploratory trenching to track visual evidence of contamination from the debris in the waste pile. Up to 5 grab soil samples will be collected for analysis from each of the exploratory trenches to determine if the materials in the debris pile are a source of COPCs at the Site. In addition, approximately 4 to 6 soil borings will be installed around the perimeter of the debris pile. The specific location of the exploratory trenches and the number of grab samples and the exact number and location of perimeter borings will be identified in the SAP following analysis of DQOs and a field survey of the area to identify potential physical obstructions.
- **Soil in the area between the debris pile and Pond AP-5.** Relatively high concentrations of perchlorate and chromium have been detected in groundwater in this area. Approximately 12 to 15 soil borings are anticipated to be installed in this area. The exact number and location of these borings will be identified in the SAP following analysis of DQOs and a field survey of the area to identify potential physical obstructions.
- **Area West of Pond Mn-1.** Relatively high concentrations of perchlorate, chromium and chloroform have been identified in groundwater in this area. Approximately 6 to 8 soil borings are anticipated to be installed in this area. The exact number and location of these borings will be identified in the SAP following analysis of DQOs and a field survey of the area to identify potential physical obstructions.

Additional characterization of Category 3 soils may be identified as a data gap in conjunction with the ongoing review of available soil data for the BHRA. Further, additional characterization of soil gas is a possible data gap. However, given that groundwater has been identified as a source of VOCs in soil gas, review and identification of data gaps in the existing soil gas dataset will be completed following investigation of trespassing VOCs in groundwater from neighboring properties, as discussed in Section 5.4.2.

The specific scope and DQOs for the additional soil investigation areas will be described in detail in the SAP, which will be submitted separately from this RI/FS Work Plan in January 2014. Conceptually, soil borings will be installed in the four areas shown on Figure 5-5a to a depth of first encountered groundwater. Soil samples will be collected continuously and analyzed for COPCs in groundwater. Soil samples will also be analyzed, at a minimum, for: redox potential, total organic carbon (TOC), pH, ferrous iron, ferric iron, chloride, nitrate, nitrite, pH, sulfide, sulfate, calcium, potassium, and sodium. In addition to a discussion of the nature and extent of soil investigation activities and DQOs for the areas of investigation, the SAP will include a field sampling plan, Quality Assurance Project Plan (QAPP), and a Health and Safety Plan (HASP).

5.4.1.2 Unit Buildings Investigation Approach

In addition to the four areas discussed in Section 5.4.1.1, data are needed to evaluate the Category 1 soil areas with limited soil characterization due to access constraints (e.g., soils beneath Unit buildings). As discussed in Section 2.2, the major buildings on the Site include Units 1 through 6, which are aligned in a row extending in a west-east direction across the southern portion of the Site as shown on Figure 5-5a. These buildings were constructed during World War II for magnesium production. Unit buildings 3 through 6 and the southern portions of Unit buildings 1 and 2 are within the boundaries of the Tronox-leased area. Tronox uses Units 5 and 6 for production of manganese dioxide; Unit 5 is also used for storage. Units 1, 2, and most of Unit 4 are no longer used and have been partially demolished. The remaining portion of Unit 4 has been retrofitted to house an advanced battery manufacturing process that started up in 2012. Tronox currently uses Unit 3 for office and storage activities. In addition, Tronox produces boron products within a Boron Plant to the north of Unit 4, and manganese sulfate solution (for use in the manganese dioxide production process) is produced within a Leach Plant north of Units 5 and 6. This area of the Site is crossed by asphalt and concrete roads, dirt roads, active utility lines, a gaseous chlorine line, and railroad spurs. An extensive network of active and inactive underground utility lines is present under the roads and open areas in this area of the Site.

As discussed in Section 5.1.1.1, historic reported releases at the Site include process chemicals leaking to soil through cracks in the central basements of Units 4 and 5 (LOUs 43 and 61) and the basement of Unit 6 (LOU 44). The concrete basements served as sumps to collect process liquor, spillage, and wash water. Removal activities were undertaken in the Unit 6 basement in 1987 to remove the cracked concrete floor, followed by recontouring of the underlying soil and installation of a liner system. Other process leaks and spills (associated with the Units) to soils have been documented. The Unit process effluents contained high levels of TDS, perchlorate, and to a lesser degree, hexavalent chromium (Kleinfelder 1993).

Review of Available Data

During previous investigations, approximately 81 deep soil borings were drilled in the immediate vicinity of the Unit buildings and surrounding area. The majority of these borings were drilled between September-November 2009, with a few earlier borings advanced in 2006 and 2007. Generally, two (sometimes three) soil samples were collected between 0 and 12.5 feet bgs, with two (sometimes three) deeper samples collected at depths between 20 and 45 feet. In addition, nine shallow borings were drilled to depths between 5.5 and 11.5 feet in 2010, and one additional shallow boring was drilled in this area in 2011.

To better assess data gaps associated with the Unit buildings, the existing soil data were evaluated along with the May-June 2012 groundwater data to identify areas of impacted soil and groundwater around and downgradient of the Unit buildings. Due to its high solubility, perchlorate distribution was evaluated as the primary indicator of areas where perchlorate remaining in deep soils may be a continuing source to underlying groundwater and where additional investigation of the deep soils may be needed.

Perchlorate concentrations in shallow groundwater below the Unit buildings at the Site are shown on Figure 5-5b. Three monitoring wells are located downgradient of the three Unit buildings that had reported releases through cracks in central basement concrete floors. Well M-12A is located downgradient of Unit 4 and the Boron Plant, well M-11 is located downgradient of Unit 5, and well M-29 is located downgradient of Unit 6. The highest perchlorate concentration was detected downgradient of Unit 4 in well M-12A, where the perchlorate concentration was 200 mg/L. In contrast, the perchlorate concentration downgradient of Unit 5 in well M-11 was 29 mg/L. Downgradient of Unit 6, the perchlorate concentration at well M-29 was 4.4 mg/L in May 2011 (this well was not sampled in 2012). These downgradient groundwater concentrations suggest that, if present, deep soils impacted by past releases are most likely to be present beneath Unit 4, followed by Unit 5. As noted above, the basement floor in Unit 6 has been replaced with a new concrete slab and an underlying liner. Given the comparatively low perchlorate concentration in downgradient well M-29, investigation of deep soil sources beneath Unit 6 does not appear warranted at this time.

As also shown on Figure 5-5b, higher perchlorate concentrations were detected in wells located within and downgradient of the Leach Plant (M-52, 570 mg/L; M-141, 630 mg/L; M-31A, 1,100 mg/L), suggesting a potential for deep impacted soil to be present in the Leach Plant area downgradient of the Unit buildings.

Additional information on perchlorate in shallow groundwater can be inferred from the deep soil borings drilled around the Unit buildings in 2009. Based on groundwater levels measured in May 2013, the depth to water ranges from approximately 34 to 45 feet bgs in the existing shallow wells near the Unit buildings. The deepest soil sample depths at each of the 81 deep borings were compared to the groundwater depth in the nearest shallow groundwater well. Based on this comparison, the deepest soil samples in 75 of the borings were collected from just below the water table or within the capillary fringe zone just above it. In addition, the deepest soil samples at many of these borings had higher concentrations than the shallow soil samples above them, further indicating that the pore water in the deepest samples contained perchlorate concentrations that are reflective of underlying groundwater.

To provide a more comprehensive screening level assessment of perchlorate distribution, the soil perchlorate concentrations were converted to equivalent groundwater concentrations. For those soil samples below the water table depth or close enough to be in the capillary fringe, an equivalent groundwater concentration was calculated from the soil perchlorate results.[34] These one-time equivalent groundwater concentrations are posted along with the May and June 2012 groundwater monitoring results on Figure 5-5c. Together, these concentrations provide a more complete screening level "snapshot" of areas of higher concentration that may warrant further investigation outside the Unit building footprints.

[34] The equivalent groundwater concentration was calculated by multiplying the saturated soil concentration by the bulk density (assumed to be 1.2 grams per cubic centimeter) and dividing by the porosity (assumed to be 0.6). The saturated soil samples were collected from the UMCf, so values of bulk density and porosity generally representative of the UMCf were selected.

As shown on Figure 5-5c, equivalent groundwater perchlorate concentrations >1,000 mg/L were present in the deep soil borings located west of Unit 4, between Units 4 and 5, and between Units 5 and 6. Based on these results, three shallow groundwater monitoring wells will be installed at these locations. Two additional shallow wells will be installed upgradient of Units 4 and 5 to provide better delineation in the area south of the buildings.

Methods for obtaining deep soil samples directly beneath the Unit 4 and 5 buildings will be affected by factors including worker safety issues, severe access constraints for drilling equipment within the operating Unit buildings, low ceiling heights in the basements, and limited access to the basement levels. Based on discussions with Tronox, historically the southern portion of each building consisted of a substation with two basement levels. The central portion was occupied by electrolytic cells with one basement level (this is the portion of the Unit 4, 5, and 6 buildings where historic releases were reported). The northern portion was a four-story chlorination unit above ground level with limited ceiling height.

In Unit 4, the southern portion of the building is now used for advanced battery manufacturing. The central cell area has been demolished to floor level; however, the condition of the floor slab is very poor and would not support more than occasional foot traffic. Access to the basement beneath the unstable floor slab is unsafe in its current condition. The northern portion is occupied by an air compressor and storage. In Unit 5, active operations conducted in the southern and central portions of the building and the presence of closely spaced equipment would prevent access to the basements. The northern portion of Unit 5 is unused, but access is limited by low ceiling height on the ground floor level. Based on these building conditions, vertical drilling through the Unit 4 and 5 basement floors will not be feasible even with limited access equipment.

Directional drilling may be feasible, subject to several limitations. To achieve the target sampling depth, a 5:1 setback is required. For example, a target sampling depth of 20 feet below grade would require that the rig be positioned 100 feet away from the first soil sampling location. Soil samples are typically collected at 20 to 30 feet intervals along the horizontal drill path. The drill bit is maintained on course by tracking with an above ground instrument that detects signals transmitted from the drill bit. The detection instrument is operated by a worker who walks on the paved or unpaved ground surface directly above the bit. Based on discussions with Tronox, this will not be possible in the basement of Unit 4 due to safety issues and may not be possible in Unit 5 due to the density of operating equipment. In addition, the detection instrument is affected by interference from electrical equipment and electric fields, which may be an issue in Unit 5. However, it may be feasible to use directional drilling to obtain soil samples from beneath the western portion of the Leach Plant where higher perchlorate concentrations are present in shallow wells.

Proposed Investigation Approach

The specific scope and DQOs for the additional Unit building investigation will be described in detail in the SAP, which will be submitted separately from this Work Plan in January 2014. Conceptually, five shallow groundwater monitoring wells will be installed at the locations shown on Figure 5-5c. Soil samples will be collected continuously during drilling. The feasibility of directional drilling beneath Unit buildings 4 and 5 and beneath the western portion of the Leach

Plant will be evaluated by an experienced directional drilling contractor prior to submittal of the SAP. The investigation results will provide additional data to evaluate whether perchlorate and other site related chemicals may be present in soil beneath the Unit buildings or Leach Plant at concentrations of potential concern with respect to transport to underlying groundwater. For this transport to occur, sufficient water would need to percolate the ground surface, contact COPCs currently bound to soils, and transport the COPCs in the aqueous phase through the entire vadose zone. If current operations at the Unit buildings and Leach Plant are managed to minimize sources of infiltrating water, COPCs present in the vadose zone from historic releases would remain in place in the absence of a transporting fluid.

Soil and groundwater samples will be analyzed for COPCs in groundwater. Selected soil samples will also be analyzed for general characterization parameters including redox potential, total organic carbon (TOC), pH, ferrous iron, ferric iron, chloride, nitrate, nitrite, pH, sulfide, sulfate, calcium, potassium, and sodium. The detailed field sampling plans for this investigation will be provided in the forthcoming SAP.

5.4.2 Groundwater

The Site has been studied extensively; over 1,000 wells and borings have been drilled in and around the BMI Complex to characterize subsurface conditions. Groundwater and surface water impacts have been monitored and evaluated, and removal actions have been implemented to partially mitigate chromium and perchlorate impacts.

As discussed in Section 2.5, lateral transport of shallow groundwater is primarily within paleochannels incised within the Muddy Creek Formation. In addition, infiltration of surface water from the COH ponds in the Bird Viewing Preserve and from Las Vegas Wash near the SWF affect groundwater flow in the northern portion of the downgradient plume. Figure 5-6 shows the May-June 2012 potentiometric surface in shallow groundwater, along with the paleochannels and major surface water features. As can be seen on Figure 5-6, the on-site barrier wall and IWF, the off-site downgradient AWF, and the SWF adjacent to Las Vegas Wash operated by the Trust, as well as the extraction well systems operated by OSSM and AMPAC, are positioned across the preferential flow pathways formed by the paleochannels.

Perchlorate is the primary Site-related chemical detected in groundwater downgradient of the Site. Figure 5-7 presents the May-June 2012 perchlorate shallow groundwater isoconcentration contour map along with the paleochannels and locations of the on-site barrier wall/IWF, the off-site downgradient AWF, and the SWF adjacent to Las Vegas Wash. The May-June 2012 isoconcentration contour maps for total chromium and total dissolved solids are presented on Figures 5-8 and 5-9, respectively. The detailed maps showing the data for these schematic figures are presented on Plates 2 through 5. In addition, an isoconcentration contour map for chloroform in shallow groundwater is presented on Figure 5-10, and a detailed map is presented on Plate 6. Chloroform was tested for during the Phase B Site investigation conducted in 2008-2009. To provide the most complete data set, Figure 5-10 is based on the Site data and off-site data collected during that time period.

The following data gaps for groundwater have been identified:

- **Background Determination.** As described in the 2005 CSM, although regional information is available, background concentrations of metals and other naturally occurring compounds of concern in soil and groundwater have not been determined for the localized area. This issue is being jointly evaluated by BMI Complex members. An outline for a Background Study Work Plan was submitted to NDEP by Tronox in 2008 (Tronox 2008). For purposes of this RI/FS, naturally occurring compounds will be compared to upgradient concentrations in four wells located on the upgradient (southern) Site boundary. These include Shallow WBZ wells M-120 and M-121 (screened in UMCf-cg1) and Middle WBZ wells M-117 and M-118 (screened in UMCf-fg1). The alluvium is unsaturated at the upgradient Site boundary.

- **Chemicals of Potential Concern.** In Section 5.1.4.2, a preliminary list of groundwater COPCs is presented based on screening of groundwater data collected since 2006. As part of the RI, ENVIRON will review available groundwater data to determine whether any revisions to this list are necessary.

- **Middle Water-Bearing Zone/Muddy Creek Formation.** There are currently 23 on-site monitoring wells completed in the Middle WBZ. Three of these wells (MC-MW-18, MC-MW-39, MC-MW-42) are owned by Montrose and were installed to assess the extent of DNAPL originating at the OSSM property west of the Site. The DNAPL is a trespassing chemical and is discussed further below.

  At the Site, the soils within the Middle WBZ consist predominantly of the UMCf-fg1. The UMCf-cg2 occurs below the fine-grained unit at the base of the Middle WBZ. The top of the UMCf-cg2 unit varies depending on location; it has been encountered at depths ranging from 175 ft bgs to as deep as 272 ft bgs. The UMCf-cg2 unit has been defined below the western portion of the Site by six deep wells (TR-1, TR-5, TR-7, TR-9, TR-11, TR-12) and below the northern portion of the Site by two deep wells (M-154 and M-155). The UMCf-cg2 unit is confined, as indicated by artesian groundwater elevations consistently measured in these wells. These eight wells were sampled for perchlorate and chromium in May 2012. Perchlorate was not detected (ND<0.254 µg/L) in any of the wells. Total chromium concentrations were all below the MCL of 100 µg/L; the detected chromium concentrations ranged from 13 to 48 µg/L. These results indicate that the UMCf-cg2 unit at the base of the Middle WBZ is not impacted by Site-related chemicals.

  <u>Vertical Extent of Site-related Chemicals in the UMCf Fine-grained Unit</u> – The vertical extent of Site-related chemicals in the UMCf-fg1 unit has been partially defined by recent deeper wells installed in the central portion of the Site and in the vicinity of the IWF. Installation of deeper wells to further delineate vertical extent is recommended at three Site locations to add one or more deeper wells to existing well clusters:

  - Adjacent to Middle WBZ monitoring well M-186 located on the eastern Site boundary.
  - Adjacent to Middle WBZ monitoring well M-161 located on the north-central side of the barrier wall and IWF.

- Adjacent to Middle WBZ monitoring well M-162 located on the north side of the barrier wall and IWF at its western end.

The recommended additional well locations are shown on Figure 5-11.

Additional Hydraulic Characterization – In order to better characterize hydraulic properties in the Middle WBZ UMCf fine-grained unit, slug tests will be conducted in all the existing and new Trust-owned wells completed in this unit. These data will be incorporated into the numerical model developed to assess remedial alternative extraction scenarios for Site groundwater. While the majority of groundwater flow and transport occurs in the shallow alluvial deposits, evaluation of flow rates and mass transport in the deeper Muddy Creek formation will be conducted as part of the FS assessment of the IWF effectiveness.

Evaluation of Vertical Head Differences – Previous investigations of the Middle WBZ at the Site and surrounding sites indicate, with a few exceptions, a vertically upward gradient between the Middle and Shallow Zones that generally increases with depth. Following installation of the recommended new Middle WBZ wells, the previous evaluations of vertical head differences will be updated with current data.

- **Trespassing Chemicals.** The Site is situated in between two other operating facilities that are part of the BMI Complex. The Site is bordered by TIMET on the east and the Olin property on the west. All three facilities released wastewater into the former Beta Ditch for transport to former ponds in the BMI Common Area (see Figure 2-3 for the location of the former Beta Ditch). During the past decades of operation, chemicals released to groundwater at the individual facilities have become commingled, particularly in the areas near the property boundaries, below the unlined Beta Ditch, and in downgradient plume areas.

  At the Olin property, Montrose is conducting an investigation of DNAPL that has been detected in several wells completed in the Middle WBZ. As shown on Figure 5-11, DNAPL has also been found in well MC-MW-18 located on the Site. The DNAPL has been tested, and it contains several VOCs (primarily benzene, dichlorobenzenes, and chloroform), pesticides, and herbicides. The most recent phase of Montrose's investigation is an assessment of DNAPL mobility for recovery purposes.

  The Trust provides access to Montrose and its consultants for their ongoing monitoring and investigations. To further assess the extent of impact by dissolved VOCs from this adjacent site, VOCs will be added to the Trust's groundwater sampling program as discussed in Section 5.4.2.1.

- **Downgradient Plume – Lateral Extent.** As a result of its high solubility, perchlorate is the primary Site-related chemical detected in groundwater downgradient of the Site. The Interim Drinking Water Health Advisory and federal PRG of 15 µg/L for perchlorate will be used as the basis to delineate the boundaries of the area-wide BMI Complex commingled groundwater plume. However, within the area of commingled groundwater, a different approach is needed to define the Study Area to be addressed in the RI/FS. Based on the existing data, a 1 mg/L perchlorate concentration is assumed for separation between the Trust plume and the AMPAC plume to the west.

As illustrated on Figure 5-7, the lateral extent of the Site downgradient perchlorate plume can be delineated by the 1 mg/L isoconcentration contour on its western side. As discussed in Section 3.2.4, perchlorate was also released to groundwater from the AMPAC facility located approximately 1.5 miles southwest of the Site. The downgradient AMPAC perchlorate plume is located west of the Site-related downgradient plume. The AMPAC extraction and re-injection systems and the northern portion of the AMPAC perchlorate plume are shown on Figure 5-7. However, the separation between the two plumes is based on reasonable extrapolation of 1 mg/L contours. In order to confirm this interpretation, additional sampling will be conducted along Galleria Road east of the AWF. As shown on Figure 5-12a, three existing wells (L637, L639, L641) are located along the road in this area. These wells will be evaluated for sampling. Assuming access can be obtained from the well owner, one additional new shallow well will be installed west of L645. If the three existing wells are not suitable for sampling, or if access cannot be obtained, 2-3 additional new shallow wells will be installed nearby. In addition, 2-3 new shallow monitoring wells will be installed along Sunset Road in the area between the Site-related downgradient plume and the AMPAC downgradient plume. The recommended well locations are shown on Figure 5-12a.

On the east side, commingling between the Trust plume and the BMI Common Areas plume is more extensive. The BMI Common Area pond complex, located to the east, appears to represent a separate and distinct source of perchlorate to shallow groundwater. As illustrated on Figure 5-13, perchlorate concentrations in wells located on the western portion of the BMI Common Areas property below former unlined ponds contain perchlorate at concentrations higher than 1 mg/L. The most recent data available in the BMI Complex database shows concentrations ranging from 3.6 to 9.6 mg/L in wells located east of Pabco Road. Based on this preliminary evaluation, separation between the Site downgradient plume and the BMI Common Area plume may need to be defined by a 5 or 10 mg/L contour. A more thorough evaluation of groundwater conditions and current data in wells along the east side of Pabco Road will be conducted during the RI. However, as previously discussed with NDEP, a geographic boundary (Pabco Road), will be used to delineate the eastern boundary of the Trust plume for purposes of the RI/FS.

- **Downgradient Plume – Vertical Extent.** The vertical extent of perchlorate in the Muddy Creek Formation beneath the AWF extraction wells has not been fully delineated. Existing wells PC-134A and PC-137 are screened in the UMCf. In May 2012, perchlorate concentrations were 32 mg/L in PC-134A and 0.27 mg/L in PC-137. Deeper monitoring wells will be installed adjacent to these two existing wells to define the vertical extent of perchlorate-impacted groundwater. The recommended well locations are shown on Figure 5-12a.

- **Downgradient Plume – Chloroform.** Eight shallow groundwater wells located between the Site and the Athens Road Well Field will be sampled for VOCs to assess current chloroform concentrations in shallow groundwater. The well locations (AA-11, BHE1-10, PC-24, PC-28, PC-64, PC-65, PC-66, PC-67) are shown on Figure 5-12b. Six of these wells have been sampled previously for chloroform. The most recent concentrations have ranged between 3.2 µg/L (PC-64) and 860 µg/L (PC-67) (see Plate 6). After the planned groundwater sampling is completed, the data will be reviewed along with previous available sampling results. If the current chloroform concentrations are above the chloroform RBCs for vapor intrusion established for the Sale Parcels, soil gas samples will be collected at two depths adjacent to the three wells with the highest concentrations. This information will be used to establish the relationship between groundwater and soil gas concentrations in this area of the downgradient plume and to develop a chloroform groundwater RBC for vapor intrusion.

- **Stream-Aquifer Interaction with Las Vegas Wash.** An initial evaluation of stream-aquifer interaction is being conducted as part of the 2013 GWETS Optimization Project (ENVIRON 2013c). Comparison of the water levels in Las Vegas Wash at the Pabco Road stream gage with the water levels in the groundwater monitoring wells at the SWF indicate that some amount of surface water from Las Vegas Wash is flowing into the extraction wells of the SWF. Additional wells between the SWF and Las Vegas Wash are proposed in order to better quantify the amount of surface water being extracted by the SWF and to better delineate the extent of the area in which the SWF is causing a reversal of groundwater flow. Near the proposed new wells are two existing wells owned by SNWA (WMW6.15S and WMW6.55S) that would be useful to include in the evaluation. Water levels are measured in these SNWA wells periodically; however, a surveyed measuring point is reportedly not available to determine absolute water table elevation. In order to allow comparisons of water table elevations among the wells near the Wash and the stream gage elevation, it is recommended that the existing SNWA wells and the Pabco Road stream gage be surveyed to a standard vertical datum. The proposed well locations are shown on Figure 5-12a.

The specific nature, extent and the DQOs for the elements of the additional groundwater investigation will be described in detail in the SAP.

5.4.2.1 Groundwater Analytical Program

As part of the ongoing groundwater monitoring program, groundwater samples from designated Site wells are analyzed for chlorate, chromium, hexavalent chromium, perchlorate, and TDS. It is proposed that for 2014, to address data gaps as part of the RI/FS, groundwater samples will be analyzed for the list of chemicals presented in Section 5.1.4.2 identified as a preliminary list of groundwater COPCs that exceed USEPA MCLs, NDEP BCLs, or other criteria. The SAP will detail the proposed subset of wells and analytes and sampling frequency.

In addition, to gain a better understanding of Site geochemistry and how redox conditions may control the mobility of hexavalent chromium in groundwater, groundwater samples will be analyzed for: dissolved oxygen, redox potential, TOC, pH, alkalinity, ferrous iron, ferric iron, chloride, nitrate, nitrite, pH, sulfide, sulfate, calcium, potassium, and sodium. The SAP will present the details of the analytical program to be included following NDEP approval of this Work Plan.

6.0 Remedial Investigation/Feasibility Study Tasks

The following sections describe key tasks within the RI/FS framework identified in USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988).

6.1 Task 1: Project Planning

The contents of this Work Plan and associated supporting documents – i.e., task-specific sampling and analysis plans, a health and safety plan, and the Community Involvement Plan (CIP) (ENVIRON 2013g) – describe planning activities for the project. Activities under this task include:

- Collecting and evaluating available information on the Site, including information on historical operations, historical characterization data and analyses, regulatory actions, and removal actions completed to date (Sections 2 through 4);
- Developing a CSM on the basis of available information (Section 5.1);
- Identifying data needs (data gaps are identified in Section 5.4, and DQOs will be developed in the SAP);
- Identifying ARARs (Section 5.2.1);
- Identifying preliminary RAOs (Section 5.2.2);
- Screening of preliminary remedial technologies and process options, and identifying potential remedial alternatives (Section 5.3);
- Treatability studies (identified in individual treatability study work plans; ENVIRON 2013e,f);
- Identifying projection organization and project management (Section 7.1); and
- Developing schedules for completion of major project elements (Section 7.2).

All of these elements are included in this Work Plan and associated supporting documents (e.g., the SAP). Many elements are summaries of more comprehensive documents or identify the document in which the element is provided. Each of the summaries provided in this Work Plan reflects the current status of the respective tasks, with some tasks at the preliminary planning stage and others completed or nearing completion.

6.2 Task 2: Community Relations

Task 2 incorporates all efforts related to the preparation and implementation of the CIP for the Site. A draft CIP was submitted to NDEP on April 30, 2012 and NDEP provided comments on the draft CIP on June 18, 2013. On behalf of the Trust, ENVIRON responded to NDEP's comments on October 4, 2013. A revised CIP was submitted to NDEP on December 27, 2013 (ENVIRON 2013g).

The CIP was developed in accordance with the NCP (40 CFR 300) to guide the facilitation of communication between the community surrounding the Site with NDEP and the Trust and to encourage community involvement in Site activities. The CIP provides a Site description; a community profile and history of community involvement; information on community relations and community concerns; communication needs and strategies; lists of contacts and interested parties; and a description of activities the Trust is undertaking to ensure full public participation at the Site, as listed below. As required by the NCP, the CIP identifies local information repositories, describes the maintenance of the administrative record, and summarizes the community interviews and community relations activities, which have provided opportunities for public involvement, review, and comment. As described in the CIP, the administrative record was established and is maintained at NDEP's Las Vegas office. A second location will be established at the James I. Gibson Library in Henderson, Nevada. NDEP will continue to be responsible for maintaining the two sets of the administrative record following approval of the revised CIP. A previous CIP (ENSR 2007b) was implemented for the Site by Tronox, and NDEP has maintained a public website with various Site-related documents and related information since 2006. For the draft 2012 CIP, the Trust drew from multiple sources, including community input (through stakeholder calls and meetings; community interview meetings and questionnaires; and open communications with interested parties, such as local residents, business owners, schools, local industries, and municipal programs) and through reviews of public information and Site files to develop the plan. The major community involvement activities associated with this plan are identified below:

- Designate the Community Involvement Coordinator (CIC), the primary liaison between the community, NDEP, and the Trust. The CIC was previously designated as Shannon Harbour in April 2012, and a new CIC was designated in the December 2013 CIP as James Dotchin of NDEP;
- Prepare and distribute fact sheets and technical summaries;
- Maintain a mailing list for the Site;
- Establish and maintain information repositories;
- Provide key resources for both general and specific information about the Site;
- Establish and maintain the Administrative Record;
- Hold public meetings or public availability sessions; and
- Revise the CIP as community input warrants or at least every three years until the Site is closed out.

To date, information related to Site activities has been provided to the public through NDEP's *Remediation of the BMI Complex* website available at http://ndep.nv.gov/bmi/tronox.htm, fact sheets and technical summaries, public meetings, and briefings. The Trust will continue to use these public mechanisms to inform the public regarding activities at the Site. In addition, the public has access to documentation related to the RI/FS process for the Site at the NDEP office in Las Vegas, Nevada. Once the CIP is approved by NDEP, a local information repository will be established at the James I. Gibson Library on Lake Mead Parkway in Henderson, Nevada.

6.3 Task 3: Groundwater Modeling

Task 3 includes the on-going development of the groundwater flow model, including the development of a transient model. As part of the 2013 GWETS Optimization Project, the initial steady-state groundwater model developed by Northgate is being updated to early 2012 conditions and revised to include additional information about aquifer properties and boundary conditions. This updated model will be used to make recommendations about how to optimize the existing GWETS. These initial recommendations will be based on the steady-state model.

Under Task 3, a transient groundwater model will be developed that builds upon the steady-state model. A transient model is needed in order to predict how changing groundwater conditions will affect the effectiveness of GWETS and to evaluate potential remedial alternatives considered in the FS. In addition, a contaminant transport model will be developed in order to estimate aquifer clean-up times for various remedial alternatives.

6.4 Task 4: Field Investigation

Task 4 involves field investigation activities to be undertaken during the RI phase to complete characterization activities (i.e., to address data gaps) at the Facility Area and ensure that adequate data is available to conduct the BHRA and support the development and evaluation of remedial alternatives.[35]

As presented in Section 5.4, the following data gaps are to be addressed during field investigation activities:

- Additional characterization of shallow and deep soils to determine whether these areas serve as potential sources of COPCs in groundwater;
- Additional characterization of Category 3 soils, as needed, to provide a sufficient data set for risk assessment;
- Characterization of the Debris Pile (Category 4 area);
- Investigation of soil and groundwater in the vicinity of the Unit buildings;
- Additional characterization of groundwater, to include (1) a background determination, (2) identification of groundwater COPCs, (3) further investigation of the Middle WBZ/Muddy Creek formation, (4) further investigation of trespassing chemicals from neighboring properties, (5) further investigation of the lateral and vertical extent of the downgradient plume, and (6) further investigation of concentrations of chloroform in the downgradient plume[36].
- An initial evaluation of stream-aquifer interaction in the vicinity of the SWF and Las Vegas Wash.
- Additional characterization of soil gas, as needed, to address possible data gaps. However, given that groundwater has been identified as a source of VOCs in soil gas, review and identification of data gaps in the existing soil gas dataset will be completed following investigation of trespassing VOCs in groundwater from neighboring properties.

[35] As noted previously in Section 2.2, Parcels C, D, F, G, and H are not being addressed in the RI. Environmental investigations for these parcels have been completed and risk assessments have been completed or are in progress.

[36] Depending on the results of testing groundwater for chloroform, soil gas sampling in the downgradient plume area may also be performed.

For risk assessment purposes, it is anticipated that indoor and outdoor air concentrations of airborne particulates and VOCs will be estimated based on modeling and not measured concentrations. Additional data gaps may be identified following further review and evaluation of existing data and data collected as part of the RI.

A detailed SAP will be developed to address the data gaps and submitted to NDEP as a separate deliverable, following submittal of this revised RI/FS Work Plan. The SAP will include field sampling plans, a QAPP, and a site-specific HASP. Information related to DQOs, methods for sample collection and analysis, methods for data evaluation and quality assurance, and other components will be included in the SAP. The QAPP will describe the quality assurance procedures, quality control specifications, and other technical activities that must be implemented to ensure that the results of the project or task performed during the RI/FS process will meet project specifications. The SAP will be submitted to NDEP on or before January 24, 2014. Upon NDEP and Trust approval of the SAP, subcontractors will be mobilized for field investigations. The following typical activities are anticipated to be conducted as part of Task 4:

- Mobilization of field activities;
- Exploratory trenching;
- Grab soil sampling;
- Soil boring installation and sampling;
- Well Installation, development and sampling;
- Laboratory analysis of soil and groundwater samples;
- Aquifer testing;
- Field measurements;
- Site surveys; and
- Task management and quality control.

All field investigations will be conducted in accordance with the SAP, QAPP, and HASP.

6.5 Task 5: Sample Analysis and Data Verification and Validation

Under Task 5, samples collected during the field investigations will be reviewed in accordance with the DQOs established for the specific field activity, as detailed in the SAP and QAPP to be prepared following submittal of this RI/FS Work Plan. Data validation will be conducted in accordance with NDEP's *Supplemental Guidance on Data Validation* (NDEP 2009d) and *Guidance on Validation for Asbestos Data in Soils for the BMI Plant Sites and Common Areas Projects* (NDEP 2012b). Electronic data deliverables (EDDs) will be prepared in accordance with the NDEP's *Guidance* on *Unified Chemical Electronic Data Deliverable Format* (NDEP 2013b) and submitted to NDEP for uploading to the NDEP Site-Wide Database. The SAP and QAPP will provide details regarding how sample analysis and data validation will be conducted for the data gap field investigation, including:

- COPCs, media, and associated analytical methods;

- Laboratories that will analyze samples and required detection limits;
- The entity who will perform data validation; and
- Procedure(s) for establishing data quality criteria.

6.6 Task 6: Data Evaluation

The data evaluation task includes the data usability evaluation, data analysis, and the data quality assessment. USEPA states in its *Data Usability Guidance* (USEPA 1992a) that "data usability is the process of assuring or determining that the quality of data generated meets the intended use," and that when risk assessment is the intended use, USEPA's guidance "provide[s] direction for planning and assessing analytical data collection activities for the HRA…" The analytical data set identified for the BHRA will be evaluated using the six USEPA data usability criteria, as modified by NDEP (2010c).

As described by 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." Consistent with guidance, summary statistics, simple data plots, and spatial plots of the data will be included in the BHRA. Finally, the data quality assessment is conducted following completion of the risk assessment to evaluate whether the data meet the desired DQOs.

The data usability evaluation, data analysis, and the data quality assessment will be completed consistent with the following guidance documents from USEPA:

- *Data Usability Guidance* (USEPA 1992a).
- *Guidance for Data Usability in Risk Assessment (Parts A and B)* (USEPA 1992a,b).

and NDEP:

- *Guidance on the Development of Summary Statistic Tables at the BMI Complex and Common Areas in Henderson, Nevada* (NDEP 2008e).
- *Significance Levels for The Gilbert Toolbox of Background Comparison Tests for the BMI Plant Sites and Common Areas Projects* (NDEP 2009f).
- *NDEP Supplemental Guidance for Assessing Data Usability for Environmental Investigations at the BMI Facility in Henderson, NV* (NDEP 2010c).

It is anticipated that the Facility Area will be divided into two or more subareas (exposure units) for evaluation in the BHRA. The proposed subareas will be identified in the BHRA Work Plan. In the BHRA, the data usability evaluation, data analysis, and the data quality assessment will be conducted for each subarea identified.

Other NDEP guidance, available on NDEP's Technical Topics website,[37] will be consulted, as appropriate to the intended use of the data, including NDEP's guidance for data processing (NDEP 2008c,d, 2012a) and evaluating radionuclide data (NDEP 2007b, 2008a, 2009b,c,e).

6.7 Task 7: Risk Assessment

Task 7 includes preparation of the BHRA work plan and BHRA. As part of Task 7, ENVIRON reviewed the NDEP-approved HRA work plan prepared by Northgate and dated March 9, 2010 (Northgate 2010d). ENVIRON will adopt the general risk assessment methodology, including exposure equations, toxicity values, and risk equations, outlined in the Northgate 2010 HRA work plan. However, some elements of the 2010 work plan lacked sufficient detail for implementation or do not account for the soil removal action completed in 2011. The ENVIRON BHRA work plan will update background information for the Facility Area, and describe the approach for dividing the Facility Area into exposure units. The BHRA work plan will also include preliminary summary statistics for the post-removal data set. Applicable elements from the 2010 HRA work plan will be incorporated by reference, and, for completeness, the 2010 HRA will be included as an attachment to the ENVIRON BHRA work plan. The BHRA work plan will be submitted to NDEP on or before February 21, 2014.

ENVIRON also reviewed the 2010 *Site-Wide Soil Gas Human Health Risk Assessment* (Northgate 2010r), which has been submitted to, but not reviewed by, NDEP. The soil gas HRA evaluated risks associated with soil gas in Parcels A, B, C, D, F, G, and H and in the Facility Area. The available soil gas data for the Facility Area included in the 2010 soil gas HRA will be reviewed in the context of our current understanding of groundwater VOC contamination. However, given that investigation of trespassing chemicals (primarily VOCs) from neighboring properties has been identified as a groundwater data gap (see Section 5.4.2 and Task 4, above), it is anticipated that identification of data gaps for the existing soil gas data within the Facility Area can be completed only following the collection of additional groundwater samples and the review of the soil gas sampling locations relative to an updated understanding of groundwater VOC contamination. Depending on the need to collect additional soil gas samples within the Facility Area, an updated soil gas evaluation will be submitted either as part of the soil BHRA or as a separate deliverable.

The BHRA will evaluate the potential for adverse human health effects associated with exposures to impacted environmental media under current and anticipated future land-use conditions. The BHRA will take into consideration all removal actions completed at the time the BHRA is prepared. The results of the BHRA will be used to support activities related to the screening of remedial alternatives and development of cleanup goals for impacted media. The elements of the BHRA report will include (1) data evaluation (as described under Task 6, above); (2) identification of Site-related COPCs (including chemical and radiological contaminants and asbestos); (3) exposure assessment, including fate and transport modeling; (4) toxicity assessment; and (5) risk characterization. Cumulative risks will be presented for COPCs and radionuclides, combined, and risks will be presented separately for asbestos. Uncertainties associated with the risk characterization will be discussed.

[37] http://ndep.nv.gov/bmi/technical.htm

As noted in the NDEP-approved 2010 work plan (Northgate 2010d), an ecological risk assessment will not be conducted for the Facility Area. However, following aquifer restoration, an ecological risk assessment will be conducted for impacted areas downgradient of the Facility Area (which includes Las Vegas Wash), consistent with NDEP comments (NDEP 2013c) on the 2012 RI/FS work plan (ENVIRON 2012f).

6.8 Task 8: Treatability Studies

Under Task 8, information needs are identified and studies conducted to support the further development of the preliminary remedial action alternatives for evaluation during the RI/FS process. Treatability studies can provide data important to an adequate evaluation of certain technologies for a given response action – including information on performance, operating parameters, and cost – in sufficient detail to support the remedy selection process and subsequent design activities. This task can involve efforts for bench-scale or pilot-scale tests, including associated procurement activities. Treatability studies can be identified at different times during the RI/FS (e.g., from the scoping stage through the screening of preliminary alternatives).

Work plans for the following proposed treatability studies were submitted to NDEP on December 27, 2013 and are currently under NDEP review. These work plans may be modified in response to NDEP's review:

- PRB Treatability Study Work Plan (ENVIRON 2013e); and
- In-Situ Soil Flushing Treatability Study Work Plan (ENVIRON 2013f).

Additional treatability studies may be identified as further information is developed during the RI.

6.9 Task 9: Remedial Investigation Report

Task 9 includes all activities undertaken to prepare and complete the RI report for the Site. This report will include the following:

- A comprehensive description of the area that comprises the Site;
- A brief Site history and discussion of the origin of contamination to provide rationale for the characterization activities completed;
- Summaries of field investigations and relevant Site characterization data, including historical data used to support the CSM and evaluation of remedial alternatives;
- A synthesis of previous groundwater investigations that will also incorporate the results of additional work conducted for the RI. As has been discussed previously, the Shallow WBZ has been well characterized, particularly with respect to the distribution of chromium, TDS, and perchlorate. However, additional evaluation of the lateral extent of the downgradient perchlorate plume will be conducted during the RI. The RI report will also present an evaluation of the presence and extent of other Site-related COPCs identified for groundwater. The RI report will include an evaluation of the nature and extent of COPC impacts to groundwater in the Middle WBZ, both from Site-related COPCs and trespassing chemicals. Existing and new information on aquifer properties

will be compiled that will include estimates of groundwater gradient, flow velocities, and an evaluation of vertical head differences at well cluster locations;

- An updated CSM for the Site, revised to incorporate additional information obtained through the RI process; and
- A summary of the BHRA performed for the Site. A separate report will be prepared to present the analysis and results of the BHRA based on the updated CSM.

6.10 Task 10: Remedial Alternatives Development

Task 10 involves the initial development and preliminary screening of remedial alternatives; the preliminary alternatives are then fully evaluated under Task 11. The objective of the screening process is to narrow the number of alternatives that undergo detailed evaluation. The screening process begins with identification of RAOs, then proceeds through narrowing of the potential technologies on the basis of applicability, effectiveness, implementability, and cost. From this list of retained technologies and process options a list of RAAs is developed for further evaluation. Each RAA may involve application of a single technology or a combination of two or more technologies. Task 10 consists of the following activities:

- Identifying RAOs and ARARs (Section 5.2);
- Listing potential remedial technologies (Section 5.3);
- Screening remedial technologies and process options based on Site-specific criteria (initial screening performed in Section 5.3);
- Assembling potential RAAs from the screened technologies and process options (preliminary conceptual RAAs are provided in Section 5.3.4); and
- Evaluating potential RAAs on the basis of screening criteria (i.e., effectiveness, implementability, and cost).

Identifying candidate remedial action alternatives for detailed evaluation is described under Task 11.

6.11 Task 11: Detailed Analysis of Alternatives

Under Task 11, the candidate RAAs that passed the screening process in Task 10 will be evaluated in detail. The following criteria, identified in USEPA guidance (USEPA 1988), will be used for evaluating the alternatives:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume;
- Short-term effectiveness;
- Implementability;
- Cost;

- Acceptance by the state; and
- Acceptance by the community.

A summary of each alternative, including the no-action alternative, will be prepared on the basis of these nine criteria, consistent with the NCP. The first two criteria (i.e. overall protection of human health and the environment and compliance with ARARs) are categorized as threshold criteria that every alternative must meet in order to be considered for implementation. The next five criteria (i.e. long-term effectiveness and permanence; reduction of toxicity, mobility and volume; short-term effectiveness; implementability; and cost) are so-called balancing criteria used during the analysis process. The final two criteria (acceptance by the state and community) are evaluated during the final decision-making process and after the RI/FS report is complete.

As described in USEPA guidance (1988), long-term effectiveness will be evaluated to ensure the magnitude of residual risks are understood for each RAA. For some COPCs this may include estimates of contaminant volume or concentrations that are anticipated to remain at the Site following implementation. The reliability and/or expected life cycle of each RAA will also be incorporated into evaluations of long-term effectiveness. Understanding the long-term effectiveness of a particular RAA is critical to meeting the Site's long-term RAOs.

Short-term effectiveness is described in USEPA guidance (1988) as the impact of each RAA during the initial construction and/or implementation phase and lasts until cleanup criteria are achieved. RAAs will therefore be evaluated for potential risks to the local community, on-site workers, and the environment during the implementation period. Measures used to mitigate potential short-term impacts will be evaluated for their reliability and effectiveness. This section will also evaluate the anticipated time for each RAA to achieve the Site's RAOs.

According to USEPA guidance (1988), there is a statutory preference for the selection of RAAs that result in a significant reduction in the toxicity, mobility, and volume of hazardous substances in the environment (USEPA 1988). Alternatives should therefore be evaluated based on factors such as the quantity of COPCs treated and the irreversibility of treatment techniques. Alternatives that satisfy this statutory preference will be favored over those that do not include treatment as a primary element. In the case of on-site contamination, RAAs will be evaluated based on their ability to eliminate COPCs from the Site. As an example, source depletion of perchlorate would have the effect of reducing the volume of hazardous materials, the benefits of which would be compared with containment alternatives.

Understanding the implementability of each RAA involves an evaluation of the technical and administrative feasibility of each alternative. An evaluation of technical feasibility will examine the reliability of existing technologies and unknowns of emerging technologies, the impacts of any interim actions on possible future Site activities, and any monitoring associated with a particular RAA. An evaluation of administrative feasibility will consider coordination with various agencies, the availability of services (e.g., disposal services, treatment facilities), or additional resources such as specialized knowledge or equipment. When evaluating on-site groundwater control options, various RAAs will be ranked based on the anticipated administrative effort and technical knowledge. For example, the potential benefits of a technology that requires a pilot study prior to implementation will need to be balanced with the need to meet short-term RAOs.

The comparative analysis of RAAs will include development of both direct and indirect capital costs, as well as annual/periodic O&M costs. The comparative analysis of alternatives will include a present-value analysis of capital and O&M costs consistent with USEPA guidance (USEPA 1988). Life cycle costs will also be considered in evaluation of the RAAs. Optimization/enhancement of the groundwater extraction and treatment system, which is a short term RAO for the Site, will be evaluated using a cost comparison framework specifically designed for optimizing the operation of pump and treat systems. The revised groundwater model will be used as appropriate to quantitatively evaluate the effectiveness of the alternatives.

6.12 Task 12: Feasibility Study Report

Task 12 involves the coordination and preparation of the FS report. The report will contain descriptions of the activities, results, and associated conclusions of the entire RI/FS process. The report will include a description of the screening process and a detailed evaluation of RAAs (from Tasks 10 and 11). A RAA will be recommended for implementation.

7.0 Project Schedule and Project Management

The following sections present the schedule for the RI/FS project tasks and outline the project organization and responsibilities.

7.1 Project Organization and Responsibilities

Mr. Weiquan Dong, PE is the NDEP Project Manager for the Site and handles all Site-related correspondence. Mr. James Dotchin has responsibility for overall supervision of all projects in the NDEP Bureau of Corrective Actions Special Projects Branch. All Site characterization activities and remedial actions carried out by the Trust for the Site are subject to NDEP oversight under the Settlement Agreement, effective February 14, 2011.

The responsibilities of the two major organizations under contract to the Trust are as follows:

- ENVIRON
  - Provide overall project management support for the Trust's remediation of the Site. This support includes implementation and documentation of activities related to health and safety requirements, cost control procedures, sample and data management, and project schedule tracking.
  - Administer procurement and quality assurance functions.
  - Perform general administrative functions.
  - Assist with maintaining compliance with environmental permits and regulations.
  - Direct all engineering activities.
  - Provide technical input to the preparation of environmental documents.
  - Perform community relations duties.
- Envirogen[38]
  - Operate the groundwater treatment facilities as described in Section 4.3.2.1.

The ENVIRON project manager and task leaders working on this project include:

- Project Manager, **Allan J. DeLorme, PE** – The Project Manager is responsible for the overall technical and policy decisions involving the project, including interaction and coordination with ENVIRON project staff, the GWETS operator, the Trust, and NDEP.
- Task Leader, **John M. Pekala, PG, CEM** – This Task Leader is responsible for the overall development and implementation of ENVIRON's remediation strategy as approved by NDEP.
- Task Leader, **Jessica E. Donovan, PG** – This Task Leader is responsible for the overall execution of the approved Work Plan. She will work with the Project Manager and

[38] The operation of the groundwater treatment facilities was transitioned from Veolia to Envirogen on July 24, 2013, following an approximately 5 month transition period from February 15 to July 24, 2013.

Quality Assurance (QA) Officer to ensure that work is conducted in compliance with project-specific objectives and applicable QA procedures.

- Task Leader, **Lynne Haroun, MPH** – This Task Leader is responsible for executing the health risk assessment components of the approved Work Plan. She will work with the Project Manager and QA Officer to ensure that work is conducted in compliance with project-specific objectives and applicable QA procedures.
- Project (QA) Officer, **John M. Pekala, PG, CEM –** The QA Officer is responsible for reviewing the project QA program as it relates to the collection and completeness of data from field and laboratory programs.
- Data Manager, **Craig J. Knox** – The data manager is responsible for management of the applicable databases, including updating and maintaining the databases as needed.

7.2 Project Schedule

The overall schedule for the RI/FS process at the Site is shown on Figure 7-1. The schedule identifies the primary RI/FS tasks, beginning with the submittal of this Work Plan and continuing through preparation and NDEP approval of the Site RI and FS reports. The projected durations of each task are provided, as well as the relationships between the various tasks.

The following major elements of the RI/FS process are identified in the schedule:

- NDEP review and approval of this RI/FS Work Plan, as well as two previously submitted treatability study work plans (ENVIRON 2013e,f) and the CIP (ENVIRON 2013g), which would complete the initial scoping and planning phase of the RI/FS process (January – May 2014).
- Preparation of a SAP to address data gaps, to include the HASP and QAPP (January 2014).
- Preparation of a BHRA work plan (January – February 2014).
- NDEP review and approval of the SAP, QAPP, and HASP (February – May 2014)
- NDEP review and approval of the BHRA work plan (March – May 2014).
- Implementation of additional field investigation activities to address the data gaps and the fieldwork outlined in the SAP (June – November 2014).
- Preparation of the BHRA (January – July 2015).
- Implementation of the soil flushing treatability study (September 2014 – June 2015).
- Preparation and submittal of the soil flushing treatability study report (June – August 2015).
- Implementation of the PRB treatability study (January – December 2015).
- Preparation and submittal of the PRB treatability study report (December 2015 – February 2016).
- Preparation of the RI and BHRA reports (February – July 2015).

- FS Analysis and Preparation of the FS report (April – October 2016).
- NDEP review and approval of the treatability study, RI, and FS reports (within 4 months following completion of each report; anticipated completion in late 2016 / early 2017).

All listed documents include document submittal to NDEP for review, document revisions to address NDEP comments, and final NDEP approval. Figure 7-1 provides the anticipated RI/FS schedule based on currently available information and is subject to revision based on NDEP comments on work plans, contractor availability, and other factors.

This RI/FS Work Plan has been prepared in accordance with CERCLA, as amended, and the Interim Consent Agreement between NDEP and the Trust to investigate the nature and extent of contamination at the Site and downgradient plume and to develop remedial action alternatives, as appropriate. This Work Plan follows USEPA (1988) *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* as well as other relevant USEPA and NDEP guidance. Subsequent work plans (including the BHRA Work Plan, SAP, QAPP, and HASP) and deliverables (including the treatability study reports, RI report, and FS report) will be prepared at the direction of NDEP and the Trust.

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Tables

Table 2-1. SUMMARY OF NEIGHBORING PROPERTIES
Nevada Environmental Response Trust Site; Henderson, Nevada

PROPERTY	LOCATION
American Pacific Corporation (AMPAC) formerly Pacific Engineering and Production Company of Nevada (PEPCON)	This property is located 1.5 miles southwest of the Site.
Black Mountain Industrial (BMI) Common Areas includes the following Eastside Sub-Areas: Hook-Open Space, Southern RIBs, Galleria North School Site, Galleria Alignment, Sunset North Commercial, Phase I Development, City of Henderson Water Reclamation Facility, Eastside Main, Mohawk, Parcels 4A and 4B, ditches, and various flood conveyance channels. The ditches in this area include: the Western Ditch and the Northwest Ditch in the Hook-Open Space, and the Alpha Ditch and the Beta Ditch througout the area. The following CAMU Sub-Areas include: Eastern W. Ditch, Northern Landfill Lobe, Northern Lobe of the Borrow Area, Slit Trench Area, Southern Landfill Lobe, Southern Lobe of the Borrow Area, and Western W. Ditch. The Northern Landfill Lobe and the Southern Landfill Lobe combined are referred to as the historical BMI Dump. The ditches and conveyances in this area include: the Beta Ditch Extension, the Western Ditch, and the Western Ditch Extension.	The Eastside Sub-Areas are located east of the Site across the Boulder Highway. The CAMU Sub-Areas are located adjacent to the west of the Site and north of the Olin property. The flood conveyance channels are located around the perimeters of the Eastside Sub-Areas, and the ditches are located throughout the Eastside and CAMU Sub-Areas.
Lhoist North America (Lhoist) formerly Chemstar Lime Company of Nevada and Chemstar, Inc.	This property is located in the center of the Site north of Unit Buildings 3 and 4.
Olin Chlor-Alkali Products (Olin) formerly Pioneer Americas LLC which was referred to as Pioneer Americas/Olin Chlor Alkali/Stauffer Management Company/Syngenta Crop Protection, Inc./Montrose Chemical Corporation of California (POSSM and OSSM). The Beta Ditch Extension extends into this property from the Site.	This property is located adjacent to the west of the Site and south of the BMI CAMU Sub-Areas.
Titanium Metals Corporation (TIMET) includes the BMI Beta/Northwest Ditch.	This property is located adjacent to the east of the Site. There is a small portion of the property that is located to the west of the Site, north of Parcel F.
Western Area Power Administration (WAPA)	This property is located south of Unit Buildings 1 through 6, east of Parcel G, and north of Parcel H.

Notes:

CAMU = Corrective Action Management Unit

RIB = Rapid Infiltration Basin

Site = Nevada Environmental Response Trust Site

Table 2-2. SUMMARY OF ON-SITE TENANTS
Nevada Environmental Response Trust Site; Henderson, Nevada

<table>
<tr><th>PROPERTY</th><th>LOCATION</th></tr>
<tr><td>Tronox LLC (Tronox)
operates processes to produce manganese dioxide, boron trichloride, elemental boron, and batteries on 114 acres of the Site.</td><td>This property is located primarily on the eastern portion of the Site. The lease area also extends across the central portion of the Site, around the unit buildings, and south of Parcel G on the western portion of the Site.</td></tr>
<tr><td>Envirogen Technologies, Inc (Envirogen)
operates the groundwater treatment facilities on the northwestern portion of the Site.</td><td>This property is located in a trailer south of the groundwater barrier wall near the hexavalent chromium and perchlorate treatment facilities.</td></tr>
<tr><td>Industrial Supply
provides tools and supplies for manufacturing, construction, and utilities.</td><td rowspan="2">These properties are located in a warehouse north of the western portion of Parcel H.</td></tr>
<tr><td>Angelo & Newton
provides technical and managerial consulting services, specializing in chemical process plant safety compliance, regulatory compliance, and battery and energy systems.</td></tr>
<tr><td>Pronto Constructors
provides construction services.</td><td>This property is located south of unit building 1 and southeast of Parcel G.</td></tr>
</table>

Notes:

Site = Nevada Environmental Response Trust Site

TABLE 4-1. SUMMARY OF GWETS PIPELINES
Nevada Environmental Response Trust Site; Henderson, Nevada

FLOW	LOCATION	PIPELINE SECTION	DIAMETER (in)	ESTIMATED LENGTH (ft)
Influent	Lift Station 1 to Lift Station 2	Continuous section	10	8200
	Lift Station 3 to Lift Station 2	LS3 to Pabco Rd	10	630
		Pabco Rd to LS2	8	1730
	Lift Station 2 to GWETS	LS2 to south end of Pabco Rd	12	6780
		South end of Pabco Rd to GW-11 pond	12	3680
	IWF East Feed	Single pipe conveying flows from the following wells: I-D, I-M, I-E, I-N, I-X, I-F, I-Q, I-G, I-T, I-U, I-H, I-P, I-W, I-O, I-V, I-I, I-Z, I-J, I-K, I-AC, and I-AD	6	1320
	IWF West Feed	Single pipe conveying flows from the following wells: I-AA, I-AB, I-AR, I-B, I-R, I-Y, I-L, I-S, and I-C	4	450
	AWF Well Lines to Lift Station 3	Single pipe to each pumping well	4	various lengths
	SWF Well Lines to Lift Station 1	Single pipe to each pumping well	4	various lengths
Effluent	FBR to Effluent Discharge Point at Las Vegas Wash	FBR to GW-11 pond	8	700
		GW-11 Pond to South End of Pabco Road	12	3680
		South End of Pabco Road to LS2	10	6780
		LS2 to LS1	10	8200
		LS1 to Discharge Point	12	710

Notes:

The information presented in this table is summarized from communications with current and former GWETS Operators as well as from available design drawings—not all of which were Drawings of Record, or so-called “as-builts”. The information in this table has not been field-verified. Additional information will be reviewed (and field verified when deemed appropriate) as part of the implementation of this work plan to confirm and add to the information presented.

AWF = Athens Road Well Field

IWF = Interceptor Well Field

SWF = Seep Well Field

FBR = fluidized-bed reactor

ft = feet

GWETS = Groundwater Extraction and Treatment System

in = inches

LS1 = Lift Station #1

LS2 = Lift Station #2

LS3 = Lift Station #3

TABLE 4-2. SUMMARY OF PUMP CAPACITY
Nevada Environmental Response Trust Site; Henderson, Nevada

PUMP LOCATION		NUMBER OF PUMPS	POWER (hp)	FLOW RATE
Extraction Wells				
SWF Pumping Wells [a]	PC-115R	1	5	91.5 gpm
	PC-116R	1	7.5	124.8 gpm
	PC-117	1	5	92.6 gpm
	PC118	1	5	76.3 gpm
	PC-119	1	5	65.0 gpm
	PC-120	1	5	0.0 gpm
	PC-121	1	5	0.0 gpm
	PC-133	1	1.5	2.2 gpm
	PC-99R2	1	20	58.0 gpm*
	PC-99R3	1	5	
AWF Pumping Wells [b]	ART-1	1	2	33 gpm
	ART-2	1	3	71 gpm
	ART-3A	1	1.5	54 gpm
	ART-4A	1	1.5	10 gpm
	ART-7	1	0.75	32 gpm
	ART-8	1	5	85 gpm
	ART-9	1	0.75	47 gpm
IWF Pumping Wells [b]	I-AR	1	0.5	1 gpm
	I-B	1	0.5	1.5 gpm
	I-C	1	0.5	6 gpm
	I-D	1	0.5	2 gpm
	I-E	1	0.5	1.5 gpm
	I-F	1	0.5	5.7 gpm
	I-G	1	0.5	0.5 gpm
	I-H	1	0.5	1.2 gpm
	I-I	1	0.5	5 gpm
	I-J	1	0.5	8 gpm
	I-K	1	0.5	4 gpm
	I-L	1	0.5	2.5 gpm
	I-M	1	0.5	2.6 gpm
	I-N	1	0.5	3.5 gpm
	I-O	1	0.5	2.5 gpm
	I-P	1	0.5	3 gpm
	I-Q	1	0.5	2.5 gpm
	I-R	1	0.5	2.5 gpm
	I-S	1	0.5	5 gpm
	I-T	1	0.5	0.4 gpm
	I-U	1	0.5	0.8 gpm
	I-V	1	0.5	4.8 gpm
	I-Z	1	0.5	8 gpm
Water Conveyance				
Lift station #1 vertical turbine pumps		2	50	625 gpm
Lift station	Vertical turbine	1	100	approx. 925 gpm
	Submersible pump	1	100	900 gpm
Lift station #3 submersible pumps		2	10	350 gpm

TABLE 4-2. SUMMARY OF PUMP CAPACITY
Nevada Environmental Response Trust Site; Henderson, Nevada

PUMP LOCATION	NUMBER OF PUMPS	POWER (hp)	FLOW RATE
Treatment System Pumps			
Raw Water feed pump P-102a/b	1	100	1000 gpm
Pond transfer pump P-104	2	5	75 gpm
Chrome plant effluent to FBR feed pumps P-103a/b	1	2	100 gpm
FBR fluidization pumps	14	30	2000 gpm
FBR media return pumps	5	1	30 gpm
DAF pressurization pumps	2	25	206 gpm
DAF float pumps	2	2	20 gpm
Effluent pumps p-601/602	1	30	1000 gpm
Sand filter reject pumps	2	5	150 gpm
Effluent booster pumps	2	100	1000 gpm
Sludge transfer pump	1	10	213 gpm
Sludge filter press pumps, air operated	2	--	150 gpm
Sludge filtrate pump	1	1.5	20 gpm
Chrome plant Feed pumps	2	5	100 gpm
Chrome plant pumps to and from the BT tanks (no longer in use)	--	6	50 gpm
Chemical pump lift station #3 ferrous injection	1	0.05	--
Chemical pump ethanol, front stage	5	--	20 gph
Chemical pump ethanol, back stage	4	--	8 gph
Chemical pump caustic	9	0.1	0.12-7.6 gph
Chemical pump urea	5	--	1.67 gph
Chemical pump Phosphoric Acid	9	--	0.08-0.54 gph
Chemical pump micronutrient blend, output varies with tube size	2	--	75 ml/min
Chemical pump Hydrogen peroxide, output varies with tube size	2	--	20 ml/min
Chemical pump Ferric chloride, output varies with tube size	2	--	10 ml/min
Chemical pump ferric chloride pump for the conditioning tank	1	--	40 gpm

Notes:

well as from available design drawings—not all of which were Drawings of Record, or so-called “as-builts”. The information

[a] Average flow rates are provided for the SWF wells.

[b] Maximum sustainable flow rates are provided for the AWF and IWF wells.

* Wells PC-99R2 and PC-99R3 are connected and operate as a single pumping well.

-- = no information available

AWF = Athens Road Well Field

IWF = Interceptor Well Field

SWF = Seep Well Field

BT = Balance Tanks

DAF = dilution attenuation factor

FBR = fluidized-bed reactor

gpm = gallons per minute

gph = gallons per hour

GWETS = Groundwater Extraction and Treatment System

hp = horsepower

ml/min = milliliters per minute

NDEP = Nevada Division of Environmental Protection

TABLE 4-3. SUBSURFACE PERCHLORATE MASS ESTIMATES
Nevada Environmental Response Trust Site; Henderson, Nevada

	ON-SITE		OFF-SITE TO AWF		AWF TO WASH		ENTIRE AREA
	ALLUVIUM	UMCF	ALLUVIUM	UMCF	ALLUVIUM	UMCF	
Kriging							
2002	16	3,339	617	1,455	86	0	5,514
2006	11	2,106	488	1,110	10	0	3,724
2012	9	1,564	348	741	12	0	2,674
Spline							
2002	15	3,986	864	1,924	105	0	6,893
2006	11	2,246	605	1,321	15	0	4,199
2012	10	1,774	418	846	14	0	3,061
Contour							
2002	22	3,905	865	1,789	162	0	6,743
2006	11	2,181	523	1,111	17	0	3,843
2012	16	2,296	453	947	16	0	3,728

Notes:
Mass values are presented in metric tons.
AWF = Athens Road Well Field
UMCF = Upper Muddy Creek Formation

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
Interceptor wells: Located across the highest concentrations of the plume; comprise the on-site groundwater extraction network, the "IWF"							
I-AA	On-site	Extraction	46	23.7 - 43.7	W	P, T, Cr, pH	P, T, Cr, pH
I-AB	On-site	Extraction	51	25 - 45	W	P, T, Cr, pH	P, T, Cr, pH
I-AC	On-site	Extraction	50	24.5 - 44.5	W	P, T, Cr, pH	P, T, Cr, pH
I-AD	On-site	Extraction	50	24.5 - 44.5	W	P, T, Cr, pH	P, T, Cr, pH
I-AR	On-site	Extraction	45	25 - 45	W	P, T, Cr, pH	P, T, Cr, pH
I-B	On-site	Extraction	43	17.8 - 42.5	W	P, T, Cr, pH	P, T, Cr, pH
I-C	On-site	Extraction	43	13.2 - 42.5	W	P, T, Cr, pH	P, T, Cr, pH
I-D	On-site	Extraction	45	16 - 44.5	W	P, T, Cr, pH	P, T, Cr, pH
I-E	On-site	Extraction	44	21.5 - 43.5	W	P, T, Cr, pH	P, T, Cr, pH
I-F	On-site	Extraction	43.8	11.8 - 43.3	W	P, T, Cr, pH	P, T, Cr, pH
I-G	On-site	Extraction	39.3	9.5 - 38.8	W	P, T, Cr, pH	P, T, Cr, pH
I-H	On-site	Extraction	43.6	13.6 - 43.1	W	P, T, Cr, pH	P, T, Cr, pH
I-I	On-site	Extraction	41	11.3 - 40.5	W	P, T, Cr, pH	P, T, Cr, pH
I-J	On-site	Extraction	41	11.2 - 40.5	W	P, T, Cr, pH	P, T, Cr, pH
I-K	On-site	Extraction	35.8	7 - 35.2	W	P, T, Cr, pH	P, T, Cr, pH
I-L	On-site	Extraction	40	9 - 39	W	P, T, Cr, pH	P, T, Cr, pH
I-M	On-site	Extraction	40	9 - 39	W	P, T, Cr, pH	P, T, Cr, pH
I-N	On-site	Extraction	38	7 - 37	W	P, T, Cr, pH	P, T, Cr, pH
I-O	On-site	Extraction	40	9 - 39	W	P, T, Cr, pH	P, T, Cr, pH
I-P	On-site	Extraction	44.5	14 - 44	W	P, T, Cr, pH	P, T, Cr, pH
I-Q	On-site	Extraction	40	9.6 - 39.6	W	P, T, Cr, pH	P, T, Cr, pH
I-R	On-site	Extraction	43	9.8 - 39.8	W	P, T, Cr, pH	P, T, Cr, pH
I-S	On-site	Extraction	45.2	12 - 42	W	P, T, Cr, pH	P, T, Cr, pH
I-T	On-site	Extraction	45.2	12 - 42	W	P, T, Cr, pH	P, T, Cr, pH
I-U	On-site	Extraction	45	12 - 42	W	P, T, Cr, pH	P, T, Cr, pH
I-V	On-site	Extraction	45	12 - 42	W	P, T, Cr, pH	P, T, Cr, pH
I-W	On-site	Extraction	50.5	20 - 50	W	P, T, Cr, pH	P, T, Cr, pH
I-X	On-site	Extraction	50.5	20 - 50	W	P, T, Cr, pH	P, T, Cr, pH
I-Y	On-site	Extraction	50.5	20 - 50	W	P, T, Cr, pH	P, T, Cr, pH
I-Z	On-site	Extraction	35	15 - 35	W	P, T, Cr, pH	P, T, Cr, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
M-series wells: On-site groundwater monitoring wells; for groundwater characterization/investigation and IWF performance monitoring							
M-10	On-site	Monitoring	67	43 - 63	W	P, T, Cr, pH, Cr6, *	P, T, Cr, pH, Cr6, Ch, N, *
M-100	On-site	Monitoring	30.5	19 - 29	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6
M-101	On-site	Monitoring	29	17 - 27	W	P, T, Cr, pH	P, T, Cr, pH
M-103	On-site	Monitoring	90	19.4 - 39.4			P, T, Cr, pH
M-11	On-site	Monitoring	58	33.3 - 53	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6, Ch, N
M-115	On-site	Monitoring	45.2	35 - 45	W	W	P, T, Cr, pH
M-117	On-site	Monitoring	155	130 - 150			P, T, Cr, pH
M-118	On-site	Monitoring	163	138 - 158			P, T, Cr, pH
M-120	On-site	Monitoring	105	80 - 100			P, T, Cr, pH
M-121	On-site	Monitoring	102	77 - 97			P, T, Cr, pH
M-123	On-site	Monitoring	51.3	36 - 51			P, T, Cr, pH
M-124	On-site	Monitoring	49.3	34 - 49			P, T, Cr, pH
M-125	On-site	Monitoring	50.3	35 - 50			P, T, Cr, pH
M-126	On-site	Monitoring	40	19.7 - 39.7			P, T, Cr, pH
M-128	On-site	Monitoring	55.3	35 - 50			P, T, Cr, pH
M-129	On-site	Monitoring	40	40 - 55			P, T, Cr, pH
M-12A	On-site	Monitoring	50	20 - 40		P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6, Ch, N
M-13	On-site	Monitoring	52.5	28 - 48			P, T, Cr, pH, Ch, N
M-130	On-site	Monitoring	40	20 - 40			P, T, Cr, pH
M-131	On-site	Monitoring	39	28.7 - 38.7		P, T, Cr, pH	P, T, Cr, pH
M-132	On-site	Monitoring	90	79.7 - 89.7			P, T, Cr, pH
M-133	On-site	Monitoring	70	59.7 - 69.7			P, T, Cr, pH
M-134	On-site	Monitoring	70	59.7 - 69.7			P, T, Cr, pH
M-135	On-site	Monitoring	39	28.7 - 38.7		P, T, Cr, pH	P, T, Cr, pH
M-136	On-site	Monitoring	90	79.7 - 89.7			P, T, Cr, pH
M-137	Off-site	Monitoring	75	52 - 72			P, T, Cr, pH
M-138	On-site	Monitoring	65	50.5 - 65.5			P, T, Cr, pH
M-139	On-site	Monitoring	60	45 - 60			P, T, Cr, pH
M-140	On-site	Monitoring	43	22.7 - 42.7			P, T, Cr, pH
M-141	On-site	Monitoring	40	37.5 - 47.5			P, T, Cr, pH
M-142	On-site	Monitoring	45.3	30 - 45.3			P, T, Cr, pH
M-144	On-site	Monitoring	45	35 - 45			P, T, Cr, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
M-145	On-site	Monitoring	60	45 - 60			P, T, Cr, pH
M-146	On-site	Monitoring	50	40 - 50			P, T, Cr, pH
M-147	On-site	Monitoring	40	25 - 40			P, T, Cr, pH
M-148A	On-site	Monitoring	50	35 - 50			P, T, Cr, pH
M-149	On-site	Monitoring	120	100 - 120			P, T, Cr, pH
M-14A	On-site	Monitoring	40.2	20 - 40	W	P, T, Cr, pH	P, T, Cr, pH
M-150	On-site	Monitoring	145	125 - 145			P, T, Cr, pH
M-151	On-site	Monitoring	145	125 - 145			P, T, Cr, pH
M-152	Off-site	Monitoring	145	125 - 145			P, T, Cr, pH
M-153	On-site	Monitoring	170	150 - 170			P, T, Cr, pH
M-154	On-site	Monitoring	195	175 - 195			P, T, Cr, pH
M-155	On-site	Monitoring	220	200 - 220			P, T, Cr, pH
M-156	Off-site	Monitoring	195	175 - 195			P, T, Cr, pH
M-161	On-site	Monitoring	110	99.7 - 110			P, T, Cr, pH
M-162	On-site	Monitoring	110	99.7 - 110			P, T, Cr, pH
M-163	On-site	Monitoring	90	79.7 - 89.7			P, T, Cr, pH
M-164	On-site	Monitoring	70	59.7 - 69.7			P, T, Cr, pH
M-165	On-site	Monitoring	120	110 - 120			P, T, Cr, pH
M-166	On-site	Monitoring	32	21.7 - 31.7		W	W
M-167	On-site	Monitoring	30	19.7 - 29.7		W	W
M-168	On-site	Monitoring	32	21.7 - 31.7		W	W
M-169	On-site	Monitoring	35	24.7 - 34.7		W	W
M-170	On-site	Monitoring	35	24.7 - 34.7		W	W
M-172	On-site	Monitoring	37	26.7 - 36.7		W	W
M-173	On-site	Monitoring	40	24.7 - 39.7		W	W
M-174	On-site	Monitoring	28	17.7 - 27.7		W	W
M-175	On-site	Monitoring	29	18.7 - 28.7		W	W
M-176	On-site	Monitoring	30	19.7 - 29.7		W	W
M-177	On-site	Monitoring	30	19.7 - 29.7		W	W
M-181	On-site	Monitoring	115	105 - 115			P, T, Cr, pH
M-182	On-site	Monitoring	90	79.7 - 89.7			P, T, Cr, pH
M-186	On-site	Monitoring	115	105 - 115			P, T, Cr, pH
M-19	On-site	Monitoring	40	14.5 - 34.5	W	P, T, Cr, pH	P, T, Cr, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
M-21	On-site	Monitoring	43	18 - 38			P, T, Cr, pH
M-22A	On-site	Monitoring	36.4	16 - 36	W	P, T, Cr, pH	P, T, Cr, pH
M-23	On-site	Monitoring	43	9.4 - 37.4	W	P, T, Cr, pH	P, T, Cr, pH, Ch, N
M-25	On-site	Monitoring	39	24 - 39	W	P, T, Cr, pH	P, T, Cr, pH, Ch, N
M-29	On-site	Monitoring	42	22 - 42			P, T, Cr, pH, Ch, N
M-2A	On-site	Monitoring	45	30 - 40			P, T, Cr, pH
M-31A	On-site	Monitoring	55	35 - 55	W	P, T, Cr, pH	P, T, Cr, pH
M-32	On-site	Monitoring	45	30 - 45			P, T, Cr, pH
M-33	On-site	Monitoring	45	30 - 45			P, T, Cr, pH
M-35	On-site	Monitoring	40	25 - 40	W	P, T, Cr, pH	P, T, Cr, pH
M-36	On-site	Monitoring	35	20 - 35	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6, Ch, N
M-37	On-site	Monitoring	35	20 - 35	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6, Ch, N
M-38	On-site	Monitoring	35	20 - 35	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6
M-44	On-site	Monitoring	35	5 - 35	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6
M-48A	Off-site	Monitoring	40	19.7 - 39.7	W	P, T, Cr, pH	P, T, Cr, pH, Ch, N
M-52	On-site	Monitoring	45	34.5 - 44.5		P, T, Cr, pH	P, T, Cr, pH
M-55	On-site	Monitoring	44.6	14.6 - 44.6	W	W	W
M-56	On-site	Monitoring	40	15 - 40	W	W	W
M-57A	On-site	Monitoring	40.2	20 - 40	W	P, T, Cr, pH	P, T, Cr, pH
M-58	On-site	Monitoring	45	15 - 45	W	W	W
M-5A	On-site	Monitoring	50	40 - 50		P, T, Cr, pH, **	P, T, Cr, pH, **
M-60	On-site	Monitoring	43	17.8 - 42.8	W	W	W
M-64	On-site	Monitoring	37.5	12.7 - 37.3	W	P, T, Cr, pH	P, T, Cr, pH
M-65	On-site	Monitoring	39.2	14.4 - 39	W	P, T, Cr, pH	P, T, Cr, pH
M-66	On-site	Monitoring	42.5	17.5 - 42.3	W	P, T, Cr, pH	P, T, Cr, pH
M-67	On-site	Monitoring	38	7.8 - 37.8	W	P, T, Cr, pH	P, T, Cr, pH
M-68	On-site	Monitoring	41	11.2 - 39.8	W	P, T, Cr, pH	P, T, Cr, pH
M-69	On-site	Monitoring	40	19.9 - 39.3	W	P, T, Cr, pH	P, T, Cr, pH
M-6A	On-site	Monitoring	43.6	26.8 - 41.5		P, T, Cr, pH, **	P, T, Cr, pH, **
M-70	On-site	Monitoring	40.2	15.3 - 40	W	P, T, Cr, pH	P, T, Cr, pH
M-71	On-site	Monitoring	42.2	17.5 - 42	W	P, T, Cr, pH	P, T, Cr, pH
M-72	On-site	Monitoring	35	10.1 - 34.8	W	P, T, Cr, pH	P, T, Cr, pH
M-73	On-site	Monitoring	36	11 - 35.8	W	P, T, Cr, pH	P, T, Cr, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
M-74	On-site	Monitoring	39	9.2 - 38.8	W	P, T, Cr, pH	P, T, Cr, pH
M-75	On-site	Monitoring	51.5	34.6 - 49.3	W	W	P, T, Cr, pH
M-76	On-site	Monitoring	51.4	34.6 - 49.3	W	W	P, T, Cr, pH
M-77	On-site	Monitoring	45.9	29 - 43.8	W	W	P, T, Cr, pH
M-78	On-site	Monitoring	43.6	21.5 - 41.5	W	W	W
M-79	On-site	Monitoring	37.6	10.8 - 35.4	W	P, T, Cr, pH	P, T, Cr, pH
M-7B	On-site	Monitoring	52.5	25.5 - 50.5		P, T, Cr, pH, **	P, T, Cr, pH, **
M-80	On-site	Monitoring	43.7	11.5 - 41.5	W	W	P, T, Cr, pH
M-81A	On-site	Monitoring	40	30 - 40	W	W	P, T, Cr, pH
M-83	On-site	Monitoring	42.5	10.8 - 40.3	P, T	P, T, Cr, pH	P, T, Cr, pH
M-92	On-site	Monitoring	45.5	34.9 - 44.9	W	W	P, T, Cr, pH
M-93	On-site	Monitoring	46	35.4 - 45.4	W	W	P, T, Cr, pH
M-95	Off-site	Monitoring	22	12 - 22	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6
M-96	Off-site	Monitoring	20.5	10.5 - 20.5	W	P, T, Cr, pH, Cr6	P, T, Cr, pH, Cr6
M-97	On-site	Monitoring	45.5	35 - 45	W	W	P, T, Cr, pH
M-98	On-site	Monitoring	31	19 - 29	W	P, T, Cr, pH	P, T, Cr, pH
M-99	On-site	Monitoring	33	16 - 31	W	P, T, Cr, pH	P, T, Cr, pH
MW-16	On-site	Monitoring	40	24.7 - 39.7			P, T, Cr, pH
ART (Athens Road Transect) wells: Located off-site at Galleria Drive at the COH WRF; comprise the mid-plume groundwater extraction network, the "AWF"							
ART-1	Downgradient	Extraction	56	14 - 54	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-1A	Downgradient	Extraction	56	19 - 54	W	W	W
ART-2	Downgradient	Extraction	56	19 - 54	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-2A	Downgradient	Extraction	58	21 - 56	W	W	W
ART-3	Downgradient	Extraction	47	15 - 45	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-3A	Downgradient	Extraction	55	18 - 53	W	W	W
ART-4	Downgradient	Extraction	46.4	19.4 - 44.4	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-4A	Downgradient	Extraction	45.4	18.4 - 43.4	W	W	W
ART-6	Downgradient	Extraction	39.9	17.9 - 37.9	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-7	Downgradient	Extraction	41	19 - 39	W	W	W
ART-7A	Downgradient	Extraction	41.7	19.7 - 39.7	W	W	W
ART-7B	Downgradient	Extraction	50	29.5 - 44.5	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-8	Downgradient	Extraction	50.5	18 - 48	P, T	P, T, Cr, pH	P, T, Cr, pH
ART-8A	Downgradient	Extraction	54	22 - 52	W	W	W

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
ART-9	Downgradient	Extraction	45.5	23 - 43	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP (Athens Road Piezometer) wells: Located immediately downgradient of AWF on COH property; for monitoring ART well performance							
ARP-1	Downgradient	Monitoring	44.2	14 - 44	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP-2A	Downgradient	Monitoring	54	23.7 - 53.7	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP-3A	Downgradient	Monitoring	41	20.7 - 40.7	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP-4A	Downgradient	Monitoring	33	17.7 - 32.7	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP-5A	Downgradient	Monitoring	38	12.7 - 37.7	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP-6B	Downgradient	Monitoring	43	27.7 - 42.7	P, T	P, T, Cr, pH	P, T, Cr, pH
ARP-7	Downgradient	Monitoring	39.2	14 - 39	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-series extraction wells: Located near the Las Vegas Wash; comprise the furthest downgradient groundwater extraction network, the "SWF"							
PC-99R2/R3	Downgradient	Extraction	55.4	10 - 50	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-115R	Downgradient	Extraction	55.5	10 - 50	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-116R	Downgradient	Extraction	55.5	10 - 50	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-117	Downgradient	Extraction	53	11 - 51	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-118	Downgradient	Extraction	51	9 - 49	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-119	Downgradient	Extraction	47	15 - 45	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-120	Downgradient	Extraction	47	15 - 45	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-121	Downgradient	Extraction	38.5	6.5 - 36.5	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-133	Downgradient	Extraction	40.2	5 - 40	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-series monitoring wells: Most located in downgradient plume; for monitoring perchlorate and chromium plumes; some situated near AWF and SWF							
PC-1	Downgradient	Monitoring	30	14.7 - 29.7			P, T, Cr, pH, Ch, N
PC-101R	Downgradient	Monitoring	50.5	20 - 50	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-103	Downgradient	Monitoring	29.5	9 - 29	P, T	P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-107	Downgradient	Monitoring	18	7.7 - 17.7			P, T, pH
PC-108	Downgradient	Monitoring	45	9.7 - 44.7			P, T, pH
PC-110	Downgradient	Monitoring	37	6.7 - 36.7			P, T, pH
PC-122	Downgradient	Monitoring	38.9	23.9 - 38.9	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-123	Downgradient	Monitoring	35.2	20 - 35		P, T, Cr, pH	P, T, Cr, pH
PC-124	Downgradient	Monitoring	35.5	20.3 - 35.3		P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-125	Downgradient	Monitoring	33.9	18.7 - 33.7		P, T, Cr, pH	P, T, Cr, pH
PC-126	Downgradient	Monitoring	34.7	19.5 - 34.5		P, T, Cr, pH	P, T, Cr, pH, Ch, N

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
PC-127	Downgradient	Monitoring	35.5	15 - 35		P, T, Cr, pH	P, T, Cr, pH
PC-128	Downgradient	Monitoring	35	14.8 - 34.8		P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-129	Downgradient	Monitoring	39	38 - 12.8		P, T, Cr, pH	P, T, Cr, pH
PC-130	Downgradient	Monitoring	50	14.8 - 49.8		P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-131	Downgradient	Monitoring	40	9.8 - 39.8		P, T, Cr, pH	P, T, Cr, pH
PC-132	Downgradient	Monitoring	40	9.8 - 39.8		P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-134A	Downgradient	Monitoring	70	59.7 - 69.7			P, T, Cr, pH
PC-135A	Downgradient	Monitoring	51	30.7 - 50.7		P, T, Cr, pH	P, T, Cr, pH
PC-136	Downgradient	Monitoring	40.6	21 - 41		P, T, Cr, pH	P, T, Cr, pH
PC-137	Downgradient	Monitoring	73.3	63.3 - 73.3			P, T, Cr, pH
PC-142	Downgradient	Monitoring	32	21.7 - 31.7			P, T, Cr, pH
PC-143	Downgradient	Monitoring	65	29.7 - 64.7			P, T, Cr, pH
PC-144	Downgradient	Monitoring	40	29.7 - 39.7		P, T, Cr, pH	P, T, Cr, pH
PC-145	Downgradient	Monitoring	40	24.7 - 39.7			P, T, Cr, pH
PC-146	Downgradient	Monitoring	30	19.7 - 29.7			P, T, Cr, pH
PC-147	Downgradient	Monitoring	32	21.7 - 31.7			P, T, Cr, pH
PC-148	Downgradient	Monitoring	50	24.5 - 44.5		P, T, Cr, pH	P, T, Cr, pH
PC-149	Downgradient	Monitoring	50	24.5 - 44.5		P, T, Cr, pH	P, T, Cr, pH
PC-150	Downgradient	Monitoring	45	19.5 - 39.5		P, T, Cr, pH	P, T, Cr, pH
PC-18	Downgradient	Monitoring	52	11.5 - 51.5	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-2	Downgradient	Monitoring	30	14 - 29			P, T, Cr, pH, Ch, N
PC-21A	Downgradient	Monitoring	34.4	14.2 - 34.2			P, T, Cr, pH, Ch, N
PC-24	Downgradient	Monitoring	30.2	15 - 30			P, T, Cr, pH
PC-28	Downgradient	Monitoring	20	10 - 19.5			P, T, Cr, pH
PC-31	Downgradient	Monitoring	50	14.5 - 49.5			P, T, Cr, pH
PC-37	Off-site	Monitoring	42	16.8 - 41.8	W	P, T, Cr, pH	P, T, Cr, pH
PC-4	Downgradient	Monitoring	43	17.7 - 42.7			P, T, Cr, pH, Ch, N
PC-40	On-site	Monitoring	55.2	15 - 55			P, T, Cr, pH
PC-50	Downgradient	Monitoring	42	11.8 - 41.8			P, T, Cr, pH
PC-53	Downgradient	Monitoring	33	13 - 32.5	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-54	Downgradient	Monitoring	35	9.5 - 34.5	W	P, T, Cr, pH	P, T, Cr, pH
PC-55	Downgradient	Monitoring	56.3	15.3 - 55.3	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-56	Downgradient	Monitoring	55	4.8 - 54.8	P, T	P, T, Cr, pH	P, T, Cr, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
PC-58	Downgradient	Monitoring	33	7.8 - 32.8	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-59	Downgradient	Monitoring	35	4.8 - 34.8	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-60	Downgradient	Monitoring	40	4.5 - 38.5	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-62	Downgradient	Monitoring	38	7.6 - 37.6	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-64	Downgradient	Monitoring	19.5	4 - 19			P, T, Cr, pH
PC-65	Downgradient	Monitoring	19.1	4.1 - 18.7			P, T, Cr, pH
PC-66	Downgradient	Monitoring	27.3	6.9 - 26.9			P, T, Cr, pH
PC-67	Downgradient	Monitoring	36	11 - 35.6			P, T, Cr, pH
PC-68	Downgradient	Monitoring	55.3	9.9 - 54.9	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-71	Off-site	Monitoring	30.4	13.4 - 15	W	P, T, Cr, pH	P, T, Cr, pH
PC-72	Off-site	Monitoring	37	15 - 20	W	P, T, Cr, pH	P, T, Cr, pH
PC-73	Off-site	Monitoring	47.5	20 - 25	W	P, T, Cr, pH	P, T, Cr, pH
PC-74	Downgradient	Monitoring	50	39.5 - 10			P, T, pH
PC-76	Downgradient	Monitoring	20.5	15 - 20			W
PC-77	Downgradient	Monitoring	40	29.5 - 39.5			P, T, pH
PC-78	Downgradient	Monitoring	22	11.5 - 21.5			W
PC-79	Downgradient	Monitoring	45	34.5 - 44.5			P, T, Cr, pH
PC-80	Downgradient	Monitoring	30	19.5 - 29.5			W
PC-81	Downgradient	Monitoring	15	9.5 - 14.5			W
PC-82	Downgradient	Monitoring	57.5	47 - 57			P, T, Cr, pH, Ch, N
PC-83	Downgradient	Monitoring	31	20.5 - 30.5		P, T, Cr, pH	W
PC-85	Downgradient	Monitoring	43	32.5 - 42.5			W
PC-86	Downgradient	Monitoring	28	17.5 - 27.5	P, T	P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-87	Downgradient	Monitoring	13	2.5 - 12.5			W
PC-88	Downgradient	Monitoring	50.5	40 - 50			W
PC-90	Downgradient	Monitoring	15	4.5 - 14.5	P, T	P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-91	Downgradient	Monitoring	37	26.5 - 36.5	P, T	P, T, Cr, pH	P, T, Cr, pH, Ch, N
PC-92	Downgradient	Monitoring	22	11.5 - 21.5			P, T, Cr, pH
PC-94	Downgradient	Monitoring	20	9.5 - 19.5		P, T, Cr, pH	P, T, Cr, pH
PC-96	Downgradient	Monitoring	39.5	29 - 39			P, T, pH
PC-97	Downgradient	Monitoring	33.5	23 - 33	P, T	P, T, Cr, pH	P, T, Cr, pH
PC-98R	Downgradient	Monitoring	40.5	20 - 35	P, T	P, T, Cr, pH	P, T, Cr, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
TR-series wells: Located on-site along western property boundary; for Middle/Deep Water Bearing Zone monitoring							
TR-1	On-site	Monitoring	312	282 - 312			P, T, Cr, pH
TR-2	On-site	Monitoring	175	145 - 175			P, T, Cr, pH
TR-3	On-site	Monitoring	250	220 - 250			P, T, Cr, pH
TR-4	On-site	Monitoring	145	125 - 145			P, T, Cr, pH
TR-5	On-site	Monitoring	251.5	221 - 251			P, T, Cr, pH
TR-6	On-site	Monitoring	80	60 - 80			P, T, Cr, pH
TR-7	On-site	Monitoring	290.5	260 - 290			P, T, Cr, pH
TR-8	On-site	Monitoring	93.5	63 - 93			P, T, Cr, pH
TR-9	On-site	Monitoring	250.5	230 - 250			P, T, Cr, pH
TR-10	On-site	Monitoring	100.5	80 - 100			P, T, Cr, pH
TR-11	On-site	Monitoring	230.5	210 - 230			P, T, Cr, pH
TR-12	Off-site	Monitoring	292.5	272 - 292			P, T, Cr, pH
Owned by BRC; located on east side of downgradient plume							
AA-01	Downgradient	Monitoring	49	29 - 49			P, T, pH
AA-11	Downgradient	Monitoring	29	9 - 29			P, T, Cr, pH
BEC-1	Downgradient	Monitoring	40	25 - 40			P, T, pH
DM-4	Downgradient	Monitoring	26.5	8 - 23			P, T, Cr, pH
DM-5	Downgradient	Monitoring	26.5	7 - 22			P, T, Cr, pH
Owned by TIMET; located east of the IWF							
CLD-1R	Off-site	Monitoring	35	Shallow			P, T, Cr, pH
Owned by Stauffer; located on-site and off-site							
H-11	Off-site	Monitoring	116	Shallow			P, T, pH
H-28A	On-site	Monitoring	48	Shallow		P, T, Cr, pH, **	P, T, Cr, pH, **
H-48	On-site	Monitoring	35	Shallow			P, T, Cr, pH
H-58A	Off-site	Monitoring	57	37 - 57			P, T, Cr, pH
Owned by COH; located downgradient of AWF; for downgradient plume monitoring							
HM-2	Downgradient	Monitoring	22	Shallow			P, T, pH
HMW-13	Downgradient	Monitoring	40	Shallow			P, T, pH
HMW-14	Downgradient	Monitoring	40	Shallow			P, T, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
HMW-15	Downgradient	Monitoring	30	Shallow			P, T, pH
HMW-16	Downgradient	Monitoring	30	Shallow			P, T, pH
HSW-1	Downgradient	Monitoring	24	Shallow			P, T, pH
Owned by USEPA; located just to the west of the AWF; for downgradient plume monitoring							
L635	Downgradient	Monitoring	45	30 - 45	P, T	P, T, Cr, pH	P, T, Cr, pH
L637	Downgradient	Monitoring	29	14 - 29	P, T	P, T, Cr, pH	P, T, Cr, pH
Owned by OSSM; located on-site and off-site; installed by OSSM for monitoring VOCs west of Site							
MC3	Off-site	Monitoring	44	Shallow			P, T, pH
MC6	Off-site	Monitoring	42	Shallow			P, T, pH
MC7	Off-site	Monitoring	39	Shallow			P, T, pH
MC29	On-site	Monitoring	50	37.5 - 50			P, T, pH
MC45	Off-site	Monitoring	34	4 - 34			P, T, pH
MC50	On-site	Monitoring	49	24 - 49			P, T, pH
MC51	On-site	Monitoring	44	24 - 49			P, T, pH
MC53	On-site	Monitoring	38	20 - 40			P, T, Cr, pH
MC65	Off-site	Monitoring	41	20 - 41			P, T, Cr, pH
MC69	Off-site	Monitoring	44	29 - 44			P, T, pH
MC93	On-site	Monitoring	42	32 - 42			P, T, pH
MC97	On-site	Monitoring	41	31 - 41			P, T, pH

TABLE 4-4. SUMMARY OF THE GROUNDWATER MONITORING PROGRAM
Nevada Environmental Response Trust Site; Henderson, Nevada

WELL ID	LOCATION	WELL TYPE	TOTAL WELL DEPTH (ft bgs)	SCREEN INTERVAL [1] (ft bgs)	MONTHLY SAMPLING	QUARTERLY SAMPLING	ANNUAL [2] SAMPLING
Owned by AMPAC; located downgradient of AWF							
MW-K4	Downgradient	Monitoring	50	9.5 - 50	P, T	P, T, Cr, pH	P, T, Cr, pH
MW-K5	Downgradient	Monitoring	44	28.5 - 44	P, T	P, T, Cr, pH	P, T, Cr, pH, Ch, N
TOTALS				**Sample/Water Level**	**135**	**171**	**297**
				Sample	**46**	**139**	**266**
				Water Level Only	**89**	**32**	**31**

Notes:

If a sampling field is blank for a well during a certain sampling event, then no action is taken for that well during that event.

[1] If a screen interval is unknown, then the known water bearing zone is listed.

[2] The annual sampling event takes place in the second quarter, replacing the quarterly event.

Abreviations:

ft bgs = feet below ground surface

P = Perchlorate	AMPAC = American Pacific Corporation
T = Total Dissolved Solids (TDS)	BRC = Basic Remediation Company
Cr = Total Chromium	COH WRF = City of Henderson Water Reclamation Facility
Cr6 = Hexavalent Chromium	OSSM = Olin/Stauffer/Syngenta/Montrose
Ch = Chlorate	TIMET = Titanium Metals Corporation
N = Nitrate	USEPA = United State Environmental Protection Agency
W = Water level measurement only	

Additional explanations:

* Designates well sampled under National Pollution Discharge Elimination System (NPDES) Permit - additional analytes required as follows:

Ammonia Nitrogen	Total Boron
Nitrate as Nitrate	Total Iron
Nitrate as Nitrogen	Total Manganese
Nitrite as Nitrogen	Chloride
Total Inorganic Nitrogen	

** Designates well sampled under the Resource Conservation and Recovery Act (RCRA) - additional analytes required as follows:

Chloride	Total Iron	Total Boron
Phenols	Total Manganese	Total Sodium
Specific Conductance	Total Organic Carbon	
Sulfate	Total Organic Halides (4 Replicates)	

TABLE 5-1. CATEGORY 3 AREA INFORMATION
Nevada Environmental Response Trust Site; Henderson, Nevada

AREA #	DESCRIPTION	SAMPLE INFORMATION SAMPLE LOCATION	DEPTH INTERVAL (feet bgs)	CHEMICAL [1]	RESULT [2]	BCL or SRG [3]	Unit
1	Dioxin TEQ > BCL at two locations at ground surface (0-1.5 ft). Northgate did not define a soil removal polygon for this area and soil was not removed. RSAI7 is slightly north of an existing ECA and along fenceline where removal of the BMI Haul Road is anticipated. TSB-CJ-09 is just north of this area.	RSAI7	0 - 0.5	Dioxin TEQ	31,000	2,700	pg/g
		TSB-CJ-09	0 - 1.5	Dioxin TEQ	3,900	2,700	pg/g
2	Dioxin TEQ and HCB > BCL originally at ground surface and is now buried by approximately 2 ft of soil. Northgate did not define a soil removal polygon for this area and soil was not removed.	SSAK3-05	2.5 - 3	Hexachlorobenzene	4.7	1.2	mg/kg
			2.5 - 3	Dioxin TEQ	11,000	2,700	pg/g
3	Hexachlorobenzene > BCL at 1.5-2 ft deep. Northgate did not define a soil removal polygon for this area and soil was not removed.	RSAK4	1.5 - 2	Hexachlorobenzene	2.1	1.2	mg/kg
4	Arsenic slightly > background at 2-5 ft deep. These samples were originally collected at 10-13 ft deep. Polygon excavation was planned to 4 ft, but actual soil excavation was to ~8 ft (due to discolored soil or grading).	BDT-2-S-5	2 - 3	Arsenic	10	7.2	mg/kg
			4 - 5	Arsenic	7.7	7.2	mg/kg
			4 - 5	Arsenic	9.0	7.2	mg/kg
5	Perchlorate > BCL at various locations at and near ground surface (within retention basin). These samples were originally collected at 10-12 ft deep. Polygon excavation was performed to 10 ft. In consultation with NDEP, grading was performed to construct retention basin in this area. Also, perchlorate is present at >9 ft below "new" ground surface in this area.	RSAM5	1 - 2.5	Perchlorate	2,620	795	mg/kg
		SA15	0 - 0.5	Perchlorate	1,160	795	mg/kg
			0 - 0.5	Perchlorate	1,210	795	mg/kg
			9 - 10.5	Perchlorate	943	795	mg/kg
		SA65	surface	Perchlorate	1,690	795	mg/kg
			8.5 - 10	Perchlorate	984	795	mg/kg
6	Arsenic slightly > background at 6-7 ft deep. These samples were originally collected at 5-6 ft deep. Polygon excavation was planned and performed to 1 ft, with approximately 1 ft of backfill in this area. Soil removal polygons were not originally designed to excavate this deep, presumably since the concentration of arsenic was only slightly above the arsenic background concentration.	SA63	6 - 7	Arsenic	7.5	7.2	mg/kg
7	Arsenic slightly > background at ~4 ft deep. After polygon excavation to 1 ft and additional discolored soil excavation, a confirmation sample was collected which indicated that arsenic was slightly above background. In consultation with NDEP and because arsenic concentrations were only slightly above background, no further excavation was performed in this area and the area was backfilled with approximately 4 ft of soil.	CS-D31A-1	4	Arsenic	8.1	7.2	mg/kg
8	Perchlorate > BCL at ~8.5-18 ft deep. These samples were originally collected at 12-21.5 ft deep. Polygon excavation was performed to 10 ft, then area partially backfilled.	SA106	8.5 - 10	Perchlorate	1,050	795	mg/kg
9	Arsenic > background at surface. After soil removal and cleanup following stockpile staging area use in this area, a confirmation sample (DS-C45-2) was collected which indicated arsenic was slightly above background. In consultation with NDEP and because arsenic concentrations were only slightly above background, no further excavation was performed in this area.	DS-C45-2	surface	Arsenic	10	7.2	mg/kg
			surface	Arsenic	12	7.2	mg/kg
10	Arsenic > background at ~8 ft deep. After polygon excavation and additional discolored soil removal to ~8 ft, a confirmation sample was collected which indicated arsenic was slightly above background. In consultation with NDEP and because the arsenic concentration was only slightly above background, no further excavation was performed in this area and the area was backfilled with approximately 8 ft of soil.	CS-C27-1	8	Arsenic	11	7.2	mg/kg
11 [4]	Arsenic > background at 2-3.5 ft. After soil removal and cleanup following stockpile staging area use in this area, a confirmation sample (DS-C45-2) was collected which indicated arsenic was slightly above background. In consultation with NDEP and because arsenic concentrations were only slightly above background, no further excavation was performed in this area.	SA149	2 - 3.5	Arsenic	25	7.2	mg/kg
			2 - 3.5	Arsenic	21	7.2	mg/kg
12	Arsenic slightly > background in upper 3.5 ft. This sample appears to have been collected on the neighboring property (Lhoist), so soil removal was not planned in this area.	RSAQ5	1 - 2.5	Arsenic	7.4	7.2	mg/kg
			1.5 - 2.5	Arsenic	8.7	7.2	mg/kg
			2.5 - 3.5	Arsenic	7.7	7.2	mg/kg

TABLE 5-1. CATEGORY 3 AREA INFORMATION
Nevada Environmental Response Trust Site; Henderson, Nevada

Notes:

Samples and analytical results listed on this table are from samples presently within 10 ft of the "new" ground surface. Analytical results for deeper samples are not provided on this table.

[1] An NDEP approved site-specific BCL is used as the SRG for dioxins/furans, i.e., dioxin TEQ of 2,700 mg/kg (NDEP 2010a). For arsenic, "contaminated" soil is defined as concentrations greater than

[2] One sample result (dioxin TEQ result of 29,000 pg/g collected at soil boring location RSAI7 from 0 to 0.5 ft bgs) in Category 3 area 1 was removed from Table 5-1 presented in the December 17, 2012 report (ENVIRON 2012f). Following further review of the data, it was determined that this sample was a screening result for the same sample that was detected at 31,000 pg/g.

[3] The BCL for white phosphorus was not compared to the analytical results for phosphorus because the site history does not suggest that white phosphorus is present on-site.

[4] This sample was previously listed in category area #9.

Abbreviations:

bgs = below ground surface
BCL = Basic Comparison Level
BMI = Black Mountain Industrial
ECA = Excavation Control Area
ft = foot or feet
mg/kg = milligrams per kilogram
NDEP = Nevada Division of Environmental Protection
pg/g = picograms per gram
SRG = Soil Remediation Goal
TEQ = toxicity equivalent
TIMET = Titanium Metals Corporation

References:

ENVIRON, 2012f. Remedial Investigation and Feasibility Study Work Plan, Nevada Environmental Response Trust Site; Henderson, Nevada. December 17.

Nevada Division of Environmental Protection (NDEP), 2010a. NDEP Response to: *Results of Bioaccessibility Study for Dioxin/Furans in Soil, Tronox LLC, Henderson, Nevada (Revised) Dated: May 24, 2010.* May 25.

TABLE 5-2a. Preliminary Identification of On-site Receptors and Exposure Pathways
Nevada Environmental Response Trust Site, Henderson, Nevada

Receptor	Soil: Direct Contact Pathways						Soil: Indirect Contact Pathways		Groundwater		Groundwater (extracted)	Surface Water
	Ingestion		Dermal Contact		External Gamma		Inhalation (Particulates)	Inhalation (Soil vapors)	Inhalation (VOCs)	Ingestion, Dermal Contact	Ingestion, Dermal Contact, Inhalation (VOCs)	Ingestion, Dermal Contact
	C1	C3/C4	C1	C3/C4	C1	C3/C4	C1/C3/C4	C1/C3/C4				
Short-term Construction Worker	SMP	✓	SMP	✓	SMP	✓	✓	⊙	⊙	inc	inc	○
Outdoor Commercial/ Industrial Worker	SMP	✓	SMP	✓	SMP	✓	✓	⊙	⊙	inc	OSHA	○
Indoor Commercial/ Industrial Worker	✓	✓	o	o	✓	✓	✓	✓	✓	inc	inc	inc
Visitor/ Trespasser	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	inc	inc	⊙

Notes:

C1 Category 1 soils 0 – 10 feet bgs post-excavation in an Excavation Control Area
C2 Category 2 soils 0 – 10 feet bgs post-excavation with concentrations <Basic Comparison Levels (BCLs) (not shown in this table)
C3 Category 3 soils 0 – 10 feet bgs post-excavation with concentrations >BCLs
C4 Category 4 soils 0 – 10 feet bgs post-excavation not previously sampled or available information considered inadequate

inc Incomplete exposure pathway
OSHA Workers at the groundwater extraction and treatment facilities could potentially be exposed to contaminants in extracted groundwater. However, potential exposures will not be evaluated quantitatively because the workers are regulated by the Occupational Safety and Health Administration (OSHA) and a comprehensive worker health and safety plan (HASP) is in place to mitigate potential exposures.
SMP Site Management Plan -- potential exposures for direct-contact pathways will be managed through the SMP

✓ Complete exposure pathway; evaluated quantitatively in the BHRA.
⊙ Exposures of outdoor workers via inhalation of soil or groundwater vapors would be less than exposures of indoor workers; inhalation of vapors in outdoor air will be evaluated only if estimated risks for the vapor intrusion (indoor) pathway are $>1 \times 10^{-6}$ or the hazard index is >1.
○ Potentially complete, but insignificant exposure pathway; not evaluated quantitatively because potential exposures are expected to be intermittent and of short duration; surface water pathways are discussed qualitatively.
o Complete, but insignificant exposure pathway. Consistent with USEPA guidance (USEPA 2002) and the NDEP-approved 2010 HRA work plan (Northgate 2010d), potential exposures of indoor workers to soil from dermal exposure are not evaluated quantitatively, but will be discussed qualitatively.
⊙ Potentially complete exposure pathway; not evaluated quantitatively because potential exposures of a trespasser would be less than those of an on-site worker; the trespasser is discussed qualitatively.

TABLE 5-2b. Preliminary Identification of Off-site Receptors and Exposure Pathways

Nevada Environmental Response Trust Site, Henderson, Nevada

Receptor	Soil (C1, C3, C4)	Groundwater		Surface Water (Las Vegas Wash, Lake Mead, downstream Colorado River)
	Inhalation (Particulates)	Inhalation (VOCs)	Ingestion, Dermal Contact	Ingestion, Dermal Contact
Off-site Resident	o	(✓)	inc	(✓)
Off-site outdoor Commercial/ Industrial Worker	o	(✓)	inc	(✓)
Off-site Indoor Commercial/ Industrial Worker	o	(✓)	inc	(✓)
Recreational User (Child/Adult)	o	(✓)	inc	(✓)

Notes:

C1 Category 1 soils 0 – 10 feet bgs post-excavation in an Excavation Control Area
C2 Category 2 soils 0 – 10 feet bgs post-excavation with concentrations <Basic Comparison Levels (BCLs) (not shown in this table)
C3 Category 3 soils 0 – 10 feet bgs post-excavation with concentrations >BCLs
C4 Category 4 soils 0 – 10 feet bgs post-excavation not previously sampled or available information considered inadequate

inc Incomplete exposure pathway

(✓) Potentially complete exposure pathway for indoor and outdoor air; pathway will be evaluated quantitatively using analytical results for soil gas and/or groundwater depending on receptor location and data availability. The specific receptors and pathways (i.e., indoor and outdoor exposures) that will be evaluated quantitatively will depend on various factors, including the results from additional sampling for VOCs in the downgradient groundwater plume and/or results from off-site soil gas investigations.

(✓) Complete exposure pathway; for perchlorate, pathway will be evaluated by comparing surface water concentrations to the Nevada Provisional Action Level for perchlorate.

o Exposures of all off-site receptors via inhalation of airborne soil particulates would be significantly less than exposures of on-site workers; inhalation of particulates will be evaluated only if estimated risks for on-site receptors are >1E-06 or the hazard index is >1.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
NO FURTHER ACTION	**No Further Action**	**No Action**	No action to be taken beyond the previous and current Interim Removal Actions described in Section 4 of this Work Plan, including the Interim Soil Removal Actions described in Sections 4.1 through 4.3, the historical and current Groundwater Removal Actions described in Section 4.4 (i.e., the construction and operation of the GWETS), and the Groundwater Monitoring described in Section 4.5. The relevant technologies and process options implemented as part of these Interim Removal Actions are described and evaluated below along with comparable alternatives.	Not likely to meet RAOs. Required for comparison by National Contingency Plan (NCP).
INSTITUTIONAL CONTROLS	**Groundwater Use Restrictions**	**Access Restrictions to Groundwater**	Restrict use of groundwater in contaminated areas.	POTENTIALLY APPLICABLE.
	Site Access Restrictions	**Site Management Plan (SMP)**	Manage risk to site occupants and workers through implementation of an SMP identifying remaining contamination left in place in Excavation Control Areas (ECAs) and detailing the procedures necessary to follow when disturbing ECAs.	APPLICABLE as an SMP has been developed and implemented for the Site to manage risks from residual contamination.
		Fences / Gates	Block unauthorized access to parts of the Site to prevent exposure to residual contamination and/or hazardous materials and equipment.	APPLICABLE as it is currently in use at some areas of the Site.
		Warning Signs	Post signs to warn against unauthorized access and to inform of potential hazards to prevent exposure to residual contamination and/or hazardous materials and equipment.	APPLICABLE as it is currently in use at some areas of the Site.
	Legal Restrictions to Land Use	**Deed Restrictions**	Restrict use of the impacted land at the Site by writing land use restrictions into the property deed.	POTENTIALLY APPLICABLE.
MONITORING	**Groundwater Monitoring**	**Routine Sampling and Measurement of Groundwater**	Continue sampling and analysis of groundwater.	APPLICABLE as it is currently being conducted at the Site.
MONITORED NATURAL ATTENUATION	**Monitored Natural Attenuation**	**Monitored Natural Attenuation of Groundwater**	Conduct groundwater quality monitoring to demonstrate effectiveness of natural attenuation processes in reducing COPC concentrations to acceptable levels. Additional monitoring network/parameters may be required.	POTENTIALLY APPLICABLE where COPC concentrations are relatively low but are higher than RAOs, and aquifer conditions favorable to natural attenuation processes have been established.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
CONTAINMENT	**Vertical Subsurface Barriers**	**Slurry Wall**	Construct physical barrier using very low permeability slurry to isolate an area and/or control groundwater migration.	APPLICABLE as it is currently in use at the Site for controlling groundwater flow and contaminant migration.
		Grout Curtain	Create subsurface barrier to horizontal groundwater flow by grout injection.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
		Diaphragm Walls	Vertical barrier constructed of reinforced concrete panels.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
		Steel Sheet Pile Walls	Vertical barrier comprised of steel sheet piles.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
		Vibrating Beam Slurry Walls	Vertical barrier constructed by inserting a series of overlapping I-beams into the ground, followed by slurry injection under pressure.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
	Horizontal Subsurface Barriers	**Grout Injection by Vertical Drilling**	Create subsurface barrier to vertical migration of groundwater by grout injection at a fixed depth via tightly-spaced vertical boreholes.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
		Grout Injection by Vertical Drilling and Jet Grouting	Create subsurface barrier to vertical migration of groundwater by grout injection at a fixed depth via tightly-spaced vertical boreholes and jet grouting.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
		Grout Injection by Horizontal Drilling	Create subsurface barrier to vertical migration of groundwater by grout injection at a fixed depth via horizontal boreholes.	POTENTIALLY APPLICABLE for controlling shallow groundwater flow and contaminant migration.
	Capping / Surface Water Recharge Control	**Single-Layer Clay Cap**	Areas of concern (usually areas of impacted soil) are covered with a clay cap and protective surface cover to reduce storm water infiltration and prevent contaminant transport.	POTENTIALLY APPLICABLE to defined source areas within Site boundaries to reduce infiltration and contaminant migration.
		Single-Layer Synthetic Membrane	Areas of concern are covered using a synthetic membrane with protective base and cover material to reduce storm water infiltration and prevent contaminant transport.	POTENTIALLY APPLICABLE to defined source areas within Site boundaries to reduce infiltration and contaminant migration.
		Single-Layer Soil Cement / Clay Mixture	A barrier layer is formed by adding bentonite clay or Portland cement to surface soil in the areas of concern.	POTENTIALLY APPLICABLE to defined source areas within Site boundaries to reduce infiltration and contaminant migration.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
CONTAINMENT (continued)	**Capping / Surface Water Recharge Control (continued)**	**Multi-Layered Cap System**	Areas of concern are covered with a multi-layered cap system to reduce storm water infiltration and prevent contaminant transport.	POTENTIALLY APPLICABLE to defined source areas within Site boundaries to reduce infiltration and contaminant migration.
		Asphalt / Concrete Paving	Paving forms a relatively impervious surface to prevent erosion and infiltration of storm water into underlying soil thereby reducing contaminant transport.	POTENTIALLY APPLICABLE to defined source areas within Site boundaries to reduce infiltration and contaminant migration.
		Shotcrete	Shotcrete is sprayed concrete which forms a relatively impervious surface to prevent erosion and prevent storm water from contacting underlying impacted soil. The cap also prevents infiltration of storm water into underlying soil and groundwater.	POTENTIALLY APPLICABLE to defined source areas within Site boundaries to reduce infiltration and contaminant migration.
		Fly Ash Mixtures	Use of ash mixture as an absorbent in conjunction with other cover materials.	REJECTED; fly ash may contain metal residues.
GROUNDWATER EXTRACTION	**Groundwater Extraction ("Pump & Treat")**	**Extraction Wells**	Install extraction wells (vertical or horizontal) to capture contaminated groundwater to control plume migration and/or for groundwater restoration. May be used in concert with various containment process options and ex-situ treatment process options.	APPLICABLE as it is currently being conducted at the Site.
		Subsurface Drains and Interceptor Trenches	Install perforated pipe in trenches backfilled with porous media to capture contaminated groundwater to control plume migration and/or for groundwater restoration. May be used in concert with various containment process options and ex-situ treatment process options.	POTENTIALLY APPLICABLE.
EX-SITU GROUNDWATER TREATMENT	**Ex-Situ Physical-Chemical Treatment**	**Air Stripping**	Use forced air flow to transfer volatile contaminants from the aqueous phase to the vapor phase.	POTENTIALLY APPLICABLE for treatment of VOCs.
		Steam Stripping	Use forced steam to remove volatile contaminants from extracted groundwater.	POTENTIALLY APPLICABLE for treatment of VOCs/DNAPLs.
		Liquid- Liquid Separation / Extraction	Extract contaminants based on solubility using liquid extractants. Contaminants are solubilized into an extraction fluid that requires further treatment.	POTENTIALLY APPLICABLE for treatment of VOCs/DNAPLs.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Liquid-Phase Carbon Adsorption Using Granular Activated Carbon (GAC)**	Use granular activated carbon (GAC) to remove organic compounds from water in a non-destructive process that results in clean water and spent GAC loaded with the target contaminants. Spent GAC requires regeneration (e.g. off-site thermal regeneration) or disposal.	APPLICABLE as it is currently being conducted at the Site for pretreatment of extracted groundwater prior to biological reduction of perchlorate.
		Liquid-Phase Carbon Adsorption Using Tailored GAC (T-GAC)	Use specially treated GAC to remove residual (low-level) perchlorate from extracted groundwater.	POTENTIALLY APPLICABLE for a polishing step for low-level perchlorate treatment.
		Chemical Reduction	Chemical treatment to reduce oxidation state of target contaminants in extracted groundwater thereby reducing mass, toxicity, and or mobility.	APPLICABLE as it is currently being conducted at the Site in conjunction with chemical precipitation for removal of Cr(VI) from extracted groundwater.
		Chemical Oxidation	Use chemical oxidants to destroy organic contaminants in extracted groundwater.	POTENTIALLY APPLICABLE for treatment of VOCs.
		Advanced Oxidation Processes	Use ultraviolet (UV) radiation, ozone, and/or hydrogen peroxide to destroy organic contaminants as water flows into a treatment tank.	POTENTIALLY APPLICABLE for treatment of VOCs.
		Chemical Precipitation	Use chemical amendments to remove metals from extracted groundwater as a sludge via precipitation.	APPLICABLE as it is currently being conducted at the Site in conjunction with chemical reduction for removal of Cr(VI) from extracted groundwater.
		Coagulation / Flocculation	Use chemical coagulants/flocculants (e.g., ferric chloride, various commercial polymers, etc.) to clarify water of settleable solids.	POTENTIALLY APPLICABLE for use in combination with other ex-situ process options as part of a treatment train.
		Electrochemical Precipitation	Use electrochemically generated ferrous ions from a sacrificial iron electrode to reduce metals in extracted groundwater thereby reducing mass, toxicity, and or mobility.	POTENTIALLY APPLICABLE for removal of Cr(VI) from extracted groundwater.
		Ion Exchange Using Single-Use Resins	Use ion-exchange resins to remove cations and/or anions from extracted groundwater in a non-destructive process that results in clean water and resins loaded with the target contaminants. Nonregenerable resins loaded with contaminant are properly disposed (e.g. incineration).	APPLICABLE for treatment of perchlorate and Cr(VI) and has been implemented at the Site in the past.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Ion Exchange Using Regenerable Resins**	Use ion-exchange resins to remove cations and/or anions from extracted groundwater in a non-destructive process that results in clean water and resins loaded with the target contaminants. Contaminants are removed from resin before reuse.	APPLICABLE for treatment of perchlorate and Cr(VI) and has been implemented at the Site in the past.
		Reverse Osmosis	Use high pressure membrane to remove ionic contaminants in extracted groundwater in a non-destructive process that results in clean water and a concentrated brine solution requiring further treatment.	POTENTIALLY APPLICABLE as a polishing step in an aboveground treatment train.
		Nanofiltration / Ultrafiltration	Similar to reverse osmosis except uses membranes with larger pore sizes and lower pressures reducing energy usage. It is a non-destructive process resulting in clean water and a concentrated brine solution requiring further treatment.	POTENTIALLY APPLICABLE as a polishing or pretreatment step in an aboveground treatment train.
		Electrodialysis	An emerging technology that uses electric current and semi-permeable membrane to separate ions from extracted groundwater in a non-destructive process that results in clean water and a concentrated brine solution requiring further treatment.	POTENTIALLY APPLICABLE as a perchlorate removal process option in an aboveground treatment train. This technology is in the early stages of development.
		Electrolysis	An emerging technology that uses electricity to decompose an electrolyte solution into positive and negative ions and thereby reducing perchlorate and nitrates in a destructive process that leaves no brine solution requiring treatment.	POTENTIALLY APPLICABLE as a perchlorate removal process option in an aboveground treatment train. This technology is in the early stages of development.
		Ultraviolet (UV) Laser Reduction	An emerging technology using photons to reduce perchlorate. Photons provide the activation energy necessary for some stable molecules in water solution, such as perchlorate, to react and be destroyed leaving no brine requiring treatment.	POTENTIALLY APPLICABLE as a perchlorate removal process option in an aboveground treatment train. This technology is in the early stages of development.
		Capacitive Deionization	An emerging technology that uses an electric field between electrodes to separate anions and cations from extracted groundwater in a non-destructive process that results in clean water and electrodes loaded with the target contaminants. Reversing the electric charge unloads the contaminants into a concentrated brine solution requiring further treatment.	POTENTIALLY APPLICABLE as a polishing or pretreatment step in an aboveground treatment train. This technology is in the early stages of development.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Zero Valent Iron (ZVI) Reduction of Perchlorate**	An emerging technology employing an enhanced method of chemical reduction using zero-valent iron (ZVI) reduction. Due to the high activation energy of perchlorate reduction, chemical reduction via ZVI is generally not feasible; however, enhancement of this process using UV radiation or phosphoric acid allows the reaction to proceed.	POTENTIALLY APPLICABLE as a perchlorate removal process option in an aboveground treatment train. This technology is in the early stages of development.
		Titanium Reduction	An emerging technology employing titanous ions [Ti(III)] to reduce perchlorate in aqueous solutions.	POTENTIALLY APPLICABLE as a perchlorate removal process option in an aboveground treatment train. This technology is in the early stages of development.
		Catalytic Hydrogen Gas Membrane	An emerging technology incorporating hydrogen gas and catalysts (screened for their hydrogen and perchlorate adsorption capacity and catalytic hydrogen reduction of perchlorate) into porous membrane that works to filter perchlorate from water.	POTENTIALLY APPLICABLE as a perchlorate removal process option in an aboveground treatment train. This technology is in the early stages of development.
		Nanoscale Materials and Bimetallic Particles	Nanoscale particles represent a new generation of remediation technologies that employ particles having large surface areas and high surface reactivity. Nanoscale zero-valent iron (nZVI) ,bimetallic particles (BNPs), and titanium dioxide (TiO_2) can potentially treat a wide variety of contaminants including VOCs/DNAPLs and perchlorate in contaminated water.	POTENTIALLY APPLICABLE for treatment of perchlorate and VOCs/DNAPLs. This technology is in the early stages of development.
	Ex-Situ Biological Treatment	**Anaerobic Fluidized Bed Reactors (FBRs)**	Use anaerobic and facultative bacteria growing on a hydraulically-fluidized bed of media within an upflow bioreactor to degrade contaminants in extracted groundwater under anaerobic conditions. A carbon source is added to establish anaerobic conditions and to provide an electron donor for biological reduction of perchlorate.	APPLICABLE as it is currently in use at the Site as the primary process option for treatment of perchlorate in groundwater.
		Anaerobic Packed-Bed Reactors (PBRs)	Use anaerobic and facultative bacteria growing on stationary media within an upflow or downflow bioreactor to degrade contaminants in extracted groundwater under anaerobic conditions. A carbon source is added to establish anaerobic conditions and to provide an electron donor for biological reduction of perchlorate.	POTENTIALLY APPLICABLE as an alternative to FBRs.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Biological Treatment (continued)**	**Anaerobic Continuously-Stirred Tank Reactors (CSTRs)**	Use anaerobic and facultative bacteria growing in suspension to degrade contaminants in extracted groundwater under anaerobic conditions. Lower pumping requirements than FBRs. A carbon source is added to establish anaerobic conditions and to provide an electron donor for biological reduction of perchlorate.	POTENTIALLY APPLICABLE as an alternative to FBRs.
		Aerobic Bioreactors	Use aerobic bacteria growing in suspension (e.g., activated sludge) or on fixed media (e.g., trickling filters and rotating biological contactors[RBCs]) to degrade contaminants in water under aerobic conditions.	REJECTED. This process option has limited applicability to the range of chemical constituents encountered at the Site.
		Constructed Wetlands	Discharge extracted groundwater and/or other process wastewaters to an artificially constructed wetland area. Uses natural geochemical and biological processes inherent in a wetland ecosystem to accumulate and remove metals, organics, and other contaminants from influent waters.	POTENTIALLY APPLICABLE for treatment of extracted groundwater.
EXCAVATION	**Source Area Soil Excavation**	**Excavation for Off-site Treatment/Disposal**	Excavation and removal of shallow source area soils for off-site treatment and/or disposal at an appropriate Treatment Storage Disposal Facility (TSDF).	POTENTIALLY APPLICABLE for removal and management of vadose zone source area soils.
		Excavation for On-site Treatment/Disposal	Excavation of shallow source area soils for ex-situ treatment.	POTENTIALLY APPLICABLE for removal and management of vadose zone source area soils.
EX-SITU SOURCE AREA TREATMENT	**Ex-Situ Physical-Chemical Treatment**	**Thermal Treatment**	Treatment of excavated soils to destroy contaminants via thermal processes such as electric infrared incineration, fluidized bed incineration, liquid injection incineration, multiple hearth incineration, pyrolysis, and rotary kiln incineration.	POTENTIALLY APPLICABLE for ex-situ treatment of excavated source area soils.
		Thermal Desorption	Lower-temperature thermal process for removing VOCs and low-boiling-point compounds from excavated soils by volatilization, followed by organic destruction in a high temperature combustion chamber, or recovery by condensation or GAC adsorption.	POTENTIALLY APPLICABLE for ex-situ treatment of excavated source area soils.
		Soil Aeration	Controlled aeration of excavated soils to reduce VOCs.	REJECTED. Difficulties in controlling releases of VOCs to the air. Does not address inorganic contaminants.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU SOURCE AREA TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Off-Site Land Disposal**	Transport excavated soils to an appropriately-permitted off-site land disposal facility.	POTENTIALLY APPLICABLE for management of excavated source area soils.
		On-Site Land Disposal	Dispose of excavated soils within an appropriately-designed on-site land disposal facility (or facilities).	POTENTIALLY APPLICABLE for management of excavated source area soils.
		Solidification / Stabilization (S/S)	Treatment of excavated soil to immobilize contaminants via various solidification/stabilization agents (e.g., absorbents, cement-based, lime-based or pozzolanic, thermoplastic, organic polymer, silicon- or organic-based, surface encapsulation).	POTENTIALLY APPLICABLE for ex-situ treatment of excavated source area soils.
		Vitrification	Thermal treatment and solidification process that converts contaminated soil into a chemically inert, stable glass and crystalline product. During this process, the increased temperature may also volatilize and/or destroy organic contaminants or volatile metal species that must be collected for treatment or disposal.	POTENTIALLY APPLICABLE for ex-situ treatment of excavated source area soils.
		Soil Washing	Physical/chemical removal of contaminants from excavated soil using water or water-containing additives as extraction fluids.	POTENTIALLY APPLICABLE for ex-situ treatment of excavated source area soils.
		Solvent Extraction	Separation/removal of contaminants from excavated soil by solubilizing/dissolving the contaminants into an organic extraction fluid.	POTENTIALLY APPLICABLE for ex-situ treatment of VOCs/DNAPL in excavated source area soils.
		Chemical Oxidation	Chemical treatment to increase oxidation state of target COPCs in excavated soil thereby reducing mass, toxicity, and or mobility.	POTENTIALLY APPLICABLE for ex-situ treatment of VOCs/DNAPL in excavated source area soils.
		Chemical Reduction	Chemical treatment to reduce oxidation state of target COPCs in soil thereby reducing mass, toxicity, and or mobility.	POTENTIALLY APPLICABLE for ex-situ treatment of Cr(VI) and VOCs in excavated source area soils.
		pH Adjustment	Neutralization of excavated soil.	POTENTIALLY APPLICABLE as an enhancement to other ex-situ process options for remediating excavated source area soils.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU SOURCE AREA TREATMENT (continued)	**Ex-Situ Biological Treatment**	**Biopiles**	Excavated soils are mixed with soil amendments and placed in aboveground enclosures. It is an aerated static pile composting process in which compost is formed into piles and aerated with blowers or vacuum pumps.	REJECTED. This process option has limited applicability to the range of chemical constituents encountered at the Site.
		Composting	Excavated soil is mixed with bulking agents and organic amendments such as wood chips, hay, manure, and vegetative (e.g., potato) wastes in a controlled environment and composted under thermophillic conditions. Composting can be performed in piles or windrows, in bags (e.g. "Ag-Bags"), or in concrete treatment cells.	POTENTIALLY APPLICABLE for ex-situ treatment of perchlorate and VOCs in excavated source area soils.
		Landfarming	Contaminated media (soils, sludges, or sediments) is applied into lined beds and periodically turned over or tilled to aerate the waste. The waste, soil, climate, and biological activity interact dynamically as a system to degrade, transform, and immobilize contaminants.	REJECTED. Difficulties in controlling releases of VOCs to the air. Does not address inorganic contaminants.
		Slurry-Phase Biological Treatment	Slurry-phase biological treatment involves the controlled treatment of excavated soil in an aerobic bioreactor. The excavated soil is first processed to physically separate stones and rubble. The solids are maintained in suspension in a reactor and mixed with nutrients and oxygen. When biodegradation is complete, the soil slurry is dewatered.	REJECTED. This process option has limited applicability to the range of chemical constituents encountered at the Site.
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT	**In-Situ Physical-Chemical Treatment**	**Soil Flushing with Water**	Inject water into the subsurface or apply water at the surface in infiltration basins to enhance recovery of mobile contaminants such as perchlorate under hydraulically controlled conditions.	POTENTIALLY APPLICABLE for removal of perchlorate and chromium under hydraulically controlled conditions.
		Co-Solvent / Surfactant Flushing	Inject surfactants or solvents into the saturated zone to facilitate desorption and removal of bound contaminants and/or DNAPL. Contaminants are solubilized/dissolved into an extraction fluid that requires further treatment.	POTENTIALLY APPLICABLE for remediation of VOC/DNAPL source areas under hydraulically controlled conditions.
		Air Sparging	Inject air into saturated zone to remove contaminants through volatilization. Requires vapor extraction for recovery and aboveground treatment for treatment of vapors.	POTENTIALLY APPLICABLE for remediation of VOCs in shallow saturated zones.
		In-situ Well Stripping (UVB Wells)	In-well air stripping, aeration, and water recirculation system for VOC removal.	POTENTIALLY APPLICABLE for remediation of VOCs in groundwater.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**Soil Vapor Extraction (SVE)**	Removal of VOCs in vapor form by applying vacuum to the subsurface. Can be used as a process option along with thermal and vapor treatment technologies.	POTENTIALLY APPLICABLE for remediation of VOCs in vadose zone source areas or for use in conjunction with thermal treatment technologies.
		Multi-Phase Extraction (MPE)	Use a central vacuum source and submersible pumps to extract contaminated groundwater, vapor, and DNAPL. Ex-situ treatment is typically required for each of the extracted phases.	POTENTIALLY APPLICABLE for remediation of shallow VOC source areas where DNAPL is present.
		2-Phase Extraction (TPE)	Simultaneous extraction of vapor and groundwater using a central vacuum source (e.g., a high-vacuum liquid ring blower). Depth of treatment is limited to about 30 feet below ground surface due to limitations of liquid suction lift. Similar to SVE with the addition of dewatering effects. Ex-situ treatment is typically required for each of the extracted phases.	REJECTED. Depth to groundwater where remediation of VOCs would potentially be implemented is expected to be deeper than the effective limit of this technology.
		Dual-Phase Extraction (DPE)	Removal of VOCs via simultaneous extraction of vapor and groundwater using combination of a central vacuum source and submersible pumps. Similar to SVE with the addition of dewatering effects. Ex-situ treatment is typically required for each of the extracted phases.	POTENTIALLY APPLICABLE for remediation of shallow VOC source areas and/or for excavation or construction dewatering in lower permeability formations.
		Electrokinetics	Application of a low-intensity current between electrodes placed in the soil to mobilize metals and polar organic compounds to the electrodes in the form of charged species, particles and ions. This is a non-destructive process requiring removal and treatment of the sequestered contaminants.	POTENTIALLY APPLICABLE for remediation of Cr(VI) in low-permeability zones.
		Solidification / Stabilization (S/S)	Solidification/stabilization (S/S) uses various chemical binders to immobilize contaminants within the soil matrix instead of removing them through chemical or physical treatment. Leachability testing is typically performed to measure the immobilization of contaminants.	POTENTIALLY APPLICABLE for immobilization of metals.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**Geochemical Fixation**	In-situ fixation of metals by oxidation/reduction, precipitation, and/or complexation reactions. This is a non-destructive process that immobilizes metals in the soil matrix. Chemicals are introduced into extracted groundwater and then re-injected via wells, or in some cases, by infiltration.	POTENTIALLY APPLICABLE for immobilization of Cr(VI) using ferrous sulfate.
		Vitrification	Thermal treatment and solidification process that converts contaminated soil into a stable glass and crystalline product. This is a non-destructive process (for inorganics) that immobilizes metals in a crystalline matrix. VOCs are volatilized, and in some cases, destroyed in the process, but off-gas from this process needs to be recovered and treated.	POTENTIALLY APPLICABLE for immobilizing Cr(VI) and simultaneously removing VOCs in shallow soil.
		Steam / Hot Water Injection	Thermal treatment using injected steam or hot water applied to porous media to remove and/or vaporize volatile or semivolatile compounds. Requires vapor/water recovery and ex-situ treatment process options.	POTENTIALLY APPLICABLE for remediation of VOCs/DNAPL in groundwater and vadose zone source areas.
		Electric Resistivity Heating (ERH)	Thermal treatment using electrical resistance to heat subsurface and remove and/or vaporize volatile or semivolatile compounds. Requires vapor recovery and ex-situ treatment process options.	POTENTIALLY APPLICABLE for remediation of VOCs/DNAPL in groundwater and vadose zone source areas.
		Radio Frequency (RF) Heating	Thermal treatment using radio frequencies to heat the subsurface and remove and/or vaporize volatile or semivolatile compounds. Requires vapor recovery and ex-situ treatment process options.	POTENTIALLY APPLICABLE for remediation of VOCs/DNAPL in vadose zone source areas.
		Thermal Conductive Heating	Thermal treatment using surface or subsurface conductive heating elements to heat the subsurface and remove, and/or vaporize volatile or semivolatile compounds. Requires vapor recovery and ex-situ treatment process options.	POTENTIALLY APPLICABLE for remediation of VOCs/DNAPL in groundwater and vadose zone source areas.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**In-Situ Chemical Reduction**	Apply reductants to treat contaminants in-situ. Zero valent iron (ZVI) or other reducing agents are introduced into the subsurface by direct injection, injection via wells, recirculation, in-situ soil mixing, or construction of permeable reactive barriers to initiate chemical reduction reactions. Combining ZVI with a carbon source, would add biological reduction to this process option allowing removal of perchlorate.	POTENTIALLY APPLICABLE for remediation of Cr(VI) and VOCs/DNAPL in groundwater and vadose zone source areas.
		In-Situ Chemical Oxidation	Apply oxidants to destroy contaminants in-situ. Typically oxidants include ozone, hydrogen peroxide, sodium / potassium permanganate, and sodium persulfate. Application types include direct injection, injection via wells, recirculation, in-situ soil mixing, and construction of permeable reactive barriers.	POTENTIALLY APPLICABLE for remediation of VOCs/DNAPL in groundwater and vadose zone source areas.
		In-Situ Nanoscale Materials and Bimetallic Particles	Apply nanoscale particles for in-situ treatment of perchlorate and VOCs/DNAPLs. Nanoscale particles represent a new generation of remediation technologies that employ particles having large surface areas and high surface reactivity. Nanoscale zero-valent iron (nZVI) ,bimetallic particles (BNPs), and titanium dioxide (TiO_2) can potentially treat a wide variety of contaminants including VOCs/DNAPLs and perchlorate in contaminated water. Application types could include direct injection, injection via wells, recirculation, in-situ soil mixing, and construction of permeable reactive barriers.	POTENTIALLY APPLICABLE for remediation of VOCs/DNAPL and perchlorate in groundwater. This technology is in the early stages of development.
	In-Situ Biological Treatment	**Bioventing**	Uses low air flow rates to provide oxygen to stimulate the in-situ biodegradation of aerobically-degradable compounds in soil. Oxygen is most commonly supplied through direct air injection into residual contamination in soil.	REJECTED. Limited applicability to the range of chemical constituents encountered at the Site.
		Enhanced Reductive Bioremediation - Mobile Amendments	Use low-viscosity organic substrates to produce a reductive biological reaction zone in which contaminants are degraded by microorganisms. Substrate delivery modes can be active (e.g. recirculation via extraction and injection wells or passive (e.g., direct injection). Recirculation can be employed vertically or horizontally.	POTENTIALLY APPLICABLE for remediation of perchlorate and VOCs in groundwater.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Biological Treatment (continued)**	**Enhanced Reductive Bioremediation - Fixed Biobarriers**	Use solid or viscous organic substrates placed across the flow path of contaminated groundwater to form a permeable reactive barrier in which contaminants are reductively degraded by microorganisms. The fixed biobarrier approach can use engineered trenches or barriers containing solid-phase, slow-release substrates or viscous substrates placed crossgradient via direct-push injections. Pumping and injection of groundwater (in "active" mode) can be used to enhance performance.	POTENTIALLY APPLICABLE for remediation of perchlorate and VOCs in shallow groundwater.
		Bioaugmentation	Introduce a specialized microorganism or microbial consortium having demonstrated environmental benefits including the ability to perform biodegradation of specific contaminants. The introduction of microorganisms may add capabilities that are lacking or increase existing biodegradation rates. There are commercially-available consortia capable of a wide array of environmental activities. Delivery mechanisms are similar to those for substrates.	POTENTIALLY APPLICABLE as an enhancement to other in-situ biological treatments.
		Enhanced Reductive Bioremediation via Liquid Phase Substrate Addition to Vadose Zone	Liquid delivery of electron donors into the vadose zone to promote reductive biodegradation. Potential electron donors include ethanol, acetate, molasses, mushroom compost, and manure. Application methods include sprinkler irrigation, direct injection, or periodic flooding via infiltration galleries.	POTENTIALLY APPLICABLE for remediation of vadose zone source areas contaminated with perchlorate, Cr(VI), and VOCs.
		Enhanced Reductive Bioremediation via Gaseous Phase Substrate Addition or "Anaerobic Bioventing"	Inject gaseous electron donors in the vadose zone to promote reductive biodegradation. Gaseous substrate can also be sparged into (and through) the saturated zone to promote biodegradation. Potential electron donors include propane, hydrogen, carbon dioxide, various alkanes, or combinations thereof. Application methods include direct gas injection and soil vapor extraction, amendment and reinjection.	POTENTIALLY APPLICABLE for remediation of source areas contaminated with perchlorate.
		Enhanced Aerobic Biodegradation	Use air, oxygen, or an oxygen releasing compound and other nutrient amendments to aerobically degrade contaminants.	REJECTED. Limited applicability to the range of chemical constituents encountered at the Site.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Biological Treatment (continued)**	**Phytoremediation**	Use of plants to remove, transfer, stabilize, or destroy contaminant in soil, sediment, and groundwater. The mechanisms of phytoremediation include rhizosphere biodegradation, phytoextraction, phytodegradation, and phytostabilization.	POTENTIALLY APPLICABLE where concentrations are relatively low and contamination is shallow.
	In-Situ Process Enhancements	**Pneumatic Fracturing**	Inject pressurized gas to produce fractures in low permeability layers in order to increase effectiveness of extraction or to facilitate the delivery of chemicals/substrates in the subsurface.	POTENTIALLY APPLICABLE as an enhancement to extraction and/or various in-situ process options for increasing permeabilities in the UMCf.
		Hydraulic Fracturing	Inject high-pressure water and/or a polymer gel to produce fractures in low permeability layers in order to increase effectiveness of extraction or to facilitate the delivery of chemicals/substrates in the subsurface.	POTENTIALLY APPLICABLE as an enhancement to extraction and/or various in-situ process options for increasing permeabilities in the UMCf.
		Funnel and Gate	Direct groundwater flow with low permeability walls (funnel) to a high hydraulic conductivity treatment zone (gate). To ensure that flow beneath the system does not occur, the system must be keyed into an underlying low permeability layer.	POTENTIALLY APPLICABLE as an enhancement to extraction and/or various in-situ process options.
		Directional Wells	Use drilling techniques to position wells horizontally, or at an angle, to reach contaminants not accessible by direct vertical drilling.	POTENTIALLY APPLICABLE as an enhancement to extraction and/or various in-situ process options.
		Soil Flooding	Infiltration to enhance recovery of mobile contaminants such as perchlorate under hydraulically controlled conditions. In constant head applications, this process option can also supply a hydraulic driving force for in-situ remediation.	POTENTIALLY APPLICABLE as an enhancement to extraction and/or various in-situ process options.
		Bioremediation	Use of biological organisms for degradation and/or transformation of contaminants into less toxic, less mobile, and/or more treatable compounds. Bioremediation occurs via numerous direct metabolic pathways as well as from indirect cometabolic reactions and can involve communities of organisms working in tandem. Treatment times may be longer than other process options and depend on the type and concentration of contaminants, the availability of substrates and/or nutrients, presence of inhibiting compounds or conditions, and type and population density of the responsible organism(s).	POTENITALLY APPLICABLE as an enhancement for various extraction and/or in-situ process options.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
WATER DISCHARGE	Surface Water Discharge	Surface Water	Discharge treated water to storm sewer system or other surface water discharge under NPDES permit.	APPLICABLE as treated groundwater is currently being discharged to the Las Vegas Wash under an NPDES permit.
	Sewer Discharge	Public Owned Treatment Works (POTW)	Discharge treated water to public owned treatment works.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash.
	Water Reuse	Reclamation	Provide treated groundwater as an alternate water resource for use on-site.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash.
	Subsurface Water Discharge	Injection Wells	Pump treated groundwater or amended groundwater into subsurface via injection wells.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash or as a method of adding groundwater amendments (e.g., nutrients or substrates) for in-situ treatment.
		Deep Re-Injection Trenches (DRITs)	Re-injection of treated or amended groundwater into deep trenches backfilled with porous media.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash or as a method of adding groundwater amendments (e.g., nutrients or substrates) for in-situ treatment.
		Infiltration	Discharge treated groundwater into infiltration basins/ trenches for artificial groundwater recharge.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash or as a method of adding groundwater amendments (e.g., nutrients or substrates) for in-situ treatment.
		Pittman Bypass Pipeline	A pipeline currently used to convey discharged wastewater from nearby industrial sites to Las Vegas Wash.	POTENITALLY APPLICABLE as a means of conveying discharged water to Las Vegas Wash.
		Zero Discharge/ Enhanced Evaporation	Enhanced evaporation of treated effluent using sprayers, bubblers, or other equipment.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash.
		Solar Evaporation	Disposal of treated effluent in lined, bermed evaporation ponds.	POTENTIALLY APPLICABLE for discharge of treated groundwater as an alternative to the Las Vegas Wash.

TABLE 5-3. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES
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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
EX-SITU VAPOR TREATMENT	**Ex-Situ Vapor / Emissions / Off-gas Treatment**	**Vapor Phase Carbon Adsorption**	Treatment of extracted soil vapors and other process vapors by physical adsorption onto vapor-phase GAC. Contaminants are not destroyed and GAC must be regenerated off-site.	POTENTIALLY APPLICABLE for extracted soil vapors from MPE/TPE/DPE systems and/or from ex-situ treatment train emissions.
		Advanced Oxidation	Treatment of extracted soil vapors and other process vapors by advanced oxidation including the use of UV light to break chemical bonds.	POTENTIALLY APPLICABLE for extracted soil vapors from MPE/TPE/DPE systems and/or from ex-situ treatment train emissions.
		Catalytic Oxidation	Treatment of extracted soil vapors and other process vapors by oxidation initiated by catalysts. Catalyst systems used to oxidize VOCs typically use metal oxides such as nickel oxide, copper oxide, manganese dioxide, or chromium oxide. Noble metals such as platinum and palladium may also be used.	POTENTIALLY APPLICABLE for vapors from MPE/TPE/DPE systems and/or from ex-situ treatment train emissions.
		Scrubbing	Treatment of extracted soil vapors and other process vapors by scrubbing. Scrubbing describes a wide array of processes, both wet and dry, for cleansing air of acid gases, particulates, and other contaminants.	REJECTED. Limited applicability to the range of chemical constituents encountered at the Site.
		Thermal Oxidation	Treatment of extracted soil vapors and other process vapors by thermal oxidation using units equipped with a propane or natural gas burner and a stack.	POTENTIALLY APPLICABLE for vapors from MPE/TPE/DPE systems and/or from ex-situ treatment train emissions.
		Biofiltration	Vapor-phase organic contaminants are pumped through a bed of porous media where they sorb to the particle surface and are degraded by microorganisms. The media is typically a sieved compost material.	POTENTIALLY APPLICABLE for vapors from MPE/TPE/DPE systems and/or from ex-situ treatment train emissions.

Notes: COPCs = chemicals of potential concern; Cr(VI) = Hexavalent Chromium; DNAPL = Dense Non-Aqueous Phase Liquids; LNAPL = Light Non-Aqueous Phase Liquids; RAOs = Remedial Action Objectives; TDS = Total Dissolved Solids; UMCf = Upper Muddy Creek Formation; VOCs = volatile organic compounds; ZVI = Zero Valent Iron

Shaded boxes indicate process options that are retained for the secondary screening evaluation.
Unshaded process options have been eliminated and will not be considered further.

TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
NO FURTHER ACTION	**No Further Action**	**No Action**	Effective in meeting the short-term RAO of achieving chemical-specific ARARs/TBCs within the Las Vegas Wash, but is not effective in meeting long-term RAOs.	The No Action alternative has been implemented at the Site through the Interim Removal Actions described in Section 4 of this Work Plan.	Low	Low	Not likely to meet RAOs. Required for comparison by National Contingency Plan (NCP).
INSTITUTIONAL CONTROLS	**Groundwater Use Restrictions**	**Access Restrictions to Groundwater**	Demonstrated.	Implementable.	Low	Low	RETAINED.
	Site Access Restrictions	**Site Management Plan (SMP)**	Demonstrated effective and widely used to manage risks related to residual contamination remaining in place at industrial sites.	Readily implementable.	Low	Low	RETAINED. Already implemented at the Site to manage risks related to residual contamination.
		Fences / Gates	Demonstrated effective and widely used.	Readily implementable.	Low	Low	RETAINED. Already implemented to restrict access to certain areas of the Site.
		Warning Signs	Demonstrated effective and widely used.	Readily implementable.	Low	Low	RETAINED. Already implemented to restrict access to certain areas of the Site.
	Legal Restrictions to Land Use	**Deed Restrictions**	Demonstrated effective and widely used.	Readily implementable.	Low	Low	RETAINED.
MONITORING	**Groundwater Monitoring**	**Routine Sampling and Measurement of Groundwater**	This action alone does not meet RAOs	Readily implementable.	Low	Low	RETAINED. Already implemented at the Site to monitor groundwater contaminant plumes containing perchlorate and Cr(VI).
MONITORED NATURAL ATTENUATION	**Monitored Natural Attenuation**	**Monitored Natural Attenuation of Groundwater**	Demonstrated effective, particularly for VOCs.	Readily implementable.	Low	Low	RETAINED. May be applicable after sources of groundwater contamination have been addressed, or in areas where residual concentrations of contamination are low.

TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
CONTAINMENT	**Vertical Subsurface Barriers**	**Slurry Wall**	Demonstrated and widely used to control groundwater flow. Currently in use at the on-site Barrier Wall to increase capture of contaminated groundwater at the IWF.	Readily implementable.	Low to Moderate	Low	RETAINED.
		Grout Curtain	Demonstrated to control groundwater flow, but generally regarded as less effective than slurry walls.	Readily implementable.	Low to Moderate	Low	REJECTED. Offers no distinctive advantages over slurry walls, which have been demonstrated effective at the Site.
		Diaphragm Walls	Demonstrated to control groundwater flow. Provides a greater degree of structural strength than other vertical barriers which may not be necessary.	Readily implementable.	Moderate	Low	REJECTED. The added structural strength of diaphragm walls is not anticipated to be necessary; therefore, this process option offers no distinctive advantages over slurry walls, which have been demonstrated effective at the Site.
		Steel Sheet Pile Walls	Demonstrated to control groundwater flow, but generally regarded as less effective than slurry walls.	Readily implementable.	Low to Moderate	Low	REJECTED. Offers no distinctive advantages over slurry walls, which have been demonstrated effective at the Site.
		Vibrating Beam Slurry Walls	Demonstrated to control groundwater flow, but generally regarded as less effective than slurry walls.	Readily implementable	Low to Moderate	Low	REJECTED. Offers no distinctive advantages over slurry walls, which have been demonstrated effective at the Site.
	Horizontal Subsurface Barriers	**Grout Injection by Vertical Drilling**	Effectiveness not well-demonstrated. Studies indicate that conventional grout technology cannot produce an impermeable horizontal barrier because it cannot ensure uniform lateral distribution.	Placement of horizontal barriers below existing contamination is difficult to implement successfully.	Low to Moderate	Low	REJECTED due to limited effectiveness and expected difficulties in implementation.

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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
CONTAINMENT (continued)	**Horizontal Subsurface Barriers (continued)**	**Grout Injection by Vertical Drilling and Jet Grouting**	Effectiveness not well-demonstrated. Although studies indicate some success with jet grouting techniques in soils that contain fines with no large stones or boulders that deflect the cutting jet; however, it is difficult to ensure uniform lateral distribution.	Placement of horizontal barriers below existing contamination is difficult to implement successfully.	Low to Moderate	Low	REJECTED due to limited effectiveness and expected difficulties in implementation.
		Grout Injection by Horizontal Drilling	Effectiveness not well-demonstrated. Studies indicate that conventional grout technology cannot produce an impermeable horizontal barrier because it cannot ensure uniform lateral distribution of the grout.	Placement of horizontal barriers below existing contamination is difficult to implement successfully.	Low to Moderate	Low	REJECTED due to limited effectiveness and expected difficulties in implementation.
	Capping / Surface Water Recharge Control	**Single-Layer Clay Cap**	Demonstrated, but generally less effective than multilayered cap in reducing infiltration. Subject to erosion.	Readily implementable.	Low to Moderate	Low	REJECTED due to erosion concerns.
		Single-Layer Synthetic Membrane	Demonstrated, but generally less effective than multilayered cap in reducing infiltration.	Readily implementable.	Low to Moderate	Low	RETAINED, for possible use to reduce infiltration over localized areas. May be incompatible with future land use plans.
		Single-Layer Soil Cement / Clay Mixture	Demonstrated effective, but generally less effective than multi-layered cap in reducing infiltration. Subject to erosion.	Readily implementable.	Low to Moderate	Low	REJECTED due to erosion concerns.
		Multi-Layered Cap System	Demonstrated effective for reducing infiltration and contaminant migration. Precautions must be taken to avoid erosion or degradation of the cover materials, including the clay layer, in storm water drainage areas and steeply sloping areas.	Readily implementable in areas where slopes do not exceed 1.5:1. Multi-layer system includes a base clay layer, intermediate gravel drainage layer, and soil cover layer which must be protected from erosion.	Moderate to High	Moderate	RETAINED, for possible use to reduce infiltration over localized areas. May be incompatible with future land use plans.

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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
CONTAINMENT (continued)	**Capping / Surface Water Recharge Control (continued)**	**Asphalt / Concrete Paving**	Demonstrated effective for reducing infiltration and contaminant migration. Concrete is subject to cracking.	Readily implementable.	Low to Moderate	Low	RETAINED, for possible use to reduce infiltration over localized areas. May be incompatible with future land use plans.
		Shotcrete	Demonstrated effective in certain applications. Shotcrete can be applied to steep slopes to form a seal for slope stabilization and erosion control. Shotcrete has a tendency to crack, which reduces its effectiveness as a cover material and in preventing infiltration.	Readily implementable.	Moderate	Low to Moderate	REJECTED. Steep drainages are not present at the Site.
GROUNDWATER EXTRACTION	**Groundwater Extraction ("Pump & Treat")**	**Extraction Wells**	Demonstrated effective and widely used for groundwater recovery. Effectiveness of recovery depends primarily on local hydrogeology.	Readily implementable.	Moderate	Low to Moderate	RETAINED. Already implemented at the Site for groundwater recovery for ex-situ treatment.
		Subsurface Drains and Interceptor Trenches	Demonstrated effective and widely used for groundwater recovery. Effectiveness of recovery depends primarily on local hydrogeology.	Readily implementable.	Low to Moderate	Low	RETAINED. Potentially applicable to enhance localized groundwater recovery.
EX-SITU GROUNDWATER TREATMENT	**Ex-Situ Physical-Chemical Treatment**	**Air Stripping**	Demonstrated effective and widely used for treatment of VOCs with high Henry's Law constant.	Readily implementable.	Moderate	Moderate	RETAINED. This process is feasible for VOCs, but not effective for inorganics.
		Steam Stripping	Demonstrated effective for treatment of VOCs, but not widely used in groundwater treatment applications.	Implementable.	High	High	REJECTED. This technology is not cost competitive with other comparable technologies.
		Liquid- Liquid Separation / Extraction	Demonstrated effective for removing organic contaminants, but not widely used in groundwater treatment applications.	Implementable, but produces a new and potentially difficult-to-treat liquid waste stream.	High	Moderate to High	REJECTED. This technology is not cost competitive with other comparable technologies.

TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Liquid-Phase Carbon Adsorption Using Granular Activated Carbon (GAC)**	Demonstrated effective and widely used for treatment of organic contaminants. Not generally effective for inorganic contaminants.	Readily implementable.	Low to Moderate	Moderate	RETAINED. This process is feasible for treatment of VOCs.
		Liquid-Phase Carbon Adsorption Using Tailored GAC (T-GAC)	Demonstrated effective at smaller scales for treatment of various contaminants including perchlorate, but nitrate and sulfate will competitively adsorb resulting in faster breakthrough times for perchlorate.	Implementable, but treatability tests would be required. Limited commercial vendors for this specialized product.	Moderate	Moderate to High	REJECTED due to limited demonstrated use as full-scale groundwater treatment technology and high O&M costs when used to treat concentrated waste streams.
		Chemical Reduction	Demonstrated effective and widely used for treatment of metal-containing and some organic waste streams. Ferrous sulfate currently used at the Site for Cr(VI) removal.	Readily implementable.	Low to Moderate	Moderate	RETAINED. This process is feasible for removal of elevated concentrations of Cr(VI) in conjunction with chemical precipitation.
		Chemical Oxidation	Demonstrated effective and widely used for treatment of organic compounds including VOCs in liquid waste streams. Not effective for treating perchlorate and Cr(VI).	Readily implementable.	Low to Moderate	Moderate to High	REJECTED. This technology is not cost competitive with other comparable process options for treatment of VOCs. Not effective for perchlorate or Cr(VI).
		Advanced Oxidation Processes	Demonstrated effective and widely used for treatment of organic compounds in liquid waste streams. Not effective for treating perchlorate and Cr(VI).	Implementable.	High	High	REJECTED. This technology is not cost competitive with other comparable technologies.
		Chemical Precipitation	Demonstrated effective and widely used for treatment of metal-containing waste streams.	Readily implementable.	Low to Moderate	Moderate	RETAINED. This process is feasible for removal of elevated concentrations of Cr(VI) in conjunction with chemical reduction and is currently in use as part of the interim measures.

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EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Coagulation / Flocculation**	Demonstrated effective and widely used for clarification of suspended solids in various waste streams.	Readily implementable.	Low to Moderate	Moderate	RETAINED. Potentially applicable as a polishing or pretreatment step in an aboveground treatment train, but not likely a stand-alone or primary treatment.
		Electrochemical Precipitation	Demonstrated effective for treatment of Cr(VI) and other metal-containing waste streams. Reportedly, can produce less sludge than equivalent chemical reduction process, but involves more complexity and more intensive O&M. Used at the Site until 2004. On-site unit required weekly cleaning with hydrochloric acid to maintain effectiveness.	Readily implementable.	Moderate	Moderate	REJECTED. This process is feasible for removal of elevated concentrations of Cr(VI), but requires more intensive O&M than the ferrous sulfate process currently in use and offers no distinctive advantages.
		Ion Exchange Using Single-Use Resins	Demonstrated effective and widely used for treatment of ionic contaminants. Not effective for VOCs. Single-use ion-exchange treatment was in use at Site from 2001-2004.	Readily implementable.	Moderate	Moderate	RETAINED. This process is suitable for removal of perchlorate and Cr(VI), but not for VOCs. More cost effective at lower influent concentrations. Used at the Site from 2001-2004.
		Ion Exchange Using Regenerable Resins	Demonstrated for treatment of ionic contaminants. Not effective for VOCs. Ion-exchange using regenerable resins was in use at the Site for 6 months in 2002. Maintenance problems were reported due to elevated total dissolved solids, hardness, and sulfate.	Implementable, but requires studies on regenerative capabilities and potentially long startup times.	Moderate	High	REJECTED. Difficulties in regeneration have been encountered during previous attempted use at the Site. Costs are expected to be higher than use of single-use resins with little or no performance gains.

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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Reverse Osmosis**	Demonstrated effective as a stand-alone technology to remove perchlorate at low concentrations and produce drinking-quality water. Effective as a polishing step to further reduce perchlorate concentrations from water treated by other technologies including bioreactors, GAC, and/or ion exchange.	Implementable.	High	High	REJECTED. This technology is not cost competitive with other comparable technologies.
		Nanofiltration / Ultrafiltration	Not yet demonstrated to effectively remove perchlorate ions, but capable of managing water with high total dissolved solids as a potential pretreatment step.	Implementable, but treatability tests would be required. Limited commercial vendors for this specialized process.	Moderate	Moderate	REJECTED due to limited effectiveness for treatment of perchlorate and high costs in relation to comparable options.
		Electrodialysis	Demonstrated effective at smaller scales for treating ionic contaminants including perchlorate at low concentrations, but is more effective as a polishing step when coupled with ion exchange. Capable of managing water with high TDS.	Potentially implementable, but treatability tests would be required. Limited commercial vendors for this specialized process.	High	High	REJECTED. This technology is not cost competitive with other comparable technologies.
		Capacitive Deionization	Demonstrated effective for desalination of brackish water at pilot-scale. Not demonstrated as a full-scale treatment.	Potentially implementable, but treatability tests would be required. Limited commercial vendors for this specialized process.	High	High	REJECTED due to low rates of regeneration and current high costs of specialized electrodes.
		Electrolysis	Demonstrated effective for removal of low levels of perchlorate and nitrates in water supply wells in a pilot-scale test. No full-scale demonstrations. Currently has high energy requirements.	Still in research and development; likely not implementable for some time.	High	High	REJECTED. This technology is still in development and is therefore not expected to be cost competitive with other comparable technologies for the foreseeable future.

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EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Ultraviolet (UV) Laser Reduction**	Demonstrated in laboratory testing to be effective for decomposing low levels (<100 µg/L) of perchlorate dissolved in water. Not effective for high perchlorate concentrations. Preliminary tests using UV laser reduction indicate that other common perchlorate co-contaminants such as chlorinated solvents can also be decomposed.	Still in research and development; likely not implementable for some time.	High	High	REJECTED. This technology is still in development and is therefore not expected to be cost competitive with other comparable technologies for the foreseeable future.
		Zero Valent Iron (ZVI) Reduction of Perchlorate	Demonstrated in laboratory testing using UV light to be effective for reducing perchlorate to chloride ions, but rates were slow. Laboratory testing using phosphoric acid perchlorate was removed at low pH.	Still in research and development; likely not implementable for some time.	High	High	REJECTED. This technology is still in development and is therefore not expected to be cost competitive with other comparable technologies for the foreseeable future.
		Titanium Reduction	Normally a slow reaction, laboratory study has identified reaction media in which reduction of perchlorate to chloride by Ti(III) takes place quite rapidly (half-life of minutes). The products of the reaction are titanium dioxide and chloride salts. The produced Ti(IV) can be reduced to Ti(III) by electrochemical or chemical means.	Still in research and development; likely not implementable for some time.	High	High	REJECTED. This technology is still in development and is therefore not expected to be cost competitive with other comparable technologies for the foreseeable future.
		Catalytic Hydrogen Gas Membrane	Laboratory studies have shown that it is possible to reduce perchlorate to chloride in dilute aqueous solutions at greater than 90% efficiency using atomic hydrogen using nonprecious metal catalysts.	Still in research and development; likely not implementable for some time.	High	High	REJECTED. This technology is still in development and is therefore not expected to be cost competitive with other comparable technologies for the foreseeable future.

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EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Nanoscale Materials and Bimetallic Particles**	Bimetallic Particles (BMPs) have been demonstrated effective in treating chlorinated solvents and perchlorate in bench-scale studies. Nanoscale ZVI (nZVI) has been demonstrated for treatment of VOCs/DNAPL. High surface energy of these materials make them highly reactive and susceptible to deactivation prior to contacting the targeted contamination. Agglomeration of particles can occur due to pH and other field conditions reduces effectiveness.	Potentially implementable, but treatability/pilot testing is needed to assess implementability under Site conditions. Research is ongoing regarding the potential toxicological/ecological effects of nanoscale materials.	High	High	REJECTED. This is an emerging technology limited to bench- and field studies. Costs are currently high in relation to comparable options. Concerns exist over nanoscale particles' fate, transport, and longevity in the environment.
	Ex-Situ Biological Treatment	**Anaerobic Fluidized Bed Reactors (FBRs)**	Demonstrated effective at sites with varying influent concentrations and flows. Demonstrated effective as long-term reliability as a perchlorate treatment alternative. Can support high-volume flows with smaller reactor sizes than comparable options. Requires pretreatment for Cr(VI) and VOCs to avoid toxic effects to microorganisms.	Implementable, but requires skilled system operators.	Moderate	High	RETAINED. Currently in use at the Site as the primary perchlorate treatment process option.
		Anaerobic Packed-Bed Reactors (PBRs)	Generally effective at lower influent concentrations, and can handle high inlet flows; however, unlike FBRs, there are no known full-scale PBRs treating perchlorate waste streams. Requires pretreatment for Cr(VI) and VOCs to avoid toxic effects to microorganisms.	Implementable, but requires skilled system operators.	Moderate	High	REJECTED. Unproven full-scale performance with no distinctive advantages over comparable process options.
		Anaerobic Continuously-Stirred Tank Reactors (CSTRs)	Demonstrated. Can be effective at high influent concentrations and with mixed waste streams (e.g. industrial process flows), but at lower flows than FBRs. Can operate as batch or continuous flow. Needs less pumping energy than FBRs. Requires pretreatment for Cr(VI) and VOCs to avoid toxic effects to microorganisms.	Implementable, but requires skilled system operators.	Moderate	High	RETAINED. This process option is retained as a potential alternative to FBRs.

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EX-SITU GROUNDWATER TREATMENT (continued)	**Ex-Situ Biological Treatment (continued)**	**Constructed Wetlands**	Demonstrated for treatment of a wide variety of organic and inorganic contaminants. Generally more effective at lower inlet concentrations to avoid toxic effects of contaminants. One documented full-scale application for perchlorate had favorable results at ppb inlet concentrations. Pilot-scale tests warranted to evaluate effectiveness at the Site.	Implementable, but requires land that can be dedicated long-term to construction of a wetland. Pilot-scale tests warranted to evaluate effectiveness at the Site.	Moderate	Low	REJECTED. Experience to date with perchlorate waste streams limited to bench and pilot studies except for a single full-scale process treating ppb-level inlet concentrations.
Excavation	**Source Area Soil Excavation**	**Excavation for Off-site Treatment/Disposal**	Demonstrated effective and widely used for a wide variety of contaminants.	Readily implementable for shallow vadose zone source areas. Deeper source areas require excavation through clean soils with more engineering complexity (e.g., sidewall shoring, etc.).	High	Negligible	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of COPCs.
		Excavation for On-site Treatment/Disposal	Demonstrated effective for a wide variety of contaminants, but not as widely used as off-site disposal.	Readily implementable for shallow vadose zone source areas. Deeper source areas require excavation through clean soils with more engineering complexity (e.g., sidewall shoring, etc.).	High	Negligible	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of COPCs.
EX-SITU SOURCE AREA TREATMENT	**Ex-Situ Physical-Chemical Treatment**	**Thermal Treatment**	Effective for removing VOCs/DNAPLS and low-boiling semi-volatile organic compounds. High temperature incineration may have effectiveness with perchlorate, but experience with this is limited.	Implementable, although significant materials handling issues are involved. Requires mobilization and staging of large equipment on-site making it more applicable to large/long-term projects.	High	Moderate to High	REJECTED. Large-scale soil excavation has already been undertaken at the Site and any additional excavation is expected to be limited; therefore, the significant capital costs associated with mobilization and start-up efforts for this process option are not considered cost effective.

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EX-SITU SOURCE AREA TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Thermal Desorption**	Effective in destroying organic contaminants including VOCs/DNAPLs. Limited experience at pilot-scale and on full-scale site demonstrates some effectiveness with perchlorate.	Implementable, although significant materials handling issues are involved. Requires mobilization and staging of large equipment on-site making it more applicable to large/long-term projects.	High	Moderate to High	REJECTED. Large-scale soil excavation has already been undertaken at the Site and any additional excavation is expected to be limited; therefore, the significant capital costs associated with mobilization and start-up efforts for this process option are not considered cost effective.
		Off-Site Land Disposal	Demonstrated effective and widely used for a wide variety of contaminants.	Readily implementable.	High	Negligible	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of COPCs.
		On-Site Land Disposal	Demonstrated effective for a wide variety of contaminants, but not as widely used as off-site disposal.	Implementable, but would require a potentially large area of the Site to be dedicated as a landfill.	High	Moderate	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of COPCs.
		Solidification / Stabilization (S/S)	Demonstrated for treatment of metals in soils; however, effectiveness varies by metal and the specific agent used. Cr(VI) is difficult to stabilize in cement due to formation of anions that are soluble at high pH. Typically, chemical reduction of Cr(VI) is required as a pretreatment step. Bitumen should not be used where strong oxidants, such as chlorate and perchlorate are present due to explosive hazards.	Implementable, although significant materials handling issues are involved. Requires mobilization and staging of large equipment on-site making it more applicable to large/long-term projects.	Moderate to High	Moderate	REJECTED. Large-scale soil excavation has already been undertaken at the Site and any additional excavation is expected to be limited; therefore, the significant capital costs associated with mobilization and start-up efforts for this process option are not considered cost effective. Furthermore, concerns exist over effectiveness with Site contaminants and the long-term reliability of treatment.

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EX-SITU SOURCE AREA TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Vitrification**	Demonstrated effective and widely used for metals. Most soils can be treated by vitrification and a wide variety of inorganic and organic contaminants can be targeted. Additional treatment steps may be necessary: including physical separation, mixing, and off-gas collection and treatment. Arsenic-containing wastes may require pretreatment to produce less volatile forms.	Implementable, although significant materials handling issues are involved. Requires mobilization and staging of large equipment on-site including off-gas collection and treatment facilities making it more appropriate for large projects.	High	Moderate	REJECTED. Large-scale soil excavation has already been undertaken at the Site and any additional excavation is expected to be limited; therefore, the significant capital costs associated with mobilization and start-up efforts for this process option are not considered cost effective.
		Soil Washing	Demonstrated effective for metals including chromium, but under only certain soil conditions. Conditions that favor soil washing include: having a single principal metal that occurs in dense, insoluble particles and very water or aqueous leachant soluble; and a soil containing a high proportion of soil particles >2 mm. Soil washing is generally considered a media transfer technology. The contaminated water generated from soil washing must then be treated with the technology(s) suitable for the contaminants.	Implementable, although significant materials handling issues are involved. Complex waste mixtures (e.g., metals with organics) make formulating washing fluid difficult.	Moderate to High	Moderate	REJECTED. Large-scale soil excavation has already been undertaken at the Site and any additional excavation is expected to be limited; therefore, the significant capital costs associated with mobilization and start-up efforts for this process option are not considered cost effective.
		Solvent Extraction	Demonstrated effective in treating soils containing organic contaminants. Organically bound metals can be extracted along with the target contaminants, thereby creating residuals with special handling requirements. Traces of solvent may remain within the treated soil matrix. Higher clay content reduces extraction efficiency.	Implementable, although significant materials handling issues are involved. Produces a difficult-to-treat waste stream.	High	Moderate	REJECTED. Large-scale soil excavation has already been undertaken at the Site and any additional excavation is expected to be limited; therefore, the significant capital costs associated with mobilization and start-up efforts for this process option are not considered cost effective. Furthermore, concerns exist over the ability to treat the resulting waste stream enriched in diverse COPCs.

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EX-SITU SOURCE AREA TREATMENT (continued)	**Ex-Situ Physical-Chemical Treatment (continued)**	**Chemical Oxidation**	Demonstrated effective for VOCs using commercial oxidizing agents including potassium permanganate, hydrogen peroxide, hypochlorite and ozone. However, it is an inefficient use of oxidizing agents within a soil matrix.	Implementable, but treatability studies likely needed to determine implementability and dosing. Potential for metals mobilization (e.g., chromium) that would need to be evaluated.	Moderate	Low to Moderate	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of VOCs. However, this process option is likely not appropriate for soils co-containing chromium due to the potential for mobilizing Cr(VI).
		Chemical Reduction	Demonstrated effective for VOCs and metals using commercial reducing agents including alkali metals (Na, K), sulfur dioxide, sulfite salts, and ferrous sulfate. However, it is an inefficient use of reducing agents within a soil matrix. Not effective for perchlorate due to high activation energy of the perchlorate ion.	Implementable, but treatability studies likely needed to determine implementability and dosing. Potential for metals mobilization (e.g., arsenic) that would need to be evaluated.	Moderate	Low to Moderate	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of VOCs. However, potential for metals mobilization would need to be evaluated.
		Neutralization	Demonstrated effective for acidic soils.	Implementable, although significant materials handling issues are involved.	Moderate	Low to Moderate	RETAINED. This process is potentially applicable as an amendment to other ex-situ source area process options.
	Ex-Situ Biological Treatment	**Composting**	Demonstrated effective for perchlorate and VOCs.	Implementable, although significant materials handling issues are involved.	Moderate	Low to Moderate	RETAINED. This process is retained as an option for areas where limited removals would eliminate significant quantities of perchlorate and/or VOCs.
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT	**In-Situ Physical-Chemical Treatment**	**Soil Flushing**	Demonstrated in the homogeneous subsurface. Heterogeneity may greatly limit the extent of flushing. Fine soil fractions in the UMCf and caliche encountered in the alluvium at the Site may limit effectiveness. To limit mobilization of contaminants, hydraulic control would need to be established.	Implementable, but treatability/pilot-testing is required to evaluate site-specific performance.	Low to Moderate	Low to Moderate	RETAINED. This process option is potentially applicable for reducing high concentrations of perchlorate in on-site vadose zone soils upgradient--and within the capture zone--of the on-site extraction wells. Treatability/pilot-testing necessary to evaluate performance.

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IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**Co-Solvent / Surfactant Flushing**	Demonstrated for VOC source zone and DNAPL removal. Heterogeneity may greatly limit the extent of flushing. Limited data on performance for metals impacted soils. Fine soil fractions in the UMCf and caliche encountered in the alluvium at the Site may limit effectiveness. To limit mobilization of contaminants, hydraulic control would need to be established.	Implementable, but treatability/pilot-testing is required to evaluate site-specific performance. Relies on reagents that may hinder existing groundwater treatment.	Moderate	Moderate to High	REJECTED due to concerns of secondary effects and relatively high cost. Solubilizing concentrated contaminants into a diluted solvent/surfactant matrix makes recovery and treatment more difficult and costly. Offers no distinctive advantages over soil flushing for perchlorate and Cr(VI).
		Air Sparging	Demonstrated effective and widely used for treatment of VOCs in groundwater. Less effective in heterogeneous and low-permeability water bearing zones.	Implementable.	Low to Moderate	Low to Moderate	RETAINED. Potentially applicable for removal of VOCs from shallow groundwater. Could also be employed to deliver gaseous phase substrate for enhanced reductive bioremediation of perchlorate. Effectiveness may be limited in the UMCf.
		In-Situ Well Stripping ("UVB Wells")	Demonstrated for VOCs with high Henry's Law Constants. Radius of influence is significantly reduced in heterogeneous and low-permeability water bearing zones.	Implementable.	Moderate	Low	RETAINED. Potentially applicable for removal of VOCs from shallow groundwater.
		Soil Vapor Extraction (SVE)	Demonstrated for soil remediation of VOCs having high Henry's Law Constants. Radius of influence is significantly reduced in heterogeneous and low-permeability soils.	Implementable for shallow soils. Pilot testing is needed to assess implementability under Site conditions.	Low to Moderate	Low to Moderate	RETAINED. Potentially applicable for removal of VOCs from shallow source area soils and in conjunction with other in-situ process options (e.g., air sparging, thermal technologies).

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IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**Multi-Phase Extraction (MPE)**	Demonstrated for VOC/DNAPL source zone removal in shallow aquifers. Most effective with LNAPL; limited ability to recover DNAPL. Contaminants not destroyed in situ. Above ground treatment required.	Implementable in a shallow aquifer. Pilot testing is needed to assess implementability under Site conditions.	Moderate	Moderate	RETAINED. Potentially applicable for removal of VOCs/DNAPL from groundwater and source area soils.
		Dual-Phase Extraction (DPE)	Demonstrated for remediation of VOCs in shallow aquifers. Contaminants not destroyed in situ. Above ground treatment required.	Implementable in a shallow aquifer. Pilot testing is needed to assess implementability under Site conditions.	Moderate	Moderate	RETAINED. Potentially applicable for removal of VOCs from groundwater and source area soils.
		Electrokinetics	Demonstrated effective at bench- and pilot-scale for sequestering heavy metals, anions, and polar organics in soil, mud, sledge, and marine dredging. Effective in low permeability soils with moisture contents above 10%. There have been few, if any, commercial applications of electrokinetic remediation in the United States.	Potentially implementable, but additional studies would be necessary to assess implementability under Site conditions. Not implementable in the vicinity of underground structures, utilities, and/or buried metal debris.	High	High	REJECTED. Experience to date limited to bench and pilot studies except for a metal removal process that has been commercially operated by a single European vendor.
		Solidification / Stabilization (S/S)	In situ S/S has been demonstrated for treatment of heavy metals in soils. Cr(VI) can be difficult to stabilize due to formation of anions that are soluble at high pH. Typically, chemical reduction of Cr(VI) is required as a pretreatment step. Future usage of the site may "weather" the materials and affect the ability to maintain immobilization of contaminants.	Potentially implementable, but certain materials are incompatible with variations of this process. Also, there are challenges in achieving complete and uniform mixing in-situ. Additional studies would be necessary to assess implementability under Site conditions.	Moderate to High	Low	REJECTED. Concerns exist over effectiveness with Site contaminants and the long-term reliability of treatment. Difficulty in achieving uniform mixing in-situ limits implementability.

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IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**Geochemical Fixation**	Demonstrated effective at immobilizing Cr(VI) using ferrous sulfate reduction and precipitation. However, ferrous sulfate based reductants may result in iron precipitation and clogging aquifer pore spaces. Reduced Cr could re-oxidize to Cr(VI) under certain conditions including presence of manganese dioxide.	Implementable, but treatability/pilot-testing is required to evaluate site-specific performance and long-term reliability.	Low to Moderate	Low	REJECTED. Concerns exist over clogging aquifer pore spaces and the long-term reliability of treatment.
		Vitrification	In-situ methods still in demonstration phase. The maximum treatment depth has been demonstrated to be about 20 feet. Limited data on long-term effectiveness. When excess chlorides are present, there is a possibility that dioxins and furans may form and enter the off-gas treatment system.	Potentially implementable for a small depth horizon (>5 and <20 feet below grade), but not in the vicinity of underground structures, utilities, and/or buried metal debris. Requires extensive pilot testing. Limited commercial availability.	High	Low	REJECTED. In-situ vitrification is still in development stage and has depth limitations. Higher costs than comparable technologies. Concerns exist over the long-term reliability of treatment and the generation of off-gas that must be treated.
		Steam / Hot Water Injection	Demonstrated effective for removal of VOCs from unsaturated and saturated zones. Not demonstrated for perchlorate or Cr(VI), but is expected to have some soil flushing capability. Most effective when the steam is able to enter the pore space of the soils and best suited for zones of moderate to high permeability. Steam dissolves, vaporizes, and mobilizes contaminants, which must be recovered using vapor and liquid extraction equipment for subsequent treatment.	Implementable, but a pilot study likely necessary to evaluate vapor recovery. There are relatively few commercial vendors for this technology.	High	High	REJECTED. The primary target contaminant groups for steam or hot water flushing/stripping are SVOCs and fuels. VOCs also can be treated by this technology, but there are more cost-effective processes for VOCs.

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IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**Electric Resistivity Heating (ERH)**	Demonstrated effective for removal of VOCs from unsaturated and saturated zones. ERH is particularly suited to the treatment of lower permeability strata and to DNAPLs that have become consolidated within lower permeability zones with higher organic content. Has the potential for short-term mobilization of contaminants in groundwater that must be monitored/addressed.	Implementable, but a pilot study likely necessary to evaluate vapor recovery. There are relatively few commercial vendors for this technology.	High	High	REJECTED. This technology is not cost competitive with other comparable technologies.
		Radio Frequency (RF) Heating	RF-heating, a variety of ERH that uses radio-frequency energy, has been applied to remediation of VOCs in the unsaturated zone, but its applicability in the saturated zone has been limited. Has the potential for short-term mobilization of contaminants in groundwater that must be monitored/addressed.	Implementable, but a pilot study likely necessary to evaluate vapor recovery. There are relatively few commercial vendors for this technology.	High	High	REJECTED. The significant zones of low permeability soils at the Site are expected to be saturated; conditions where this process option has limited applicability. This technology is also not cost competitive with other comparable technologies.
		Thermal Conductive Heating	Thermal conductive heating is suited to treating VOC source zones and DNAPL in most hydrogeologic conditions. Thermal conductive heating differs from other heating methods in that it does not rely solely on steam as a heat source or water as a conductive path. It can heat soils to temperatures in excess of 500°C. Has the potential for short-term mobilization of contaminants in groundwater that must be monitored/addressed.	Implementable, but a pilot study likely necessary to evaluate vapor recovery. There are relatively few commercial vendors for this technology.	High	High	REJECTED. This technology is not cost competitive with other comparable technologies.
		In-Situ Chemical Reduction (ISCR)	Zero valent iron (ZVI) and other reducing agents are demonstrated for VOC and DNAPL removal. Organic contaminants destroyed in-situ; some inorganic contaminants are potentially immobilized. Iron particles may be difficult to distribute in a low permeability formation, such as the UMCf.	Implementable, but treatability/pilot testing needed to evaluate implementability at the Site. Potential for metals mobilization (e.g., arsenic) that would need to be evaluated.	Moderate	Low	RETAINED. Potentially applicable for remediation of VOCs in shallow groundwater.

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IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Physical-Chemical Treatment (continued)**	**In-Situ Chemical Oxidation (ISCO)**	Demonstrated effective at rapidly and completely destroying many VOCs and DNAPLs; other organics are amenable to partial degradation. Field applications demonstrate that matching the oxidant and in-situ delivery system to the target contaminants and the site conditions is the key to successful implementation. Naturally-occurring organics and other organic matter can increase oxidant demand. Not effective in treating perchlorate and Cr(VI).	Implementable, but treatability studies likely needed to determine implementability and dosing. Potential for metals mobilization (e.g., chromium) that would need to be evaluated.	Moderate	Low	RETAINED. Potentially applicable for remediation of localized high concentrations of VOCs/DNAPLs in groundwater where the potential for chromium oxidation and mobilization is minimal.
		In-Situ Nanoscale Materials and Bimetallic Particles	BNPs have been demonstrated effective in treating chlorinated solvents and perchlorate in bench and field-scale studies. nZVI has been demonstrated for treatment of VOCs/DNAPL in bench- and field-studies. High surface energy of nanoscale materials makes them highly reactive and susceptible to passivation (i.e., deactivation) prior to contacting the targeted contamination. Agglomeration of particles can occur due to pH and other field conditions reduces effectiveness.	Potentially implementable, but treatability/pilot testing is needed to assess implementability under Site conditions. Knowledge is limited on the fate and transport of nanoscale materials, and their longevity, in the environment.	High	High	REJECTED. This is an emerging technology limited to bench- and field studies. Costs are currently high in relation to comparable technologies. Research is ongoing regarding the potential toxicological effects of nanoscale materials.
	In-Situ Biological Treatment	**Enhanced Reductive Bioremediation - Mobile Amendments**	Demonstrated and widely used for VOCs and perchlorate contamination in groundwater. Perchlorate and VOCs destroyed in-situ. Cr(VI) can be reduced and immobilized by this process option, but not destroyed. Various substrate types and delivery approaches available. Biofouling of recirculation wells can hinder performance.	Implementable, but treatability/pilot testing is needed to evaluate performance under Site conditions.	Moderate	Moderate	RETAINED. Recirculation may not be cost-effective for plume-wide implementation compared to other substrate delivery modes and comparable process options due to the significant volume of groundwater to be processed.

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GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Biological Treatment (continued)**	**Enhanced Reductive Bioremediation - Fixed Biobarriers**	Demonstrated and widely used for VOCs and perchlorate contamination in shallow aquifers. Perchlorate and VOCs destroyed in-situ. Cr(VI) can be reduced and immobilized by this process option, but not destroyed. Various substrate types available. Replacement of slow-release substrates for biobarrier systems may be required if the design life for remediation extends longer than the life span of the substrate.	Potentially implementable for shallow groundwater, but substrate longevity and groundwater velocity may limit implementability. Treatability/pilot testing is needed to assess implementability under Site conditions.	Moderate to High	Low to Moderate	RETAINED. Potentially applicable downgradient of Athens Road Well Field where concentrations are lower and groundwater is shallow. Life-cycle capital costs may be high if the perchlorate concentrations upgradient of the biobarrier do not attenuate.
		Bioaugmentation	Demonstrated for VOCs, but treatability studies are be required. Since perchlorate-reducing bacteria are considered ubiquitous, bioaugmentation has yet to be demonstrated as necessary for in-situ treatment of perchlorate. Cr(VI) can have inhibitory and/or toxic effects on introduced microorganisms.	Potentially implementable, but treatability/pilot testing is needed to assess implementability under Site conditions.	Moderate to High	Low	RETAINED. Potentially applicable as an enhancement to in-situ bioremediation process options for treatment of VOCs, but presence of Cr(VI) may limit implementability.
		Enhanced Reductive Bioremediation via Liquid Phase Substrate Addition to Vadose Zone	Demonstrated at the bench- and field-scale for remediation of organic compounds and perchlorate. Perchlorate and VOCs destroyed in-situ. Cr(VI) can be reduced and immobilized by this process option, but not destroyed. Shallow fine-grained zones and caliche soils may limit infiltration. Biofouling and clogging of pore spaces is a concern under both infiltration and injection delivery scenarios. To limit mobilization of contaminants, hydraulic control may need to established.	Potentially implementable, but treatability/pilot testing is needed to assess implementability under Site conditions.	Moderate	Low to Moderate	RETAINED. Potentially applicable for remediation of perchlorate in vadose zone soils, but not cost-effective for VOCs alone.
		Phytoremediation	Demonstrated effective, but only at pilot-scale for perchlorate. Most effective where contaminated soil is within 3 feet of surface and contaminated groundwater is within 10 feet of the surface.	Implementable, but specific studies on the types of plants to be used and their viability in this environment would be necessary.	Low	Low	RETAINED. Potentially applicable in areas with shallow groundwater and lower concentrations, e.g., near the Las Vegas Wash.

TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Biological Treatment (continued)**	**Enhanced Reductive Bioremediation via Gaseous Phase Substrate Addition or "Anaerobic Bioventing"**	Demonstrated at the pilot scale for remediation of perchlorate, but still in the development stage. Perchlorate is destroyed in-situ. Theoretically, Cr(VI) could be reduced and immobilized by this process option, but there is limited data to support this. Shallow fine-grained zones and caliche soils may limit substrate delivery. May cause loss of soil moisture that sustains biological activity.	Potentially implementable, but treatability/pilot testing is needed to assess implementability under Site conditions. Limited commercial availability.	Moderate	Moderate to High	REJECTED. This technology is still in development phase and experience at this point is limited to pilot-scale demonstration.
	In-Situ Process Enhancements	**Pneumatic Fracturing**	Demonstrated. Fractures will close in non-clayey soils. For longer remediation programs, refracturing efforts may be required at 6- to 12-month intervals.	Potentially implementable in the UMCf, but pilot tests would need to be conducted. Not implementable in the shallow alluvium.	Moderate	Low	RETAINED. Potentially applicable in conjunction with other technologies to increase extraction or the effectiveness of substrate delivery in the UMCf.
		Hydraulic Fracturing	Demonstrated effective for increasing pumping yields and delivery of substrates for in-situ remediation.	Potentially implementable in the UMCf, but pilot tests would need to be conducted. Not implementable in the shallow alluvium.	Moderate	Low	RETAINED. Potentially applicable in conjunction with other technologies to increase extraction or the effectiveness of substrate delivery in the UMCf.
		Funnel and Gate	Demonstrated effective for controlling groundwater flow and enhancing remedial technologies.	Implementable.	Moderate	Low	RETAINED. Potentially applicable in conjunction with other process options to increase their effectiveness.
		Directional Wells	Demonstrated. This type of well is usually within 100 feet of ground surface. Horizontal wells generally require 5:1 (h:v) setback distances to reach target depth.	Implementable, but specific locations are subject to restrictions posed by utilities and other structures.	Moderate	Low	RETAINED. Potentially applicable in conjunction with other in-situ process options to increase their effectiveness.

TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
IN-SITU GROUNDWATER AND SOURCE AREA TREATMENT (continued)	**In-Situ Process Enhancements (continued)**	**Soil Flooding**	Demonstrated effective for delivery of amendments for in-situ remediation, for mobilizing soluble contaminants, and for supplying constant head for hydraulic control/management. Sedimentation will reduce infiltration rates over time.	Implementable, but treatability/pilot testing is needed to evaluate performance under Site conditions.	Moderate	Low	RETAINED. Potentially applicable in conjunction with other in-situ process options to increase their effectiveness.
		Bioremediation	Demonstrated effective for enhancing remedial technologies often as a polishing step. Various substrate types and delivery approaches available for treating COPCs including perchlorate, VOCs and Cr(VI). Biofouling can hinder performance. High concentrations of certain contaminants can be toxic to organisms.	Implementable, but treatability/pilot testing is needed to evaluate performance under Site conditions.	Moderate	Moderate	RETAINED. Potentially applicable in conjunction with other in-situ process options to increase their effectiveness.
WATER DISCHARGE	**Surface Water Discharge**	**Surface Water**	Demonstrated effective for discharge of treated groundwater.	Implementable.	Low	Low	RETAINED. This is the current process option for discharge under the Interim Removal Actions.
	Sewer Discharge	**Public Owned Treatment Works (POTW)**	Potentially applicable, depending on flow rates required to achieve dewatering, as well as POTW permit requirements.	Implementable if water can meet pretreatment standards and flow rate restrictions stipulated in permit.	Low	High	RETAINED. However, this option can be very costly compared to other discharge options. Likely only cost effective for small, discrete dewatering applications.
	Water Reuse	**Reclamation**	Limited effectiveness during wet periods. Effective for disposal of a limited portion of effluent.	Implementable if treated water can meet the water quality standards for specific applications.	Low	Low	RETAINED for discharge of treated groundwater if treated water can meet the water quality standards for specific applications.
	Subsurface Water Discharge	**Injection Wells**	Demonstrated effective for discharge of treated groundwater. However, there may be potential problems with biofouling and clogging.	Potentially implementable, but potential problems with biofouling and clogging would need to be studied/addressed.	Low to Moderate	Low to Moderate	RETAINED.

TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
WATER DISCHARGE (continued)	**Subsurface Water Discharge (continued)**	**Deep Re-Injection Trenches (DRITs)**	Demonstrated effective for discharge of treated groundwater. However, there may be potential problems with biofouling and clogging.	Potentially implementable, but potential problems with biofouling and clogging would need to be studied/addressed.	Moderate	Low to Moderate	RETAINED. However, alternative design configurations will need to be evaluated as part of the screening process in order to avoid biofouling.
		Infiltration	Demonstrated effective for discharge of treated groundwater. However, there may be potential problems with biofouling and clogging.	Potentially implementable, but potential problems with biofouling and clogging would need to be studied/addressed.	Low to Moderate	Low to Moderate	RETAINED. However, alternative design configurations will need to be evaluated in order to avoid biofouling.
		Pittman Bypass Pipeline	Demonstrated effective for the discharge of storm water and non-contacting cooling water from neighboring industrial sites.	Potentially implementable provided the volume of effluent does not exceed the capacity of the pipeline.	Low to moderate	Low to Moderate	RETAINED for discharge of treated groundwater.
		Zero Discharge/ Enhanced Evaporation	Demonstrated effective for evaporation of limited amounts of effluent.	Potentially implementable, although effluent volumes will need to be considered.	Moderate	Moderate	RETAINED. This process option is applicable for reduction of limited effluent volumes in lined ponds, such as GW-11, in conjunction with other process options.
		Solar Evaporation	Limited effectiveness during wet periods. Effective for disposal of a limited portion of effluent. Currently, the GWETS Operator estimates solar evaporation rates of 1-5 million gallons per month for the current groundwater impoundment, GW-11 (assuming pond is full).	Potentially implementable, although space limitations may be an issue for large effluent volumes.	Moderate	Low	RETAINED. This process option is applicable for reduction of limited effluent volumes in lined ponds, such as GW-11, in conjunction with other process options.
EX-SITU VAPOR TREATMENT	**Ex-Situ Vapor / Emissions / Off-gas Treatment**	**Vapor Phase Carbon Adsorption**	Well-demonstrated and widely-used technology for VOCs and other organic and some inorganic compounds.	Implementable. Likely to require air permit.	Low to Moderate	Moderate	RETAINED. This process option applicable only in conjunction with technologies generating vapor emissions requiring treatment.

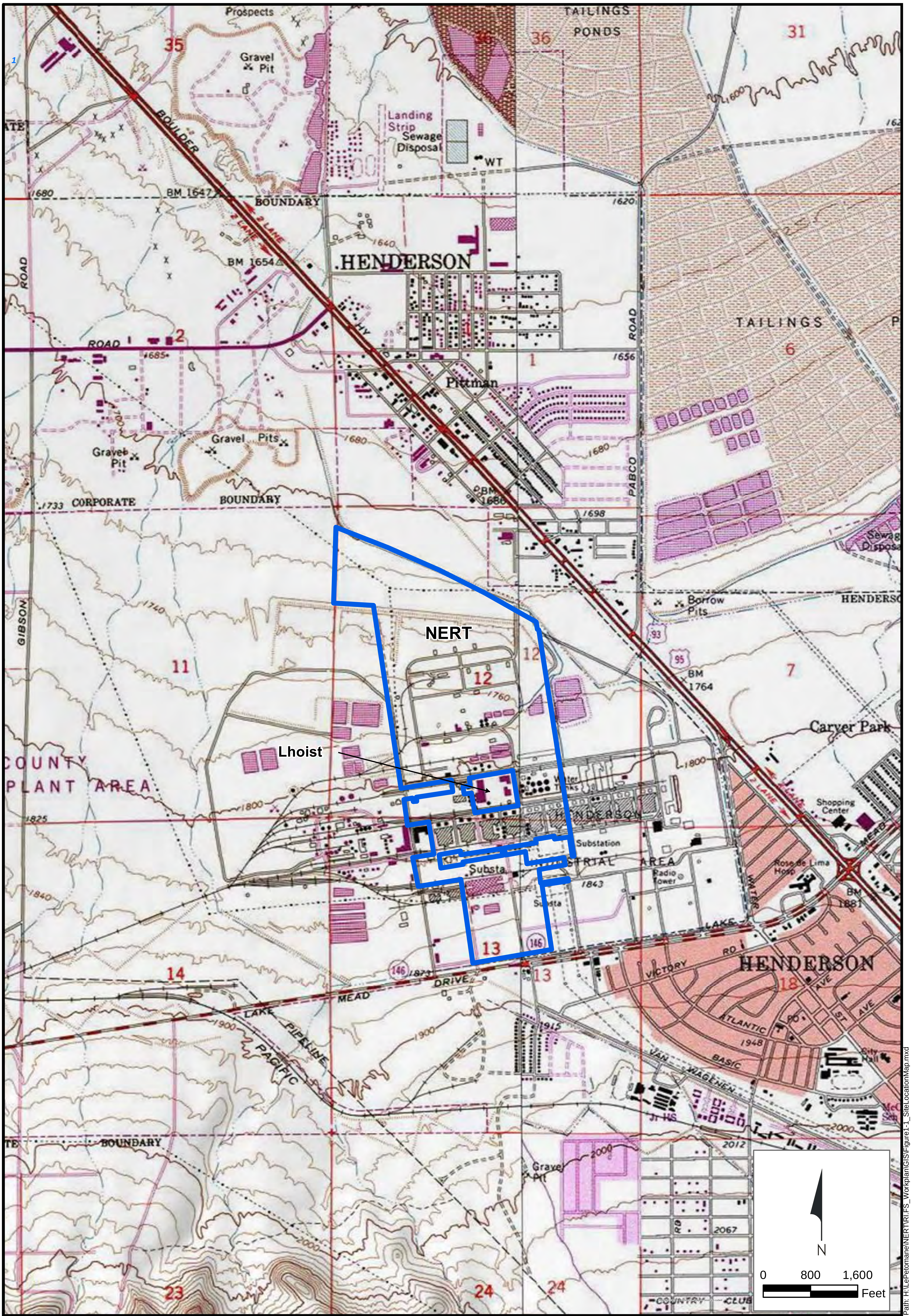
TABLE 5-4. SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES
Nevada Environmental Response Trust Site; Henderson, Nevada

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST CAPITAL	RELATIVE COST O&M	SCREENING COMMENTS
EX-SITU VAPOR TREATMENT (continued)	**Ex-Situ Vapor / Emissions / Off-gas Treatment (continued)**	**Advanced Oxidation**	Effective for VOCs, but may produce reaction by-products.	Implementable. Likely to require air permit.	Low to Moderate	Low to Moderate	RETAINED. This process option applicable only in conjunction with technologies generating vapor emissions requiring treatment.
		Catalytic Oxidation	Effective for VOCs, but may produce oxidation by-products.	Implementable. Likely to require air permit.	Moderate	Low to Moderate	RETAINED. This process option applicable only in conjunction with technologies generating vapor emissions requiring treatment.
		Thermal Oxidation	Effective for VOCs, but may produce combustion by-products.	Implementable. Likely to require air permit.	Moderate	Low to Moderate	RETAINED. This process option applicable only in conjunction with technologies generating vapor emissions requiring treatment.
		Biofiltration	Effective for non-chlorinated VOCs and for odor control from biological processes.	Implementable. Likely to require air permit.	Low	Low	RETAINED. This process option applicable only in conjunction with technologies generating vapor emissions requiring treatment.

Notes: COPCs = chemicals of potential concern; Cr(VI) = Hexavalent Chromium; DNAPL = Dense Non-Aqueous Phase Liquids; LNAPL = Light Non-Aqueous Phase Liquids; RAOs = Remedial Action Objectives; TDS = Total Dissolved Solids; UMCf = Upper Muddy Creek Formation; VOCs = volatile organic compounds; ZVI = Zero Valent Iron

Shaded boxes indicate process options that are retained for the secondary screening evaluation.
Unshaded process options have been eliminated and will not be considered further.

Figures



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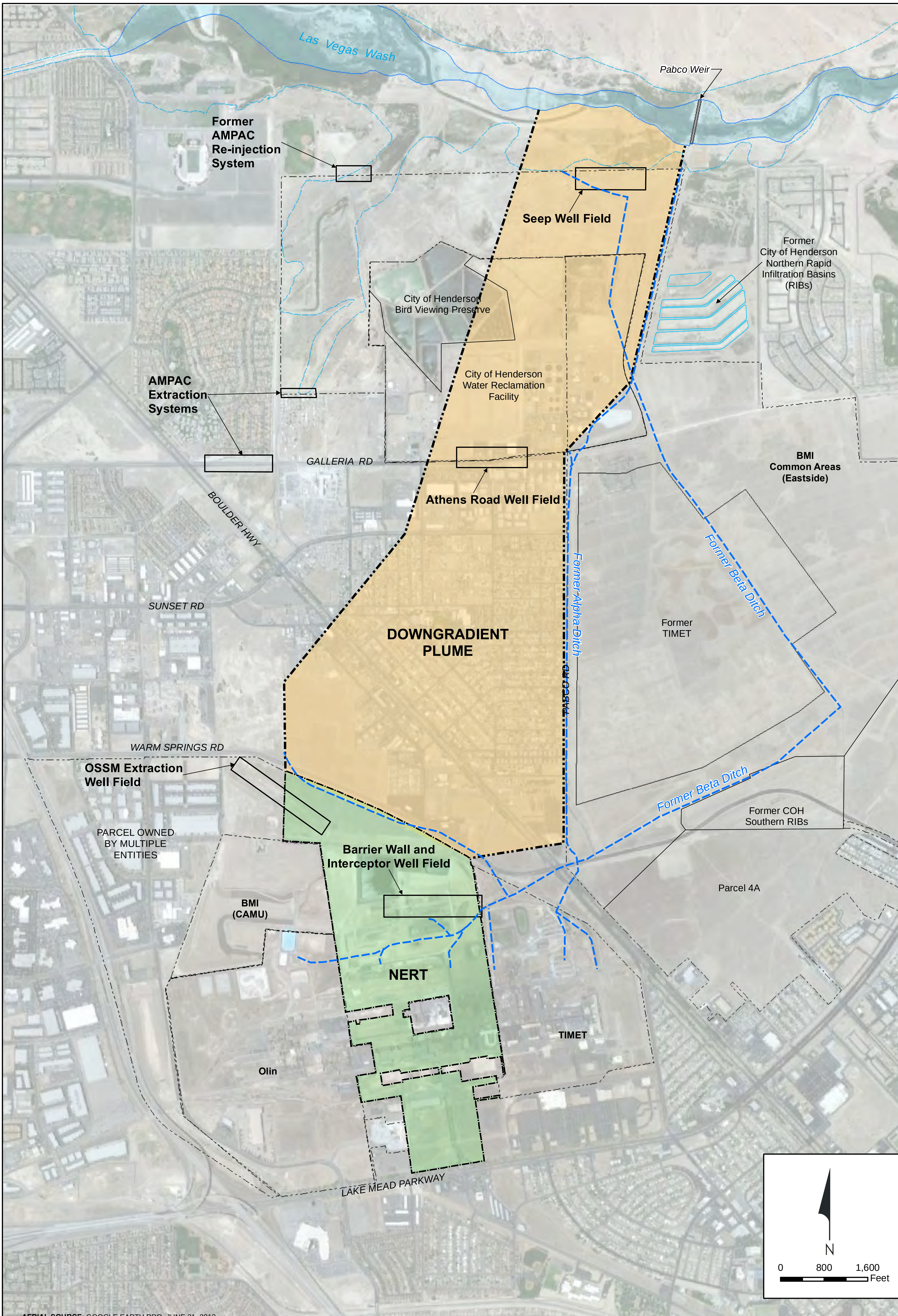
Site Location Map
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
1-1

Drafter: RS | Date: 12/13/2013 | Contract Number: 21-32100I | Approved by: | Revised:



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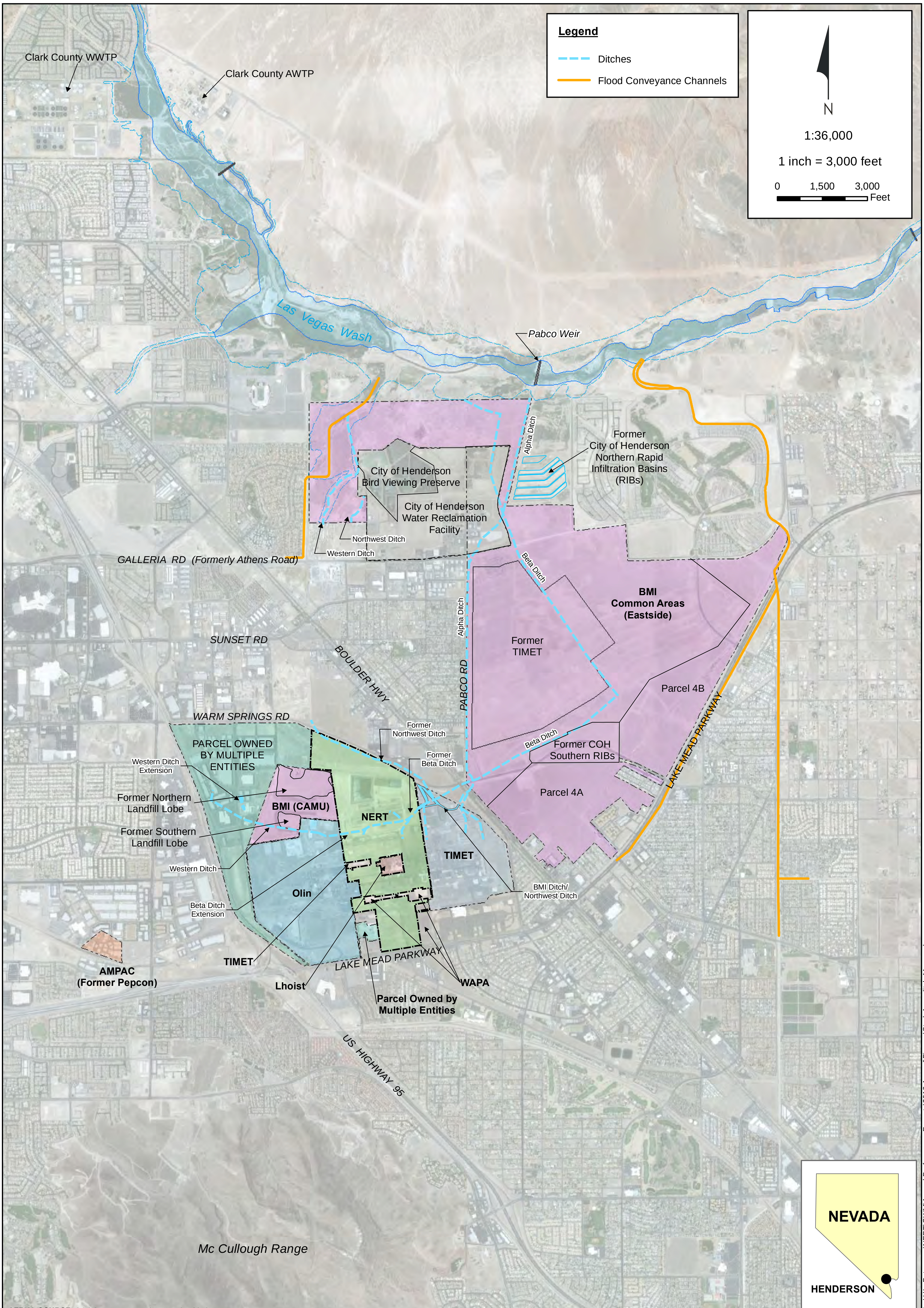
Groundwater Study Area
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
1-2

DRAWN BY: RS | DATE: 11/30/12 | CONTRACT NUMBER: 21-32100I01 | APPROVED BY: | REVISED: 12/11/13



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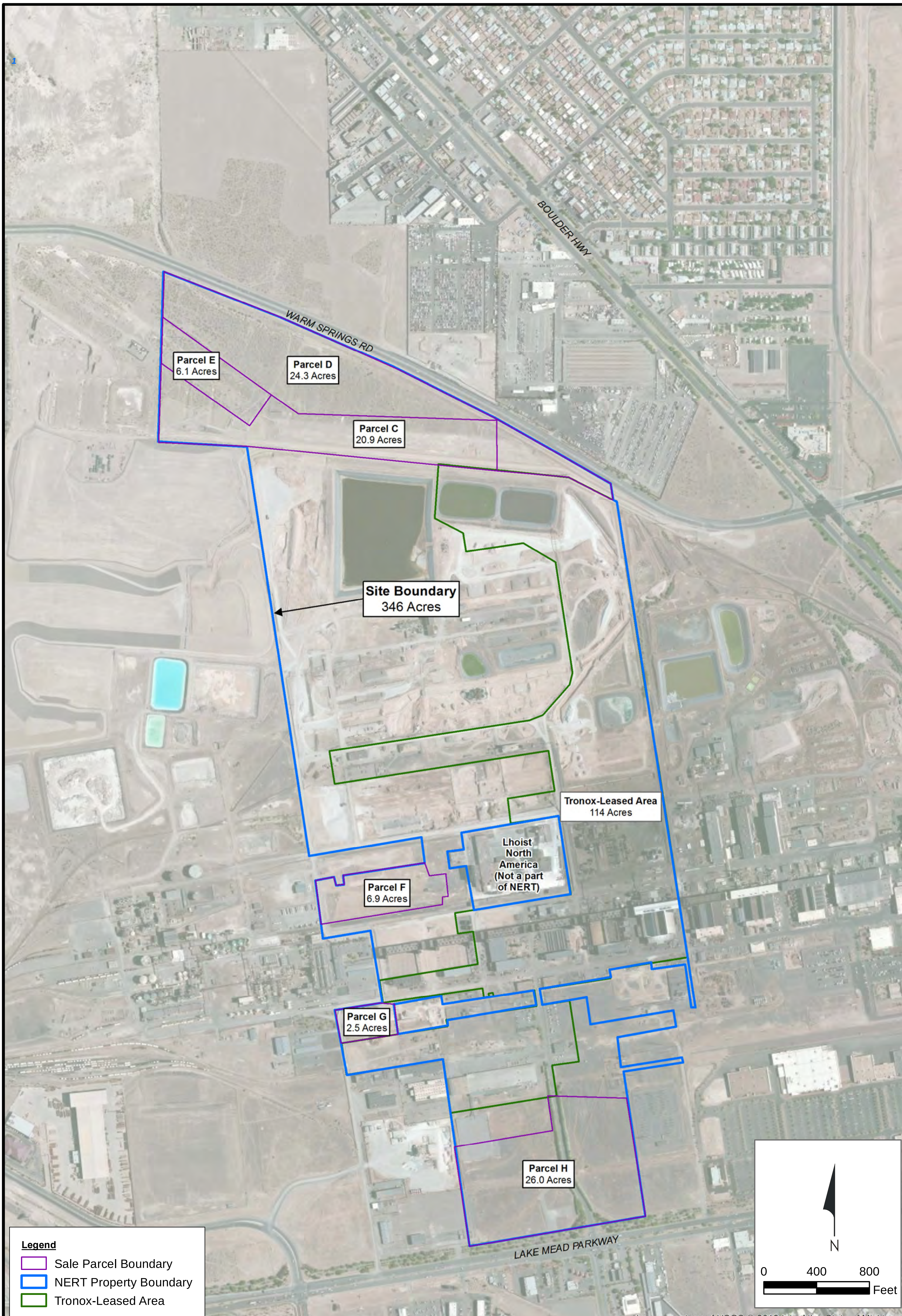
Surrounding Facilities
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
2-1

Drafter: RS | Date: 12/19/2013 | Contract Number: 21-32100I | Approved by: | Revised:



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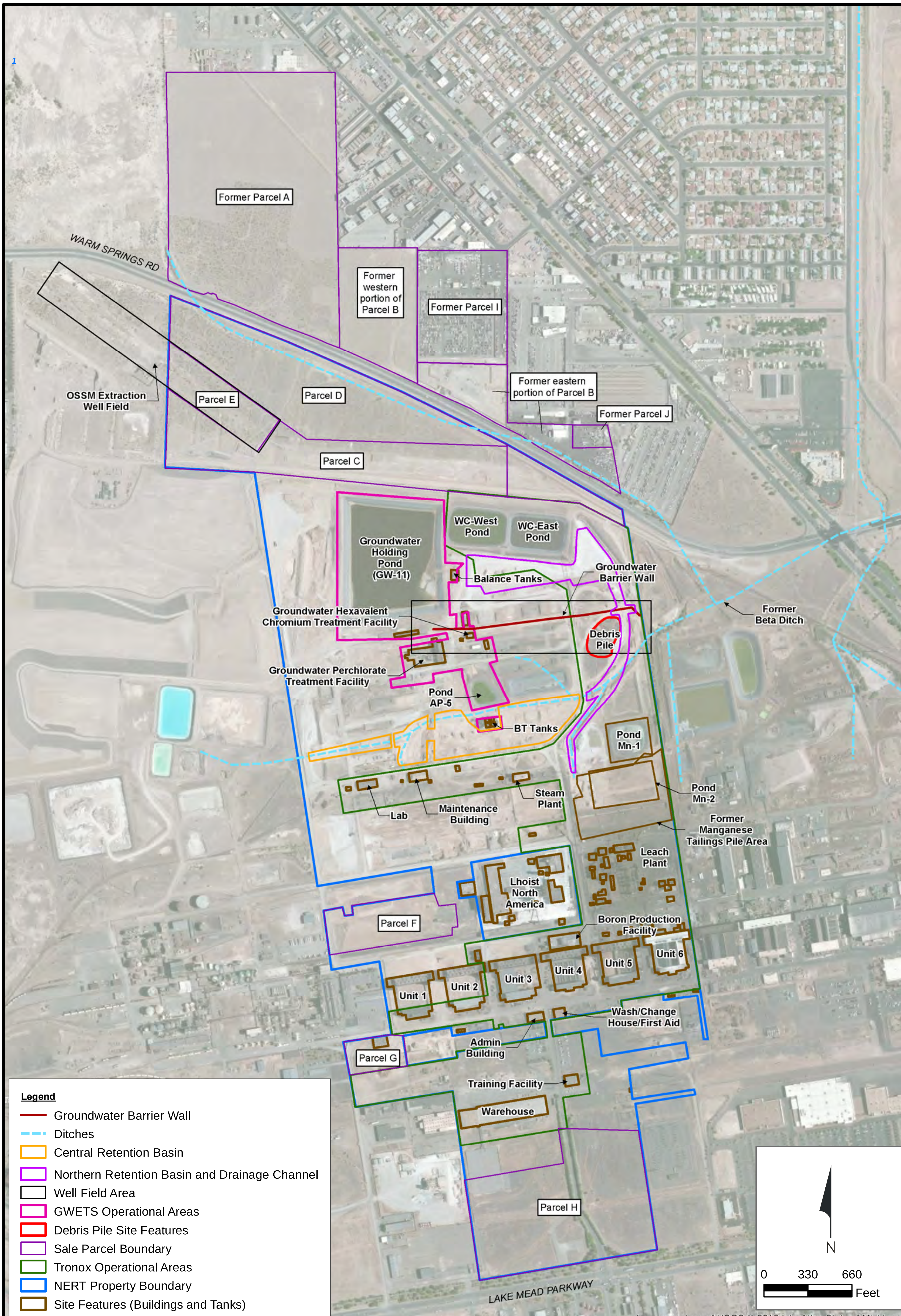
Site Boundary, Sale Parcels, and Tronox-Leased Area Acreage
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
2-2

Drafter: RS | Date: 12/12/2013 | Contract Number: 21-32100I | Approved by: | Revised:



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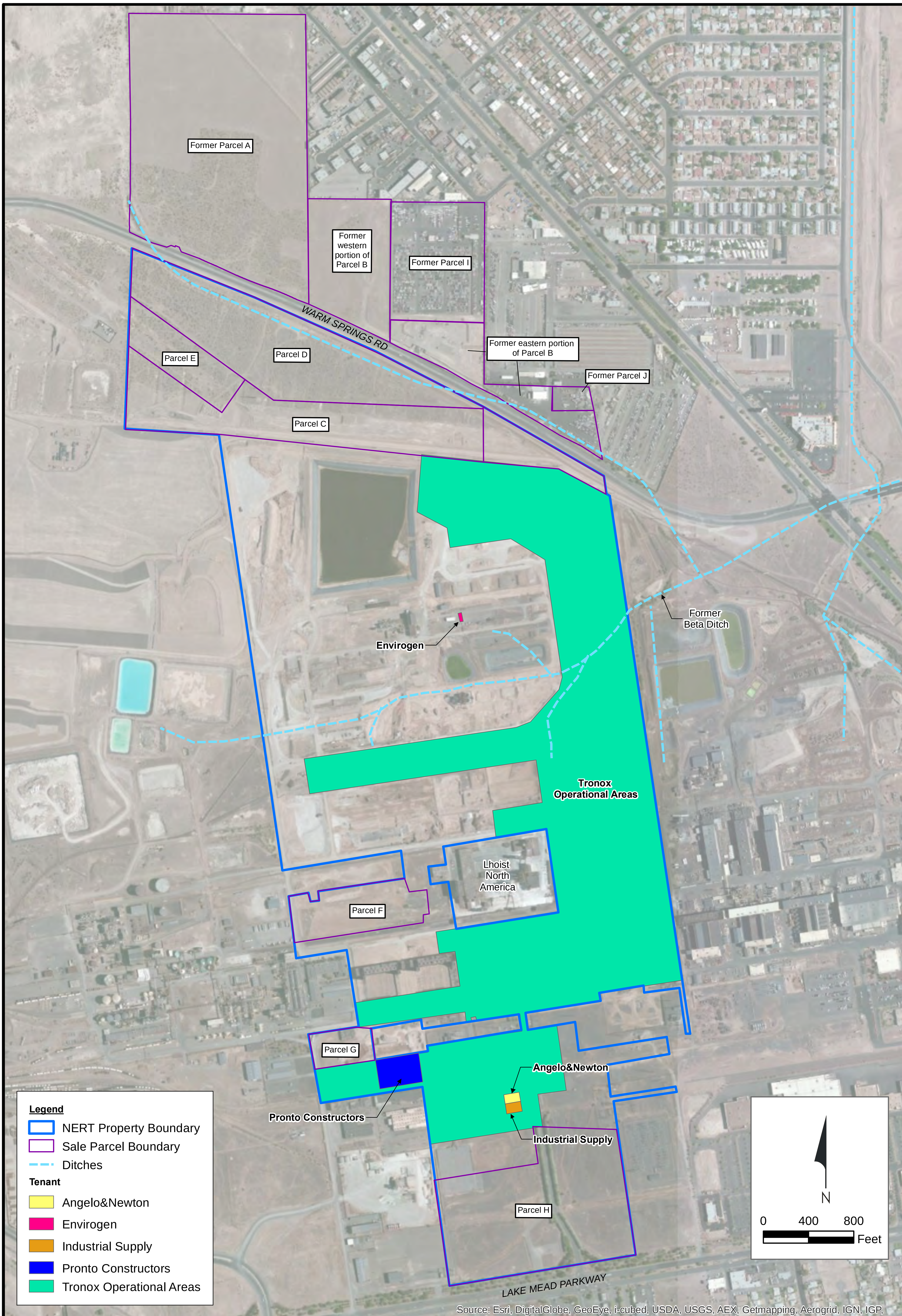
Site Features

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **2-3**

Drafter: RS | Date: 12/16/2013 | Contract Number: 21-32100I | Approved by: | Revised:



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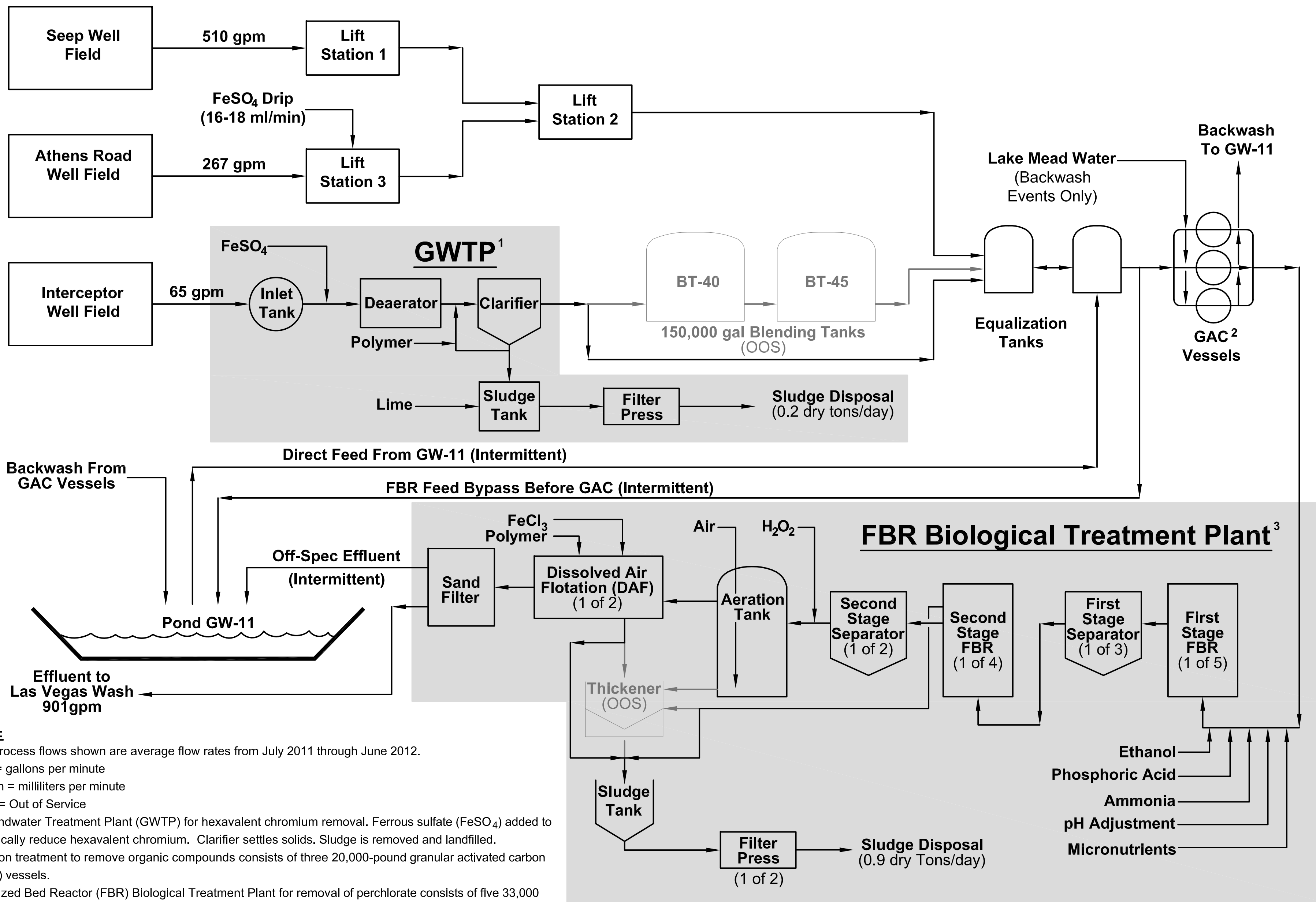
On-site Tenants

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **2-4**

Drafter: RS	Date: 12/16/2013	Contract Number: 21-32100I	Approved by:	Revised:



NOTES:

The process flows shown are average flow rates from July 2011 through June 2012.
gpm = gallons per minute
ml/min = milliliters per minute
OOS = Out of Service

1) Groundwater Treatment Plant (GWTP) for hexavalent chromium removal. Ferrous sulfate ($FeSO_4$) added to chemically reduce hexavalent chromium. Clarifier settles solids. Sludge is removed and landfilled.
2) Carbon treatment to remove organic compounds consists of three 20,000-pound granular activated carbon (GAC) vessels.
3) Fluidized Bed Reactor (FBR) Biological Treatment Plant for removal of perchlorate consists of five 33,000 gallon first-stage FBRs, four 28,800 gallon second-stage FBRs, aeration (air and hydrogen peroxide, H_2O_2), dissolved air flotation (DAF), two plate and frame filter presses, and a sand filter.

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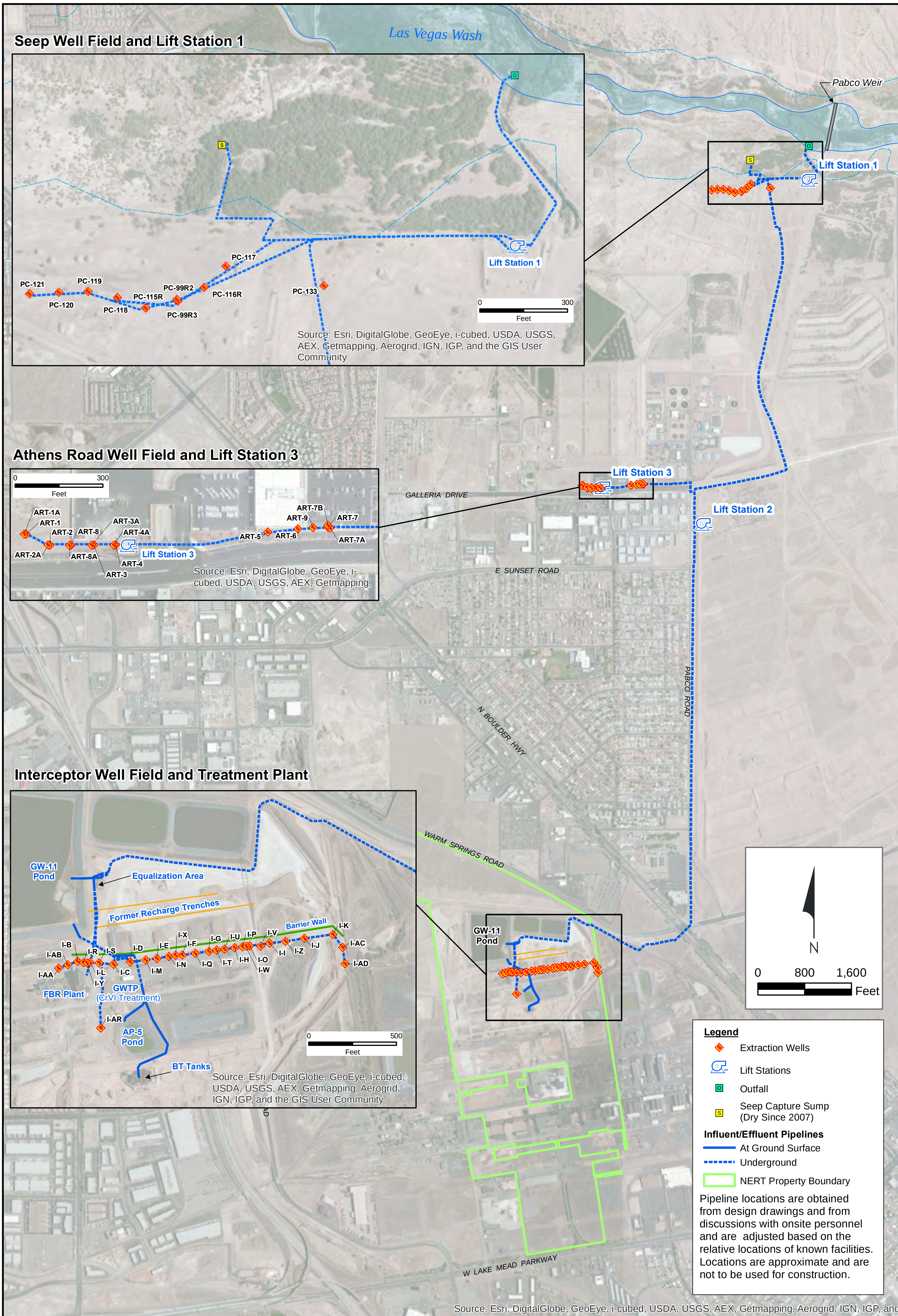
Groundwater Extraction and Treatment System (GWETS) Flow Diagram
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

Figure **4-1**

Drafter: RS | Date: 11/30/12 | Contract Number: 21–29100H | Approved: | Revised:



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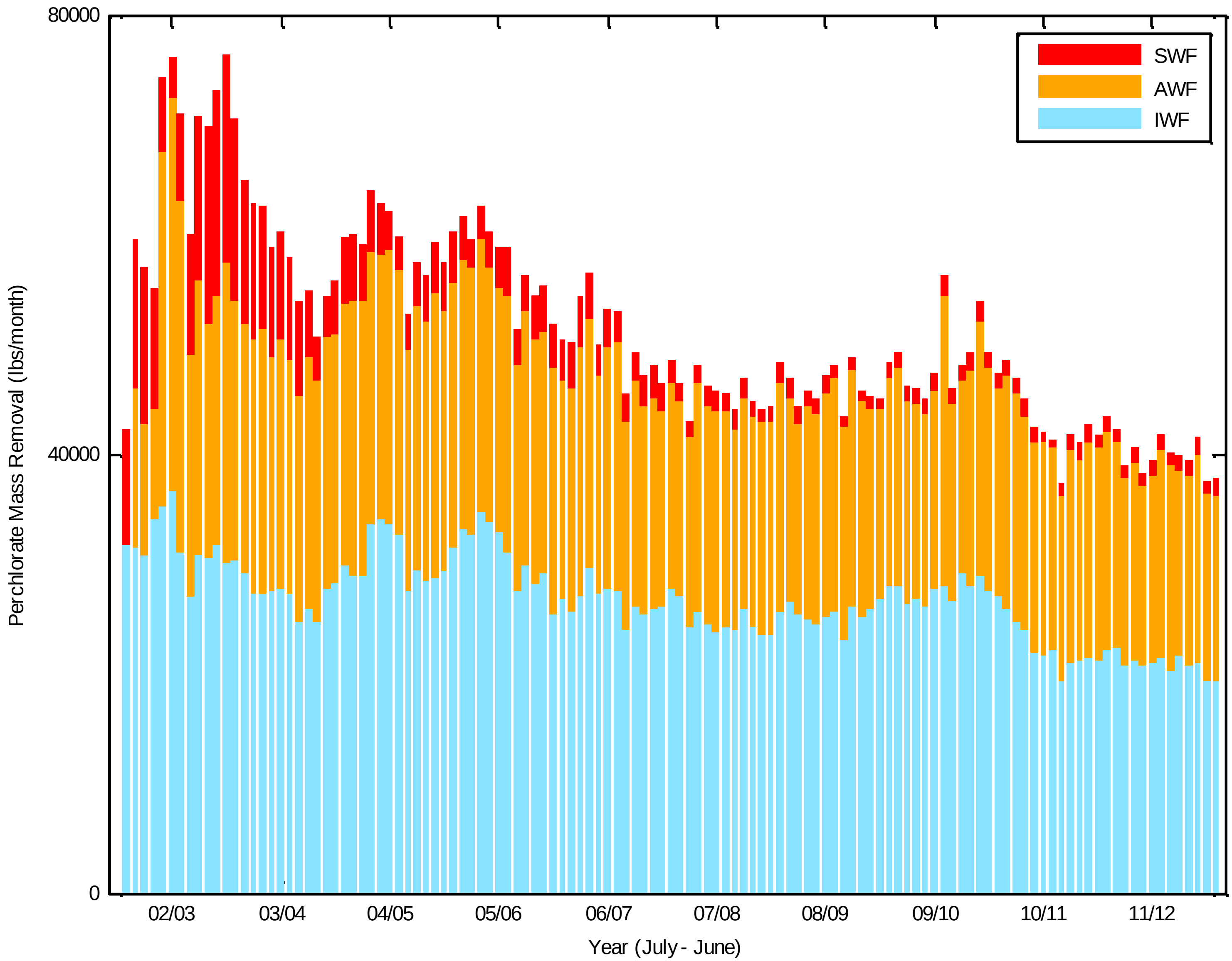
Groundwater Extraction and Treatment System Map
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-2

Drafter: EA | Date: 12/13/2013 | Contract Number: 21-29100I | Approved by: | Revised:



Note: Data are summarized monthly for the period July 2002 - June 2012.

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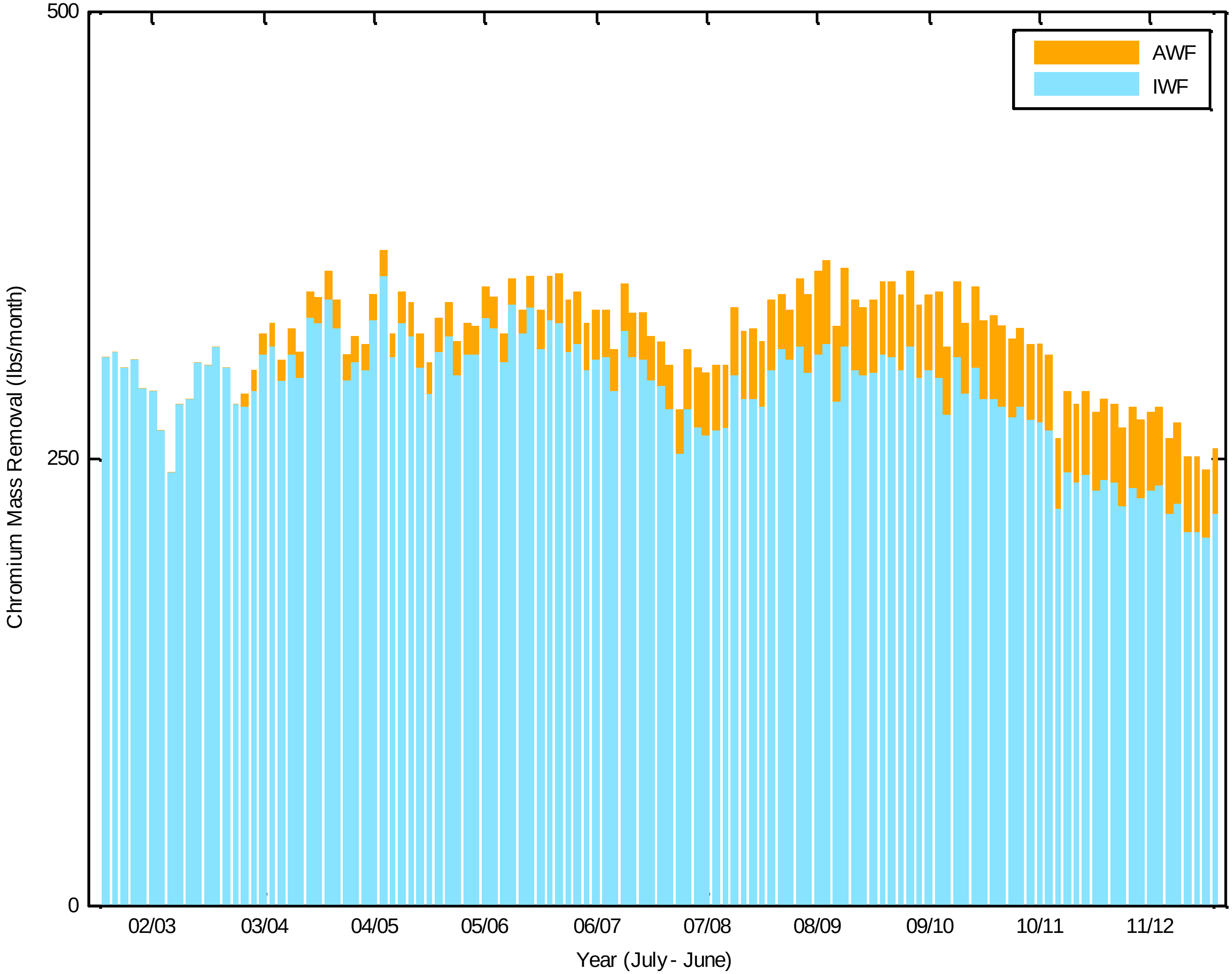
Perchlorate Mass Removal from Groundwater, 2002-2012
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-3

Drafter: JAW | Date: 12/11/13 | Contract Number: 21-23100I | Approved: CJR | Revised:



Notes: Data are summarized monthly for the period July 2002 - June 2012. Chromium concentrations in the SWF are consistently below laboratory quantitation limits; therefore, the SWF is not included in the system-wide chromium mass removal estimates.

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Chromium Mass Removal from Groundwater, 2002-2012
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-4

Drafter: JAW | Date: 12/11/2013 | Contract Number: 21-32100I | Approved: CJR | Revised:

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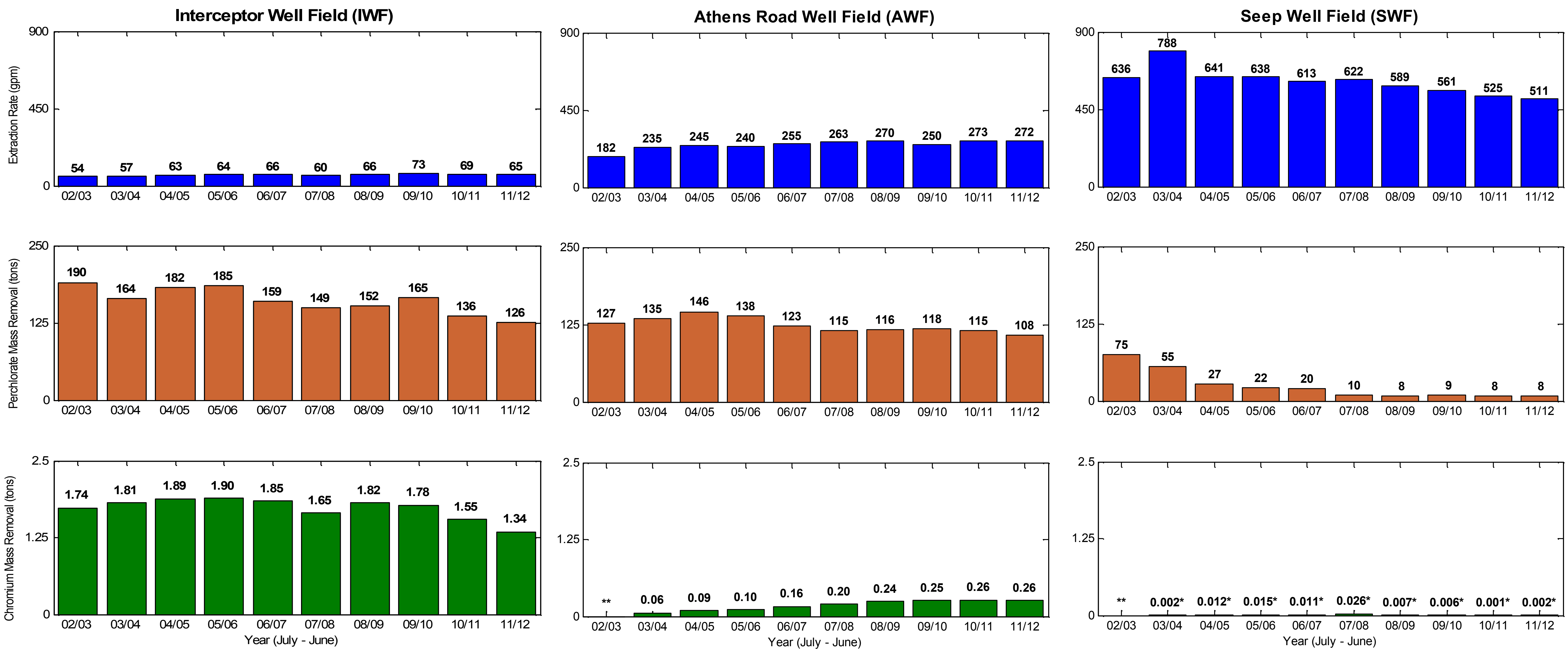

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Well Field Extraction Rates and Chromium and Perchlorate Mass Removals
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-5

Drafter: RS | Date: 12/12/13 | Contract Number: 21-32100I | Approved: | Revised:

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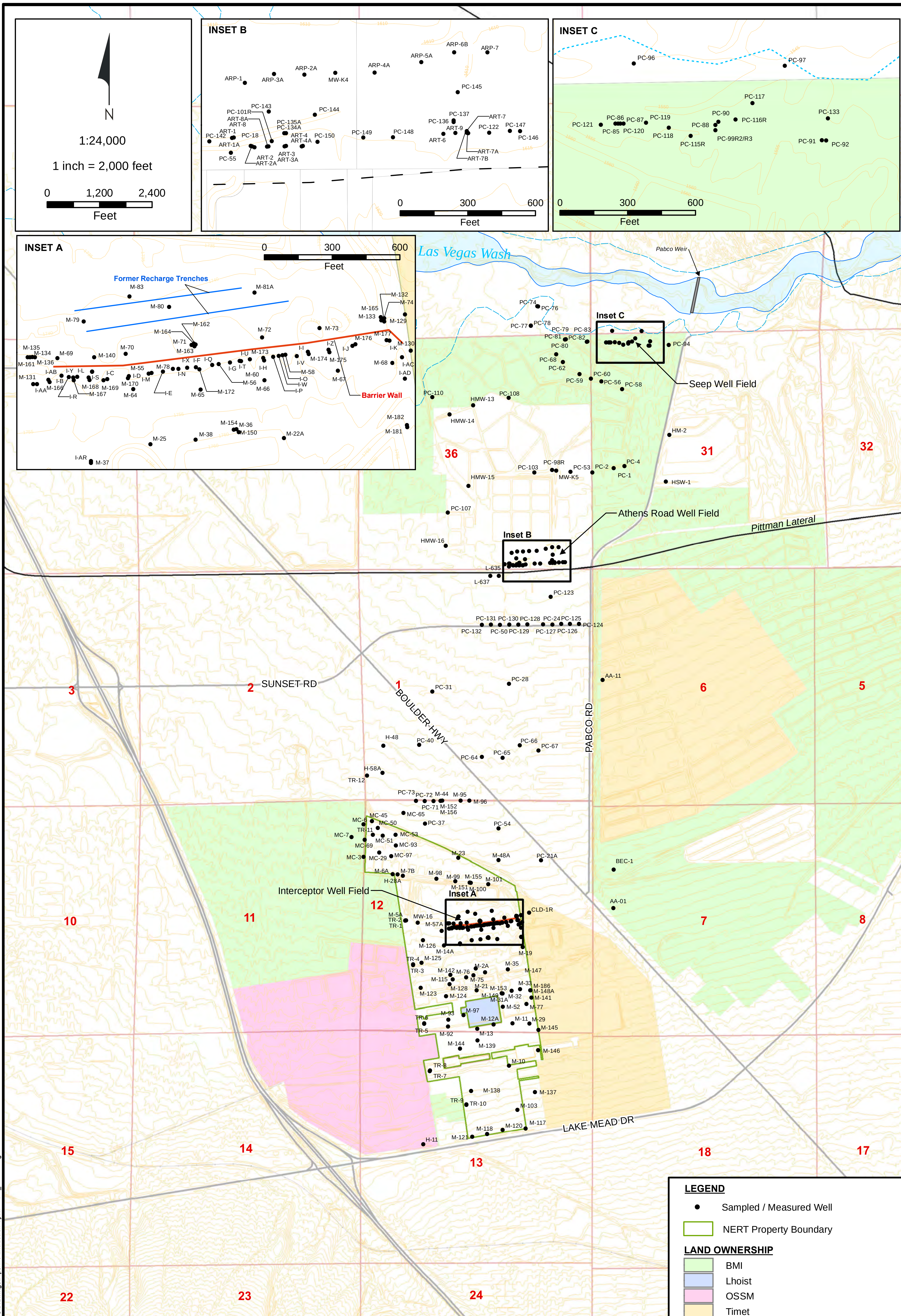

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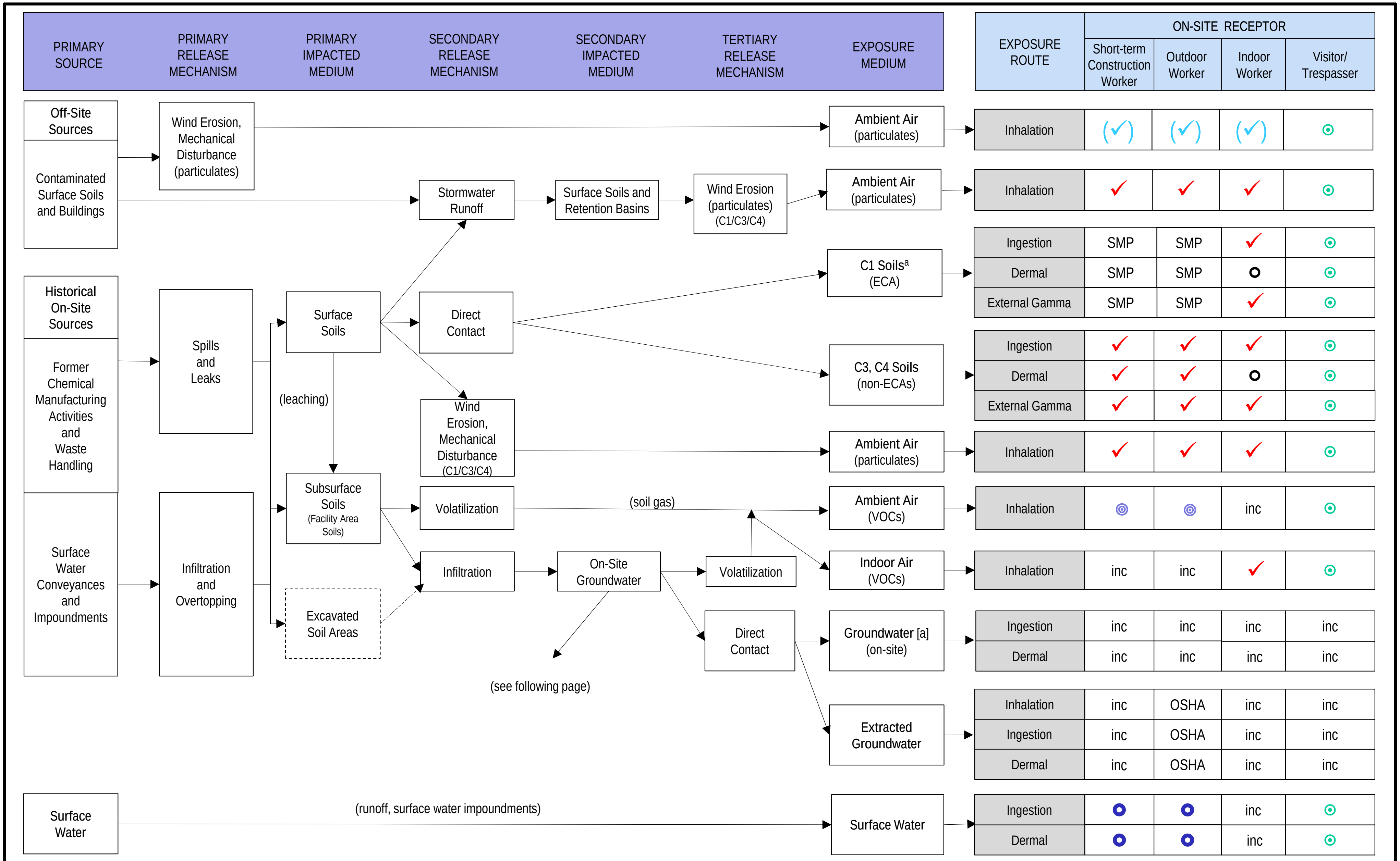
Groundwater Monitoring Locations
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4-6

Drafter: RS | Date: 12/18/2013 | Contract Number: 21-32100I | Approved by: | Revised:



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Preliminary Conceptual Site Model Diagram: Site and Downgradient Plume
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-1**

Drafter: EL | Date: 1/3/2014 | Contract Number: 21-32100I | Approved by: | Revised:

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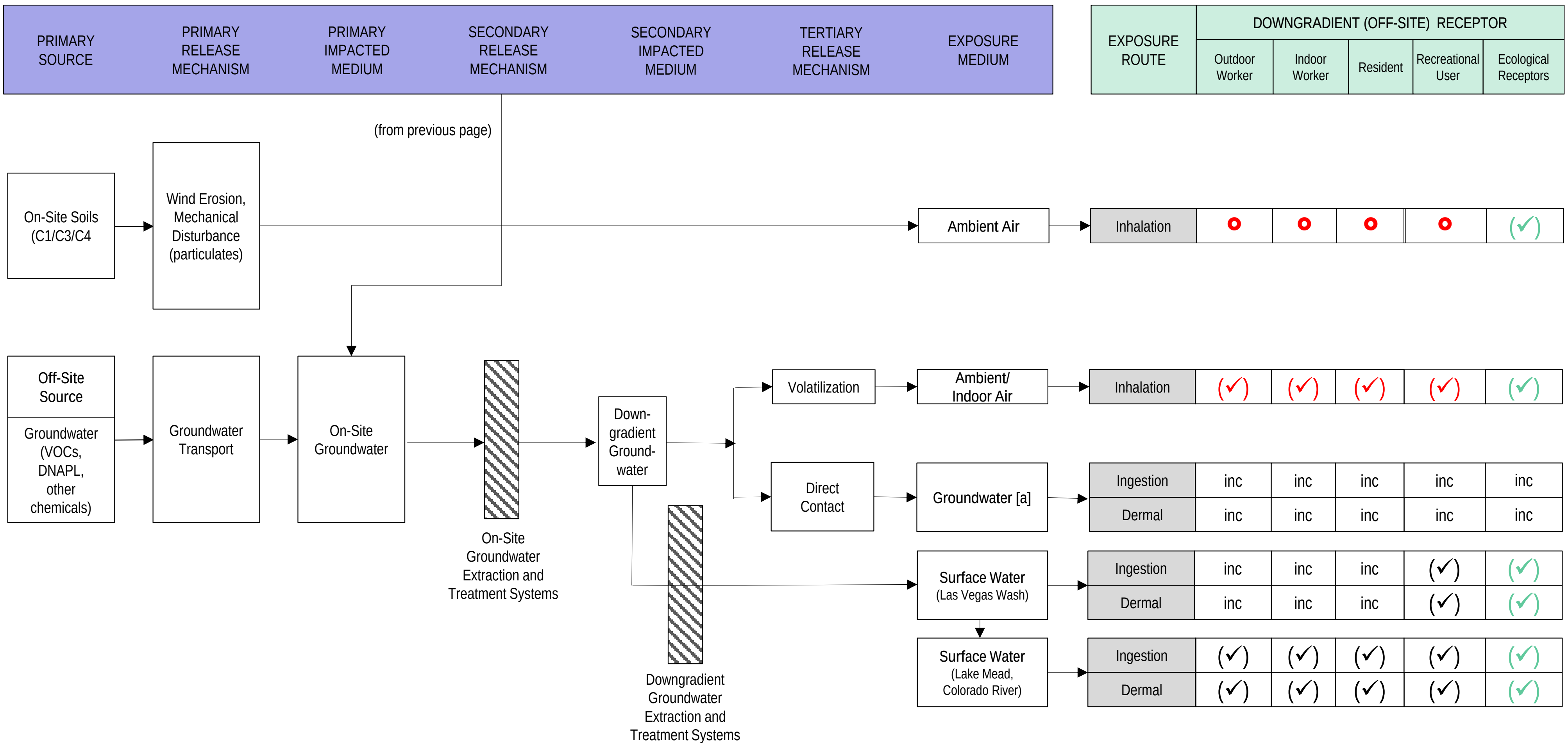

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Preliminary Conceptual Site Model Diagram: Site and Downgradient Plume
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-1**

Drafter: EL | Date: 1/3/2014 | Contract Number: 21-32100I | Approved by: | Revised:

Note:

This preliminary CSM, including the identification of sources, release mechanisms, exposure media, exposure routes, and receptors is based on current understanding of on-site and off-site environmental conditions. The CSM will be revised, as appropriate, based on evaluation of additional environmental data collected during the RI.

[a] Groundwater is not and will not be used as a source of drinking water. Incidental ingestion and dermal contact with groundwater by on-site construction workers are considered to be incomplete exposure pathways because depth to groundwater is >20 ft bgs. For off-site workers, depth to groundwater in some areas is <20 feet; however, the intermittent exposures of a construction worker to groundwater would be negligible.

Key:

C1, C3, C4	Category 1, 3, and 4 soils, where C1 = soils 0 – 10 feet bgs in ECAs; C3 = soils 0 – 10 feet bgs with concentrations >BCLs; C4 = soils 0 – 10 feet bgs not previously sampled or available information considered inadequate. C2 soils (not shown on this CSM) are soils 0 – 10 feet bgs with concentrations <BCLs.
inc	Incomplete exposure pathway
OSHA	Workers at the groundwater extraction and treatment facility could potentially be exposed to contaminants in extracted groundwater. However, potential exposures will not be evaluated quantitatively because the workers are regulated by the Occupational Safety and Health Administration (OSHA) and a comprehensive worker health and safety plan (HASP) is in place to mitigate potential exposures.
SMP	Site Management Plan -- potential exposures for direct-contact pathways will be managed through the SMP.
✓ (red)	Complete exposure pathway; evaluated quantitatively in the BHRA.
(✓) (red)	Potentially complete exposure pathway for off-site receptors. For indoor and outdoor air; pathway will be evaluated quantitatively using analytical results for soil gas and/or groundwater depending on receptor location and data availability. The specific receptors and pathways (i.e., indoor and outdoor exposures) that will be evaluated quantitatively will depend on various factors, including the results from additional sampling for VOCs in the downgradient groundwater plume and/or results from off-site soil gas investigations.
(✓) (light blue)	Complete exposure pathway. ENVIRON 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. Pathway will be discussed quantitatively in the BHRA using results of risk assessments prepared by the neighboring properties, or qualitatively, if risk assessments are not available.
(✓) (black)	Complete exposure pathway for perchlorate and possibly other site-related chemicals; for perchlorate, pathway will be evaluated by comparing surface water concentrations to the Nevada Provisional Action Level for perchlorate (NDEP 2011b).
(✓) (green)	Complete exposure pathway; as discussed in Section 6.7, the ecological risk assessment will be conducted following aquifer restoration.
○ (black)	Complete, but insignificant exposure pathway. Consistent with USEPA guidance (USEPA 2002) and the NDEP-approved 2010 HRA work plan (Northgate 2010d), potential exposures of indoor workers to soil from dermal exposure are not evaluated quantitatively, but will be discussed qualitatively.
◎ (purple)	Exposures of outdoor workers via inhalation of soil or groundwater vapors would be less than exposures of indoor workers; inhalation of vapors in outdoor air will be evaluated only if estimated risks for the vapor intrusion (indoor) pathway are >1E-06 or the hazard index is >1.
○ (red)	Exposures of all off-site receptors via inhalation of airborne soil particulates would be significantly less than exposures of on-site workers; inhalation of particulates will be evaluated for off-site receptors only if estimated risks for on-site receptors are >1E-06 or the hazard index is >1.
○ (blue)	For on-site receptors, potentially complete, but insignificant exposure pathway; not evaluated quantitatively because potential exposures would be intermittent and of short duration or regulated under OSHA; surface water pathways will be discussed qualitatively.
⊙ (green)	Potentially complete exposure pathway; not evaluated quantitatively because 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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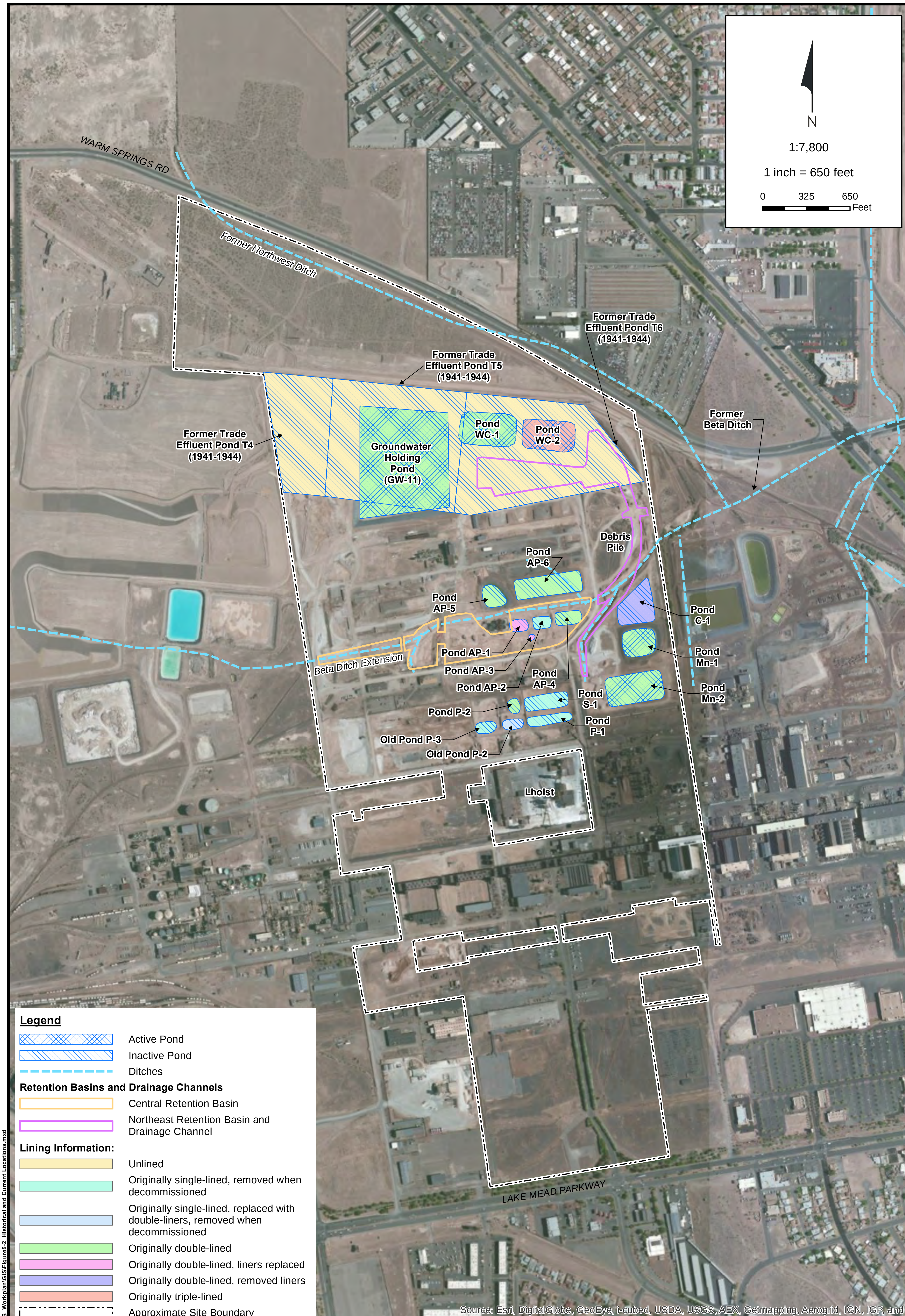
Preliminary Conceptual Site Model Diagram: Site and Downgradient Plume

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-1**

Drafter: EL | Date: 1/3/2014 | Contract Number: 21-32100I | Approved by: | Revised:



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Historical and Active Pond and Retention Basin Locations
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5-2

Drafter: RS | Date: 1/8/2014 | Contract Number: 21-32100I | Approved by: | Revised:

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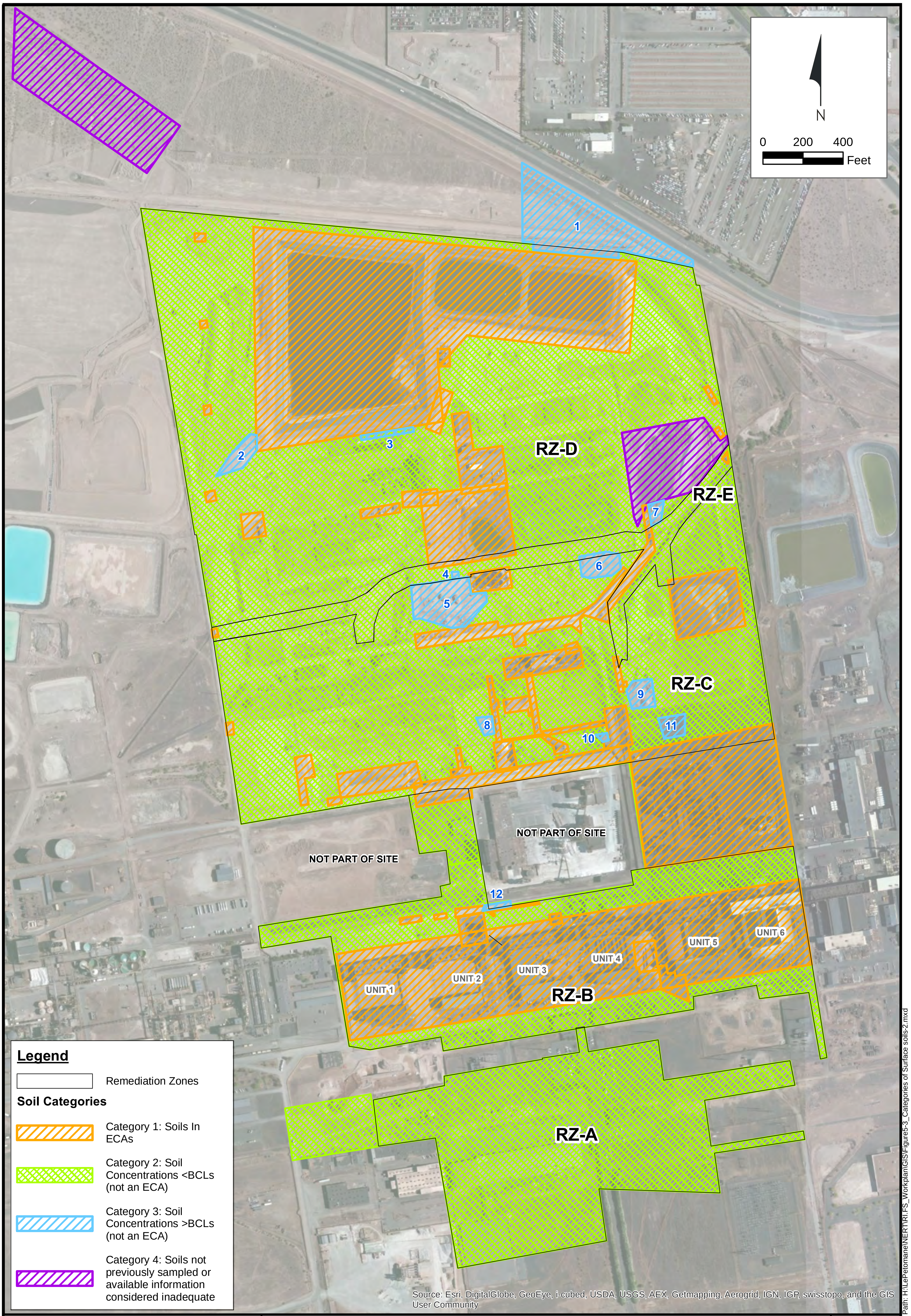

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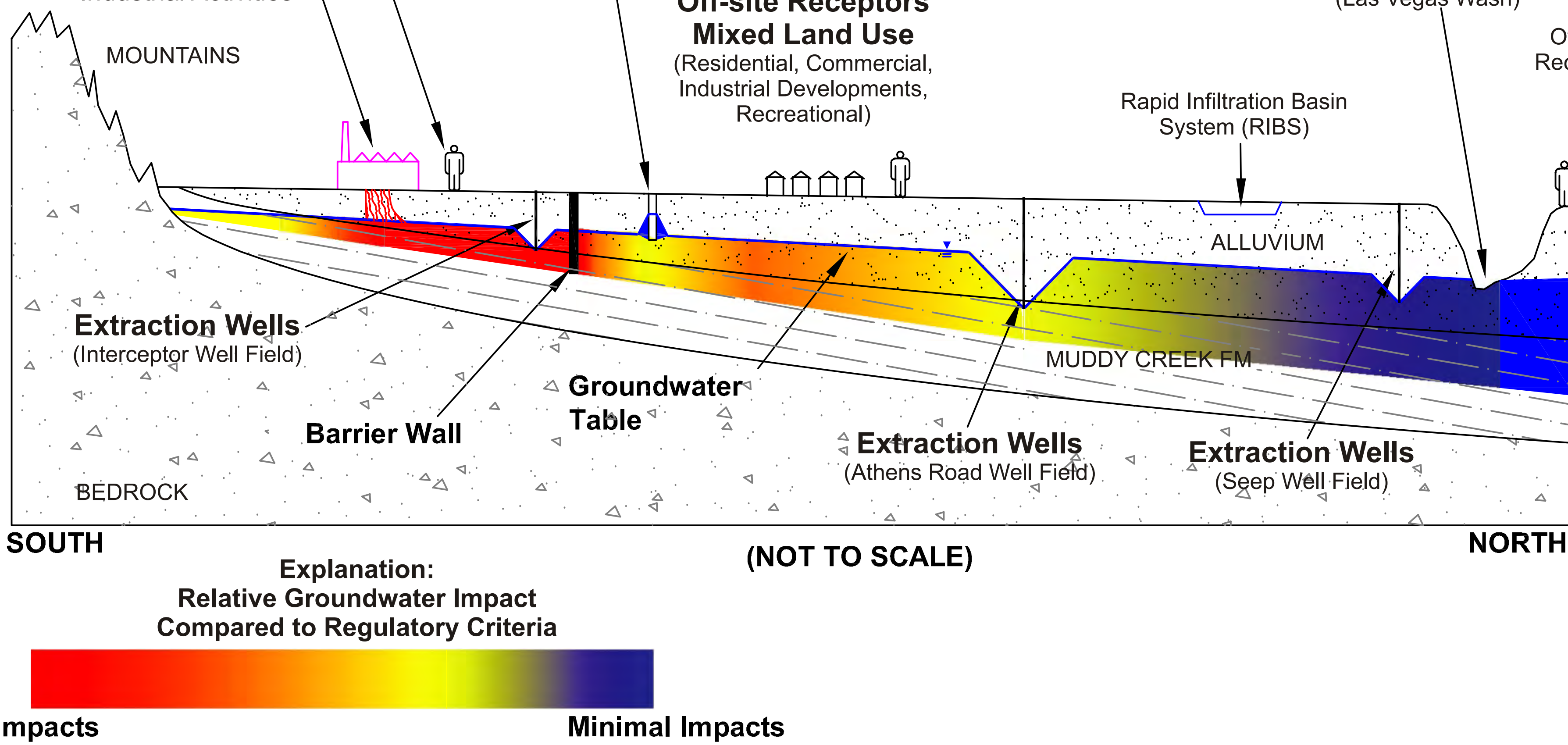
Categories for Surface and Near Surface Soils
(0-10 ft below "new" ground surface)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5-3

Drafter: RS | Date: 1/8/2014 | Contract Number: 21-32100I | Approved by: | Revised:



Sources: ENSR|AECOM, 2007.
Northgate 2010.

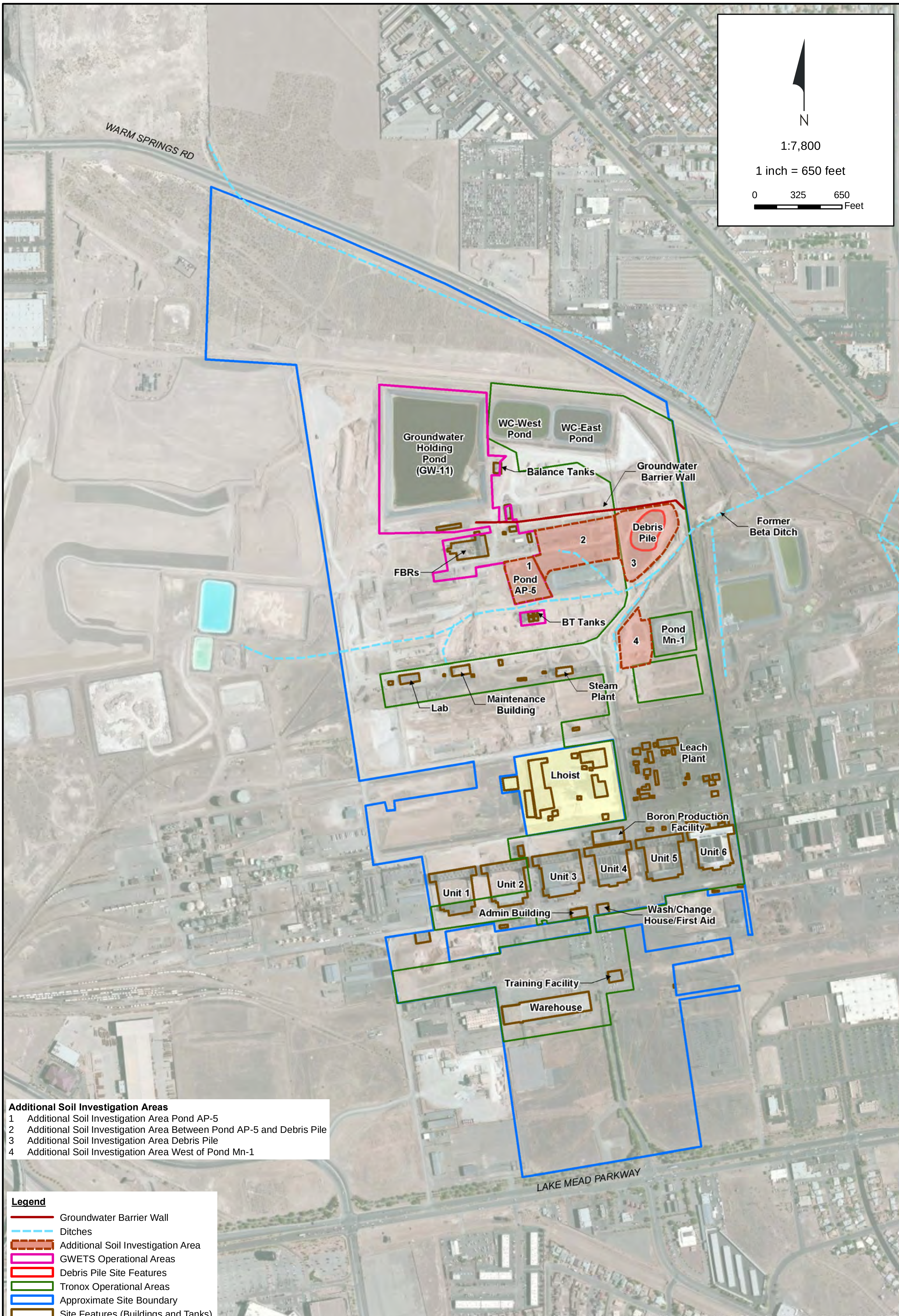
H:/LEPETOME/NERT/VI RISK/CAD/CONCEPTUAL SITE MODEL2.CDR

ENVIRON

Preliminary Conceptual Site Model Illustration
Nevada Environmental Response Trust Site
Henderson, Nevada

Figure **5-4**

Drafter: RS | Date: 11/14/12 | Contract Number: 21-32100I | Approved: | Revised:



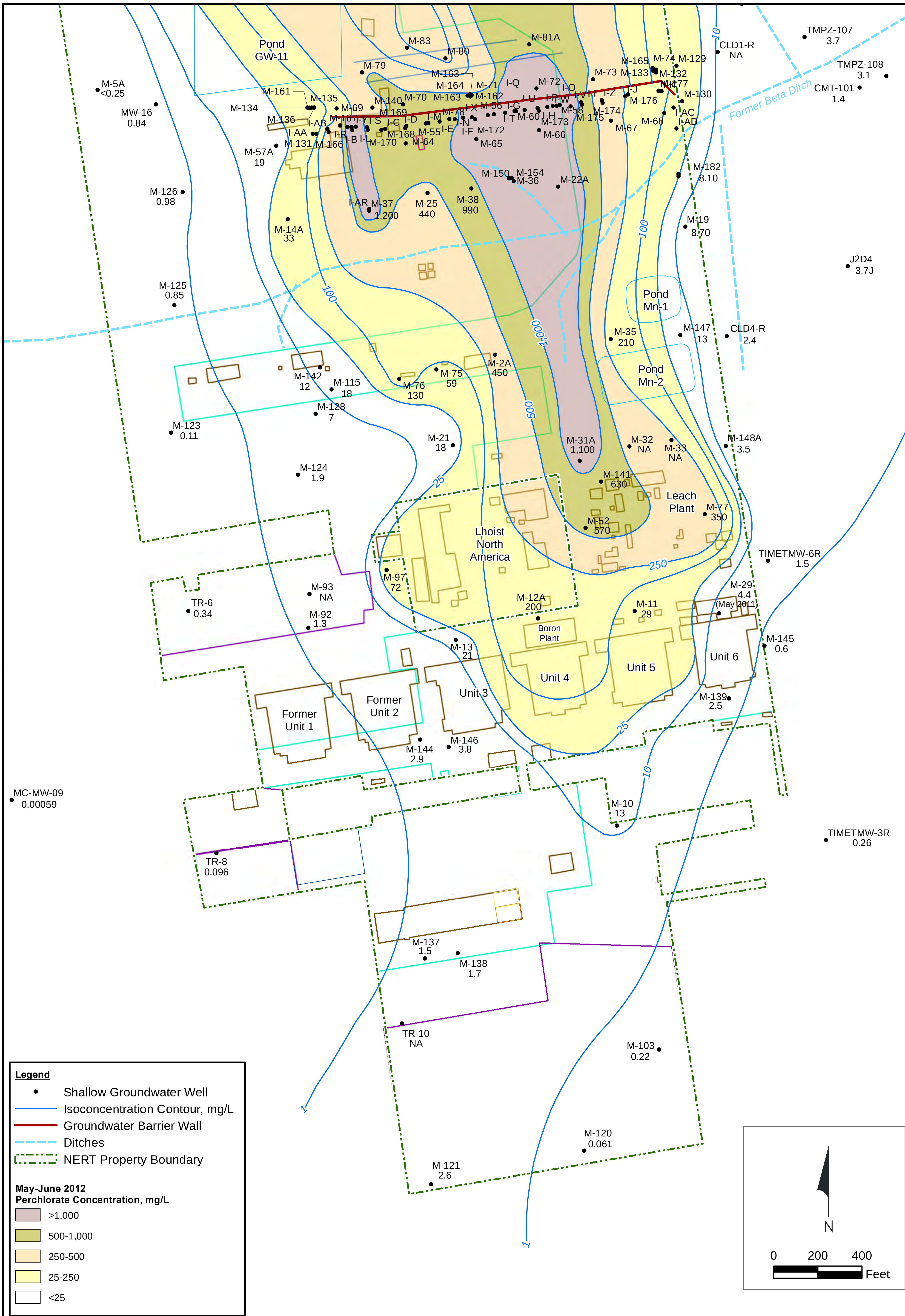
Path: H:\LePetomane\NERT\RLFS_Workplan\GIS\Figure5-5_Additional Soil Investig.mxd

ENVIRON
2200 Powell St., Suite 700, Emeryville, CA 94608

Additional Soil Investigation Areas
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-5a**

Drafter: RS | Date: 1/8/2014 | Contract Number: 21-32100I | Approved by: | Revised:



Path: H:\LePetomane\NERT\Soil Excavation\GIS\Maps\Chloroform Analysis\Fig 1b-Perchlorate in Shallow.mxd

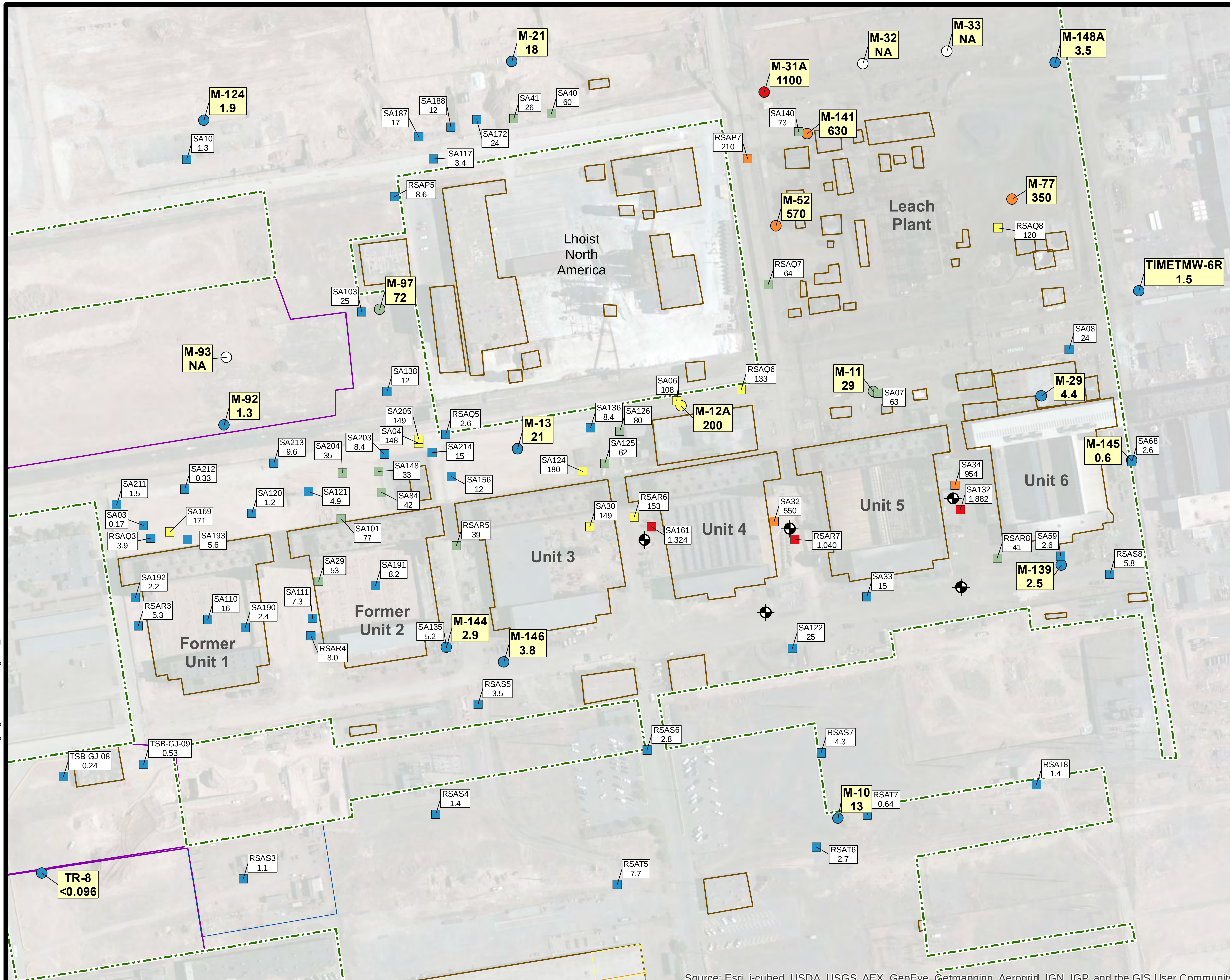
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Perchlorate in Shallow Groundwater, Site Detail
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-5b**

Drafter: RS | Date: 1/8/2014 | Contract Number: 21-32100I | Approved by: | Revised:



Legend:

- Proposed Deep Soil Boring and Shallow Monitoring Well Location
- NERT Property Boundary

Perchlorate, mg/L

- 0 - 25
- 26 - 100
- 101 - 200
- 201 - 1,000
- 1,001 - 2,000
- Shallow Monitoring Well
- Soil Sample

Notes:

1. Groundwater Samples taken May and June 2012.
2. Well M-29 was sampled in May 2011.
3. 2009 soil perchlorate results converted to equivalent mg/L.
4. Depth to groundwater ranges between 34 and 45 feet bgs in this area.

N

0 220 440

SCALE IN FEET

ENVIRON

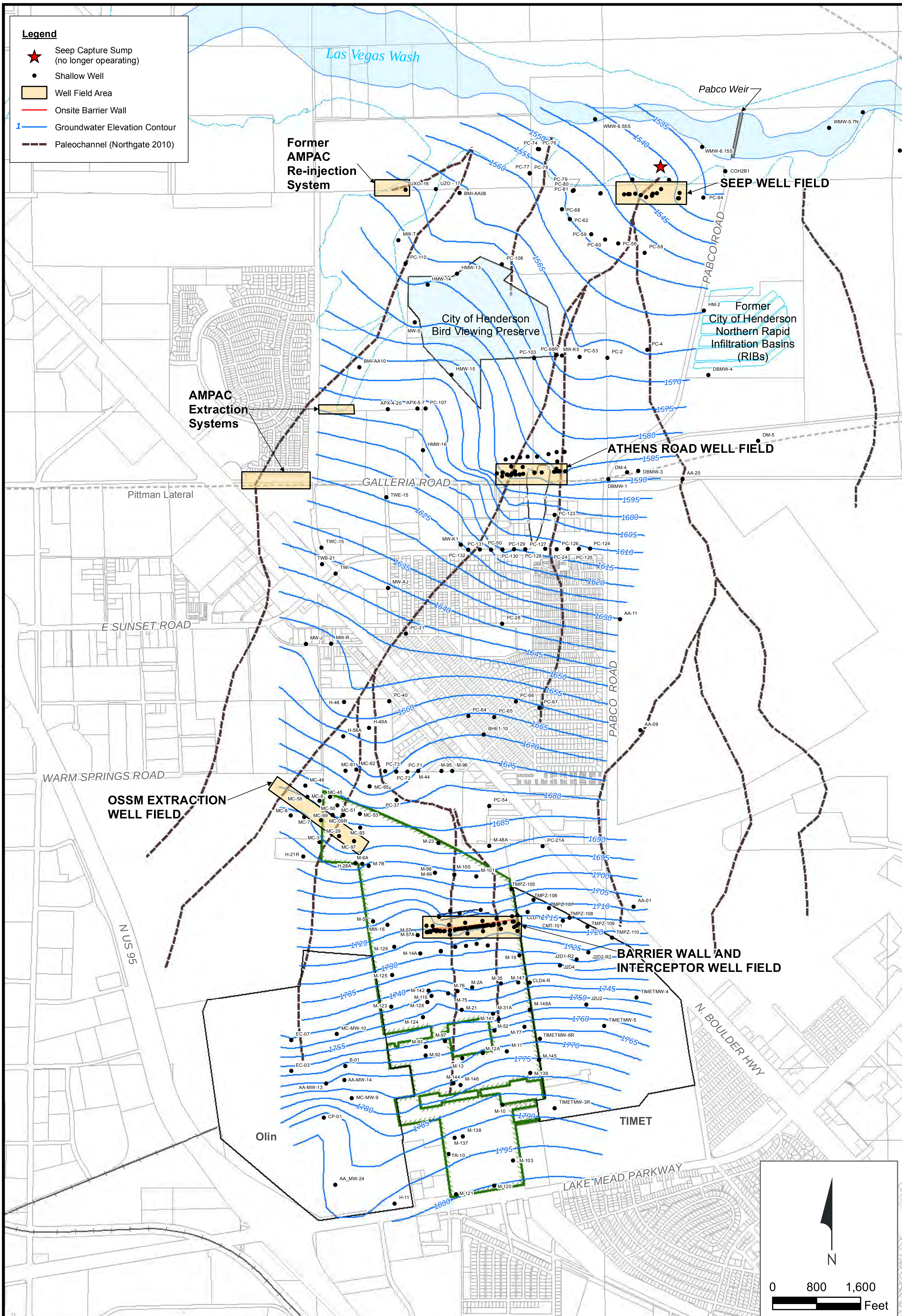
Proposed Investigation at Unit Buildings and Leach Plant

Nevada Environmental Response Trust Site

Henderson, Nevada

Date: 12/19/2013	Contract Number: 21-32100I		Figure
Drafter: RS	Approved:	Revised:	5-5c

Path: H:\LePetomane\NERT\Soil Excavation\GIS\Maps\Unit Building Figures\UnitBuildingData_Bsize-2.mxd



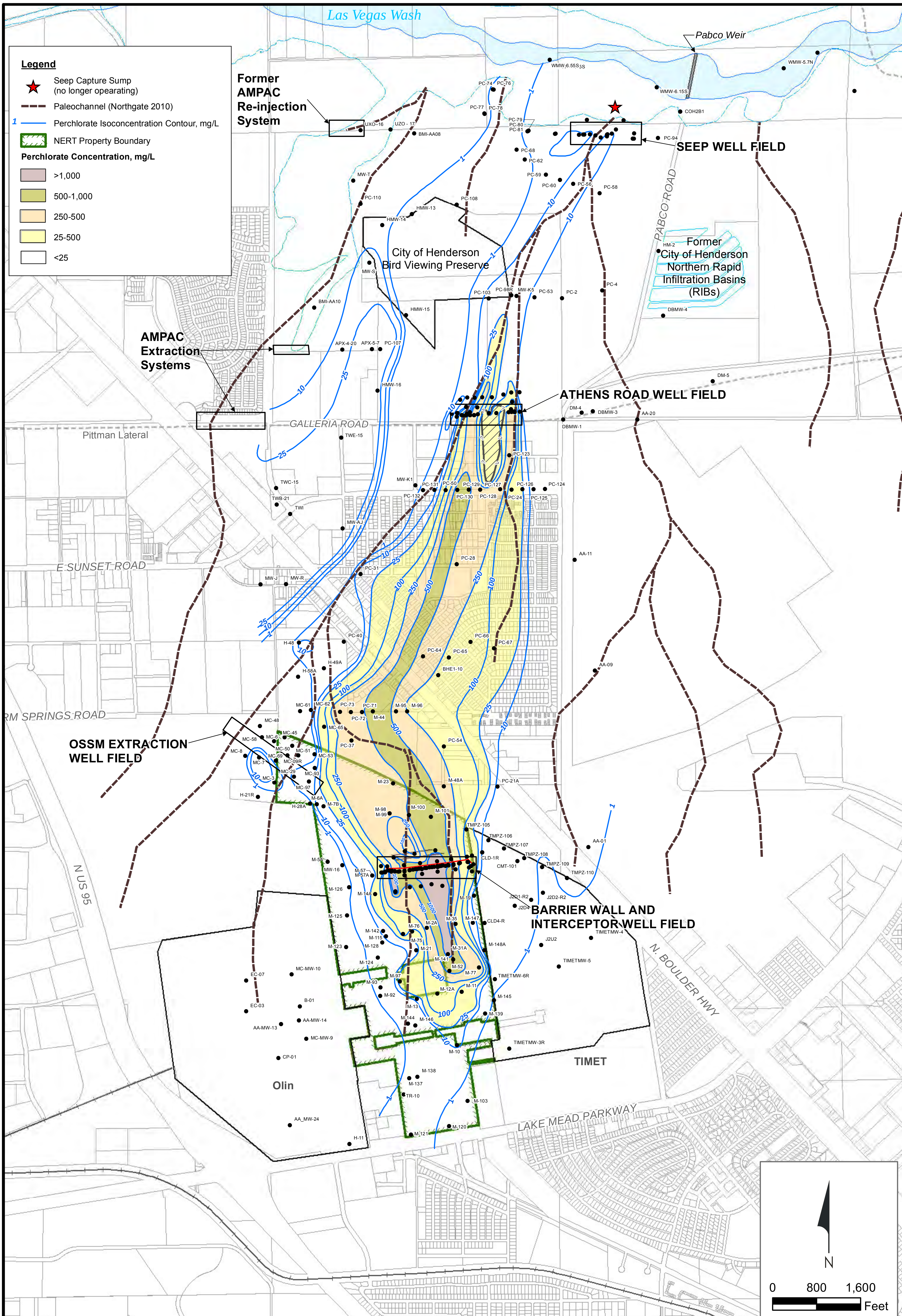
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Potentiometric Surface in Shallow Groundwater, May-June 2012
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-6**

Drafter: RS | Date: 12/19/2013 | Contract Number: 21-32100I01 | Approved by: | Revised: 12/11/13



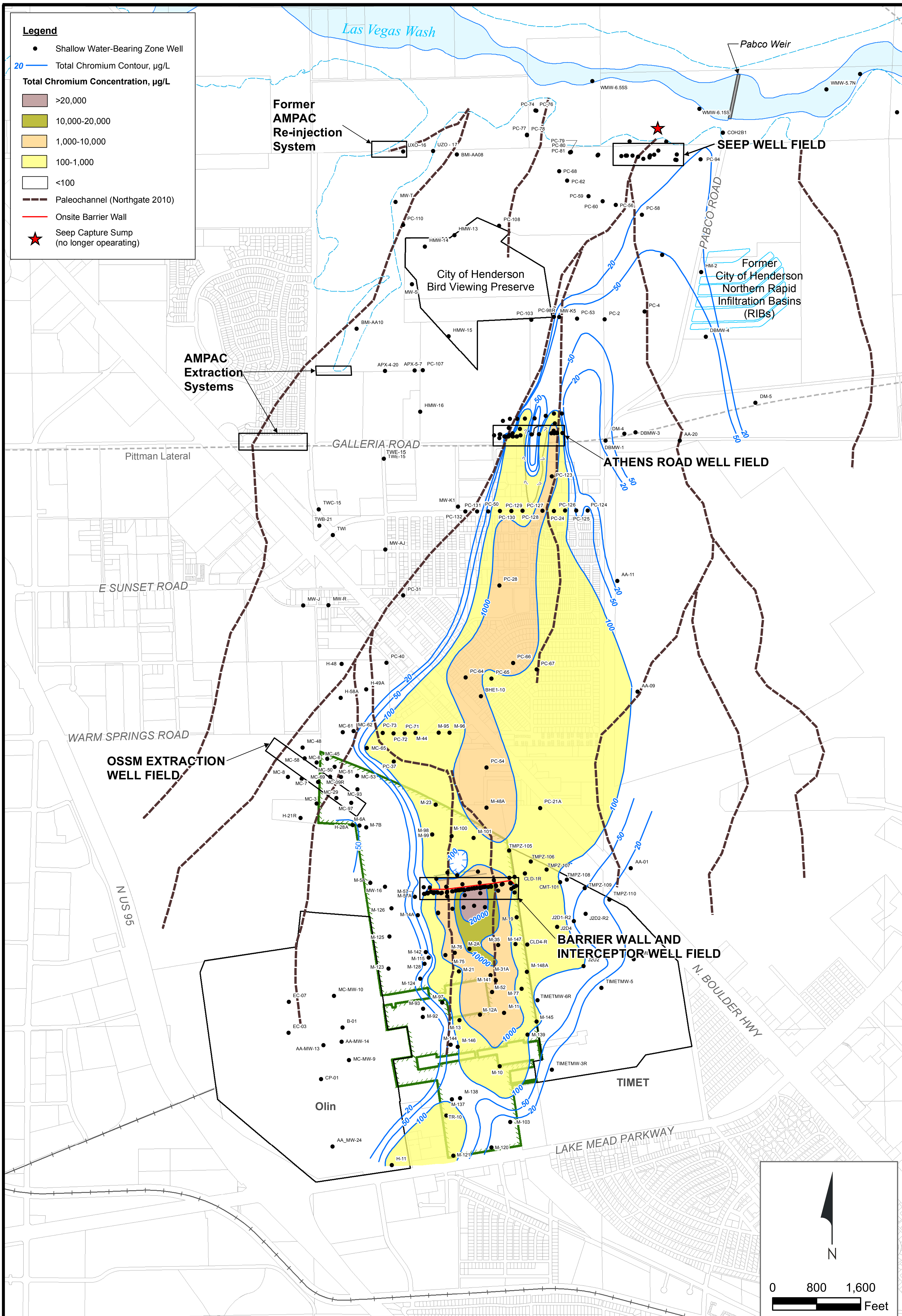
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Perchlorate in Shallow Groundwater, May-June 2012
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-7**

Drafter: RS	Date: 12/19/2013	Contract Number: 21-32100I01	Approved by:	Revised: 11/26/13



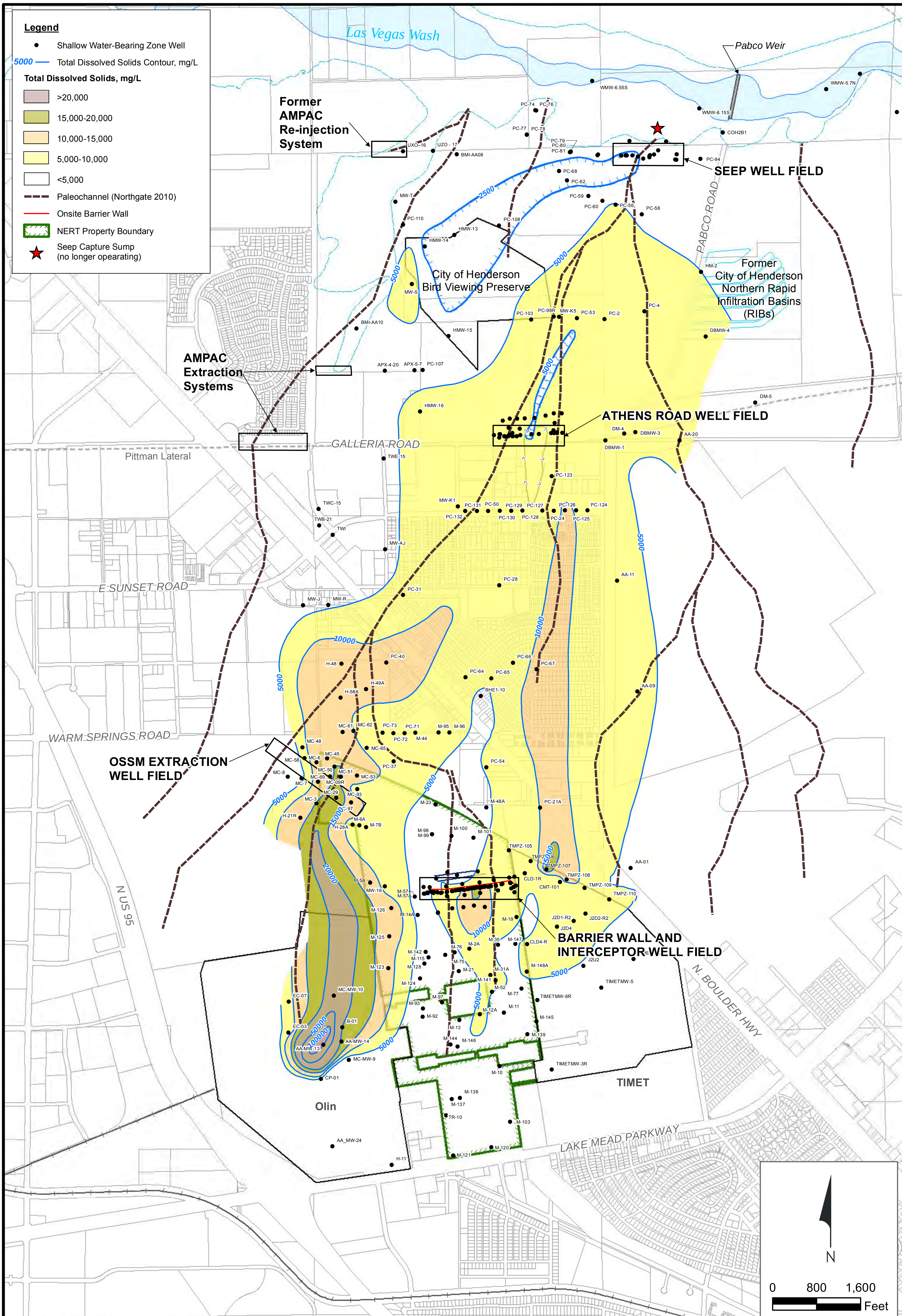
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Total Chromium in Shallow Groundwater, May-June 2012
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-8**

Drafter: RS | Date: 1/24/2014 | Contract Number: 21-32100I01 | Approved by: | Revised: 12/11/13



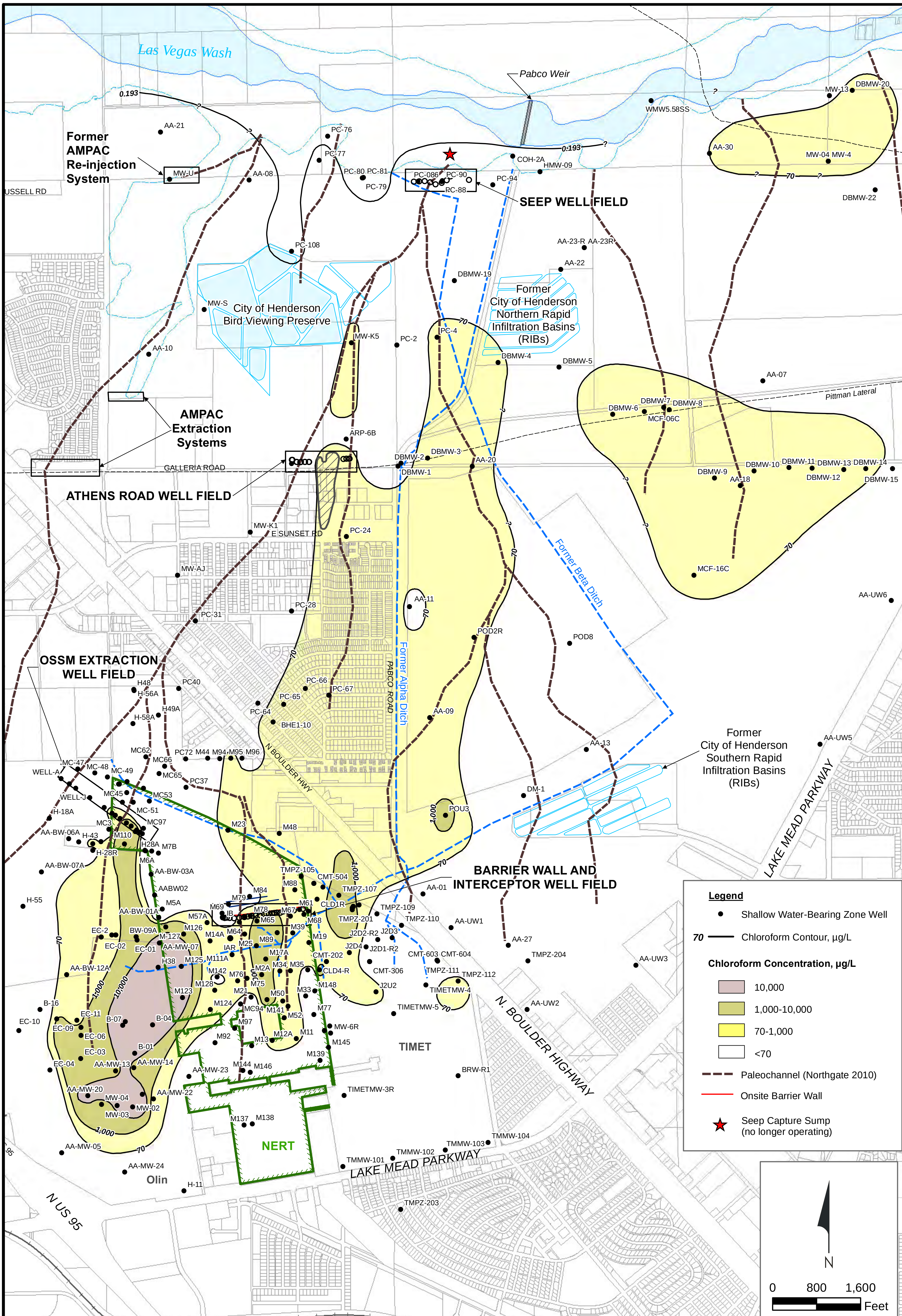
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Total Dissolved Solids in Shallow Groundwater, May-June 2012
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5-9

Drafter: RS | Date: 12/19/2013 | Contract Number: 21-32100I01 | Approved by: | Revised: 12/11/13



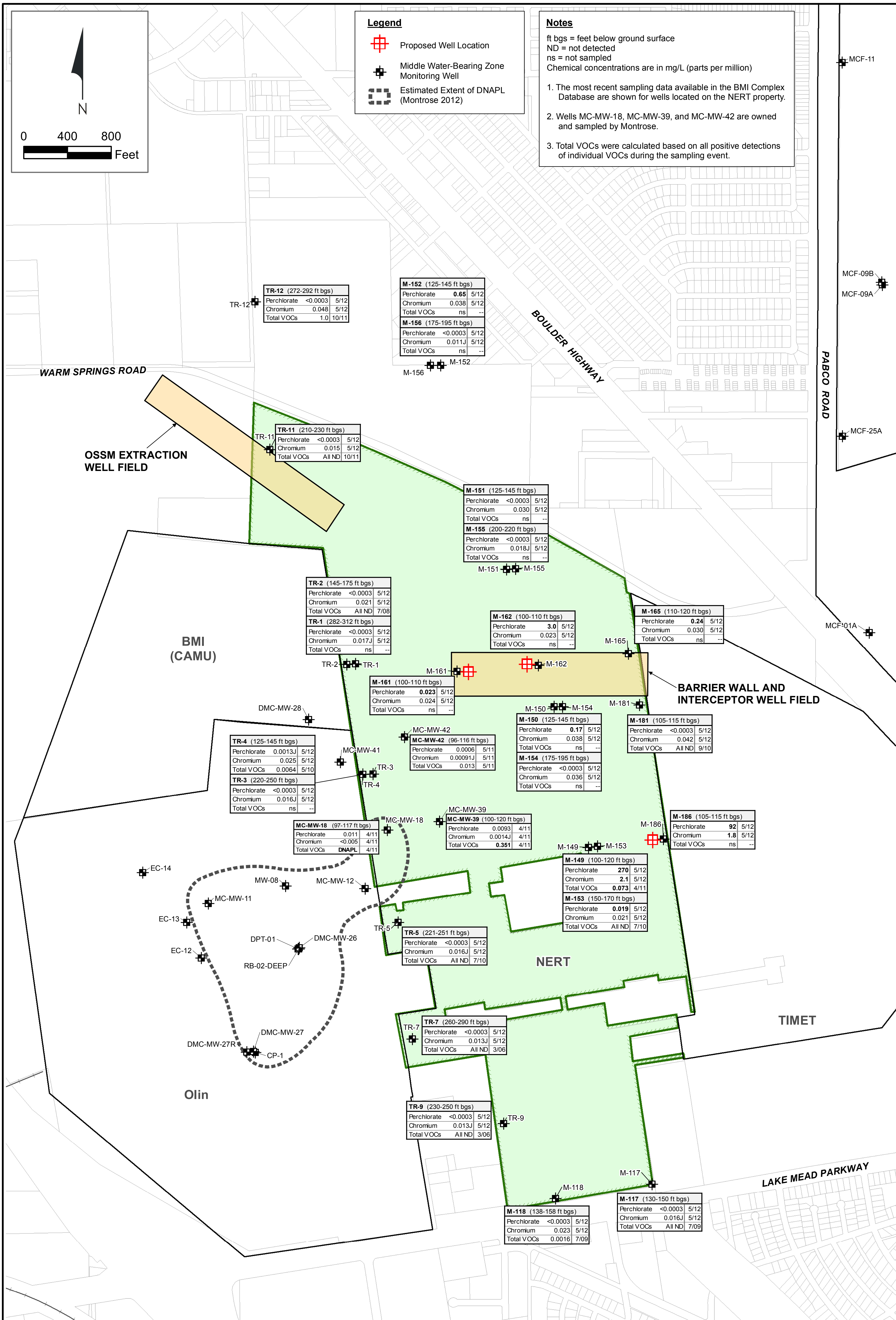
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Chloroform in Shallow Groundwater, 2008 - 2009
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5-10

Drafter: RS | Date: 12/19/2013 | Contract Number: 21-32100I01 | Approved by: | Revised:



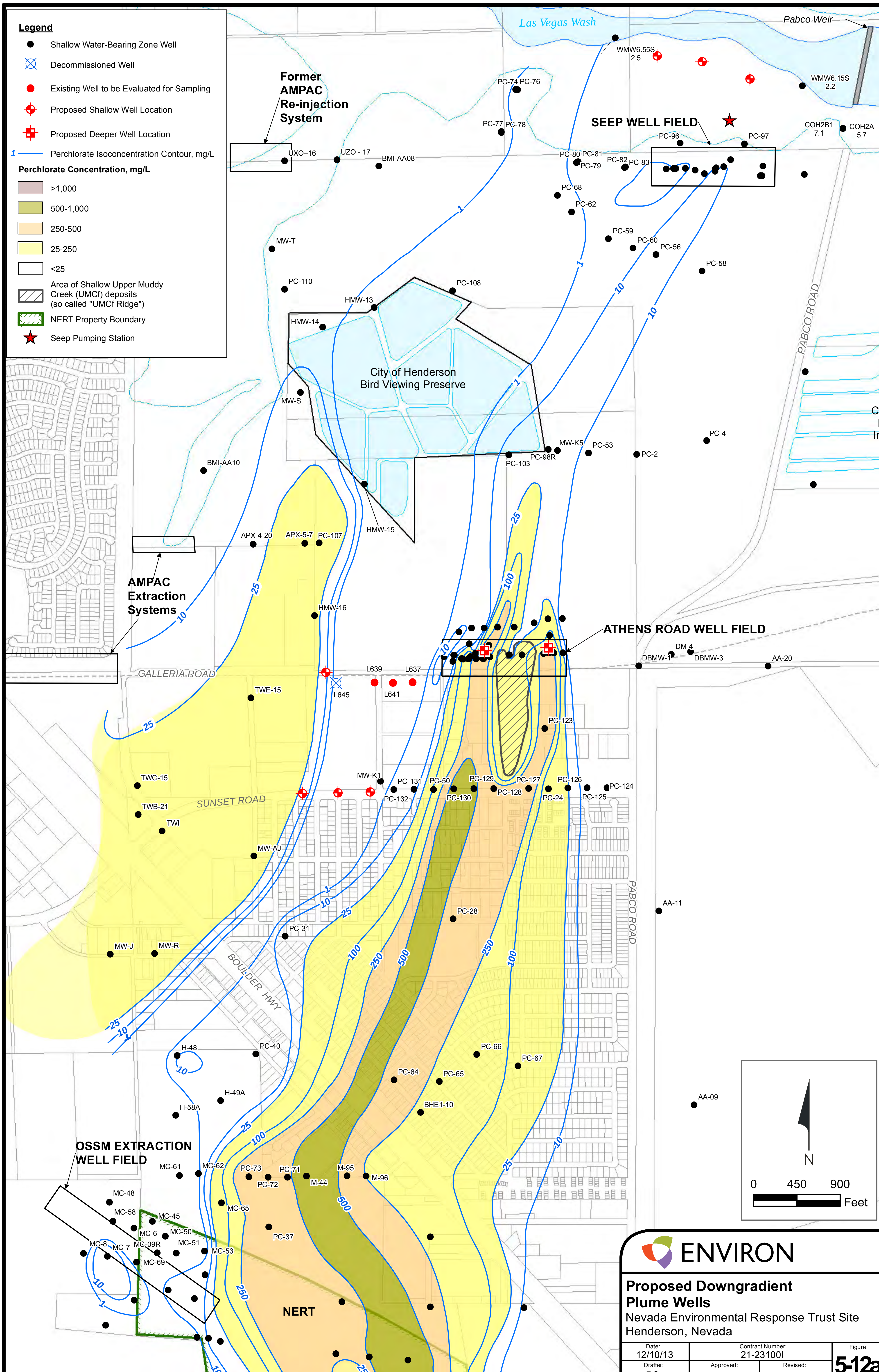
ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Proposed On-site Wells, Middle Water-Bearing Zone
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-11**

Drafter: RS | Date: 1/20/2014 | Contract Number: 21-32100I01 | Approved by: | Revised: 12/11/13

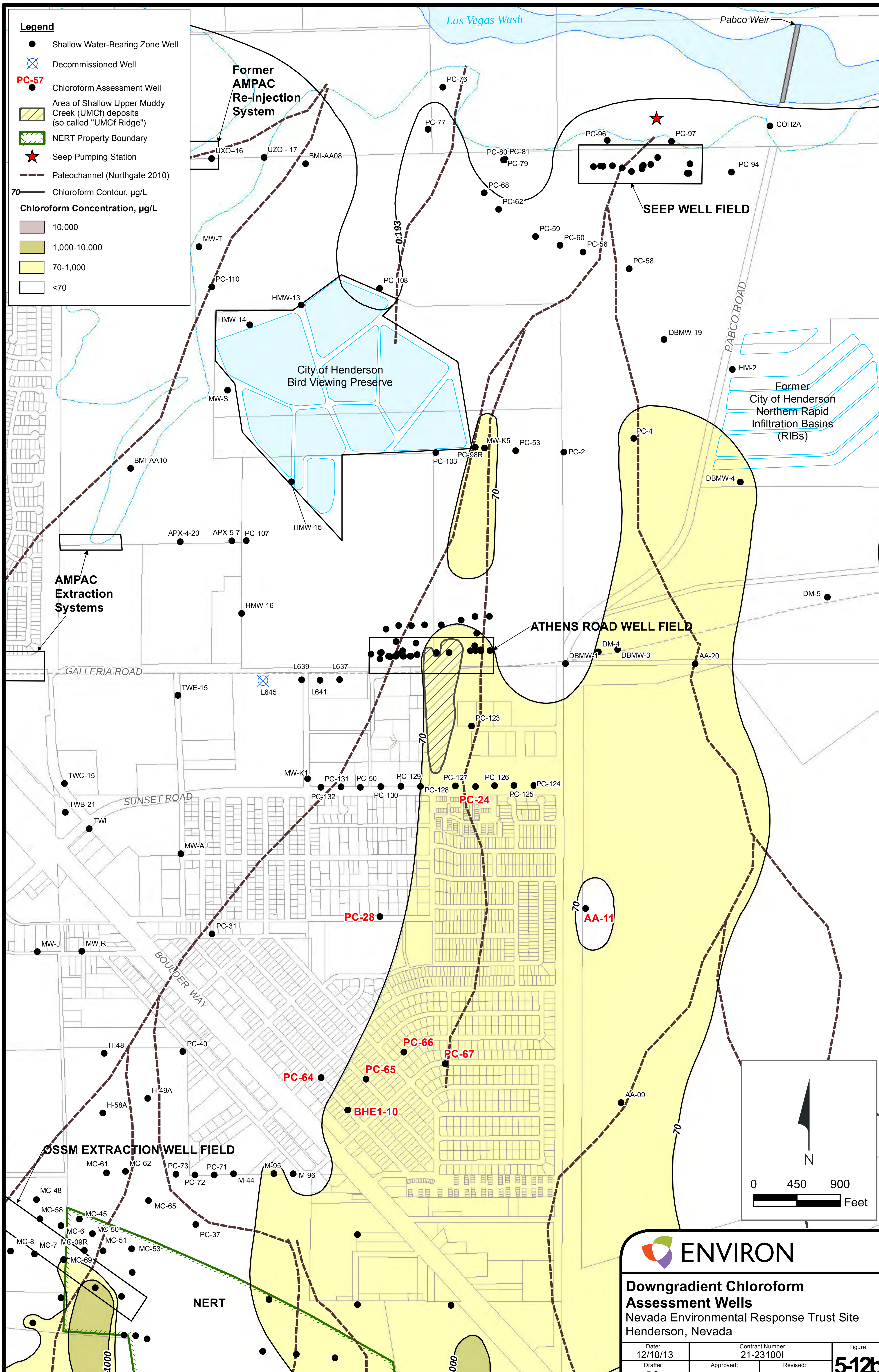


ENVIRON

Proposed Downgradient Plume Wells

Nevada Environmental Response Trust Site
Henderson, Nevada

Date:	Contract Number:	Figure
12/10/13	21-23100I	5-12a
Drafter: RS	Approved:	Revised:

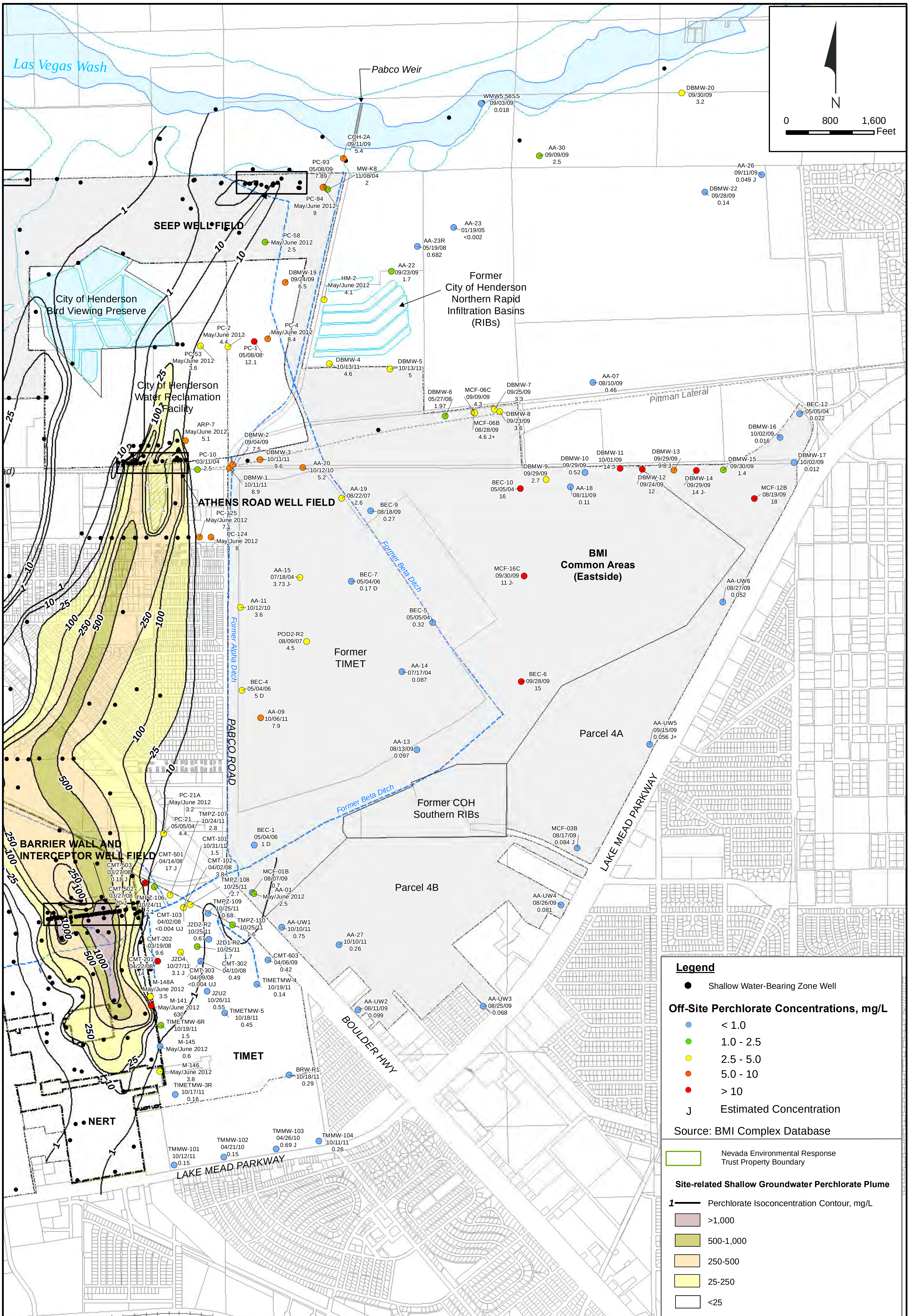


ENVIRON

Downgradient Chloroform Assessment Wells
Nevada Environmental Response Trust Site
Henderson, Nevada

Date:	Contract Number:		Figure
12/10/13	21-23100I		5-12b
Drafter: RS	Approved:	Revised:	

Path: H:\LePetomane\NERT\Soil Excavation\GIS\Maps\Chloroform Analysis\Fig 5-12b_Chloroform-GW-Area-map.mxd



ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

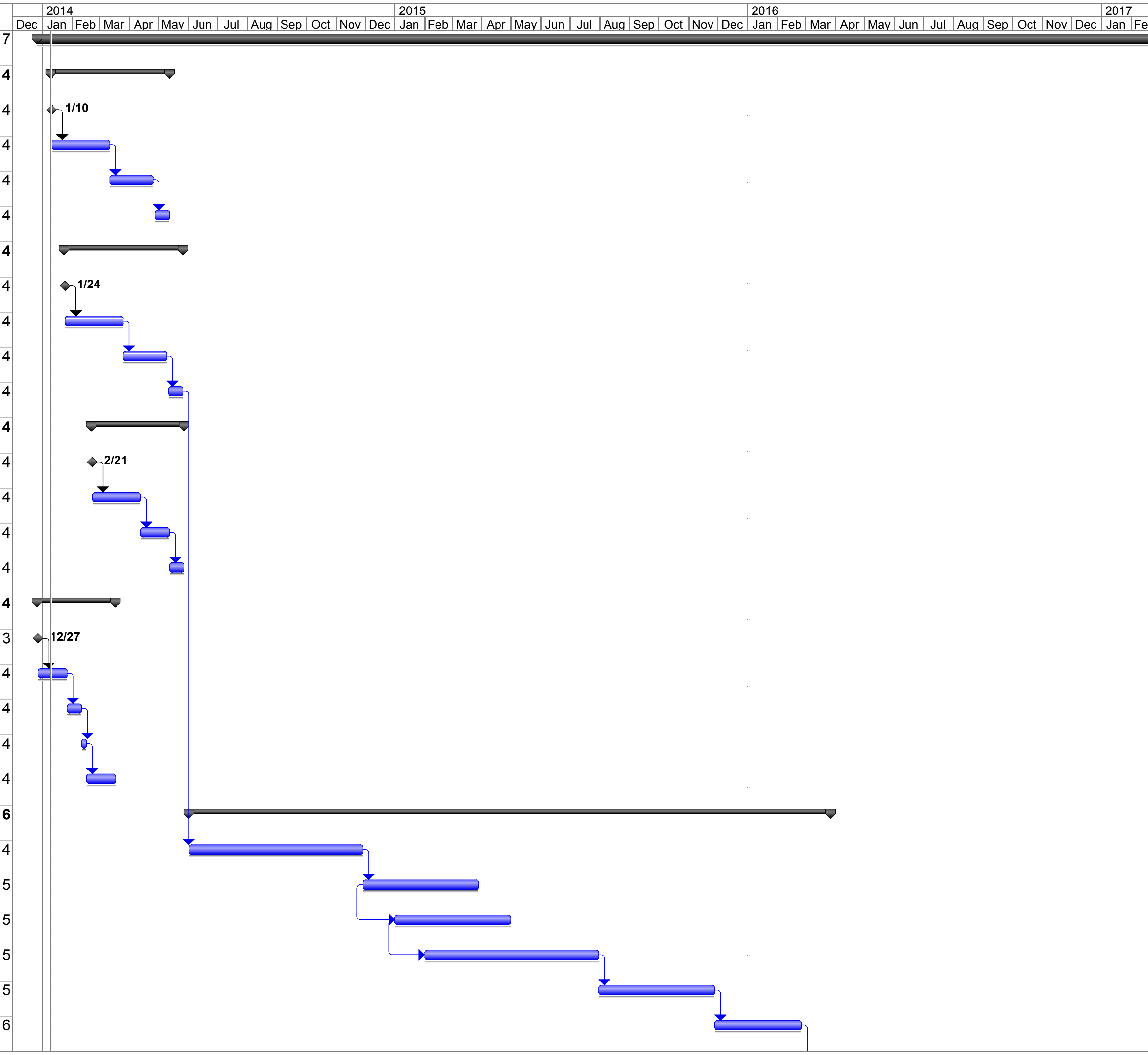
Downgradient Plume, Eastern Detail

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **5-13**

Drafter: RS | Date: 12/15/12 | Contract Number: 21-32100I01 | Approved by: | Revised: 12/11/13

ID	Task Name	Calendar Days	Start	Finish
1	**REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS)**	1156 days	12/27/13	2/24/17
2	**RI/FS Work Plan**	**123 days**	**1/10/14**	**5/12/14**
3	Submit RI/FS Work Plan to NDEP	1 day	1/10/14	1/10/14
4	NDEP Review of RI/FS Work Plan	60 days	1/11/14	3/11/14
5	Respond to Comments / Finalize RI/FS Work Plan	45 days	3/12/14	4/25/14
6	NDEP Approval of RI/FS Work Plan	15 days	4/28/14	5/12/14
7	**SAP, QAPP, and HASP**	**123 days**	**1/24/14**	**5/26/14**
8	Submit SAP, QAPP, and HASP to NDEP	1 day	1/24/14	1/24/14
9	NDEP Review of SAP, QAPP, and HASP	60 days	1/25/14	3/25/14
10	Respond to NDEP Comments / Finalize SAP, QAPP, and HASP	45 days	3/26/14	5/9/14
11	NDEP Approval of SAP, QAPP, and HASP	15 days	5/12/14	5/26/14
12	**Baseline Health Risk Asessment (BHRA) Work Plan**	**96 days**	**2/21/14**	**5/27/14**
13	Submit BHRA Work Plan to NDEP	1 day	2/21/14	2/21/14
14	NDEP Review of BHRA Work Plan	50 days	2/22/14	4/12/14
15	Respond to NDEP Comments / Finalize BHRA Work Plan	30 days	4/13/14	5/12/14
16	NDEP Approval of BHRA Work Plan	15 days	5/13/14	5/27/14
17	**Community Involvement Plan (CIP)**	**81 days**	**12/27/13**	**3/17/14**
18	Submitted CIP to NDEP	1 day	12/27/13	12/27/13
19	NDEP Review of CIP	30 days	12/28/13	1/26/14
20	Respond to NDEP Comments / Finalize CIP	15 days	1/27/14	2/10/14
21	NDEP Approval of Final CIP	5 days	2/11/14	2/15/14
22	Establish Additional Information Repository at Henderson Library	30 days	2/16/14	3/17/14
23	**Remedial Investigation (RI) and BHRA**	**664 days**	**6/2/14**	**3/26/16**
24	Data Gap Field Investigation(s)	180 days	6/2/14	11/28/14
25	Evaluate Additional Data Collected	120 days	11/29/14	3/28/15
26	Perform BHRA	120 days	1/1/15	4/30/15
27	Preparation of the RI and BHRA Reports	180 days	2/1/15	7/30/15
28	NDEP Review of the RI and BHRA Reports	120 days	7/31/15	11/27/15
29	Address NDEP Comments and Finalize RI and BHRA Reports	90 days	11/28/15	2/25/16



Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Schedule subject to change based on NDEP and contractor input.

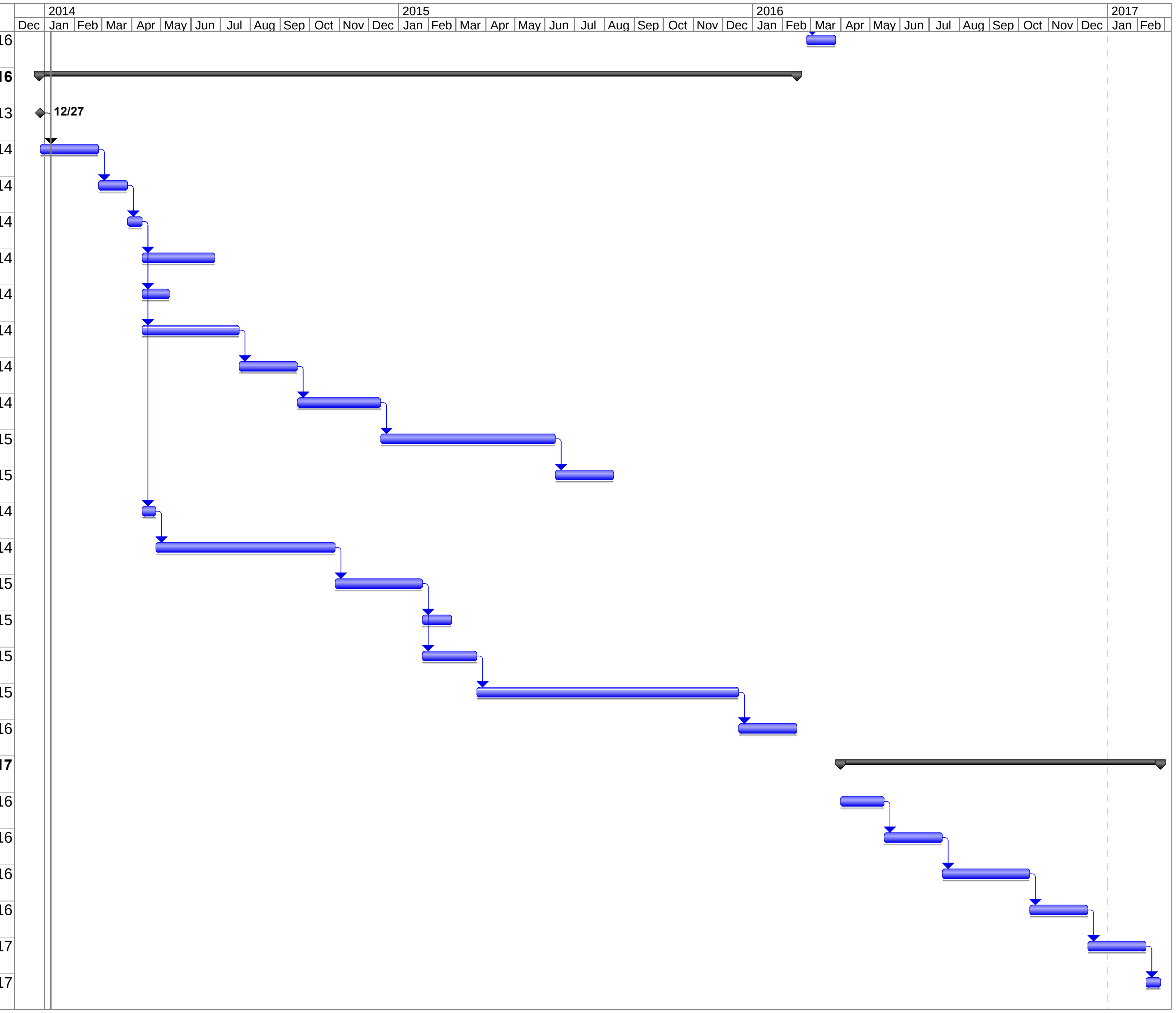
ENVIRON

Remedial Investigation and Feasibility Study Schedule
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **7-1**

Drafter: RS | Date: 1/7/14 | Contract Number: 21-32100I | Approved: | Revised:

ID	Task Name	Calendar Days	Start	Finish
30	NDEP Approval of RI and BHRA Reports	30 days	2/26/16	3/26/16
31	**Treatability Study (TS)**	**781 days**	**12/27/13**	**2/15/16**
32	Submitted TS Work Plans to NDEP	1 day	12/27/13	12/27/13
33	NDEP Review of TS Work Plans	60 days	12/28/13	2/25/14
34	Respond to NDEP Comments / Finalize TS Work Plans	30 days	2/26/14	3/27/14
35	NDEP Approval of TS Work Plans	15 days	3/28/14	4/11/14
36	Apply for and Obtain Permits	75 days	4/12/14	6/25/14
37	Soil Flushing Pilot Preliminary Field Testing	28 days	4/12/14	5/9/14
38	Soil Flushing Field-Scale Pilot Design	100 days	4/12/14	7/20/14
39	NDEP Review and Approval of Soil Flushing Field-Scale Pilot Design	60 days	7/21/14	9/18/14
40	Soil Flushing Field-Scale Pilot Construction	86 days	9/19/14	12/13/14
41	Soil Flushing Field-Scale Pilot Operation	180 days	12/14/14	6/11/15
42	Soil Flushing Treatability Study Report Preparation	60 days	6/12/15	8/10/15
43	PRB Field-Scale Pilot Preliminary Field Activities	14 days	4/12/14	4/25/14
44	PRB Dilution Testing and ISM Studies	185 days	4/26/14	10/27/14
45	PRB Field-Scale Pilot Design	90 days	10/28/14	1/25/15
46	NDEP Review and Approval of PRB Field-Scale Pilot Design	30 days	1/26/15	2/24/15
47	PRB Field-Scale Pilot Construction	56 days	1/26/15	3/22/15
48	PRB Field-Scale Pilot Operation	270 days	3/23/15	12/17/15
49	PRB Treatability Study Report Preparation	60 days	12/18/15	2/15/16
50	**Feasibility Study (FS)**	**330 days**	**4/1/16**	**2/24/17**
51	Remedial Alternatives Development	45 days	4/1/16	5/15/16
52	Detailed Analysis of Alternatives	60 days	5/16/16	7/14/16
53	Prepare FS Report	90 days	7/15/16	10/12/16
54	NDEP Review of FS Report	60 days	10/13/16	12/11/16
55	Address NDEP Comments / Finalize FS Report	60 days	12/12/16	2/9/17
56	NDEP Approval of FS Report	15 days	2/10/17	2/24/17



Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Schedule subject to change based on NDEP and contractor input.

ENVIRON

Remedial Investigation and Feasibility Study Schedule
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **7-1**

Drafter: RS | Date: 1/7/14 | Contract Number: 21-32100I | Approved: | Revised:

Plates

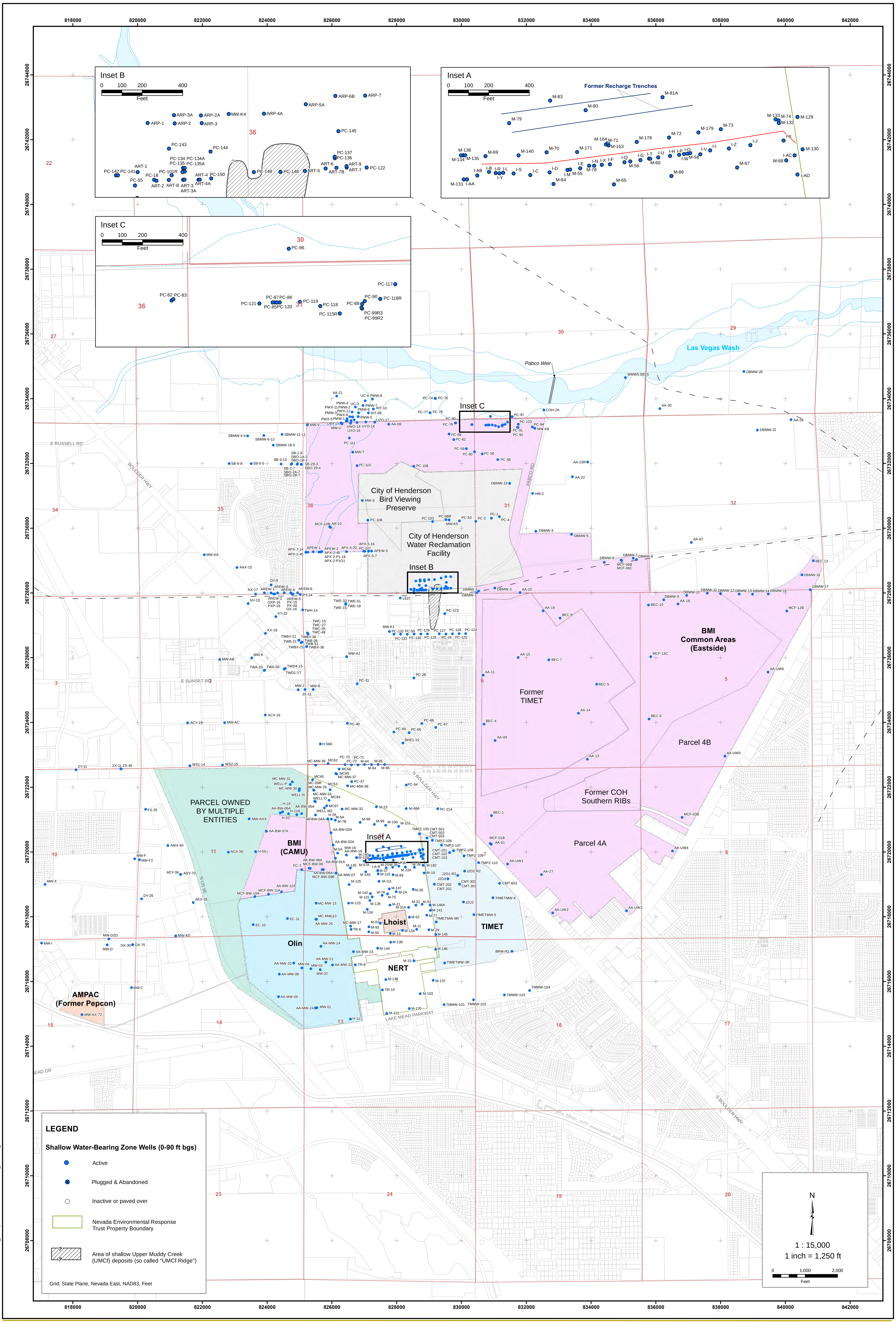


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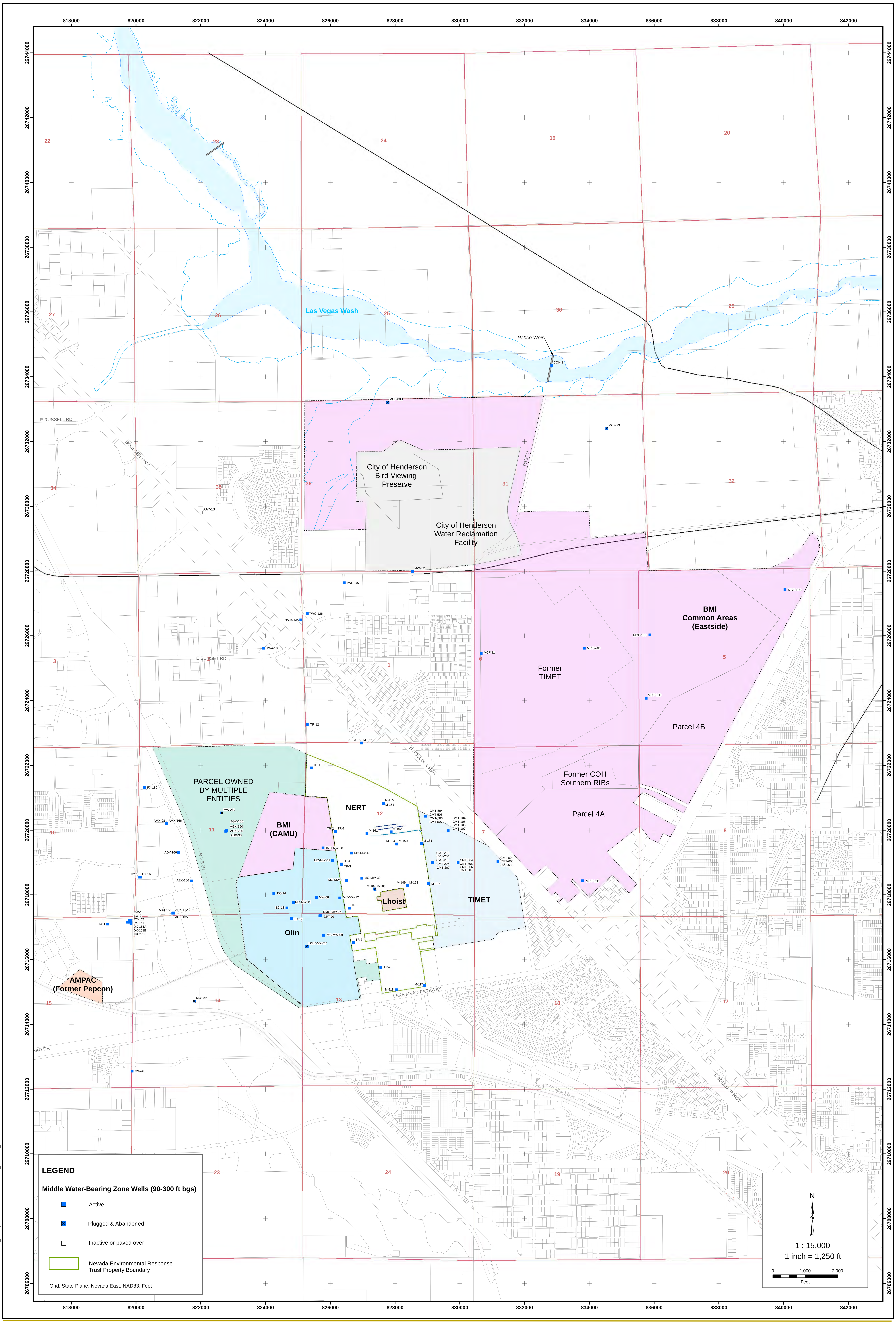
Plate 1a	WELL LOCATION MAP SHALLOW WATER-BEARING ZONE	DESIGNED BY: EJK
PROJECT: 21-32100I	Nevada Environmental Response Trust (NERT) Henderson, Nevada	DRAWN BY: EJK/RS; CHECKED BY: AS; APPROVED BY: CJR/EJK

REVISIONS

NO.	DESCRIPTION:	DATE:	BY:
0	GENERATE APPROVED MAP	12/19/2013	RS

ENVIRON



Path: H:\LePetomane\NERT\RI.FS_Workplan\GIS\Plate 1b - NERT_AllWells_MiddleNEW.mxd

Plate
1b

PROJECT: 21-23100I

WELL LOCATION MAP
MIDDLE WATER-BEARING ZONE

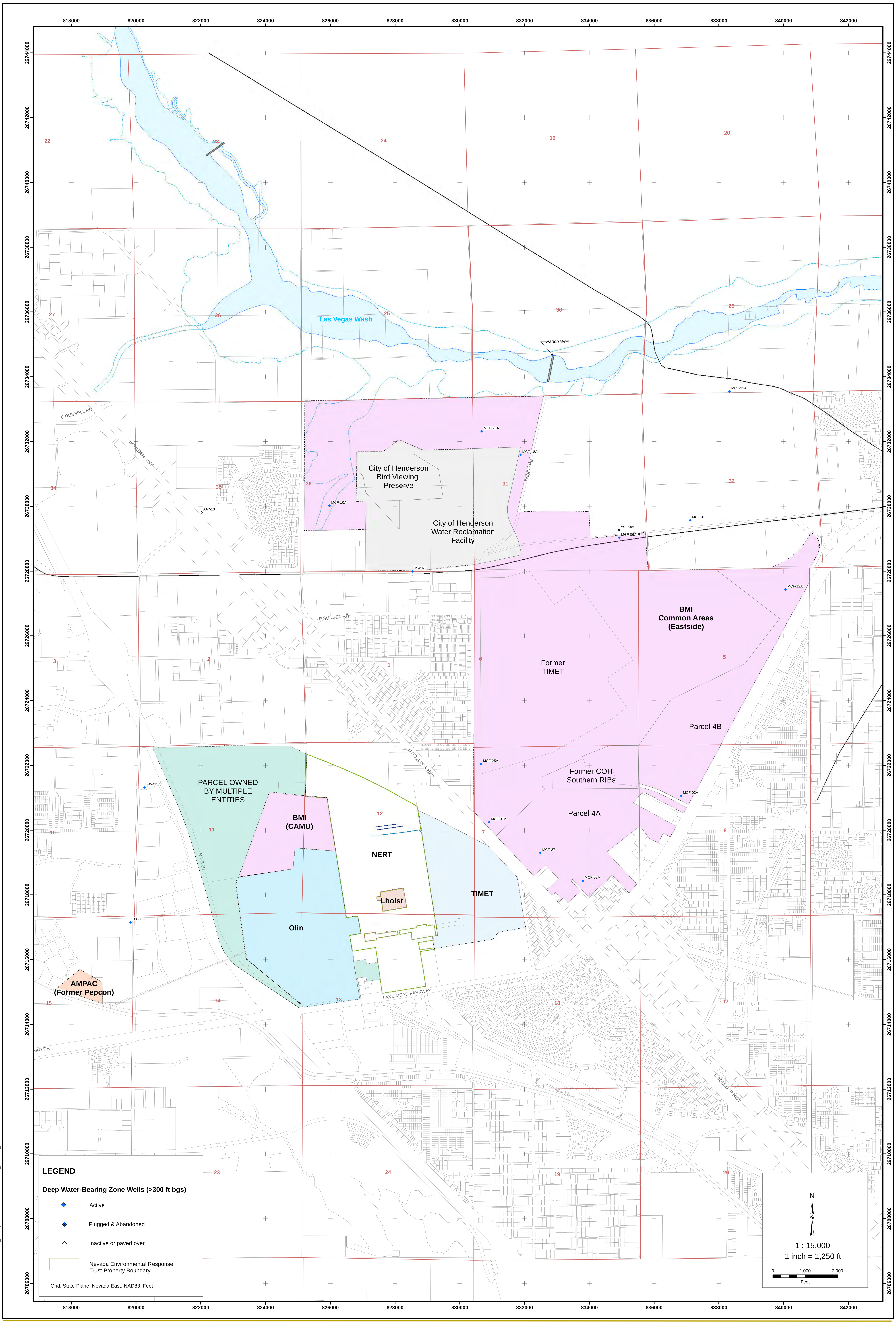
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

DESIGNED BY:
EJK
DRAWN BY:
EJK/RS
CHECKED BY:
AS
APPROVED BY:
CJR/EJK

REVISIONS

NO.	DESCRIPTION:	DATE:	BY:
0	GENERATE APPROVED MAP	12/19/2013	RS

ENVIRON



Path: H:\LePetomane\NERT\WLFS_Workplan\GIS\Plate 1c - NERT_AllWells_DeepNEW.mxd

Plate
1c

PROJECT: 21-32100I

WELL LOCATION MAP
DEEP WATER-BEARING ZONE

Nevada Environmental Response Trust (NERT)
Henderson, Nevada

DESIGNED BY:
EJK
DRAWN BY:
EJK/RS
CHECKED BY:
AS
APPROVED BY:
CJR/EJK

REVISIONS			
NO.	DESCRIPTION:	DATE:	BY:
0	GENERATE APPROVED MAP	12/19/2013	RS

ENVIRON

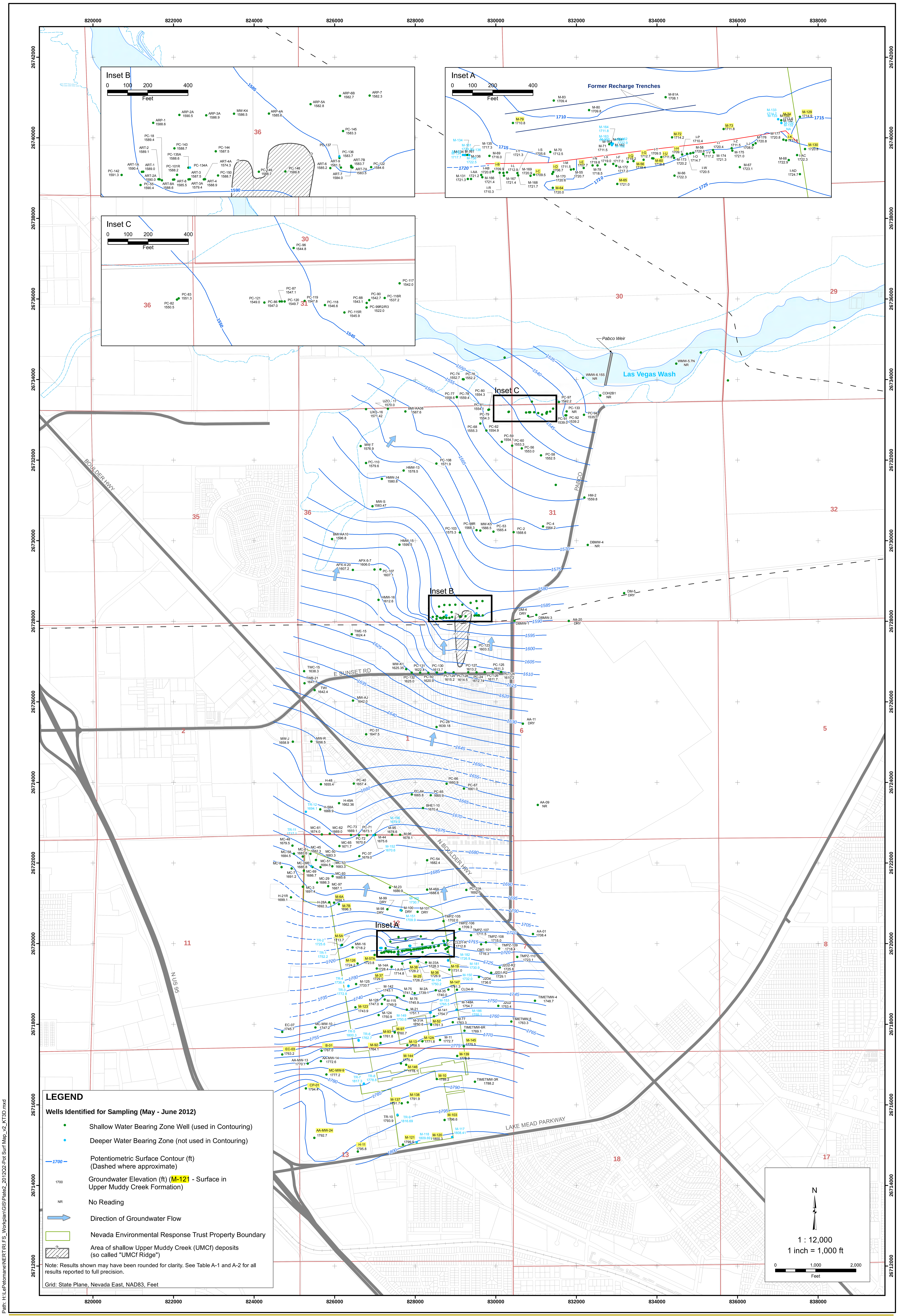


Plate
2
PROJECT: 21-32100I

POTENTIOMETRIC SURFACE MAP
SHALLOW WATER-BEARING ZONE
SECOND QUARTER 2012
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

DESIGNED BY:	REVISIONS			
EJK	NO.	DESCRIPTION:	DATE:	BY:
DRAWN BY:	0	GENERATE APPROVED MAP	12/19/2013	RS
EJK/RS				
CHECKED BY:				
AS				
APPROVED BY:				
CJR/EJK				

ENVIRON

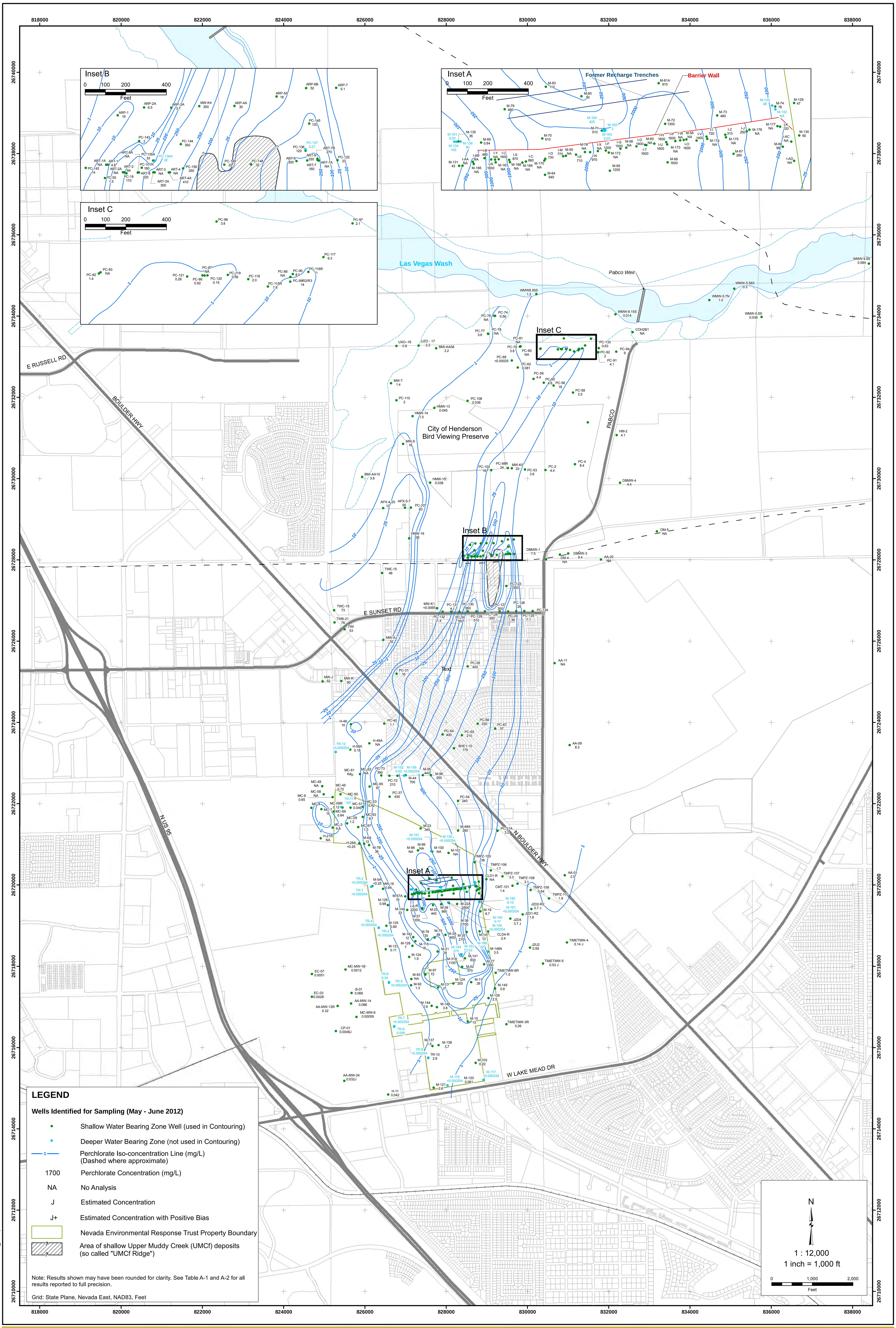


Plate
3
PROJECT: 21-32100I

GROUNDWATER PERCHLORATE MAP
SHALLOW WATER-BEARING ZONE
SECOND QUARTER 2012

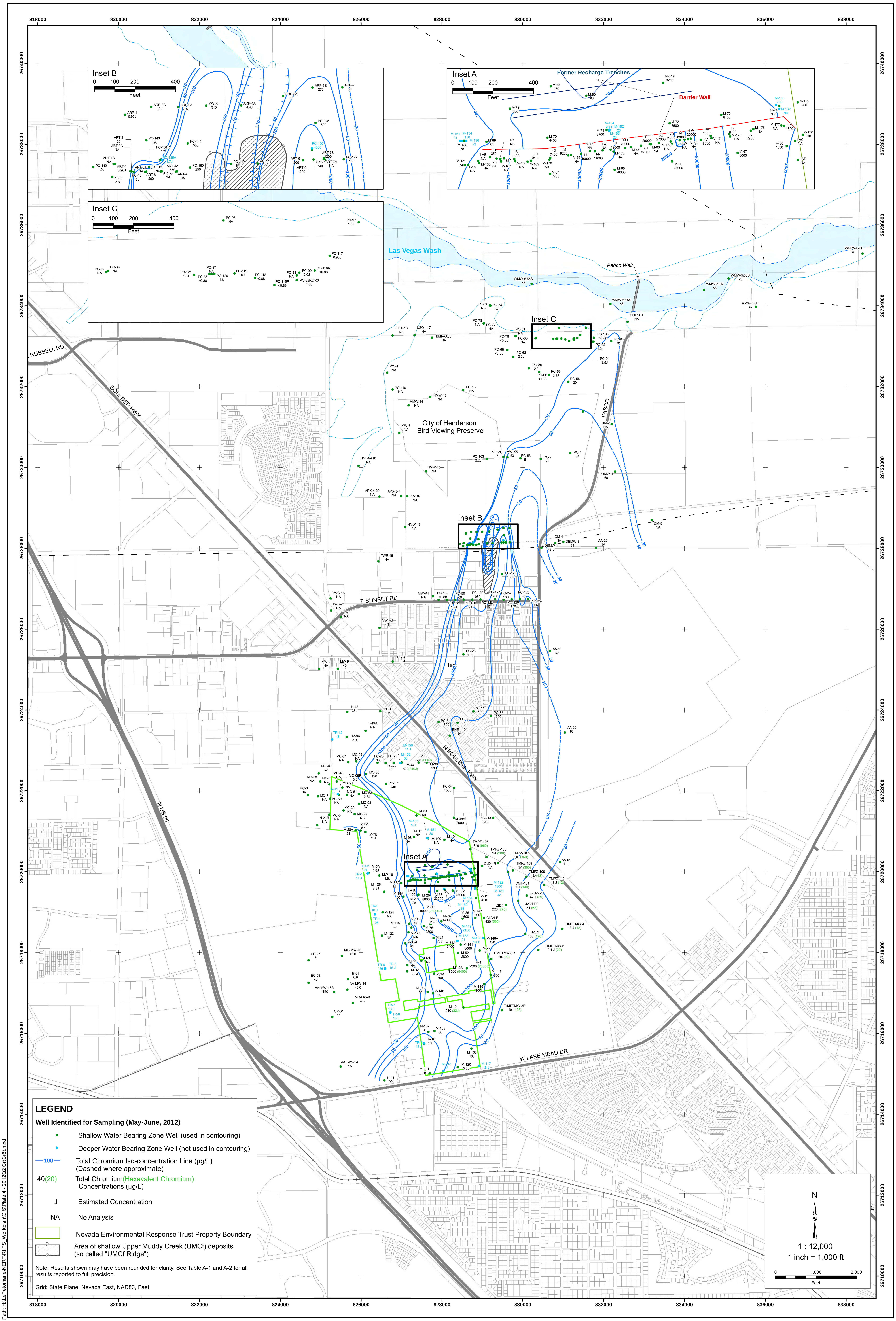
Annual Performance Report
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

DESIGNED BY:
EJK
DRAWN BY:
EJK/RS
CHECKED BY:
AS
APPROVED BY:
CJR/EJK

REVISIONS

NO.	DESCRIPTION:	DATE:	BY:
0	GENERATE APPROVED MAP	8/31/2012	AS/RS
1	ADD ADDITIONAL DATA POINTS	12/19/2013	KL/RS

ENVIRON

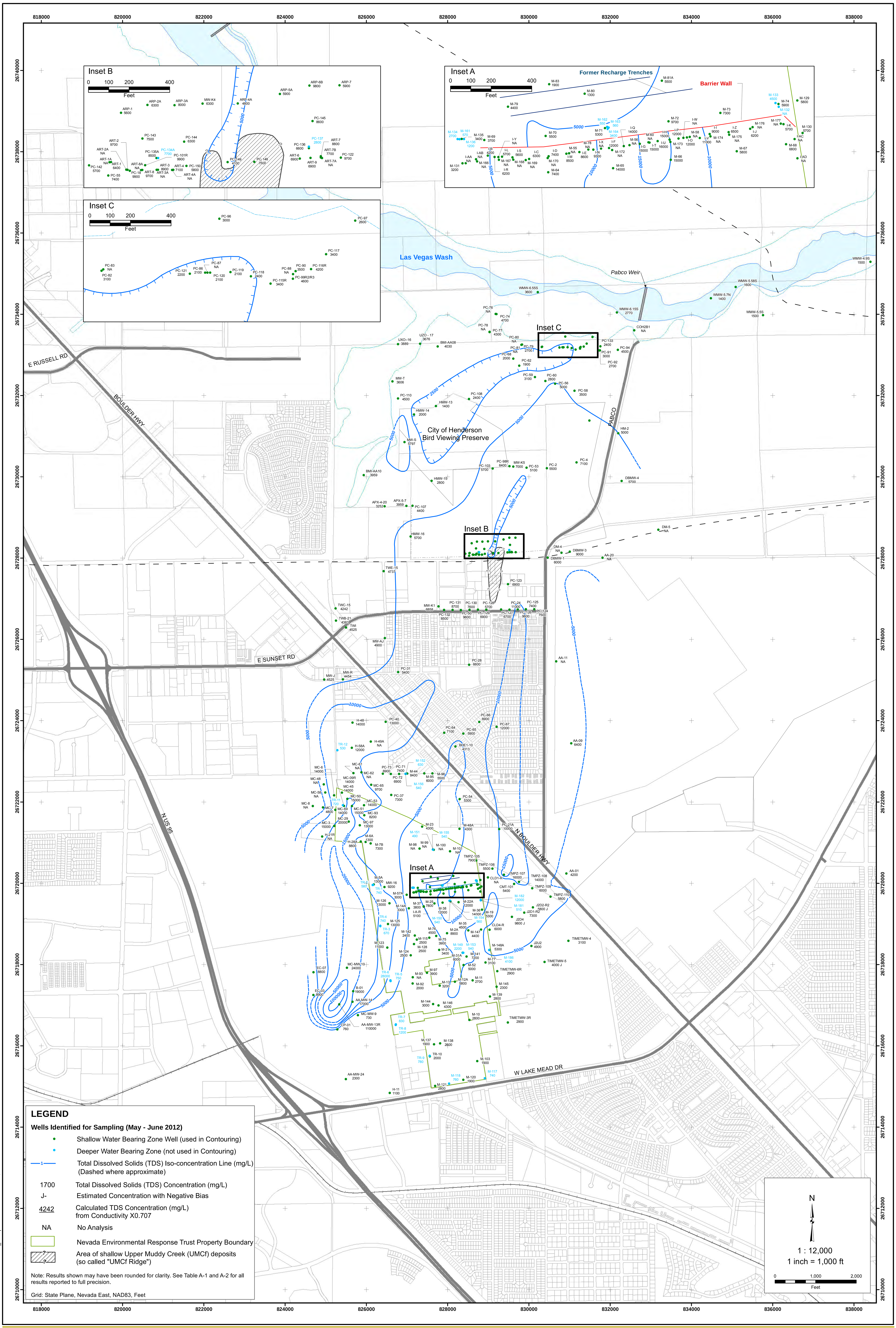


Path: H:\LePetomane\NERT\RI FS_Workplan\GIS\Plate 4 - 2012Q2 Cr(Cr6).mxd

Plate 4	GROUNDWATER TOTAL CHROMIUM MAP SHALLOW WATER-BEARING ZONE SECOND QUARTER 2012
PROJECT: 21-32100I	Annual Performance Report Nevada Environmental Response Trust (NERT) Henderson, Nevada

DESIGNED BY:	REVISIONS			
EJK	NO.	DESCRIPTION:	DATE:	BY:
DRAWN BY: EJK/RS	0	GENERATE APPROVED MAP	8/31/2012	AS/RS
CHECKED BY: AS	1	CHANGE UNITS ON CONTOUR LABELS; ADJUST CONTOURS	9/10/2012	AS/RS
APPROVED BY: CJR/EJK	2	ADD DATA POINTS NEAR LAS VEGAS WASH	12/19/2013	KL/RS

ENVIRON



Path: H:\LePetomane\NERT\RI FS_Workplan\GIS\Plate 5 - 2012Q2 TDS.mxd

Plate

5

PROJECT: 21-23210OI

GROUNDWATER TOTAL DISSOLVED SOLIDS MAP
SHALLOW WATER-BEARING ZONE
SECOND QUARTER 2012

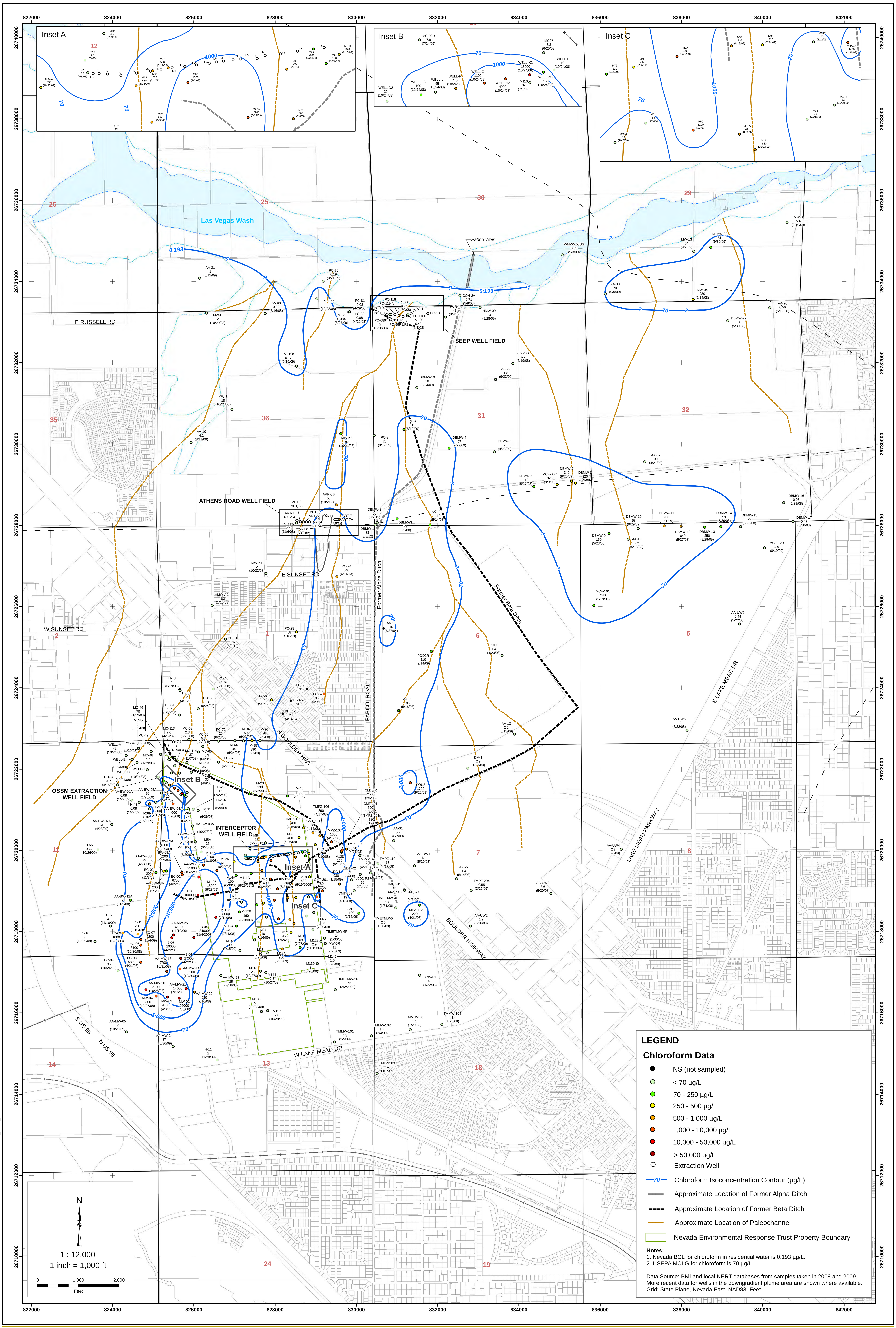
Annual Performance Report
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

DESIGNED BY:	EJK
DRAWN BY:	EJK/RS
CHECKED BY:	AS
APPROVED BY:	CJR/EJK

REVISIONS

NO.	DESCRIPTION:	DATE:	BY:
0	GENERATE APPROVED MAP	8/31/2012	AS/RS
1	ADD ADDITIONAL DATA POINTS	12/19/2013	KL/RS

ENVIRON



Path: H:\LePetomane\NERT\Soil Excavation\GIS\Maps\Chloroform Analysis\Plate-1_NEW_ChloroformMap-3.mxd

Plate

6

PROJECT: 21-32100I

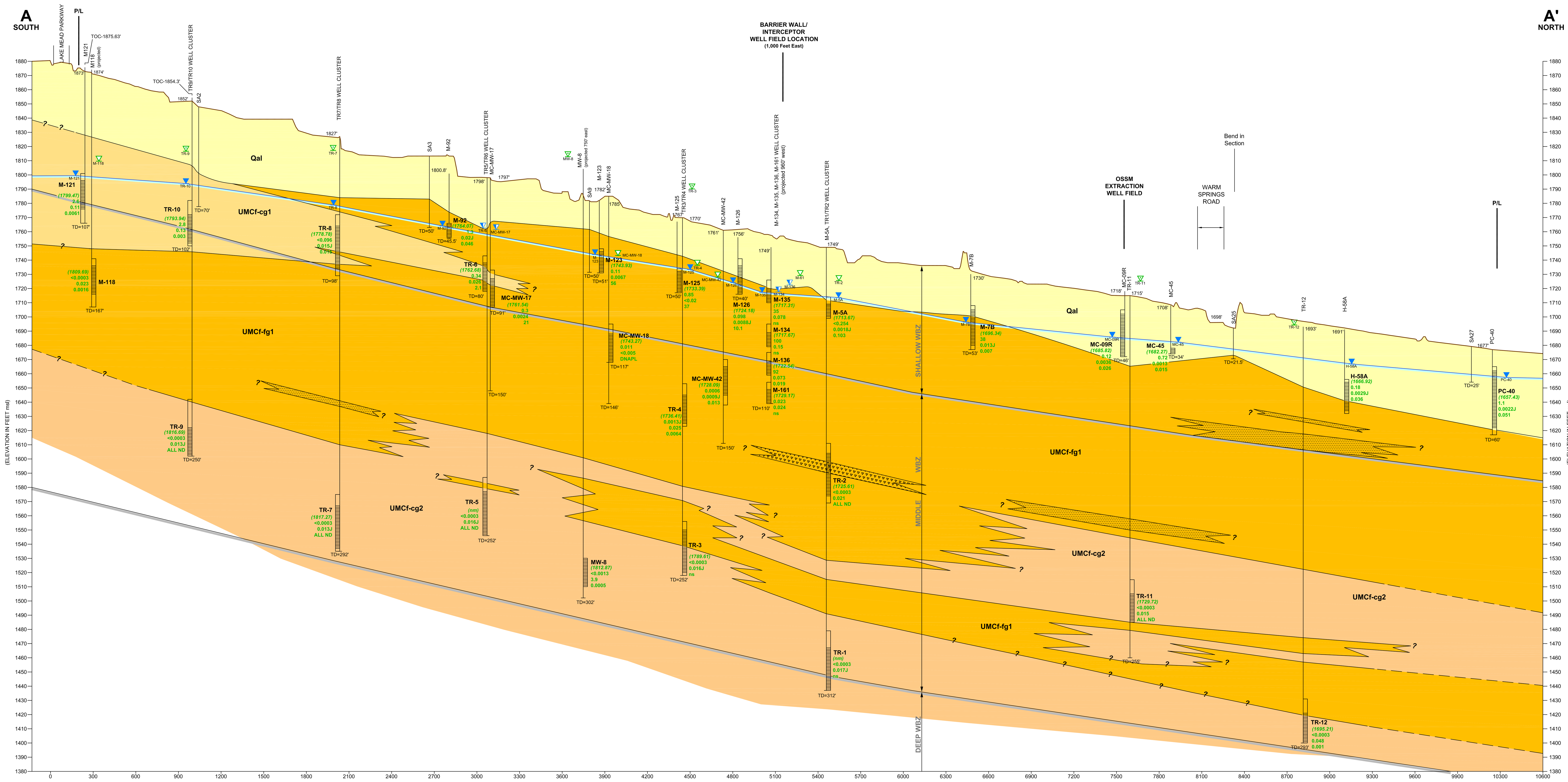
GROUNDWATER CHLOROFORM MAP
SHALLOW WATER-BEARING ZONE
2008 AND 2009

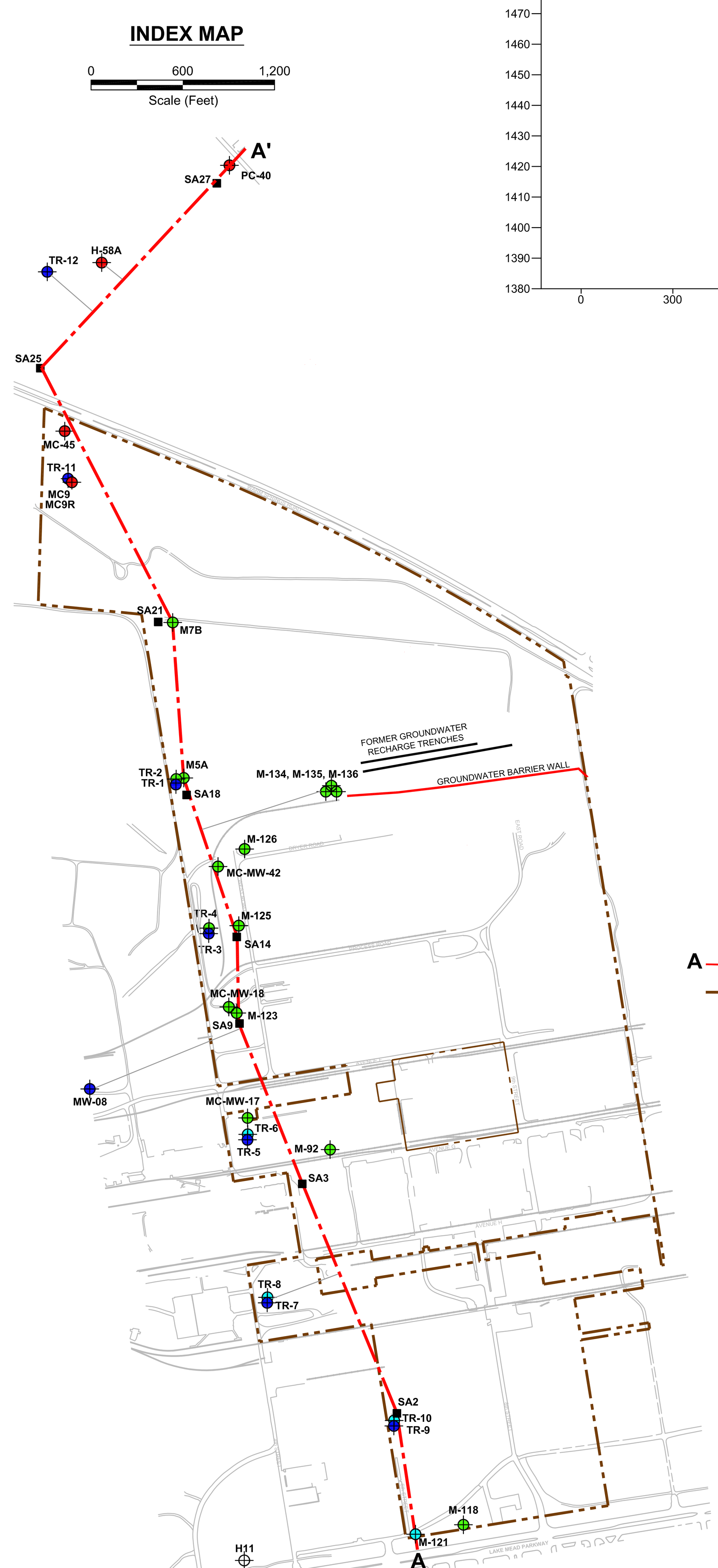
Nevada Environmental Response Trust (NERT)

Henderson, Nevada

DESIGNED BY:	REVISIONS			
EA	NO.	DESCRIPTION:	DATE:	BY:
DRAWN BY:	0	GENERATE APPROVED MAP		
RS				
CHECKED BY:				
APPROVED BY:				

ENVIRON





A — A' LINE OF GEOLOGIC SECTION

PROPERTY BOUNDARY

MONITORING WELL WITH SCREEN IN THE ALLUVIAL AQUIFER (Qal)

MONITORING WELL WITH SCREEN IN THE MUDDY CREEK FINE GRAIN FACIES (UMCf-fg1)

MONITORING WELL WITH SCREEN IN THE MUDDY CREEK COARSE GRAIN FACIES 1 (UMCf-cg1)

MONITORING WELL WITH SCREEN IN THE MUDDY CREEK COARSE GRAIN FACIES 2 (UMCf-cg2)

LEGEND

Qal	QUATERNARY ALLUVIUM
UMCf-fg1	MUDDY CREEK FORMATION FINE-GRAINED FACIES #1
	MUDDY CREEK FORMATION FINE-GRAINED FACIES #1 SILTY SAND AND SANDY BED
	MUDDY CREEK FORMATION FINE-GRAINED FACIES #1 VOLCANIC ASH DEPOSIT
UMCf-cg1	MUDDY CREEK FORMATION COARSE-GRAINED FACIES #1
UMCf-cg2	MUDDY CREEK FORMATION COARSE-GRAINED FACIES #2

GROUNDWATER ELEVATIONS
(feet, mean sea level datum)

Shallow Water-Bearing Zone (0-90 ft)

- Water Table Zone Well
- Deeper Shallow WBZ Well

Middle Water-Bearing Zone (90-300 ft)

- Upper Muddy Creek Formation, First Fine-Grained Unit (UMCf-fg1)
- Upper Muddy Creek Formation, Second Coarse-Grained Unit (UMCf-cg2)

TR-1	EXISTING BORING/WELL IDENTIFICATION
1797'	GROUND SURFACE ELEVATION (ft, msl)
	FILTER PACK
	SCREEN INTERVAL
TR-1	WELL (SCREEN) IDENTIFICATION
TD=40'	TOTAL DEPTH OF BORING/WELL

EXPLANATION:

(1799.47)	GROUNDWATER ELEVATION (April/May 2012)
2.6	PERCHLORATE CONCENTRATION (May 2012) in milligrams/liter (mg/L).
0.11	TOTAL CHROMIUM CONCENTRATION (May 2012) in milligrams/liter (mg/L).
10.1	TOTAL VOCs in milligrams/liter (mg/L).

NOTES:

"<"	NOT REPORTED AT THE PRACTICAL QUANTITATION LIMIT SHOWN
(nm)	NO WATER LEVEL
ND	NOT DETECTED
NS	NOT SAMPLED
WBZ	WATER-BEARING ZONE

1. Chemical Data for wells MC-MW-17 and MC-MW-18 are from April 2011.
2. Chemical data for well MC-MW-42 are from May 2011.
3. Chemical data for well MW-8 are from October 2011.
4. Total VOCs were calculated based on all positive detections of individual VOCs during the most recent sampling event.

REFERENCES:

APPENDIX A - ANNUAL REMEDIAL PERFORMANCE REPORT FOR CHROMIUM AND PERCHLORATE, JULY 2011 THROUGH JUNE 2012 [NEVADA ENVIRONMENTAL RESPONSE TRUST, HENDERSON, NEVADA] (AUGUST 2012)

BMI COMPLEX DATABASE

ADAPTED FROM FIGURE 4-1, PHASE A SOURCE AREA INVESTIGATION, TRONOX FACILITY, HENDERSON, NEVADA (ENSR/AECOM 2008)

HYDROSTRATIGRAPHIC NOMENCLATURE FOLLOWS UNIFIED HYDROGEOLOGIC NOMENCLATURE PROPOSED BY NDEP IN JANUARY 6, 2009 LETTER

SCALE
30'
0'
0'
300'
Vertical Exaggeration 10x

ENVIRON

Subsurface Cross-Section A-A'
Nevada Environmental Response Trust Site
Henderson, Nevada

DATE:	CONTRACT NUMBER:		PLATE
11/21/12	21-29100H10		7
DRAFTER: RS	APPROVED:	REVISED:	

Q:\DRAWINGS\2129100H\2129100H-Cross_SectionAA.DWG

Appendix A

Response to NDEP Comments on RI/FS Work Plan

Appendix A-1

Response to NDEP Comments on RI/FS Work Plan, Dated June 27, 2013

October 4, 2013

Mr. Weiquan Dong, PE
Bureau of Corrective Actions, Special Projects Branch
Nevada Division of Environmental Protection
2030 E. Flamingo Rd., Suite 230
Las Vegas, Nevada 89119

Re: NERT Response to NDEP June 27, 2013 Comments on the Remedial Investigation and Feasibility Study Work Plan; Nevada Environmental Response Trust Site, Henderson, Nevada; dated December 17, 2012 (NDEP Facility ID #H-000539)

Dear Mr. Dong:

On behalf of the Nevada Environmental Response Trust ("NERT" or the "Trust"), ENVIRON International Corporation (ENVIRON) has prepared an annotated response to the Nevada Division of Environmental Protection's (NDEP's) comments on the Remedial Investigation and Feasibility Study Work Plan (RI/FS Work Plan) for the NERT site. The comments were included as Attachment A in NDEP's letter to the Trust dated June 27, 2013. Our annotated response to comments is provided in Attachment A to this letter. Additional tables and a figure, pertaining to our responses to comments are provided in Attachments B through D.

ENVIRON requests feedback on this submittal from NDEP by October 31, 2013 to ensure a timely delivery of the final RI/FS Work Plan on or before December 27, 2013. Please contact John Pekala at (602) 734-7710 if you have any comments or questions concerning this response to comments.

Sincerely,

John M. Pekala, CEM #2347
Senior Manager

Allan J. DeLorme, PE
Principal

Attachment

cc: BMI Compliance Coordinator, NDEP, BCA, Las Vegas
Brian Rakvica, McGinley and Associates, Las Vegas
NDEP c/o McGinley and Associates, Reno

ec: JD Dotchin, NDEP
Greg Lovato, NDEP
Stephen Tyahla, USEPA
Nevada Environmental Response Trust
Tanya O'Neill, Foley & Lardner LLP
Jeff Gibson, AMPAC
Mark Paris, BMI
Lee Farris, Landwell
Ranajit Sahu, BMI
Joe Kelly, Montrose
Paul Sundberg, Montrose
Curt Richards, Olin
Jay Gear, Olin
Davis Share, Olin
Chuck Elmendorf, Stauffer
Nick Pogoncheff, Stauffer
George Crouse, Syngenta
David Hadzinsky, TIMET
Steve Sarandis, GEI Consultants
Kirk Stowers, Broadbent & Associates
Victoria Tyson, Tyson Contracting
Enoe Marcum, WAPA

Attachment A

Response to NDEP Comments on
Remedial Investigation and Feasibility Study Work Plan
Nevada Environmental Response Trust Site, Henderson, Nevada
Dated December 17, 2012

NDEP Comment	Response
1. General Comment, the NDEP recommends that NERT update all cited references to the date that this Deliverable is finalized.	The cited references in the revised Remedial Investigation/Feasibility Study (RI/FS) Work Plan will be updated to reference the most recent documents, as applicable.
2. General Comment, the NDEP recommends that Executive Summary be added to the Deliverable. The executive summary should clearly states the long-term and short-term remediation goals of the NERT site.	An Executive Summary, which clearly provides the long-term and short-term remediation goals for the NERT site, will be included in the revised RI/FS Work Plan.
3. General comment, the NDEP requests that NERT revise the Deliverable to include specific methods for calculating values for the following four performance criteria: a. The concentrations at which NERT is achieving 90% and 99% capture of perchlorate and chromium; b. Pounds per day mass removal from environment; c. Mass discharge at the Athens Road Well Field and the Seep Well Field; d. Mass loading at Northshore Road. The mass loading at Northshore Road is sum of the mass discharge from BMI Complex and Common Areas, bank and stream bed storage and upper Las Vegas Wash.	As part of the Groundwater Extraction and Treatment System (GWETS) Optimization Study, a memo describing proposed performance metrics will be developed and submitted to NDEP for review on November 15, 2013. This memo will include all of the requested metrics and a description of the methodology to be used in the calculation of each metric. The memo can be included as an appendix to the revised RI/FS Work Plan. Note also that an evaluation of the SWF was not included in the initial scope of the GWETS Optimization Study. However, a revised scope will be submitted to NDEP that includes an evaluation of the SWF in the current GWETS Optimization Study.
4. General comment, the RI/FS study tasks are outlined in Section 6 (Remedial Investigation/Feasibility Study Tasks) of the Deliverable. Information related to data quality objectives (DQO's), methods for sample collection and analysis, methods for data evaluation and quality assurance, risk assessment methodology, and other critical components to supporting documents, such as a sampling and analysis plan (SAP), should be included in this Deliverable. It is suggested that these items could be included as appendices to allow for ease of future modification.	As discussed with NDEP, a detailed Sampling and Analysis Plan (SAP) and a separate Baseline Health Risk Assessment (BHRA) Work Plan will be developed and submitted to NDEP as separate deliverables, following submittal of the revised RI/FS Work Plan. The SAP will include field sampling plans, a Quality Assurance Project Plan (QAPP) and a site-specific Health and Safety Plan (HASP). Information related to data quality objectives (DQOs), methods for sample collection and analysis, methods for data evaluation and quality assurance, risk assessment methodology, and other components, will be included in these deliverables. The SAP will be submitted to NDEP on or before January 24, 2014 and the BHRA Work Plan will be submitted to NDEP on or before February 21, 2014.

NDEP Comment	Response
5. General Comment, use of the March 9, 2010 health risk assessment (HRA) Work Plan that has been developed and approved for this site is not included in this Deliverable. Since this HRA Work Plan was approved by the NDEP on March 16, 2010, the Trust should consider including it and add the information not covered in it to this RI/FS Work Plan.	ENVIRON has reviewed the NDEP-approved Health Risk Assessment (HRA) Work Plan prepared by Northgate Environmental Management (Northgate) and dated March 9, 2010. ENVIRON will adopt the general risk assessment methodology, including exposure equations, toxicity values, and risk equations, outlined in the HRA Work Plan. However, other elements of the 2010 work plan lacked sufficient detail for ENVIRON to implement or do not account for the completed soil removal action. For example, the conceptual site model (CSM) does not include all exposure pathways that NDEP and/or ENVIRON have more recently identified for evaluation. In addition, exposure units are not identified in the 2010 work plan and the post-removal-action data sets that will be used for the risk assessment are not included. *(ENVIRON notes that these data sets were not available at the time the 2010 work plan was prepared.)* ENVIRON will prepare the BHRA Work Plan to update background information on the site, update the CSM, and describe the approach for dividing the site into exposure units. In addition, the BHRA Work Plan will include preliminary summary statistics for the post-removal data set for the Facility Area as a whole and by exposure unit. Applicable elements from the 2010 HRA Work Plan will be incorporated by reference, and, for completeness, the 2010 HRA will be included as an attachment to the ENVIRON BHRA Work Plan. The contents of the BHRA Work Plan and reliance on some elements of the 2010 HRA Work Plan (as described in this response) will be added to Section 5.0 (Initial Site Evaluation) and/or Section 6.6 (Task 6: Risk Assessment) of the RI/FS Work Plan, as appropriate.
6. General comment, since at least one site Chemical of Potential Concern (COPC) has been identified within the Las Vegas Wash; the Deliverable should include ecological risk. Due to the multiple sources of the downgradient water from the site discharge points, it is noted that this issue may be best addressed after aquifer restoration.	The text of the RI/FS Work Plan will be revised to note that an ecological risk assessment will be prepared for ecological receptors in the Las Vegas Wash (but not for on-site ecological receptors), consistent with our discussions with NDEP. The CSM will be expanded to include off-site ecological receptors. The Trust concurs with NDEP's comment that the off-site ecological risk assessment is best addressed following aquifer restoration; this timeframe will be noted in the revised RI/FS Work Plan.

NDEP Comment	Response
7. General comment, no discussion of radionuclide exposure and risk quantification was included in this Deliverable. The Trust should note that these risks should be addressed in any risk assessment performed for the site.	The text of the RI/FS Work Plan will be revised to include radionuclides as chemicals of potential concern (COPCs) and additionally, to identify exposure pathways unique to radionuclides. The CSM will be revised accordingly.
8. General comment, the RI/FS Work Plan as written does not provide any discussion as to the human health or ecological impacts for Category 1 or 2 Excavation Control Areas (ECAs), the Deliverable should clearly state that potential risks for these ECAs are managed through the Site Management Plan (SMP).	Additional discussion will be added to the RI/FS Work Plan to note that potential human health impacts associated with the Category 1 soils (Excavation Control Areas [ECAs]) will be managed through the Site Management Plan (SMP), as amended. Also, the text will be expanded to discuss the potential human health impacts associated with the Category 2 soils (i.e., soils with COPC concentrations less than soil remediation goals (SRGs) that are not in ECAs). As noted in Comment #6, an ecological risk assessment will not be conducted for on-site ecological receptors. However, potential off-site transport of contaminants from the site to the Las Vegas Wash and the associated ecological impacts will be evaluated.
9. General comment, the validation status of all data utilized in this Deliverable should be clearly stated.	The validation status of data utilized for data analysis and decision making will be provided in the revised RI/FS Work Plan. As agreed upon during discussions with NDEP, the validation status will not be provided for data cited in more qualitative general and/or overview discussions in the RI/FS Work Plan.
10. General comment, all COPCs in groundwater should be addressed in this Deliverable, not just perchlorate and hexavalent chromium.	A complete list of the groundwater COPCs identified based on a review of the available data is presented in Section 5.1.4.2 of the RI/FS Work Plan, and all COPCs in groundwater will be addressed in the SAP. Perchlorate, chromium, and chloroform are the primary site-related chemicals detected in groundwater downgradient of the site. Therefore, the distribution of these three chemicals is presented on Work Plan figures to illustrate the extent of groundwater impact. Since perchlorate is the most widely distributed COPC, the perchlorate distribution is used in the RI/FS Work Plan for the planned RI groundwater investigation locations. The presence and distribution of all COPCs in groundwater will be evaluated in the RI based on both historical data and the investigations that will be conducted as part of the RI.

NDEP Comment	Response
11. Section 2.1 Operational History, page 4, second paragraph, the Deliverables states that the 373 acres are leased to Tronox LLC. Please check the number of acreage for the NERT property, parcels proposed to sell and the leased area and make sure that they are accurate and consistent in all Deliverables.	The acreage of the Tronox-leased area has been checked and determined to be approximately 114 acres. The Trust property, including the Tronox-leased area and sale parcels, is 410 acres. The sale parcels A-H (except E) consist of approximately 145 acres, with approximately 64.2 acres located north of Warm Springs Road (Parcels A & B), 45.2 acres south of Warm Springs Road and north of the GW-11 and WC ponds (Parcels C & D), and 35.4 acres south of Avenue F (Parcels F, G, and H). The acreage of the Tronox-leased area will be corrected in the revised RI/FS Work Plan, and the property sizes noted here will be consistently provided in all future deliverables. In addition, the attached figure showing the acreage of the Trust property, including the Tronox-leased area and sale parcels, will be included in the revised RI/FS Work Plan (Attachment B).
12. Section 2.5.3 Local Hydrogeology, page 9, the Deliverable states that there is no water supply wells within four miles of the site. Please verify this through Nevada Division of Water Resources database and other related information available.	A review of publicly available information regarding the possible presence of water supply wells within four miles of the site will be conducted. A summary of any wells identified will be included in the revised RI/FS Work Plan. If none are identified, the Work Plan will be modified to read "Based on a review of publicly available records, there are no known or reported water supply wells within four miles of the site that extract water from the Shallow, Middle, or Deep Zones." The details of the records and/or databases reviewed will be included in an appendix of the revised RI/FS Work Plan.
13. Section 3.1 Overview of Regulatory Actions and Environmental Investigations: 1970 to 2005, page 10. "Between 1971 and 1976" paragraph: Please specifically identify the surface impoundments constructed and refer to an existing figure, if applicable. "In July 1981" paragraph, first sentence: Please specify the "existing on-site impoundments" and refer to an existing figure, if applicable.	Ponds P-1 and Old P-2 were constructed in May through September 1972 for management of potassium bearing process fluids. Pond S-1 was completed in October 1974 for management of chlorate process liquids. Ponds AP-1, AP-2, and AP-3 were completed by May 8, 1974 for management of ammonium perchlorate liquids. Pond C-1 was completed by December 1974 for management of nonhazardous wastes including cooling tower liquids (Kleinfelder 1993). The "existing on-site impoundments" cited in the "July 1981" paragraph refer to ponds S-1 and P-1. The surface impoundments constructed by the Kerr-McGee Chemical Corporation (KMCC) between 1971 and 1976 and the on-site impoundments existing in 1981 will be specifically identified in the text. These ponds are shown on the "Historical and Active Pond Locations" figure (currently Figure 5-2) in the RI/FS Work Plan.

NDEP Comment	Response
14. Section 3.2.1.2 Investigations of Parcel Soils, page 15, the Deliverable references the “Olin” groundwater treatment system. NDEP understands that the referenced groundwater treatment system is owned and operated by a group of companies and is generally referred to as the Olin Stauffer Syngenta Montrose (OSSM) groundwater treatment system. Please revise as necessary.	The text of the RI/FS Work Plan will be revised to indicate the groundwater treatment system on Parcel E is owned by a group of companies and referred to as the Olin Stauffer Syngenta Montrose (OSSM) groundwater treatment system.
15. Section 3.2.2 Soil Gas, page 17, please discuss why some soil borings were collected at 20’ bgs. NDEP’s understanding is that the total depth of these borings was tied to the depth of the adjacent structures.	Soil gas samples were collected at 5 feet below ground surface (ft bgs), with the exception of four samples collected at 20 ft bgs in the vicinity of Units 3, 5, and 6. 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 2008) of ENSR’s Phase B Source Area Investigation – Soil Gas Survey Work Plan (ENSR 2008b), 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 2010). 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 (ENSR 2008a); and SG-37 and SG-38, near areas with relatively lower chloroform concentrations in groundwater (ENSR 2008a). The text of Section 3.2.2 will be revised to include the rationale for collecting some soil gas samples at 20 ft bgs.

NDEP Comment	Response
16. Section 3.2.3 Indoor Air, page 18, 2nd paragraph, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. The Deliverable references "occupational exposure levels", please clarify if these are OSHA PELs or a site-specific derived number.	The text will be revised to indicate that the "occupational exposure levels" are the American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour Threshold Limit Values (TLVs). Further, to avoid possible confusion as to the intent of the statement in this paragraph regarding a 1×10^{-5} risk level, a statement regarding NDEP's point of departure will be added. The revised text is provided below: Northgate (2011a) reported that the maximum and mean indoor air concentrations of the target analytes were significantly below their respective occupational exposure levels (specifically, Threshold Limit Values [TLVs]), and that mean indoor air concentrations were below risk-based commercial air concentrations corresponding to a 1×10^{-5} risk level. (It is noted that the NDEP point of departure for exposures to chemicals in indoor air resulting from site-related releases is 1×10^{-6}.)
b. The Deliverable references 10^{-5} as a point of departure for risk due to soil gas. Please revise the Deliverable to indicate that 10^{-6} is the point of departure for risk due to soil gas.	The RI/FS Work Plan states "Northgate (2011a) reported that the measured chloroform concentrations were below occupational levels and below the 1×10^{-5} risk level." Although the Work Plan does not state that 10^{-5} is the point of departure, ENVIRON will add the following sentence to avoid possible confusion as to the intent of the statement: "(The NDEP point of departure for risk due to soil gas is 1×10^{-6}.)"

NDEP Comment	Response
17. Section 4.1 Interim Soil Removal Actions and Health Risk Assessments at the Facility Area, page 25, 2nd paragraph, please revise this paragraph to note that the Revised Interim Soil Removal Action Completion Report was approved by NDEP on December 6, 2012. Sections 4.3 Site-wide Health Risk Assessment for Soil Gas, 5.1.3 Summary of the Soil Conceptual Site Model (CSM), and 5.1.5.2 Exposure Media and Pathways, pages 26, 44, and 49, respectively, the risk assessment should address exposure to soil gas for all ECAs and all on-site receptors. Further, should the risks or HIs exceed 10^{-6} or 1, respectively, for any on-site populations, then off-site exposures should be quantified as well.	The referenced paragraph will be revised to note that the Revised Interim Soil Removal Action Completion Report was approved by NDEP on December 6, 2012. Sections 4.3, 5.1.3, and 5.1.5.2 (pages 26, 44, and 49, respectively) will be revised to note that exposures to potential current and future indoor receptors will be evaluated for all soil categories (i.e., Categories 1, 2, 3, and 4) where data indicate that groundwater and/or soil gas is contaminated with volatile organic compounds (VOCs). If risks or HIs exceed 10^{-6} or 1, respectively, for the on-site indoor commercial/industrial worker, then potential risks to on-site outdoor commercial/industrial workers will also be quantified. If risks or HIs exceed 10^{-6} or 1, respectively, for the on-site outdoor commercial/industrial worker, then potential risks to off-site populations will also be quantified.
18. Section 4.4.1.2 Perchlorate Removal and the Athens Road and Seep Well Fields, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Page 28 – 30, chromium removal should also be discussed at the Athens Road Well Field (AWF) and the Seep Well Field (SWF). Please revise as necessary.	Chromium is removed at the Athens Road Well Field (AWF) and the Seep Well Field (SWF), but at substantially lower concentrations than from the Interceptor Well Field (IWF). Because the concentrations of total chromium within extraction wells at the SWF are well below the GWETS effluent discharge limitation of 0.1 mg/L (7-day average),groundwater extracted from the SWF is not treated specifically to remove chromium. However, some incidental chromium removal is achieved in the fluidized bed reactors (FBR). Total chromium concentrations in extraction wells at the AWF range from <0.0020 to 1.4 mg/L (May 2013 data). As noted at the bottom of page 32 (in Footnote 16), a small ferrous sulfate drip system is located at the AWF lift station (Lift Station 3) to treat the chromium in groundwater captured at the AWF. Chromium removal is discussed within Sections 4.4.2.1 and 4.4.2.2 (pages 31-34) of the RI/FS Work Plan. The text of Section 4.4.1.2 (pages 28-30) will be revised to also discuss chromium at the AWF and SWF.

NDEP Comment	Response
b. Page 30, 4th paragraph, the total perchlorate removed from AP-5 is 1,176 tons that is less than the number of 1,295 tons reported in Page 4 of TRX-NDEP_RTC_ AP5 Pond Info Req 12-10-10 (ENVIRON, 2012), please show how the value was calculated identifying what data was used. Additionally, please revise text as necessary for consistency.	The estimate of 1,176 tons was calculated in ENVIRON's March 30, 2012 memo (ENVIRON 2012) regarding discontinuation of treatment of AP-5 pond water at the site. The estimate of perchlorate removed from AP-5 was calculated from monthly GW-11 flow and perchlorate data provided by Veolia, for the period from September 2006 to June 2011. Data from GW-11 was used since it has received the water pumped from AP-5. Based on the monthly flow and concentration data, the mass of perchlorate was calculated for each month, which were summed to obtain the estimate of 1,176 tons. These numbers are consistent with those presented on Figure 3 of the March 30, 2012 memo that illustrates the trend for contribution of AP-5 perchlorate, through the GW-11 Pond. The basis of the 1,295 ton estimate prepared by Northgate on behalf of Tronox in December 2010 has been requested from Northgate; however, as the date of this response, the information has not yet been received. These estimates will be further reviewed and additional information on the basis of each estimate will be included in the revised RI/FS Work Plan.
19. Section 4.4.2.1 Description of the Current Groundwater Extraction and Treatment System (GWETS), page 32. The Trust should describe the GWETS in more details. Basic information should be included is:	Additional details of the GWETS will be included in the revised RI/FS Work Plan. As of July 24, 2013, the GWETS Operator is Envirogen Technologies, Inc. (Envirogen). ENVIRON will work with Envirogen to address NDEP's specific requests listed in this comment.
a. The diameter, length and capacity of the pipe lines from the lift station 1 to lift station 2, from the lift station 3 to lift station 2, from left station 2 to the GWETS, the fluidized biological reactor (FBR) to the effluent discharge point at the Las Vegas Wash;	Pipeline diameter and lengths are generally available in design drawings, but capacities are not available. Capacity of the various sections of the pipeline would need to be determined by hydraulic analysis. The pipeline lengths and diameters are presented in Attachment C. Where specific diameters were not indicated in the design drawings, the diameters were assumed based on available information on either end of pipe. This information will be updated as necessary in the revised RI/FS Work Plan.
b. The capacity of all pumps in the GWETS;	The capacities of the pumps in the GWETS are provided in Attachment D. This information will be included in the revised RI/FS Work Plan.
c. The hydraulic and mass loading capacity of the Groundwater Treatment Plant or GWTP for the chromium treatment;	According to Envirogen, the current configuration of the Groundwater Treatment Plant (GWTP) has a design maximum capacity of 75 gallons per minute (gpm) at a maximum hexavalent chromium concentration of 15 milligrams per liter (mg/l).

NDEP Comment	Response
d. The hydraulic and mass loading capacity of the FBR;	The FBR design hydraulic flow is 1,000 gpm (at a contaminant loading of 1,800 equivalent pounds per day). Although the FBRs could handle an increased flow at a decreased contaminant load, the hydraulic capacity of the effluent discharge pipeline is approximately 1,000 gpm. The maximum contaminant (nitrate, chlorate, and perchlorate) loading to the FBR is 1,800 equivalent pounds per day as calculated with the following formula: Equivalent Pounds $=((0.9*NO_3)+(0.17*ClO_3)+(0.18*ClO_4))*((gpm*1440)/1000)*8.34$.
e. The capacity of GW-11 pond, the perchlorate concentration, water level elevation and volume of present GW-11 and the roles of GW-11 in the GWETS.	The maximum operating capacity of the GW-11 pond is approximately 62.4 million gallons (Mgal) with an allowed three feet of freeboard, which corresponds to a maximum operating water elevation of 1,747 feet above mean sea level (amsl). As an emergency contingency, the GW-11 pond may be operated at two feet of freeboard with prior notice to NDEP and the Nevada Division of Water Resources (NDWR). The capacity with two feet of freeboard is approximately 67.1 Mgal, corresponding to a water elevation of 1,748 feet amsl. The current water level elevation (as of October 3, 2013) is 1743.85 feet amsl, which corresponds to a water volume of approximately 48.2 Mgal. The most recent concentration of perchlorate in the GW-11 pond (sampled September 3, 2013) was reported as 56 mg/L. This information regarding the capacity of the GW-11 pond, the current perchlorate concentration, water level elevation and pond volume for GW-11, and the role of GW-11 in the GWETS will be included in the revised RI/FS Work Plan.

NDEP Comment	Response
20. Section 4.4.2.1 Description of the Current Groundwater Extraction and Treatment System, page 32, the Deliverable states "From the equalization tanks, the blended water flows through activated carbon beds to remove organic compounds before being filtered", NDEP provides the following comments:	Please see the following responses to the individual comments:
a. The Trust should consider or discuss some means of filtration prior to the activated carbon beds to extend their useful life. It is understood that this evaluation is being deferred to a future Deliverable. Please track this matter as a data gap and address this matter in that Deliverable.	While it is true that there is no means of filtration prior to the carbon beds, this does not necessarily reduce their useful life. When the pressure drop across the carbon beds increases—thus indicating clogging of the beds—the beds are backwashed using stabilized Lake Mead water to remove the particulates. During backwash events, the carbon remains in the vessels and is reused until the adsorptive capacity of the carbon is ultimately spent, while the particulates are discharged to the GW-11 pond. The discharge of particulates to the GW-11 pond is a matter that will be evaluated as part of the ongoing performance evaluations of the GWETS. Over time solids have accumulated in the GW-11 pond. Currently, the Trust is in the process of estimating the amount of solids in the GW-11 pond and evaluating possible removal methods. A detailed evaluation of the existing treatment system is considered beyond the scope of the RI/FS Work Plan but will be included as part of the analysis of Remedial Action Alternatives in the FS. Envirogen will evaluate the GWETS operations and recommend improvements that can be made to the GWETS to enhance performance and cost efficiency. If, based on Envirogen's analysis, changes to the GWETS are warranted to increase performance/efficiency in the short term, such changes will be proposed to NDEP.
b. NDEP is not aware of any data that has been presented to date to demonstrate what sort of efficacy the activated carbon beds have and what compounds are being addressed. This issue is of increasing importance due to the high levels of organic compounds that may be approaching the system from the west. It is understood that this evaluation is being deferred to a future Deliverable. Please track this matter as a data gap and address this matter in that Deliverable.	Trespassing organic compounds from west of the site are a data gap that will be addressed as part of the RI/FS. It is anticipated that the efficacy of carbon beds will be evaluated and as noted in the response to Comment #20a, if changes to the GWETS are warranted to increase performance/efficiency in the short term, such changes will be proposed to NDEP.

NDEP Comment	Response
c. Last paragraph, last sentence: Is the "seep surface-flow capture sump" the same as the "weir-sump" referred to in Section 4.4.1.2 that was constructed in 1999?	Yes, the "seep surface-flow capture sump" and "weir sump" refer to the same feature. The text of the RI/FS Work Plan will be revised to be consistent when referring to this feature.
21. Section 4.4.2.1 Description of the Current Groundwater Extraction and Treatment System, page 32. When referencing laboratory quantification limits, e.g., "chromium concentrations in the SWF pumping wells are below laboratory quantification limits," the Trust should identify what reporting limit is currently being used.	In the revised RI/FS Work Plan, where discussed, the specific laboratory quantitation limits will be identified.
22. Section 4.4.2.2 Performance of the Current Groundwater Extraction and Treatment System, page 33, the Trust should estimate on how much perchlorate mass remains in the subsurface and this estimate (or range) may be developed for use in assessing remedial durations of various alternatives.	The RI/FS Work Plan will be revised to include estimates of remaining perchlorate mass, which were presented in Attachment 1 of the *Annual Remedial Performance Report for Chromium and Perchlorate July 2012-June 2013* submitted to NDEP on August 30, 2013. Three methodologies were presented using 2012 data. The range of remaining perchlorate within the plume boundary was estimated to be between 2,674 and 3,728 metric tons. Estimates of perchlorate remaining were also prepared using 2006 and 2002 data. In 2006, the remaining perchlorate mass was estimated in the range of 3,724 to 3,843 metric tons. In 2002, the mass was estimated in the range of 5,514 to 6,743 metric tons. The previously referenced report includes a detailed discussion of the methods and assumptions used to prepare the mass estimates.
23. Section 4.4.2.2 Performance of the Current Groundwater Extraction and Treatment System, page 34, there is no description of chromium removal for AWF and SWF, please discuss how the chromium of AWF and SWF is removed and identify the maximum capacity of chromium removal for these two well fields.	Please see response to Comment #18a.
24. Section 4.4.2.2 Performance of the Current Groundwater Extraction and Treatment System, last paragraph, page 34. The installation of new extraction wells to capture the current withdrawal gaps at the ends of the IWF and downgradient of the AWF. The Deliverable suggests upgrading the existing system and adding additional wells at IWF and AWF to capture bypass flows in those areas. It would seem that additional wells and augmented treatment between the Wash and the AWF could potentially be installed along the center line of the perchlorate plume.	Preliminary Remedial Action Alternatives (RAAs) (Section 5.3.4) were identified in the Work Plan based on the proposed Remedial Action Objectives (RAOs) identified and preliminary screening of remedial technologies and process options. Based on this analysis, enhanced groundwater containment and recovery has been identified as a required component of future remedial action at the site and was included as a component of each Preliminary RAA identified in the Work Plan. The installation of additional wells and augmented treatment to target the center of the plume between the AWF and the Wash will be evaluated as part of the RI/FS, as will other potential configurations.

NDEP Comment	Response
25. Section 4.5 Groundwater Monitoring Program, page 35, last paragraph, the Deliverable states that samples are analyzed for perchlorate and total dissolved solids (TDS). Please clarify whether chromium is analyzed and if not; please discuss why chromium is not included. Please clarify if all of the sampling and analyses described are related directly or indirectly to NPDES permit compliance.	This particular paragraph discusses only the monthly sampling of groundwater wells, which is intended to evaluate performance of the perchlorate removal measures specifically. Chromium sampling and analysis is performed during the quarterly and annual events The majority of groundwater sampling and analysis is not related to NPDES permit compliance. In fact, only one groundwater well is sampled quarterly as part of the NPDES monitoring. The remaining groundwater samples are for monitoring the status of the groundwater plumes and for evaluating performance of the GWETS. The text of the RI/FS Work Plan will be revised to clarify this information.
26. Section 4.6 Proposed Additional Interim Removal Actions, page 36, Remove "Interim" from title of this section for consistency with the National Contingency Plan (NCP).	The requested change will be incorporated into the revised RI/FS Work Plan.
27. Section 4.6 Proposed Additional Interim Removal Actions, page 36. As described at the February 2013 NERT Annual Stakeholder Meeting, an ion-exchange system is currently being considered by the new GWETS operator for treatment of the seep area wells. This proposed remedial alternative is not described in the RI/FS Work Plan. It would appear this effort should be considered as a treatability pilot study, similar to the intent of the permeable reactive barrier (PRB) proposal. This effort to consider ion-exchange for downstream plume remediation should be included as part of the RI/FS with the proposed approach fully described in the RI/FS Work Plan.	Ion exchange was evaluated as part of the screening process and retained as a process option (see Table 5-3 page 6 of 23) for further evaluation in the RI/FS. At this time, we do not believe that a treatability study is warranted because ion exchange is a well-developed technology with significant operational information readily available to allow evaluation in the RI/FS.
28. Section 4.6.2 AP-5 Pond Solids Characterization and Disposal, page 37, the Deliverable states that "step two has been completed to the extent possible utilizing the existing AP-5 pond pumping system." Please clarify whether additional dewatering will be needed prior to implementation of Task 3 (solids removal and disposal) or if implementation of Task 3 can commence without additional dewatering.	Since submittal of the RI/FS Work Plan, the AP-5 pond dewatering (step 2) has been completed and characterization of residual solids in the AP-5 pond for off-site disposal (step 3) is in progress. In addition, the AP-5 pond solids characterization work plan, submitted to NDEP on September 28, 2012, was approved by NDEP on February 4, 2013. Section 4.6.2 of the RI/FS Work Plan will be updated to provide the current status of work for the AP-5 pond solids characterization, removal, and disposal.
29. Section 5.1.1 Potential Contaminant Sources and Release Mechanisms, page 40, 5^{th} bullet the discussion should include the remainder of the ditch system and conveyance systems. Please revise as necessary.	The text of the 5^{th} bullet in Section 5.1.1 of the Work Plan will be revised to include the remainder of the ditch system and conveyance systems.

NDEP Comment	Response
30. Section 5.1.1.1 Source Area, page 41, this section does not address the numerous tenants that have occupied the site. Any effects that these operations have on work to be performed during development of the RI/FS should be described. Also, if current or anticipated tenant operations have the potential to impact the recommendations that may result from the RI/FS process, that should also be fully described in the Work Plan. Please discuss how this issue will be addressed in the RI/FS process.	The RI/FS Work Plan will be revised to acknowledge the existence of data gaps in areas with no or limited sampling because of access constraints that precluded soil characterization (e.g., soils beneath Unit Buildings or active ponds). As part of the RI/FS process, the available sampling data for all areas of the site, including areas with no or limited data and deeper soils (>10 ft bgs) will be reviewed to identify data gaps and strategies for sampling, containment, and/or remediation. The RI/FS Work Plan will be revised to integrate the following points: • With respect to former tenants at the site, it is ENVIRON's understanding that the need to investigate areas potentially impacted as a result of former tenant operations would have been addressed through NDEP's identification of LOUs and the Phase A and B investigations conducted at the LOUs. • While the primary current tenant, Tronox, is discussed in the work plan, additional information (location and operations) will be provided for other current tenants. • The revised RI/FS Work Plan will acknowledge that RI/FS planning must take into consideration the presence of current tenants and that soil investigations conducted to date have been impeded by current building footprints and associated infrastructure, leaving data gaps in the investigation. • The revised Work Plan will acknowledge that the presence of tenant buildings and associated infrastructure will be considered in evaluating possible remedial alternatives. • In conducting any remedial action, potential exposures/risks associated with the inhalation pathway (and any other relevant pathways) for tenants (and off-site receptors) will be considered.
31. Section 5.1.1.2 Neighboring Properties, NDEP provides the following comments:	The information requested in points (a) through (c) will be added to the text of the revised RI/FS Work Plan.
a. Page 42, 1st paragraph of section, NDEP would like to clarify that the unlined Beta Ditch transported the contaminants from the west through the Trust site.	
b. Page 43, 2nd paragraph, please include the LOU number for the Hazardous Waste Landfill for consistency.	

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NDEP Comment	Response
c. Page 43, the historic BMI Dump is not listed as an off-site source. This facility was upwind of the Trust site and reportedly received asbestos containing materials (ACM) amongst other wastes streams. Please include the BMI Dump in all off-site source lists.	
32. Section 5.1.2 Release Mechanisms and Potential Migration Pathways, page 44, it appears that vapor intrusion and rewetting of the soil column via rising water levels and subsequent smear zones is not addressed in this Section. Please revise to address this comment.	Section 5.1.2 will be revised to include vapor intrusion and rewetting of the soil column and subsequent smear zones as a transport pathway.
33. Section 5.1.3 Summary of the Soil CSM, page 44, there is the appearance of an inconsistency with respect to the emphasis on leaching to groundwater as a basis for data gaps and the site history described in earlier sections of this Deliverable. A well-documented rationale for focusing on groundwater leaching must be provided or the Deliverable must be amended to address sampling to characterize surface and near-surface exposures. Soil COPCs related to possible surface exposure pathways must include all site-related COPCs, not only those identified in groundwater. The basis for this request follows: As described in the last paragraph of Section 5.1.3 of this Deliverable, the interim soil removal focused on the 0 to 10 ft below ground surface (bgs) horizon with the primary concern for deeper soils being leaching to groundwater. Following the interim removal, footnote 21 states that there was backfilling and grading, such that the new ground surface may consist (presumably) of clean fill of some (presumably variable) thickness. This Deliverable, therefore, addresses soils within the ECAs where grading and backfill may only partially address potential future soil exposures (that is, grading and backfill resulting in fill depth of <10 ft). The work plan also addresses soils outside of ECAs where contamination may (presumably) exist at or near the ground surface. COPCs, DQOs and sampling designs to address surface exposure pathways and groundwater-leaching pathways may substantially differ.	The text of the RI/FS Work Plan will be revised to provide a more balanced discussion of (1) leaching to groundwater as a basis for data gaps and (2) soils with post-removal contamination in the 0-10 ft depth interval as a basis for data gaps. The current emphasis on leaching to groundwater is supported by (1) the relatively small area of the site where soil remediation goals (SRGs) are exceeded within the post-removal 0-10 ft depth interval and the area is not identified as an ECA (see Category 3 areas shown on Figure 5-3 of the RI/FS Work Plan), and (2) a substantial number of post-removal subsurface samples in Category 3 areas that can be used to support the BHRA. Text will be added to the Work Plan to state that there are post-removal soil samples in Category 3 areas and that these samples will be used for the risk assessment. In addition, the text will note that an ongoing review of the available analytical results for these samples is being conducted as part of the BHRA Work Plan and data gaps evaluation for the SAP. Soil samples for collection will be identified in the SAP to address any data gaps identified based on this review. *(We note that Category 1 and 2 soils do not require a soils data gap evaluation. Specifically, Category 1 soils are ECAs and risks will be managed through the SMP. For Category 2 soils, COPC concentrations are less than SRGs within the current 0-10 ft depth interval. Category 4 soils [soils not previously investigated] are identified for investigation in the Work Plan.)*

NDEP Comment	Response
34. Section 5.1.3 Summary of the Soil CSM, page 45, last paragraph, please clarify if the soil horizons referenced are the pre-excavation 0 to 10 ft bgs horizon or the post-excavation 0-10 ft bgs horizon. Please note that this issue occurs several times in this Deliverable but will not be repeated. Please revise the Deliverable as necessary to address this comment.	The text throughout the Work Plan will be revised to identify if the discussion is in reference to pre- or post-excavation 0-10 ft soil horizons.
35. Section 5.1.3 Summary of the Soil CSM and Section 5.4.1 Soil (Data Gaps), pages 44 and 65. The soil CSM focuses on accessible soils with COPCs that exceeded soil remediation goals (SRGs) in the upper 10 feet of the soil column. Based on the soils evaluation, the surface and near surface soils were placed into four categories, and ECAs were identified where soils with COPCs that exceeded the SRGs were removed. The ECAs included accessible areas and depths to 10 feet. Unfortunately, the soil removal actions did not address inaccessible areas or those areas where high perchlorate and other COPCs exist at depths greater than 10 feet below the ground surface. The RI/FS Work Plan should also provide greater information with regards to the "access and other constraints" that did not allow characterization of some soils. A significant data gap needs to be acknowledged for the areas where soluble compounds, perchlorate specifically, exist in inaccessible areas such as beneath existing and former processing buildings or at depths greater than 10 feet. These areas should be identified in the Work Plan as requiring investigation for remediation planning.	For clarification, ENVIRON notes that ECAs were established where soils with COPCs exceeding SRGs were left in-place due to access constraints. On-site human health risks associated with ECAs are managed through the approved SMP. The RI/FS Work Plan will be revised to acknowledge the existence of data gaps in areas with no or limited sampling because of access constraints that precluded soil characterization (e.g., soils beneath Unit Buildings or active ponds). As part of the RI/FS process, the available sampling data for all areas of the site, including areas with no or limited data and deeper soils (>10 ft bgs) will be reviewed to identify data gaps and strategies for sampling, containment, and/or remediation.
36. Section 5.1.4 Summary of the Groundwater CSM, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Page 45, the Deliverable states that the data has not been fully evaluated for the Category 3 and 4 areas. The data has been collected and available for evaluation. Please discuss and establish a schedule to address this comment.	It appears that this comment refers to Section 5.1.3 (Summary of the Soil CSM) rather than Section 5.1.4. The text on p. 45 states "Based on the review conducted to date…" and footnote 22 states "Additional Category 3 and 4 areas may be identified during completion of the data review." This section will be revised to state that during the detailed data review that will be completed during preparation of the BHRA Work Plan, it is possible that additional areas would be classified as Category 3 or 4.

NDEP Comment	Response
b. Page 46, the Deliverable states that the Leaching-Based Site-Specific Level (LSSL) Deliverables have not been approved by NDEP. Please clarify the approval status of these LSSL documents. Please note that NDEP disagrees with the use of DAF 20 for any evaluation at the site without supporting documentation and approval, which affects a number of sections of the Deliverable. Please revise the Deliverable as necessary to address this comment.	As stated in the RI/FS Work Plan, the Leaching-Based Site-Specific Level (LSSL) document by Northgate dated February 14, 2011, has not been approved by NDEP. The RI/FS Work Plan will be revised to clarify that the Northgate LSSL document will not be revised and resubmitted, and that it will not be used in future evaluations. The initial screening of soil COPCs based on the Northgate document presented in the current draft of the RI/FS Work Plan will be replaced in the revised Work Plan by an updated screening against NDEP's leaching-based basic comparison levels (LBCLs). This revised screening will be based on a dilution attenuation factor (DAF) of 1. If warranted, ENVIRON may develop LSSLs for specific chemicals and/or locations, and will include appropriate justification for their use.
c. Page 46, the Deliverable states "ENVIRON is currently updating the screening of vadose zone soil concentrations against the leaching-based basic comparison levels (LBCLs) using a soil dataset that has been revised to incorporate changes resulting from the interim soil removal action." If LSSLs are not going to be derived, then please remove or modify the discussion of the LSSL Deliverable to clearly state that the LSSLs Deliverable will not be used in the future and the Trust will default to the LBCLs.	See response to Comment #36b.
d. Page 46, the Trust proposes to use a 5% frequency of detection (FOD) as a screen for site-related chemicals (SRCs). NDEP disagrees with this approach as on a general site-wide basis without localized hot spots analysis. Please provide how hot spot analysis will be performed to address this concern.	The RI/FS Work Plan will be revised to clarify how hot spot analysis will be performed as part of the screening process for COPCs. Before a chemical is screened out as a COPC for having a detection frequency of less than 5%, the spatial distribution of detections will be evaluated to determine whether they occur in a limited "hot spot" area or are spread more or less randomly throughout the site.
37. Section 5.1.4.1 Leaching-Based Soil COPCs, page 47, 1st paragraph. Please provide the reference for the NDEP guidance that is being cited in this paragraph.	The RI/FS Work Plan will be revised to include the referenced NDEP memo in the reference list.
38. Section 5.1.4.2 Groundwater COPCs, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Page 47, USEPA MCLs should have primacy over NDEP basic comparison levels (BCLs). Please revise.	The hierarchy will be revised to list USEPA maximum contaminant levels (MCLs) first and NDEP basic comparison levels (BCLs) second. The remainder of the hierarchy will not change.

NDEP Comment	Response
b. Page 47, per the NDEP comment above, NDEP does not agree with the 5% FOD without inclusion of a hot spot analysis procedure.	The RI/FS Work Plan will be revised to include a description of the hot spot analysis procedure that will be followed as part of the groundwater COPC screening process.
c. Page 47, NDEP believes that TDS should be included in the future evaluations of background and upgradient conditions.	The RI/FS Work Plan will be revised to indicate that the future background evaluation will include total dissolved solids (TDS) and other constituents that may be present in background groundwater above screening criteria.
d. Page 48, screening metals should include mercury and selenium.	Selenium and mercury were not included in the preliminary list of groundwater COPCs because the maximum detected concentrations were below MCLs. When revising the RI/FS Work Plan, we will confirm that the list of COPCs is complete.
e. Page 48, TDS is listed as having no comparison criteria; however, there is a secondary USEPA MCL. Please revise.	The RI/FS Work Plan will be revised to clarify that TDS has a secondary MCL. ENVIRON notes that the secondary MCL is not a health-based criterion.
39. Section 5.1.4.2 Groundwater COPCs, page 47, perchlorate and chromium are the primary site-related chemicals detected in groundwater downgradient of the site but chloroform is present in groundwater downgradient of the site and appears to have potential on-site sources. Please revise to include chloroform in this discussion.	Section 5.1.4.2 of the RI/FS Work Plan will be revised to include chloroform in the discussion.
40. Section 5.1.4.2, groundwater COPCs at the Trust site include radionuclides, which have been identified by previous soil investigations as site-related contaminants. However, external radiation is not identified as a potentially complete exposure pathway in Section 5.1.5.2. This Deliverable pertains to soils within and outside of ECAs that have not been adequately characterized. Unless there is well-documented rationale for limiting the scope of the analyses in un-sampled areas, exposure models must address all potentially complete pathways not only those related to contaminants that exceeded SRGs in existing samples.	Section 5.1.5.2 of the Work Plan will be revised to include external radiation as an exposure pathway.

NDEP Comment	Response
41. Section 5.1.5.2 Exposure Media and Pathways, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Page 50, regarding off-site receptors, BMI has historically collected ambient air data, which indicates elevated levels of a number of compounds possibly sourcing from the Trust site. Please contact NDEP regarding incorporation of this data into the revised Deliverable.	Our review of the ambient air data collected by BMI indicates that the data are not representative of potential exposures of off-site receptors to site releases of airborne soil particulates. The first consideration leading to this conclusion is that the BMI ambient air data were collected from 2008 through 2010, before the extensive soil removal activities that occurred on the NERT site (i.e., between August 2010 and November 2011). Because site surface soil concentrations decreased as a result of the removal action, BMI's ambient air data would no longer be representative of current site releases. Our review also indicates that the purpose of many of the BMI air monitoring studies was to collect samples to evaluate off-site emissions during remediation and material hauling operations on the BMI Complex, as well as emergency collections in response to chemical odors detected on the BMI Complex. Again, this data would not be representative of current conditions at the site. In the absence of monitoring data, ENVIRON anticipates modeling potential airborne concentrations of COPCs resulting from site releases. The specific approach to be used will be provided in the BHRA Work Plan.
b. Page 50, regarding surface water, the Trust should also consider the impacts to stormwater channels and retention basins adjacent the unit buildings 4, 5, and 6.	The RI/FS Work Plan will be revised to include an expanded discussion of retention basins, storm water channels, and conveyance lines around the unit buildings and other areas of the site. The discussion will include consideration of contaminant transport and associated potential for exposures of on-site and off-site receptors.
c. Page 51, Groundwater paragraph, please contact NDEP regarding revising the text to account for uncertainty (e.g. unknown or historic domestic wells in the area, small potential for groundwater to be used as drinking water in the future, etc.)	Groundwater at the site is not currently used as a source of drinking water and is not planned to be used as a source of drinking water in the future. As described in the response to Comment #12, a review of publicly available information regarding the possible presence of water supply wells within four miles of the site will be conducted. If any such wells are identified in the downgradient area, we will attempt to identify their current status and use. However, given the high TDS concentrations in groundwater in this area, it is highly unlikely that groundwater is currently being used for drinking water from unknown wells or that it would be used for drinking water in the future.

NDEP Comment	Response
d. Pages 50 and 51, for off-site receptors paragraph, the Deliverable states that, "The nine wells operating at the SWF were installed to mitigate this exposure pathway. This system has been extremely effective, reducing the amount of perchlorate entering Las Vegas Wash by approximately 90 percent (Las Vegas Water District 2012)." Please clarify whether this means that the SWF alone has reduced the perchlorate load entering Las Vegas Wash by 90% or the combined IWF/AWF/SWF.	Section 5.1.5.2 of the RI/FS Work Plan will be revised to clarify that the combined effect of the IWF, AWF, and SWF has reduced the perchlorate mass loading to Las Vegas Wash by approximately 90%.
e. Page 51, bulleted list of exposure pathways, this listing should include all pathways of exposure for each population. For example, the "Long term outdoor industrial/commercial workers" should have "inhalation of vapors" included even though this pathway will only be quantified should indoor risk and/or hazards be greater than 10^{-6} and/or a HI of 1, respectively. Figure 5-1 should be updated accordingly.	A comprehensive table detailing all exposure pathways will be prepared to replace the bulleted list of pathways on page 51 and Figure 5-1 will be updated for consistency with the table.
f. The RI/FS Work Plan should also acknowledge that Lake Mead and the downstream Colorado River provides municipal and agricultural water sources for California, Arizona, and Mexico and that these downstream users are also affected by the noted exposure pathways, which, again, have been demonstrated as complete (as opposed to "potentially complete"). Language should be added to identify these additional off-site receptors.	The text of the RI/FS Work Plan will be revised to note that Lake Mead and the downstream Colorado River are the sources of municipal and agricultural water for areas of California, Arizona, and New Mexico, and to identify the additional off-site receptors noted in NDEP's comment.
42. Section 5.2.1.1 Potential Chemical-Specific ARARs and TBC Criteria, page 53, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. None of the solid waste or RCRA regulations appear to be listed.	The solid waste and Resource Conservation and Recovery Act (RCRA) regulations will be added as applicable.
b. The National Historic Preservation Act of 1966 (NHPA) should be included as a potential ARAR. (e.g., historic places, archeological sites).	The National Historic Preservation Act of 1966 (NHPA) will be included as a potential Applicable or Relevant and Appropriate Requirement (ARAR).
c. There are additional sections of NAC 445A which have not been cited such as 445A.121, .122, and .1236. Please re-review NAC445A and include a comprehensive listing of citations.	Following review of NAC445A, the NAC 445A sections 445A.121, 445A.122, and 445A.1236 will be included as relevant.

NDEP Comment	Response
d. Please discuss if the spill control and countermeasures (SPCC) regulation under 40 CFR Part 112 apply to any of the facilities at the site.	The spill control and countermeasures (SPCC) regulation under 40 CFR Part 112 applicability will be considered in the revised RI/FS Work Plan.
e. There are other OSHA citations, such as PELs which appear to be applicable. Please clarify.	Clarification will be provided in the revised Work Plan, as appropriate.
f. Please provide a specific citation for "Clark County Air Quality Regulations", also please clarify if this address issues specific to the county specific to asbestos.	There are numerous Clark County Air Quality Regulations that are potentially applicable to the various remedial alternatives being evaluated. Although the potentially applicable air regulations are too numerous to list here, the specific and relevant Clark County Air Quality Regulations will be cited in the revised RI/FS Work Plan.
43. Section 5.2.2 Potential Remedial Action Objectives (RAOs) for the Site, page 55. Under "Perchlorate:" Should add EPA's December 2008 Interim Drinking Water Health Advisory for Perchlorate (of 15 µg/L) as a TBC and PRG (Advisory: Office of Water, EPA 822-R-08-25 of December 2008; and PRG guidance: OSWER Memo of January 8, 2009).	The requested RAOs will be added to the revised RI/FS Work Plan as applicable.
44. Section 5.2.2.1 Short-Term Remedial Objectives, page 55, the Deliverable states that, "This RAO is currently being achieved and (in the short-term) will be met via continued operation of the SWF, the AWF, and the IWF and Barrier Wall System." The foregoing should be restated to indicate that this RAO is "partially" being achieved, as the perchlorate load in Las Vegas Wash is currently estimated at about 60 to 80 pounds per day.	This RAO was intended to address the primary CERCLA objective of protection of human health and the environment. Implementation and continued operation of the GWETS has reduced perchlorate concentrations in Lake Mead to below current health-based regulatory criteria and is thus determined to be protective and consistent with this short-term RAO. The RI/FS Work Plan will be revised to clarify this statement.
45. Section 5.2.2.1 Short-Term Remedial Objectives, page 55, please provide perchlorate concentrations with references for Las Vegas Wash, Lake Mead, and "downgradient surface water."	Current perchlorate concentrations for Las Vegas Wash, Lake Mead, and downgradient surface water will be included in the revised RI/FS Work Plan.
46. Section 5.2.2.2 Long-term Remedial Action Objectives, page 56. "Vadose Zone Source Control" bullet: This does not mention prevention of direct contact with constituents in soil that would cause unacceptable risks, such as the "Shallow Soil" for the short-term RAO.	This bullet in Section 5.2.2.2 of the Work Plan will be updated as applicable to include prevention of direct contact with constituents in soil that would cause unacceptable risks.
47. Section 5.3 Development General Response Objectives and Screening Technologies and Process Options, page 56. Please change "Objectives" to "Actions" in title.	The requested change will be made in the revised RI/FS Work Plan.

NDEP Comment	Response
48. Section 5.3.3.1 Process Option Screening Criteria, page 60. Cost is identified as a secondary screening criterion, with a qualitative comparison of capital and O&M costs listed in Table 5-3. Have life cycle costs for the listed technologies been considering this evaluation? If a lower cost treatment will require several more years of operation, this will need to be part of the cost evaluation considered during the RI/FS process, and the approach to conduct this analysis should be clearly defined in the RI/FS Work Plan.	Life cycle costs have been considered, though not explicitly, in the relative cost comparisons in the initial screening process. The initial screening process is intended, consistent with USEPA guidance, to evaluate technologies and process options to determine their overall applicability to the site considering technical feasibility, practical implementability, and cost. Detailed cost estimates are generally not conducted at the screening stage as such estimates require sufficient site-specific information to develop at least a conceptual design. However, this type of detailed analysis, including evaluation of life cycle costs, will be conducted as part of the comparative analysis of RAAs in the feasibility study. The comparative analysis of RAAs will include development of both direct and indirect capital costs, as well as annual/periodic operations and maintenance (O&M) costs. The comparative analysis of alternatives will include a present-value analysis of capital and O&M costs consistent with USEPA guidance (*Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA; EPA/540/G-89/004; USEPA 1988*)
49. Section 5.3.3.2 Preliminary Selection of Feasible Technology, NDEP provides the following comments:	The requested changes will be made in the revised RI/FS Work Plan.
a. Page 61, Source Control Options, please include soil excavation, hydraulic containment and bioremediation options.	
b. Page 62, Downgradient Plume Options, please also include slurry walls or other containment options.	
c. Page 62, In-Situ Process Enhancement Options, please also include soil flooding and bioremediation options.	
d. Page 63, Discharge Options, please also include the Pittman Bypass Pipeline and enhanced Zero Discharge (i.e. utilize enhanced evaporation mechanisms) as options.	

NDEP Comment	Response
50. Section 5.3.4 Preliminary Remedial Action Alternatives, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Page 63, it appears that this Section only address groundwater RAOs, please clarify how soil and soil vapor RAAs will be addressed.	This section presented several conceptual RAAs that would be considered likely alternatives given what is known at present. As there are remaining data gaps (particularly for VOCs), this section was not intended to include all potentially applicable alternatives. As discussed at the bottom of page 63 and the top of page 64, it is anticipated that numerous variations on each conceptual RAA identified below will be included for analysis in the FS. As information is obtained in the RI to address data gaps, additional RAAs may be identified and included in future analyses.
b. Page 64, RAA-2, please clarify how this RAA addresses the other COPCs, which are referenced.	As discussed at the bottom of page 63, these conceptual RAAs were developed to address the *primary* COPCs at the site (perchlorate and hexavalent chromium). It is anticipated that refinement of the RAAs presented in the Work Plan will occur throughout the RI/FS process as additional information is obtained. Specifically, consistent with USEPA guidance, the COPC list will be investigated and refined during the RI, and development of refined RAAs to address all identified COPCs would be incorporated into the FS.
51. Section 5.3.4 Preliminary Remedial Action Alternatives, page 64. Criteria should be established that will be used to evaluate the various technologies/strategies that could be implemented to meet the short-term and long-term RAOs. The NERT should answer if remedial measures that satisfy short-term RAOs and are compatible with long-term RAOs are rated higher than those that satisfy only short-term or only long-term RAOs.	Section 6.10 of the Work Plan identifies the nine criteria, as required by the National Contingency Plan (NCP) [40 CFR 300 (e)(9)(iii)], against which all Remedial Action Alternatives will be evaluated in the FS. As noted in Section 6.10, Compliance with ARARs and Overall Protection of Human Health and Environment (both of which are consistent with the RAOs proposed in the Work Plan) are the primary criteria which all RAAs must meet to be consistent with the objectives of CERCLA. Short-Term Effectiveness, and Long-Term Effectiveness and Permanence are balancing criteria with which to evaluate RAAs, on a comparative basis. The revised Work Plan will present more site-specific criteria for evaluating RAAs with respect to short-term and long-term RAOs.
52. Section 5.4.1 Soil, page 65. The evaluation of soils within all ECAs should be done based on the existing soil boring data.	Analytical results for existing soil borings in ECAs (Category 1 soils) and in all other areas of the site (Categories 2, 3, and 4 soils) will be used to evaluate the potential for leaching to groundwater. The data gap evaluation (presented in the BHRA Work Plan and/or SAP) will consider the existing data and whether additional sample collection and analyses are needed to evaluate leaching of soil contaminants to groundwater.

NDEP Comment	Response
53. Section 5.4.1 Soil, page 65. The areas below Site unit processing buildings have been identified as a significant contaminated source area with presumably the highest levels of perchlorate and possibly other COPCs within the footprint of the contaminated plume. As indicated within earlier comments, greater investigation and characterization of the contamination within the areas below and adjacent to the unit processing buildings must be included within the RI/FS development, with the focus of identifying the potential for these areas to be sources of COPCs that may migrate to groundwater.	The RI/FS Work Plan will be revised to acknowledge the existence of data gaps in areas with no or limited sampling because of access constraints that precluded soil characterization (e.g., soils beneath Unit Buildings or active ponds). As part of the RI/FS process, the available sampling data for all areas of the site, including areas with no or limited data and deeper soils (>10 ft bgs) will be reviewed to identify data gaps and strategies for sampling, containment, and/or remediation. The RI/FS Work Plan will be revised to include an evaluation of the feasibility for assessment of the areas below the site unit processing buildings as potential sources of COPCs that may migrate to groundwater. This evaluation will include a description of the unit buildings, historic operations, and their current status; a summary of existing data collected from previous borings near the unit buildings; identification of data gaps; evaluation of potential investigation methods (including directional drilling) that would include implementability in light of the significant access constraints in this area, and a proposed investigation approach.
54. Section 5.4.2 Groundwater, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Page 66, the last sentence of the first paragraph should be changed to state that chromium and perchlorate impacts are “partially” mitigated.	The requested change will be made to the text of the revised RI/FS Work Plan.
b. Page 68, Trespassing Chemicals, please note and discuss that there are a number of compounds besides VOCs in the plume approaching from the west.	As noted on page 68, the DNAPL in the trespassing chemicals plume has been analyzed by Montrose and found to contain several VOCs, pesticides, and herbicides. A more detailed review of the Montrose investigation reports will be conducted as part of the RI. ENVIRON believes that this effort is more appropriately part of the RI rather than the RI/FS Work Plan. It will be important for NDEP to keep the Trust informed on the plans by other parties to address the chemicals originating from their sites. It is our understanding that the Trust should assume in conducting the RI/FS, that NDEP will require Responsible Parties at sites upgradient of the NERT site, to contain chemicals at the downgradient property boundary of the site which contains the source.

NDEP Comment	Response
c. Pages 68 and 69, Downgradient Plume – Lateral Extent, NDEP provides the following comments: i. NDEP would like to know how the suggested wells will help the Trust in its remediation, well field optimization, and mitigation efforts at the IWF, AWF, and SWF. ii. Page 68, last paragraph, no basis has been provided for the 1 mg/L cut off for delineation of perchlorate versus the health-based screening level of 18 µg/l. Please include justification and discussion addressing this comment. iii. Page 69, 1st partial paragraph, per comments above, NDEP is not aware of any NDEP-approved Deliverable that has been submitted to date that demonstrates a separation of the Trust and AMPAC plumes with an approved screening value, please revise. iv. Page 69, 1st partial paragraph, reference to Figure 5-10 should be revised to Figure 5-11. v. Page 69, 1st full paragraph, NDEP disagrees with the Trust's statements regarding a separate BMI Common Areas plume due to the comparison using a 5 mg/L or 10 mg/L metric that has not been approved by NDEP.	Subsequent to these comments, there has been additional discussion with NDEP regarding the delineation of the downgradient plume to be addressed by the Trust in its RI/FS. We understand that the Nevada provisional action level of 18 µg/L for perchlorate will be used as the basis to delineate the boundaries of the area-wide BMI complex commingled groundwater plume. However, within the area of commingled groundwater, where concentrations are several orders of magnitude higher, a different approach is needed to define the Trust's Study Area. Based on the existing data, a 1 mg/L perchlorate concentration appears to provide a basis for separation between the Trust plume and the AMPAC plume to the west. However, on the east side, commingling between the Trust plume and BMI Common Areas plume is more extensive. A geographic boundary (such as Pabco Road) appears to be more practical. Regarding Comment #54c i, the core area of the downgradient plume within the mapped paleochannels will be a primary focus of the FS remedial alternatives evaluations. The suggested wells are positioned to confirm the extrapolated separation between the Trust plume and the AMPAC plume in areas where little data are available. Regarding Comment #54c iv, the figure reference will be corrected.
55. Section 5.4.2.1, Groundwater Analytic Program, page 69, extensive testing of the chromium versus hexavalent chromium speciation has been completed historically. Please review historical data to confirm if this is truly a data gap and revise the Deliverable as necessary.	The text of the RI/FS Work Plan will be revised to clarify that the data gap is related to redox potential which will control the solubility of chromium in groundwater. It is clear from existing data that all dissolved-phase chromium detected in groundwater is hexavalent chromium.
56. Section 6.2 Task 2: Community Relations, page 71. Refer to the NCP to identify the essentials of a community relations plan. Establishing and maintaining an administrative record and public involvement / opportunity to comment at the proposed plan stage are especially important.	Section 6.2 of the RI/FS Work Plan will be revised to reference the NCP and confirm the components of the Community Involvement Plan (CIP) meet the requirements of the NCP, including maintaining an administrative record and providing appropriate opportunities for public involvement, review, and comment. The text will be revised to indicate NDEP has been and will continue to be responsible for maintaining the administrative record.

NDEP Comment	Response
57. Section 6.3 Task 3: Field Investigation, page 72, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Please clearly describe how the Parcels will addressed or will not be addressed as a part of this and associated future Deliverables.	As discussed with NDEP, the Parcels (i.e., Parcels A, B, C, D, E, F, G, and H) have generally been evaluated in separate investigations and on a timeline separate from investigations of the Facility Area. As agreed with NDEP, the status of the Parcels will be discussed briefly in Sections 1 and/or 2 of the revised Work Plan and all other reference to the Parcels will be deleted from the Work Plan. More specifically, Sections 3.2.1.2 (Investigations of Parcel Soils, p15) and 4.2 (Soil Removal Actions and Health Risk Assessments at the Parcel Areas, p25) will be deleted from the Work Plan. In addition, all text within a section that focuses solely on the Parcels will be deleted.
b. The investigations or evaluation relating to soil gas or ambient air do not appear to be addressed in this Section. Please contact NDEP to discuss how these topics may be handled.	The SAP and/or BHRA Work Plan will describe how soil gas and ambient air will be addressed.
58. Section 6.3 Task 3: Field Investigation, page 72, a Field Sampling Plan should be referenced here or the relevant methodological information should be cited and provided for the activities identified in the bullets.	See response to Comment #4. The detailed SAP will include field sampling plans.
59. Section 6.4 Task 4: Sample Analysis and Data Verification and Validation, page 73, while some relevant references have been cited, this section lacks the details needed to provide a thorough explanation of how sample analysis and data validation will be conducted for this particular investigation. Additional information that needs to be included or identified as to be included in the SAP is:	See response to Comment #4. The detailed SAP will include a QAPP with the requested information.
a. COPCs, media, and associated analytical methods	
b. Laboratories that will be analyzing the data; required detection limits	
c. Identity of who will be performing data validation	
d. Procedure for establishing data quality criteria.	
e. Additionally, please identify that electronic data deliverables will be uploaded to the NDEP Site-Wide Database and will comply with promulgated NDEP guidance on this matter.	

NDEP Comment	Response
60. Sections 6.4 Task 4: Sample Analysis and Data Verification and Validation and 6.5 Task 5: Data Evaluation, pages 73 – 74, the Trust should consider addressing the section of the process in a sub-area fashion.	It is anticipated that the Facility Area will be divided into subareas (exposure units) for risk assessment purposes. Accordingly, Tasks 4 (Sample Analysis and Data Verification and Validation) and 5 (Data Evaluation) would be conducted for the corresponding exposure units. The text of the RI/FS Work Plan for Tasks 4 and 5 will be revised to reflect this approach. Detailed information on the proposed exposure units will be provided in the BHRA Work Plan.
61. Section 6.6 Task 6: Risk Assessment, page 74, NDEP provides the following comments:	Please see the following responses to the individual comments:
a. Superfund guidance for human health risk assessment (OSWER 9200.4-18, August 1997; OSWER 9200.4-31P, December 1999) recommends that cancer risks related to radionuclide and chemical COPCs should be summed. This consideration should inform supporting documents including the SAP and the Baseline Health Risk Assessment Work Plan.	The Trust will use the cited guidance document to inform supporting documents such as the SAP and the BHRA Work Plan.
b. This section is generic and does not provide any specific information or references to indicate how the risk assessment will be conducted. The methods and assumptions for the risk assessment can have a substantial impact on the identification of data gaps and identifying appropriate sampling designs. The work plan should include a discussion of risk assessment methods and assumptions related to these and other relevant subjects to inform the SAP. The references (Section 8) include Environ 2012g, which is listed as a Baseline Health Risk Assessment Work Plan (*in preparation*) but this reference does not appear in the text and was not available during review.	Please see responses to Comments #4 and 5. The requested information (i.e., the specific details of how the risk assessment will be conducted) will be presented in the BHRA Work Plan and the BHRA approach will inform the SAP.
62. Section 6.7 Task 7: Treatability Studies, page 75. It was indicated at the February 2013 NERT Annual Stakeholder Meeting that pilot testing of an ex-situ ion exchange system will be pursued for the SWF. Is this considered another treatability study with a work plan to be developed?	See response to Comment #27.

NDEP Comment	Response
63. Section 6.10 Task 10 Detailed Analysis of Alternatives, page 76. In evaluating the cost of the alternatives, suggest including alternatives' cost per mass of perchlorate removed/destroyed. In evaluating the "Short-term effectiveness," the Trust should assess the anticipated times to achieve cleanup goals will be particularly important. The RI/FS Work Plan should discuss the means and methods that will be used to identify those cost-effective alternatives that will likely provide the greatest benefit towards achieving the RAOs considering the limited funds available.	The revised RI/FS Work Plan will provide more detail on the approach for performing the detailed analysis of alternatives including discussion of how treatment times will be considered in the analysis. Also see response to Comments #48 and #51.
64. Section 7.1 Project Organization and Responsibilities, page 78. "Ms. Shannon Harbour, PE, previously project manager for the site," should be replaced with "Mr. Weiquan Dong, PE, project manager for the site".	The requested change will be made in the revised RI/FS Work Plan.
65. Section 7.1 Project Organization and Responsibilities, page 78. Suggest updating to reflect transition to Envirogen, giving key milestone dates.	The requested change will be made in the revised RI/FS Work Plan.
66. Section 7.2 Project Schedule, page 79, Add dates on schedule	Calendar dates for anticipated timeframes and completion dates of project tasks will be added to the text of Section 7.2 and to the anticipated project schedule in Figure 7-1 of the revised RI/FS Work Plan.
67. Table 2-1 Summary of Neighboring Properties, NDEP provides the following comments that should be addressed in the revised Deliverable:	Please see the following responses to the individual comments:
a. AMPAC, as discussed above, NDEP has not approved the theory that the AMPAC and the Trust plumes do not commingle as it appears that this theory is based on the concentration metric selected when making this determination. Please contact NDEP to discuss this issue as necessary.	See response to Comment #54c.
b. BMI Common Areas, as discussed above, the BMI Dump, the complete ditch system and other conveyances should be included in this table.	The information requested will be added to Table 2-1 of the revised RI/FS Work Plan, or this information will be provided in a separate table.
c. Tenants should be included in this Table.	Information about site tenants will be added to Table 2-1 of the revised RI/FS Work Plan, or this information will be provided in a separate table.

NDEP Comment	Response
68. Table 4-1 Summary of the Groundwater Monitoring Program. Please include units for well depth and screen interval and clarify if screen interval is referring to depths "below ground surface."	This requested change will be made in the revised RI/FS Work Plan.
69. Table 5-2 Initial Screening of Remedial Technologies, this table appears to only include groundwater, per NDEP's comments above, please include how soils, ambient air or vapor intrusion will be addressed. This is an inconsistency that affects numerous sections of the Deliverable, which should be addressed throughout the Deliverable.	This table presents a number of process options and technologies for addressing soils and vapor intrusion in addition to those for groundwater. For ease of presentation, the screening table was generally divided by whether the treatment technology or process option addressed groundwater or "source areas". Soil and soil vapor are included in the latter category. Because soils are most typically the source of airborne particulates, addressing soil contamination would typically address the ambient air pathway. Therefore, the process options addressing soil, ambient air, and soil vapor are included under the *Ex-Situ Source Area Treatments* General Response Action (GRA) on pages 7-9 and under the *In-Situ Groundwater and Source Area Treatment* GRA on pages 9-14.
70. Table 5-3 Secondary Screening of Remedial Technologies, based on issues identified in above-comments, there appear to be a number of incorrect conclusions in this table. NDEP has not provided specific comments for all instances. Please review this table in regards to other comments included in this response letter. However, NDEP provides the following specific comments for this table:	The table will be reviewed with respect to the conclusions on individual process options and technologies. Changes will be made in the revised RI/FS Work Plan where appropriate.
a. Steam/Hot Water Injection, Page 16 of 23, this technology is eliminated because it requires a pilot test, yet two pilot tests are proposed in this Deliverable. This seems like an incorrect and inconsistent screening. Please provide additional rational for elimination.	This process option was not rejected from further evaluation because it requires a pilot test. Rather, it was rejected because the target contaminants are generally fuels and Semi-Volatile Organic Compounds (SVOCs), not VOCs. On page 16 of 23 under the column "Screening Comments" the text reads as follows: *REJECTED. The primary target contaminant groups for steam or hot water flushing/stripping are SVOCs and fuels. VOCs also can be treated by this technology, but there are more cost-effective processes for VOCs.* However, as with all other process options and technologies, as the COPC list is refined during the RI/FS, process options and technologies will be re-screened and re-evaluated as necessary to develop the RAAs as part of the RI/FS.

NDEP Comment	Response
b. In-Situ Chemical Oxidation, page 18 of 23, please note that this technology is not compatible with the chromium groundwater plume and should be eliminated in areas with chromium groundwater contamination.	Table 5-3 (page 18 of 23) currently indicates that In-Situ Chemical Oxidation (ISCO) is not applicable in the treatment of perchlorate and chromium and was retained as a potential alternative for remediation of localized VOCs/DNAPLs in groundwater. It is possible that ISCO can mobilize soil-bound chromium and this will be considered during the evaluation of this technology.
c. Deep Re-Injection Trenches, page 22 of 23, this process option was problematic at the AMPAC in-situ remediation area. Please determine and discuss what studies should be implemented and how conditions at the Trust site are expected to be different than those for AMPAC.	Biofouling was a significant problem with the Deep Re-Injection Trench (DRIT) operated by AMPAC. There may be other configurations of this technology that could reduce biofouling. This process option will be further evaluated in preparation of the revised RI/FS Work Plan.
d. Secondary Screening of Remedial Technologies. Soil excavation for offsite or onsite treatment and disposal should be retained for areas where soils with high perchlorate or other COPC concentrations are present and limited removals would have a significant benefit by eliminating a large perchlorate and/or other COPC mass from the overall source.	Excavation-related process options will be retained through the secondary screening per this request. The revised RI/FS Work Plan will be changed accordingly.
e. Phytoremediation may be a viable technology that could be implemented in the seep area where perchlorate concentrations are relatively low and groundwater is close to the ground surface. This technology should be retained for further evaluation	Phytoremediation will be retained through the secondary screening process and the revised RI/FS Work Plan will be changed accordingly.
71. Figure 2-1 Surrounding Facilities, please depict the BMI Dump per NDEP comments above.	The location of the BMI Dump will be added to Figure 2-1 of the revised RI/FS Work Plan.
72. Figure 4-1 Groundwater Extraction and Treatment System Flow Diagram, NDEP provides the following comments: The ferrous sulfate is added to the Lift Station 3 of AWF. Please clarify where the precipitates are removed for this influent stream and capacity of chromium removal with this method. The comment is also applied to the SWF.	The precipitates are retained in the activated carbon beds and are subsequently backwashed into the GW-11 pond using stabilized Lake Mead water. This practice has contributed to the solids loading of the GW-11 pond, which is discussed in response to Comment #20a. The overall efficacy of the carbon beds is also discussed in response to Comment #20b. The efficacy of the carbon beds, including the effect of the precipitates and the ultimate solids loading to the GW-11 pond, will be evaluated as part of the analysis of Remedial Action Alternatives to be included in the FS.

NDEP Comment	Response
73. Figure 4-5 Well Field Extraction Rates and chromium and Perchlorate Mass Removals, the total Chromium removed from the AWF has slightly increased consistently with time; however, perchlorate has not. Please discuss in the text of the revised Deliverable.	A discussion of the chromium and perchlorate mass removed from the AWF over time will be added to the text of the revised RI/FS Work Plan.
74. Figure 5-1 Preliminary Conceptual Site Model Diagram: Site and Downgradient Plume, the figure does not include ecological receptors; please refer to Figure 5-4, which indicates both terrestrial and aquatic receptors.	See response to Comment #6.
75. Figure 5-2 Historical and Active Pond Locations, the depiction of the Northwest Ditch is inconsistent with what NDEP has seen previously. Please provide a citation for this depiction and discuss with NDEP or revise as necessary.	The depiction of the Northwest Ditch on Figure 5-2 of the RI/FS Work Plan was based on Figure 4-1 of the *Phase A Source Area Investigation Results* (ENSR 2008a) and Figure 5-2 of the *Phase B Source Area Investigation Results, Soil Gas Survey Work Plan* (ENSR 2008b). In response to NDEP's comment, ENVIRON reviewed historical reports prepared for the site and other BMI properties. Reports prepared for the TIMET site (Tetra Tech 2005, TIMET 2013) provided additional information on the current locations of the Beta Ditch and Northwest Ditch on the TIMET property as well as the ditch configurations from pre-1955 through 1979. A revised Figure 5-2, incorporating this information, will be provided in the revised RI/FS Work Plan. We note that the locations of the Northwest and Beta Ditches *within* the site boundary that were shown on Figure 5-2 of the Work Plan are consistent with the ditch locations shown on figures from earlier reports. Thus, ditch locations within the site to be depicted on the revised Figure 5-2 will not change.
76. Figure 5-4 Preliminary Conceptual Site Model Illustration, please explain the relative impact scale, (e.g., minimal relative to which water quality standard, etc.).	Figure 5-4 will be revised to incorporate the requested change.
77. Figure 5-7 Perchlorate in Shallow Groundwater, May-June 2012, please review and address the above-comments regarding justification of using 1 mg/L perchlorate as the basis for the outer concentration contours.	See response to Comment #54c.

NDEP Comment	Response
78. Figure 5-7 Perchlorate in Shallow Groundwater, May-June 2012. Greater resolution based on available monitoring data should be provided on the minimum isoconcentration contours to fully reflect the potential for interactions between the perchlorate plumes originating from the NERT and AMPAC sites.	Please see response to Comment #77. Greater resolution will be provided on the Plate 3 IWF, AWF, and SWF insets where the well density and the available data are sufficient to allow a more detailed interpretation at the scale of the insets.
79. Figure 5-8 Total Chromium in Shallow Groundwater, May-June 2012. Greater resolution based on available monitoring data should be provided on the minimum isoconcentration contours.	Greater resolution will be provided on the Plate 4 IWF, AWF, and SWF insets where the well density and the available data are sufficient to allow a more detailed interpretation at the scale of the insets.
80. Figure 7-1 Remedial Investigation and Feasibility Study Schedule, this figure presents a timeline for a baseline HRA work plan. Please clarify whether the Trust plans on submitting a new HRA work plan or revise the existing one (Northgate 2010).	See response to Comment #5.
81. Plate 2 Potentiometric scaling: Gradients are flatter below the COH Bird Viewing Ponds, possibly due to higher hydraulic conductivity. This needs to be examined in more detail to optimize perchlorate capture while reducing pumping in the SWF area. It is assumed that the SWF wells are partially capturing Las Vegas Wash water, but possibly they are capturing City of Henderson (COH) waste water effluent in the downgradient SWF wells also. Examination of major or trace ion data might be an approach to this issue.	The question of how much surface water is being captured by the SWF will be examined in more detail as part of the GWETS Optimization Study. Results of this analysis will be incorporated into the RI/FS as they are developed.
82. Plate 4 shows WMW5.7N as containing "< 3 mg/L", which is correct; but actual values are probably much lower. For example, WMW5.8SI is something over 200 µg/L. These need to be depicted in more detail to help understand the conditions near the Pabco Weir. TDS is similarly too grossly scaled, showing nothing < 5000 mg/L.	The maps were developed using data available at the time. As part of preparing the revised RI/FS Work Plan, additional data will be sought from the Southern Nevada Water Authority (SNWA) and others as appropriate in order to refine the interpretations in this area.
83. Plate 4 Groundwater Total Chromium Map, Shallow Water-Bearing Zone. The Call-out maps shows the perchlorate concentrations instead of the total chromium concentrations.	This will be corrected in the revised RI/FS Work Plan.
84. Appendix A Letter of Understanding (LOU) Roadmap, Table A-1 Road Map of Site Soil and Soil Gas investigation, NDEP provides the following comments:	As discussed with NDEP, the title of Appendix A, Table A-1 is misleading. Table A-1 identifies investigations ***completed*** as of December 2012; that is, Table A-1 was intended to show the current status of investigatory activities at the site and in particular, provide a summary that links the LOUs with historical investigations. Table A-1 is
a. Per NDEP comments above please clarify why ambient air discharges are not being evaluated as part of an HRA.	

NDEP Comment	Response
b. Please clarify whether vast areas of the site will never be redeveloped to justify that soil gas investigations are listed as N/A.	not a roadmap of future investigations planned for the site. The title of the table will be revised and the table will be reviewed and further annotated as needed for clarification. In response to NDEP's specific comment, ambient air discharges and soil gas investigations are being considered in the BHRA, as discussed in the RI/FS Work Plan.
85. Appendix C, Table C-2 McCullough Range Background Radionuclide Concentrations, the McCullough background data appear to be inappropriately divided into depth intervals of 0-6' below ground surface (bgs), 6-10' bgs, and 0-10' bgs when the text (Section C.2.1) states that two depth intervals (0-0.5' bgs and > 0.5' bgs) exist for this dataset. It is unclear what the rationale is for sub-setting the background data into these intervals in Table C-2. Please provide clarification.	Table C-2 (Appendix C), which identifies background concentrations for radionuclides from the McCullough Range dataset, was taken from the soil HRA for Parcels C, D, F, G, and H (Northgate 2012), which was based on the dataset presented in the Background Shallow Soil Summary Report for the BMI Complex and Common Areas Vicinity (Basic Remediation Company [BRC]/TIMET 2007). ENVIRON had understood that the depth intervals presented in the Northgate report (i.e., 0-10 and 0-6 ft bgs) had been discussed with and approved by NDEP. More recently, in Appendix E of the soil HRA for Parcels C, D, F, G, and H (Northgate 2013), the background evaluation for radionuclides was based on 0-10 ft (and not 0-6 ft) samples from the McCullough Range dataset. During discussions with NDEP, ENVIRON understood that NDEP approved of this dataset – and the depth interval used -- for the background evaluation. Table C-2 of the RI/FS Work Plan will be revised to present the dataset for radionuclides that ENVIRON used for the Parcels C, D, F, G, and H evaluation.
86. Appendix D PRB Treatability and Bench Scale Test Study Work Plan, Section 2.2.2 Field-Scale Pilot Objectives, page D-2, as previously stated, the Trust should consider the work completed by AMPAC in their in-situ remediation area, which could be very helpful towards addressing a number of the data gaps in this Appendix.	The work completed by AMPAC involving installation and operation of the active in-situ permeable reactive wall has been reviewed, and considerations as they may relate to the proposed in-situ Permeable Reactive Barrier (PRB) Study at the NERT site will be discussed in the revised Treatability Study Work Plan. In general, ENVIRON believes that the observed biofouling experienced by the AMPAC system was primarily related to the specific design of the system (i.e., mixing extracted groundwater with nutrients and electron donor ex-situ prior to reinjection).

NDEP Comment	Response
87. Appendix D, Section 3.2 Hydrology, page D-5, the Deliverable states that the Shallow Water-Bearing Zone will only be targeted for this study. Please include discussion as to why the Middle Zone and Deep Zone are not considered.	Current information suggests that the primary flux of contaminants is through the more permeable alluvial deposits. Due to the low permeability of the Upper Muddy Creek formation (UMCf), we believe that this zone represents only a small percentage of the contaminant flux and installation of the PRB through this formation was not considered as part of the pilot study. ENVIRON notes that the treatment effectiveness of a PRB in such a tight formation would be limited and extending the PRB into the UMCf could present certain technical challenges and potential impracticalities (particularly for a "trenched"-type PRB) for installation to these depths. The revised Treatability Study Work Plan will include an explanation of this rationale.
88. Appendix D, Section 4 Technology Overview and Rationale, page D-6, as stated above, the Trust should review AMPAC's experience immediately to the west in the downgradient area or the previous bench scale studies by Shaw and Northgate and include information from the former AMPAC In-Situ System into this work plan.	As indicated in response to Comment #86, the work completed by AMPAC involving installation and operation of the active in-situ permeable reactive wall has been reviewed, and considerations as they may relate to the proposed in-situ PRB Study at the NERT site will be discussed in the revised Treatability Study Work Plan. The results of previous bench scale studies performed by Shaw and Northgate were considered in the development of the Work Plan submitted and were the reason why bench-scale testing has been proposed. Additional discussion supporting this rationale will be provided in the revised Treatability Study Work Plan.
89. Appendix D, Section 5.3.1, Microcosm (Serum Bottle) Testing, page D-11, the Deliverable states the selected electron donors was "based on their ability to be applied to a variety of potential PRB morphologies (e.g., via direct injection, passive diffusion wells or within a trenched wall), their demonstrated success in similar environments based on review of case studies and published research." The stated success in similar environments appears to disregard AMPAC's experience less than one mile away. Please incorporate information from the former AMPAC In-Situ System into this work plan.	Additional discussion of AMPAC's experience in the installation and operation of the active in-situ permeable reactive wall will be added to the revised Treatability Study Work Plan.
90. Appendix D, Section 5.3.1 Microcosm (Serum Bottle) Testing, page D-12, please consider including chlorate analysis.	Chlorate analysis of serum bottles will be added to the revised Treatability Study Work Plan.

NDEP Comment	Response
91. Appendix D PRB Treatability and Bench Scale Test Study Work Plan. The NERT should note applicability of the bench-test results to the field scale test. The NERT may study the FBR to get some information about biomass accumulation in the PRB.	Similar to consideration of the experience of AMPAC in the installation and operation of the active in-situ permeable reactive wall (i.e., that experienced plugging due to the formation of biomass in-situ), operational considerations relative to the formation of biomass accumulation in the FBR will discussed in the revised Treatability Study Work Plan.
92. Appendix E In-Situ Soil Flushing Treatability Study Work Plan, Section 1.2 Purpose and Objectives, pages 2 – 3, the volume of water infiltrating from the flushing water should be evaluated before the pilot study. The evaluation should include the impact to the groundwater table elevation, the change of capture zones due to rising groundwater table elevation, and the capacity of GWETS and GWTP.	Preliminary Green-Ampt modeling, using various flushing water application rates, was performed to estimate potential mounding under different flushing conditions and these results are currently included in the Treatability Study Work Plan. It is noted, however, that the available information to accurately predict the effect of flushing is limited, and is the purpose of the planned initial field investigation activities (i.e., soil boring, lithologic logging, permeameter testing and soils sampling as described in Section 5 and 6 of the Treatability Study Work Plan) that is proposed. Additional discussion and a figure will be included in the revised Treatability Study Work Plan that includes a projection of potential mounding effects of flushing water (i.e., as can be reasonably predicted from the limited information available and output of the Green-Ampt model) and the effect on the current capture zones and the capacity of the GWETS and GWTP.
93. Appendix E, Section 1.2 Purpose and Objectives, page 2, 2nd bullet, the Deliverable states "Evaluate the potential for other constituents of concern to be mobilized during flushing operations". Prior to the commencement of any pilot study for soil flushing, please evaluate the mobilization of other COPCs using physical chemical properties and identify any COPCs that may be expected to mobilize due to soil flushing.	The potential for other COPCs to be mobilized during soil flushing was evaluated in bench-scale column tests performed by PRIMA Environmental in 2009. Water was flushed through three columns of soil cores taken from the NERT site. One of the soil cores was collected from RSAM-5 which is located within in the proposed soil flushing pilot area presented in the Treatability Study Work Plan of Appendix E. Based on the results presented by PRIMA, the following COPCs were detected in at least one leachate sample from the RSAM-5 column test and may be mobilized during the soil flushing pilot: chloride, fluoride, nitrate, sulfate, ammonia, chlorate, TDS, total organic carbon (TOC), total suspended solids (TSS), arsenic, boron, calcium, chromium, cobalt, iron, magnesium, manganese, potassium, sodium, uranium, beta BHC. A discussion of these results and the potential for mobilization will be included in the revised Treatability Study Work Plan.

NDEP Comment	Response
94. Appendix E, Section 5.2 Flushing Fluids Characterization, page 8, please clarify whether the cost benefit of not using stabilized Lake Mead water outweighs the complications of using GWETS effluent and the potential negative consequences of using this effluent. Additionally, the Trust should commence discussions with NDEP Bureau of Water Pollution Control prior to planning or implementing any pilot studies. If the GWETS effluent is used, new column leaching tests with the effluent should be completed prior to the commencement of the pilot study. Besides studying the perchlorate recovery from the leaching experiment, other COPCs should be evaluated. The TDS of the effluent from the column leaching experiment should also be determined.	Based on a preliminary analysis of costs, there could be significant cost-savings in using treated effluent versus Lake Mead water for flushing (approximately $23,000 per acre). This cost analysis will be presented in greater detail in the revised Treatability Study Work Plan. Prior to finalizing the plans for the field-scale pilot test, to evaluate the use of GWETS effluent as a source of flushing water and to assess the potential for leaching of COPCs from the site soils (i.e., due to the higher ionic strength of the GWETS effluent water), bench-scale column testing of site soils using GWETS effluent as a flushing liquid will be performed. This additional bench-scale testing will be incorporated into the revised Treatability Study Work Plan.
95. Appendix E, Section 6 Preliminary Pilot System Design & Operation, page 9, please clarify what sort of air emissions monitoring is expected as part of this work plan.	A discussion of the following air monitoring and control measures will be incorporated into the revised Treatability Study Work Plan. Similar to the air monitoring performed during the earlier soil removal activities at the site, air monitoring will be performed for workers during construction of soil flushing pilot cell using personal DataRAM devices programmed to measure the sixty-second average of real-time dust concentrations. Readings of upwind and downwind concentrations will be measured hourly and recorded in a daily logbook. Dust control measures consisting of wetting the ground surface in the construction area will be implemented. Water for dust control will be obtained from onsite fire hydrants.
96. Appendix E, Section 7.3 Groundwater Monitoring, page 14, please specify the anticipated screened intervals of the wells: specifically which lithologies will be screened and if any wells will be cross-screened.	A table of anticipated screen intervals for wells and piezometers and the associated lithologies screened will be provided in the revised Treatability Study Work Plan. Screened intervals have been summarized in Table 3.
97. Appendix E, Figure 5 Interceptor Trench Projected Capture Zone, please specify the concentrations that were used to develop the inferred capture zone.	An updated Figure with the most recent capture zone projection indicating the associated groundwater concentrations used to develop the inferred capture zone will be provided in the revised Treatability Study Work Plan.
98. Appendix E Treatability Study Work Plan In-Situ Soil Flushing. The NERT should note that a. Column tests are unlikely to be representative of field conditions, due to the presence of soil structure and lithologic layering and anisotropic hydraulic properties.	The Trust is aware of the potential challenges associated with groundwater mounding and in-situ lithologic conditions that may affect the treatment of perchlorate. The purpose of the treatability study is to assess such limitations, and to explore means to reduce or manage their effects on a potential full-scale application.

NDEP Comment	Response
b. In practice, maintaining full saturation in soils on a large scale would appear to be difficult, due to development of preferred pathways within the vadose zone (for example, see publications by Dr. Robert Glass, of Los Alamos National Laboratory). There is a substantial body of literature on the spatial variability of vadose zone hydraulic properties. c. The hydraulic conductivity and ability to transport perchlorate would be substantially lower in vadose zone areas adjoining the preferred pathways. This would act to prolong perchlorate residence time within the soils being treated. d. Even if perchlorate-bearing soils are fully saturated (downward unit gradient conditions) the effects of hydrodynamic dispersion and anisotropy due to stratification are likely to prolong the time required for flushing of soils. e. Removal of solute from dead-end and tight pore spaces is a diffusion-limited process, again suggesting a relatively long timeframe to clean the soils, which means that the flushing system must operate for an extended period. f. Flushing with water from sources outside the GWETS (for example, City of Henderson wastewater treatment plant effluent) for an extended period of time would add to the mass of contaminated water within the plume and increase the likelihood that perchlorate would escape the capture zones (see 10b above).	As discussed in the response to Comment #92, preliminary Green-Ampt modeling was performed to estimate potential mounding under different flushing conditions and these results are currently included in the Treatability Study Work Plan. However, the available information to accurately predict the affect of flushing is limited. During the initial field investigation activities (i.e., soil boring, lithologic logging, permeameter testing and soils sampling as described in Section 5 and 6 of the Treatability Study Work Plan) planned, the conditions encountered in the area of the planned pilot cell will be assessed and incorporated into the final design of the pilot-scale system prior to construction. A discussion of relevant research (e.g., publications by Dr. Glass) will be included in the revised Treatability Study Work Plan.
99. Appendix F Groundwater Extraction and Treatment System Optimization Study: Preliminary Analysis of Groundwater Capture and Extraction Rates at the Interceptor and Athens Road Well Fields, please note that the NDEP response letter of January 17, 2013 regarding the *Annual Remedial Performance Report for Chromium and Perchlorate* should also applied to the Appendix F.	With the initiation of the GWETS Optimization Study, Appendix F will be removed from the RI/FS Work Plan. This comment will be addressed as part of the GWETS Optimization Study.
100. Appendix F Groundwater Extraction and Treatment System Optimization Study. The NDEP recommends that capture zone analysis of the SWF should be conducted in the current study. The SWF should be included in the current evaluation and not be delayed for future studies.	An evaluation of the SWF was not included in the initial scope of the GWETS Optimization Study. However, a revised scope will be submitted to NDEP that includes an evaluation of the SWF in the current GWETS Optimization Study.

NDEP Comment	Response
101. Appendix F, Section 1 Introduction, page F-1, the Trust should consider using a RAO for capture of perchlorate, chromium, and any other COPCs above an applicable concentration metric (i.e. an ARAR). Please note that NDEP would require justification for and approval of the establishment of such a benchmark.	ENVIRON notes that optimization of the GWETS is intended primarily to increase the effectiveness and efficiency of the existing system which would be consistent with the short-term RAOs proposed in the Work Plan. Additional RAOs/metrics that are specific to evaluation of the GWETS optimization including incremental mass removal, capture, etc. will be considered and addressed in the GWETS Optimization Study.
102. Appendix F, Section 2.2, "constraints" listed in bullet format: Hydraulic loading limitations are identified, but potential increases in mass loadings to the perchlorate and chromium treatment systems are not mentioned. Were mass loadings found to be insignificant or manageable through equalization/blending?	With the initiation of the GWETS Optimization Study, Appendix F will be removed from the RI/FS Work Plan. This comment will be evaluated as part of the GWETS Optimization Study.
103. Appendix F, Section 3 Estimated Capture Zones and Potential Gaps in Capture, page F-5, with regards to the IWF, the Deliverable states, "To address this gap, ENVIRON proposes to begin pumping the several new wells, which is described in more detail in the following sections." Additionally, with regards to the AWF, the Deliverable states, "To address this gap, ENVIRON proposes to begin pumping some of the new wells, which is described in more detail in the following sections." Given that pumping and treatment system is at/or near capacity, please explain how the foregoing will be accomplished and what is expected to be accomplished.	With the initiation of the GWETS Optimization Study, Appendix F will be removed from the RI/FS Work Plan. This comment will be evaluated as part of the GWETS Optimization Study.
104. Appendix F, Section 3 Estimated Capture Zones and Potential Gaps in Capture, page F-5, this Deliverable has not discussed potential underflow beneath or through the slurry wall. NDEP is aware that Northgate collected samples for permeability testing of the slurry wall and reported the results on September 29, 2010; however, no report discussing the potential underflow beneath or flow through the slurry was submitted. Please discuss how this data gap will be addressed.	An evaluation of the effectiveness of the barrier wall based on current data will be included in the GWETS Optimization Study. Based on the results of this evaluation, additional data collection may be proposed to address any remaining data gap.

NDEP Comment	Response
105. Appendix F Groundwater Extraction and Treatment System Optimization Study, Section 5.4, page F-10. The RI/FS Work Plan should clearly identify how the model will be used and potentially upgraded to characterize capture zones, plume migration, fate and transport of COPCs, and effects of operational changes. A specific section within the RI/FS Work Plan should be dedicated to this discussion.	A description of proposed model updates and model analyses will be provided in the revised RI/FS Work Plan.
106. The NERT should test alternative capture well placement and pumping scenarios using the model and use these to guide installation of additional wells in the SWF and AWF.	The GWETS Optimization Study will evaluate the capture zones of the SWF and AWF, and will evaluate the potential effectiveness of additional wells if needed to prevent plume migration past the existing systems. As described in the response to Comment #24, installation of additional wells and their configuration (including those that target the center of the plume) will be evaluated as part of the RI/FS.

References:

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Tetra Tech EM Inc. (Tetra Tech), 2005. Potential Source Areas Technical Memorandum, Titanium Metals Corporation Facility, Henderson, Nevada. Revision 1. July 5.

Titanium Metals Corporation (TIMET), 2013. Calculation of Leaching-Based Site-Specific Levels, BMI Beta Ditch/Northwestern Ditches Located on the Titanium Metals Corporation Plant Site, BMI Common Areas, Clark County, Nevada. May 16.

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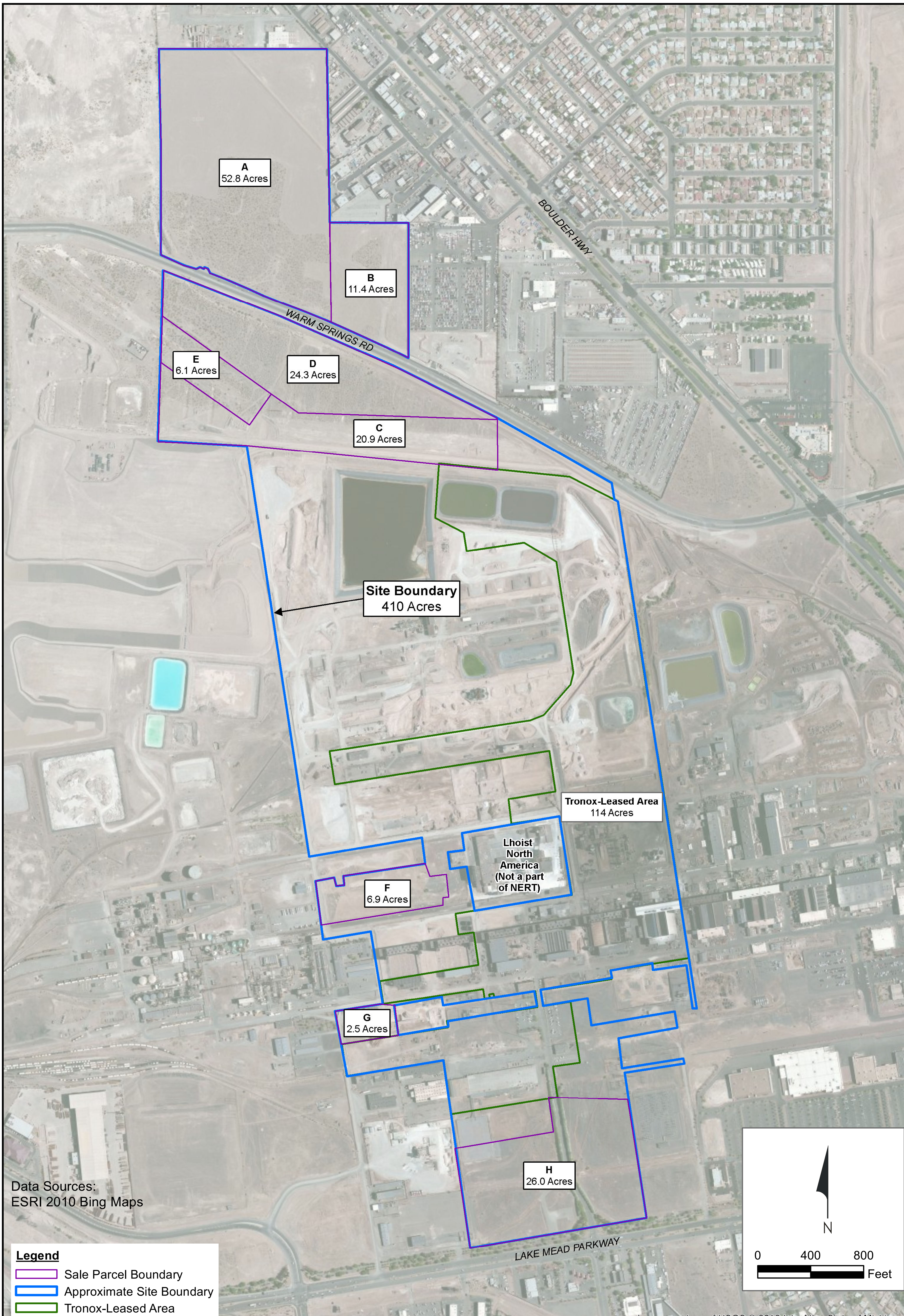
Attachment B

Figure: Site Boundary, Sale Parcels, and Tronox-Leased Area Acreage

Nevada Environmental Response Trust Site, Henderson, Nevada



ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Site Boundary, Sale Parcels, and Tronox-Leased Area Acreage

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **1**

Drafter: RS | Date: 9/30/2013 | Contract Number: 21-32100I (I01) | Approved by: | Revised:

Attachment C

Table: Pipeline Diameter and Lengths for the GWETS

Nevada Environmental Response Trust Site, Henderson, Nevada

TABLE 1. PIPELINE DIAMETER AND LENGTHS FOR THE GWETS
Nevada Environmental Response Trust Site; Henderson, Nevada

FLOW	LOCATION	PIPELINE SECTION	DIAMETER (in)	LENGTH (ft)
Influent	Lift Station 1 to Lift Station 2	Single pipe	10	8200
	Lift Station 3 to Lift Station 2	LS3 to Pabco Rd	10	630
		Pabco Rd to LS2	8	1730
	Lift Station 2 to GWETS	LS2 to south end of Pabco Rd	12	6780
		South end of Pabco Rd to GW-11 pond	12	3680
Effluent	FBR to Effluent Discharge Point at Las Vegas Wash	FBR to GW-11 pond	12 (assumed)	2160
		GW-11 Pond to South End of Pabco Road	12	3680
		South End of Pabco Road to LS2	10	6780
		LS2 to LS1	10	8200
		LS1 to Discharge Point	10 (assumed)	710

Abbreviations:

ft = foot or feet

in = inch or inches

FBR = fluidized-bed reactor

GWETS = Groundwater Extraction and Treatment System

NDEP = Nevada Division of Environmental Protection

Attachment D

Table: Capacities of Pumps in the GWETS

Nevada Environmental Response Trust Site, Henderson, Nevada

TABLE 2. CAPACITIES OF PUMPS IN THE GWETS
Nevada Environmental Response Trust Site; Henderson, Nevada

PUMP LOCATION		NUMBER OF PUMPS	POWER (hp)	FLOW RATE
Lift station #1 vertical turbine pumps		2	50	625 gpm
Lift station #2	Vertical turbine	1	100	approx. 925 gpm
	Submersible pump	1	100	900 gpm
Lift station #3 submersible pumps		2	10	350 gpm
Raw Water feed pump P-102a/b		1	100	1000 gpm
Pond transfer pump P-104		2	5	75 gpm
Chrome plant effluent to FBR feed pumps P-103a/b		1	2	100 gpm
FBR fluidization pumps		14	30	2000 gpm
FBR media return pumps		5	1	30 gpm
DAF pressurization pumps		2	25	206 gpm
DAF float pumps		2	2	20 gpm
Effluent pumps p-601/602		1	30	1000 gpm
Sand filter reject pumps		2	5	150 gpm
Effluent booster pumps		2	100	1000 gpm
Sludge transfer pump		1	10	213 gpm
Sludge filter press pumps, air operated		2	--	150 gpm
Sludge filtrate pump		1	1.5	20 gpm
Chrome plant Feed pumps		2	5	100 gpm
Chrome plant pumps to and from the BT tanks (not in use anymore)		--	6	50 gpm
Chemical pump lift station #3 ferrous injection		1	0.05	--
Chemical pump ethanol, front stage		5	--	20 gph
Chemical pump ethanol, back stage		4	--	8 gph
Chemical pump caustic		9	0.1	0.12-7.6 gph
Chemical pump urea		5	--	1.67 gph
Chemical pump Phosphoric Acid		9	--	0.08-0.54 gph
Chemical pump micronutrient blend, output varies with tube size		2	--	75 ml/min
Chemical pump Hydrogen peroxide, output varies with tube size		2	--	20 ml/min
Chemical pump Ferric chloride, output varies with tube size		2	--	10 ml/min
Chemical pump ferric chloride pump for the conditioning tank		1	--	40 gpm

Abbreviations:

gpm = gallons per minute
gph = gallons per hour
ml/min = milliliters per minute
hp = horsepower
DAF = dilution attenuation factor
BT = Balance Tanks
FBR = fluidized-bed reactor
GWETS = Groundwater Extraction and Treatment System
NDEP = Nevada Division of Environmental Protection

Appendix A-2

Response to NDEP Comments on RI/FS Work Plan, Dated November 18, 2013

NDEP Comment	Response
1. Item #19d the Hydraulic and Mass Loading Capacity of the FBR. The contaminant mass loading of FBR was 1,893 equivalent pounds per day in original design drawing (PFD-1, Shaw Environmental, Inc., 2005) and should be 1,900 equivalent pounds per day if the number is rounded.	The comment is noted and if the contaminant mass loading value from the original design drawing is rounded, it will be rounded to 1,900 equivalent pounds per day. The value from the design drawings of 1,893 equivalent pounds per day has been provided in the revised RI/FS Work Plan. In addition, the mass loading formula presented in the RI/FS Work Plan will be consistent with the 2006 Shaw Environmental design drawings: Limits based on load and calculated by the formula: ((0.90 x NO3-N) +(0.17 x ClO3)+ (0.18 x ClO4)) x ((flow x 1,440)/1,000,000)*8.34<1,893 Where: NO3-N = Nitrate-nitrogen concentration in milligrams per liter (mg/L) ClO3 = Chlorate concentration in mg/L ClO4 = Perchlorate concentration in mg/L Flow in gallons per minute (gpm)
2. Item #28 AP-5 Pond Solids Characterization and Disposal. The discussion on the AP-5 solids is pending for more information.	The discussion on the AP-5 solids characterization and disposal in Section 4.4.1 of the revised RI/FS Work Plan (Section 4.6.2 in the previous RI/FS work plan) has been updated to provide the current status of the AP-5 solids characterization and disposal effort.
3. Item 54c Downgradient Plume - Lateral Extent. More information and data is needed to define the separation between the Trust plume and the AMPAC plume to the west. The Trust may re-write "Based on the existing data, a 1 mg/L perchlorate concentration appears to provide a basis for separation between the Trust Plume and the AMPAC plume to the west" as "Based on the existing data, a 1 mg/L perchlorate concentration is assumed for separation between the Trust Plume and the AMPAC plume to the west" or other way to reflect similar meaning.	The suggested language change has been made in Section 5.4.2 of the revised RI/FS Work Plan.

NDEP Comment	Response
4. Items # 105 and 106. The GWETS is an active groundwater pump and treat (P&T) system, so transient groundwater hydraulic conditions have been dominant since 2001. Although the steady state groundwater hydraulic conditions may exist for a short period, the groundwater elevation for all three well fields generally has a downward trend from initiation of pumping in 2001, especially after the recharge trench was shut down in September 2010. The soil excavations and recent high precipitation have interrupted the trend, but overall the groundwater elevation of all three well fields show about 5 to 15 feet decrease from the initial pumping in 2001 with relatively large decrease at the east side. Therefore, a transient groundwater hydraulic condition is more representative for the GWETS. The NDEP suggest that the NERT develop a transient groundwater flow model for the GWETS based on the 2010 steady state model or the steady state model for the 2013 GWETS Optimization. The transient groundwater flow model should be an important tool to manage and optimize groundwater pump and treat for the GWETS. Furthermore the transient groundwater flow model will provide a basis to predict the groundwater remediation for the GWETS.	The Trust agrees with NDEP regarding the need to develop a transient groundwater model. A groundwater modeling task has been added to the revised RI/FS Work Plan in Section 6.3, which specifies that a transient groundwater flow model and contaminant transport model will be developed as part of the RI/FS.

Appendix B

Summary of Historical LOU Soil and Soil Gas Investigations

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
1	Trade Effluent Settling Ponds	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D3	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
2	Open Area South of Trade Effluent Settling Ponds area	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D3	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
3	Air Pollution Emissions Associated with Industrial Processes	--	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site	N/A, throughout site
4	Former Hardesty Chemical Company Site	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B4	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
5	On-Site Portion of Beta Ditch Including the Small Diversion Ditch	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-E	E2	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
6	Unnamed Drainage Ditch Segment (BMI Landfill)	--	--	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area	N/A, offsite common area
7	Old Pond P-2 and Associated Conveyance Facilities	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C9	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*

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#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
8	Old Pond P-3 and Associated Conveyance Facilities	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Categories 2 and 3	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
9	New Pond P- 2 and Associated Piping	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C10	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
10	On-Site Hazardous Waste Landfill	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	--	Category 2	--	--	--
11	Sodium Chlorate Filter Cake Holding Area	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B5	Category 1	--	--	--
12	Hazardous Waste Storage Area	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
13	Pond S-1	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C11	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*

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Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
14	Pond P-1 and Associated Conveyance Piping	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C8	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
15	Platinum Drying Unit	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	--	Category 2	--	--	--
16 / 17	Ponds AP-1, AP-2, and AP-3 and Associated Transfer Lines	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 2	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
18	Pond AP-4	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 3	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
19	Ponds AP-5 & AP-6	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D8	Category 1	--	--	--
20	Pond C-1 and Associated Piping	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C RZ-E	--	Category 2	--	--	--

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
20	Associated Piping	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C	--	Category 2	--	--	--
21	Pond Mn-1 and Associated Piping	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C17	Category 1	--	--	--
22	Pond WC-West and Associated Piping	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D3	Category 1	--	--	--
22	Pond WC-West and Associated Piping	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C RZ-E	--	Category 1	--	--	--
22	Pond WC-West and Associated Piping	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C	--	Category 1	--	--	--
23	Pond WC-East and Associated Piping	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D3	Category 1	--	--	--
23	Pond WC-East and Associated Piping	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C RZ-E	--	Category 1	--	--	--
23	Pond WC-East and Associated Piping	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C	--	Category 1	--	--	--

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
24	Leach Beds, Associated Conveyance Facilities and Former Manganese Tailings Area	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C8	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
25	Process Hardware Storage Area	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
26	Trash Storage Area	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
27	PCB Storage Area	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
28	Hazardous Waste Storage Area	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B4	Category 1	--	--	--
29	Solid Waste Dumpsters	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	--	Category 2	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
30	Ammonium Perchlorate Plant Area - Pad 35	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D8	Category 1	--	--	--

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
31	Drum Recycling Area	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D8	Category 1	--	--	--
32	Groundwater Remediation Unit	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D3	Category 1	--	--	--
33	Sodium Perchlorate Platinum By-Product Filter	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
34E	Former Manganese Tailings Area	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--
34W	Former Manganese Tailings Area	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C6	Category 1	--	--	--
35	Truck Emptying/Dumping Site	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C1	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
36	Former Satellite Accumulation Point - Unit 3, Maintenance Shop	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
37	Former Satellite Accumulation Point - Unit 3, Maintenance Shop	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
38	Former Satellite Accumulation Point - AP Change House & Laboratory	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 2	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
39	Satellite Accumulation Point - AP maintenance shop	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 2	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
40	PCB Transformer Spill	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
41	Unit 1 Tenants - Stains	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
42	Unit 2 Salt Conveyor	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
43	Unit 4 and Old Sodium Chlorate Plant Decommissioning	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B6	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
44	Unit 6 Basement	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B1	Category 1	--	--	--
45	Diesel Storage Tanks	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C5	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
46	Former Old Main Cooling Tower and Recirculation Lines	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 2	--	--	--
47	Leach Plant Area Manganese Ore Piles (current and historic)	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--
48	Leach Plant Analyte Tanks	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--
49	Leach Plant Area Sulfuric Acid Storage Tank	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--
50	Leach Plant Area Leach Lines	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--
51	Leach Plant Area Transfer Lines	III	--	1) Phase B Source Area III WP (ENSR 2008d) NDEP conditional approval: 7/21/08 2) Revised Phase B WP Areas I-IV (AECOM 2009b) NDEP approval: 1/16/09 3) Pre-Confirmation WP (Northgate 2010e) NDEP approval: 3/30/10	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--
52	AP Plant Area Screening Building, Dryer Building, and Associated Sump	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 3	--	--	--

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
53	AP Plant Area Tank Farm	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 2	--	--	--
54	AP Plant Area Change House/Laboratory and Septic Tank	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	--	Category 2	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
55	Area Affected by July 1990 Fire	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D7	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
56	AP Plant Area Old Building D-1 Washdown	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D6	Category 1	--	--	--
57	AP Plant Area Transfer Lines to Sodium Chlorate Process	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	D8	Category 1	--	--	--
58	AP Plant Area New D-1 Building Washdown	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-D	--	Category 2	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
59	Storm Sewer System	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C	N/A, throughout site	N/A, throughout site	--	--	--
59	Storm Sewer System	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C	N/A, throughout site	N/A, throughout site	--	--	--
59	Storm Sewer System	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/28* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	1) HRA WP (Northgate 2010f) *NDEP approval: 3/16/10* 2) Revised HRA for RZ-A (Northgate 2010d) *NDEP approval 8/20/10*	RZ-A RZ-B	N/A, throughout site	N/A, throughout site	--	--	--
60	Acid Drain System	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C RZ-D	N/A, throughout site	N/A, throughout site	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
60	Acid Drain System	II	--	1) Phase B Source Area II WP (ENSR 2008c) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Area II Supplemental Sampling (Northgate 2009b) *NDEP approval: 1/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) DVSR Area II (Northgate 2010a) *NDEP approval: 2/18/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C RZ-D RZ-D	N/A, throughout site	N/A, throughout site	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
60	Acid Drain System	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B RZ-C	N/A, throughout site	N/A, throughout site	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
60[c]	Acid Drain System	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/28* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	1) HRA WP (Northgate 2010f) *NDEP approval: 3/16/10* 2) Revised HRA for RZ-A (Northgate 2010d) *NDEP approval 8/20/10*	RZ-A RZ-B	N/A, throughout site	N/A, throughout site	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
61	Unit 5 Basement & Old Sodium Chlorate Plant Decommission	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	B7	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
62	State Industries, Inc. Site (Kerr-McGee tenant)	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/28* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	1) HRA WP (Northgate 2010f) *NDEP approval: 3/16/10* 2) Revised HRA for RZ-A (Northgate 2010d) *NDEP approval 8/20/10*	RZ-A	--	N/A, not in a zone	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
63	J.B. Kelley Trucking Inc. Site (Kerr-McGee tenant)	--	F	1) Phase 2 SAP Parcels C, D, F (BEC 2007d) *NDEP approval: 11/20/07* 2) Supplemental SAP Parcels C, D, F, G, and H (BEC 2008b) *NDEP approval: 6/5/08* 3) RAW Parcels C, D, F, G, and H (BEC 2008a) *NDEP approval: 7/2/08*	1) DVSR Parcels C, D, F, G, and H (ERM 2008) *NDEP approval: 4/3/08* 2) DVSR Parcels C, D, F, G, and H Supplemental Investigations (ERM 2009) *NDEP approval: 1/12/09* 3) Revised DVSR Parcels C, D, F, G, and H Soil Confirmation (Northgate 2010i) *NDEP approval: 7/28/10*	Revised Closure and Post-Remediation HRA for Parcels C, D, F, G, and H (Northgate 2013) *NDEP commented 9/30/13 and requested revised deliverable*	N/A, not in a zone	--	N/A, not in a zone	1) Draft Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H (ENVIRON 2012b) *NDEP commented 1/29/13 and approved the field work and sampling* 2) Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H (ENVIRON 2013a) *NDEP approved 4/9/13*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (DVSRs included as Appendix C; ENVIRON 2013b) *NDEP commented 10/7/13 and requested revised deliverable*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (ENVIRON 2013b) *NDEP commented 10/7/13 and requested revised deliverable*
64	Koch Materials Company Site (Kerr-McGee tenant)	I	--	1) Phase B Source Area I WP (ENSR 2008b) *NDEP conditional approval: 5/6/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Scope for Additional Sampling Area I (Northgate 2009a) *NDEP approval: 11/24/09* 4) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	1) Revised DVSR Area I (Northgate 2010g,m) *NDEP approval: 1/20/10* 2) DVSR Shallow Supplemental Sampling Areas I and II (Neptune and Company 2010) *NDEP approval: 7/28/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-C	C2	Category 1	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
65a	Ebony Construction Sites (Kerr-McGee tenant)	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	--	Category 1	--	--	--
65b	Buckles Construction Company (Kerr-McGee tenant)	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09* 3) Pre-Confirmation WP (Northgate 2010e) *NDEP approval: 3/30/10*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	RZ-B	--	Category 1	--	--	--
65c	Nevada Precast Concrete Products (Kerr-McGee tenant)	--	F	1) Phase 2 SAP Parcels C, D, F (BEC 2007d) *NDEP approval: 11/20/07* 2) Supplemental SAP Parcels C, D, F, G, and H (BEC 2008b) *NDEP approval: 6/5/08* 3) RAW Parcels C, D, F, G, and H (BEC 2008a) *NDEP approval: 7/2/08*	1) DVSR Parcels C, D, F, G, and H (ERM 2008) *NDEP approval: 4/3/08* 2) DVSR Parcels C, D, F, G, and H Supplemental Investigations (ERM 2009) *NDEP approval: 1/12/09* 3) Revised DVSR Parcels C, D, F, G, and H Soil Confirmation (Northgate 2010i) *NDEP approval: 7/28/10*	Revised Closure and Post-Remediation HRA for Parcels C, D, F, G, and H (Northgate 2013) *NDEP commented 9/30/13 and requested revised deliverable*	N/A, not in a zone	--	N/A, not in a zone	1) Draft Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H (ENVIRON 2012b) *NDEP commented 1/29/13 and approved the field work and sampling* 2) Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H (ENVIRON 2013a) *NDEP approved 4/9/13*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (DVSRs included as Appendix C; ENVIRON 2013b) *NDEP commented 10/7/13 and requested revised deliverable*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (ENVIRON 2013b) *NDEP commented 10/7/13 and requested revised deliverable*

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Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
65d	Green Ventures International (Kerr-McGee tenant)	--	G	1) Phase 2 SAP Parcel G (BEC 2007c) NDEP approval: 10/29/07 2) Supplemental SAP Parcels C, D, F, G, and H (BEC 2008b) *NDEP approval: 6/5/08* 3) RAW Parcels C, D, F, G, and H (BEC 2008a) *NDEP approval: 7/2/08*	1) DVSR Parcels C, D, F, G, and H (ERM 2008) *NDEP approval: 4/3/08* 2) DVSR Parcels C, D, F, G, and H Supplemental Investigations (ERM 2009) *NDEP approval: 1/12/09* 3) Revised DVSR Parcels C, D, F, G, and H Soil Confirmation (Northgate 2010i) *NDEP approval: 7/28/10*	Revised Closure and Post-Remediation HRA for Parcels C, D, F, G, and H (Northgate 2013) *NDEP commented 9/30/13 and requested revised deliverable*	N/A, not in a zone	--	N/A, not in a zone	1) Draft Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H (ENVIRON 2012b) *NDEP commented 1/29/13 and approved the field work and sampling* 2) Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H (ENVIRON 2013a) *NDEP approved 4/9/13*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (DVSRs included as Appendix C; ENVIRON 2013b) *NDEP commented 10/7/13*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (ENVIRON 2013b) *NDEP commented 10/7/13*
66	Above-Ground Diesel Storage Tank Leased by Flintkote Company on Chemstar Property (Kerr-McGee tenant)	IV	--	1) Phase B Source Area IV WP (ENSR 2008e) *NDEP conditional approval: 6/18/28* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area IV (Northgate 2010c,h) *NDEP approval: 3/29/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, Chemstar site	--	N/A, Chemstar site	--	--	--
67	Delbert Madsen and Estate of Delbert Madsen Site (Kerr-McGee tenant)	--	A	Phase 2 SAP Parcels A/B (BEC 2007b) *NDEP Approved: 8/24/07*	1) DVSR Parcels A/B (ERM 2007) *NDEP approval: 12/6/07* 2) Technical Memorandum Data Review Ingestigation Parcels A/B (BEC 2008c), Asbestos Data Review (BEC 2007a) & Uranium Data Review (BEC 2007e) *NDEP Approved and Issued NFA: 4/8/08*	Technical Memorandum Data Review Investigation Parcels A/B (BEC 2008c) *NDEP Issued NFA: 4/8/08*	N/A, not in a zone	--	N/A, not in a zone	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP* 3) Revised Indoor Air HRA Parcels A/B (Northgate 2010j) *NDEP response: 8/31/10* *NDEP Meeting Minutes: 9/7/10* 4) Response to NDEP Comments (ENVIRON 2013c) and Compilation of Select HRA Documents (ENVIRON 2013d) *Under NDEP Review*
68	Southern Nevada Auto Parts Site (Kerr-McGee tenant)	--	Portion of B	Phase 2 SAP Parcels A/B (BEC 2007b) *NDEP Approved: 8/24/07*	1) DVSR Parcels A/B (ERM 2007) *NDEP approval: 12/6/07* 2) Technical Memorandum Data Review Ingestigation Parcels A/B (BEC 2008c), Asbestos Data Review (BEC 2007a) & Uranium Data Review (BEC 2007e) *NDEP Approved and Issued NFA: 4/8/08*	Technical Memorandum Data Review Investigation Parcels A/B (BEC 2008c) *NDEP Issued NFA: 4/8/08*	N/A, not in a zone	--	N/A, not in a zone	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP* 3) Revised Indoor Air HRA Parcels A/B (Northgate 2010j) *NDEP response: 8/31/10* *NDEP Meeting Minutes: 9/7/10* 4) Response to NDEP Comments (ENVIRON 2013c) and Compilation of Select HRA Documents (ENVIRON 2013d) *Under NDEP Review*

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

LOU		Soil Investigations								Soil Gas Investigations		
#	Name	IA	Parcel	Investigation Work Plan	Reporting of Results	HRA	RZ[a]	ECA	Soil Category[b]	Investigation Work Plan	Reporting of Results	HRA
68	Southern Nevada Auto Parts Site (Kerr-McGee tenant)	--	Portion of D	1) Phase 2 SAP Parcels C, D, F (BEC 2007d) *NDEP approval: 11/20/07* 2) Supplemental SAP Parcels C, D, F, G, and H (BEC 2008b) *NDEP approval: 6/5/08* 3) RAW Parcels C, D, F, G, and H (BEC 2008a) *NDEP approval: 7/2/08*	1) DVSR Parcels C, D, F, G, and H (ERM 2008) *NDEP approval: 4/3/08* 2) DVSR Parcels C, D, F, G, and H Supplemental Investigations (ERM 2009) *NDEP approval: 1/12/09* 3) Revised DVSR Parcels C, D, F, G, and H Soil Confirmation (Northgate 2010i) *NDEP approval: 7/28/10*	Revised Closure and Post-Remediation HRA for Parcels C, D, F, G, and H (Northgate 2013) *NDEP commented 9/30/13 and requested revised deliverable*	N/A, not in a zone	--	N/A, not in a zone	1) Draft Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H (ENVIRON 2012b) *NDEP commented 1/29/13 and approved the field work and sampling* 2) Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H (ENVIRON 2013a) *NDEP approved 4/9/13*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (DVSRs included as Appendix C; ENVIRON 2013b) *NDEP commented 10/7/13 and requested revised deliverable*	Soil Gas Investigation Report and Health Risk Assessment for Parcels C, D, F, G, and H, Revision 0 (ENVIRON 2013b) *NDEP commented 10/7/13 and requested revised deliverable*
68	Southern Nevada Auto Parts Site (Kerr-McGee tenant)	--	Portion of I	--	--	N/A, sold to Rolly Properties LLC in 2008 (as cited by ENVIRON 2012) and subsequently remediated (as cited by NDEP 2010)	N/A, sold	--	N/A, sold	--	--	--
69	Dillon Potter Site (Kerr-McGee tenant)	--	J	N/A, sold to Robert and and Sandra Ellis in 2008 (as cited by ENVIRON 2012)	N/A, sold to Robert and and Sandra Ellis in 2008 (as cited by ENVIRON 2012)	N/A, sold to Robert and and Sandra Ellis in 2008 (as cited by ENVIRON 2012)	N/A, not in a zone	--	N/A, not in a zone	Phase B Soil Gas WP (ENSR 2008a) *NDEP approval: 3/08*	1) Revised DVSR Soil Gas Survey (ENSR 2008f) *NDEP approval: 10/20/08* 2) Draft Report Soil Gas Survey Results (AECOM 2009a)	1) HRA WP (Northgate 2010f) *NDEP Approval: 3/16/10* 2) Site-Wide Soil Gas HRA (Northgate 2010k) *Not reviewed by NDEP*
70	US Vanadium Leasehold	III	--	1) Phase B Source Area III WP (ENSR 2008d) *NDEP conditional approval: 7/21/08* 2) Revised Phase B WP Areas I-IV (AECOM 2009b) *NDEP approval: 1/16/09*	Revised DVSR Area III (Northgate 2010b,l) *NDEP approval: 3/17/10*	HRA WP (Northgate 2010f) *NDEP approval: 3/16/10*	N/A, active area	C18	Category 1	--	--	--

TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

Notes:
-- = no value
The total risk estimates highlighted light gray in **bold** exceed $1x10^{-6}$, and the total risk estimates highlighted dark gray in **bold** exceed $1x10^{-5}$.

AECOM = AECOM Inc.
BCL = Basic comparison level
BEC = Basic Environmental Company
BMI = Black Mountain Industrial complex
DVSR = Data validation summary report
ECA = Excavation control area
ENSR = ENSR Corporation
ERM = ERM-West
HRA = Health risk assessment
IA = Investigation area
LOU = Letter of understanding
N/A = Not applicable
NDEP = Nevada Division of Environmental Protection
NFA = No further action
Northgate = Northgate Environmental Management, Inc.
RAW = Removal action work plan
RZ = Remediation zone
SAP = Sampling and analysis plan
SMP = Site management plan
WP = Work plan

Remediation Zones:
RZ-A = Area on the southern portion of the site
RZ-B = Area around the Unit buildings
RZ-C = Ammonia perchlorate production area, Koch Materials area, pond and diesel storage tank area, and manganese tailings area
RZ-D = Trade Effluent ponds and ammonium perchlorate pad/drum recycling area (including the hazardous waste landfill)
RZ-E = Beta Ditch

Soil Categories:
Category 1 = soils in ECAs (risks managed through SMP, quantitative risk assessment not required)
Category 2 = soil concentrations less than BCLs at 0-10 feet below ground surface and not identified as an ECA (quantitative risk assessment not required)
Category 3 = soil concentrations greater than BCLs at 0-10 feet below ground surface at excavation areas that were not backfilled to original grade and not identified as an ECA (quantitative risk evaluation required for soil 'pathways)
Category 4 = soils not previously sampled or available information considered inadequate (risk assessment approach to be determined)

[a] Certain former tenant areas are not within the designated Remediation Zones.
[b] Surface and near surface soils (0-10 feet below ground surface following soil removal actions) were placed into one of four categories.
[c] Soil gas sample number SG45 was assigned to Area IV for analysis purposes since this sample was collected in the acid drain system west of Area IV.

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ENSR, 2008d. Phase B Source Area Investigation Work Plan Area III (Eastern LOUs) Tronox LLC Facility Henderson, Nevada. June.
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TABLE B-1. SUMMARY OF HISTORICAL LOU SOIL AND SOIL GAS INVESTIGATIONS
Nevada Environmental Response Trust Site; Henderson, Nevada

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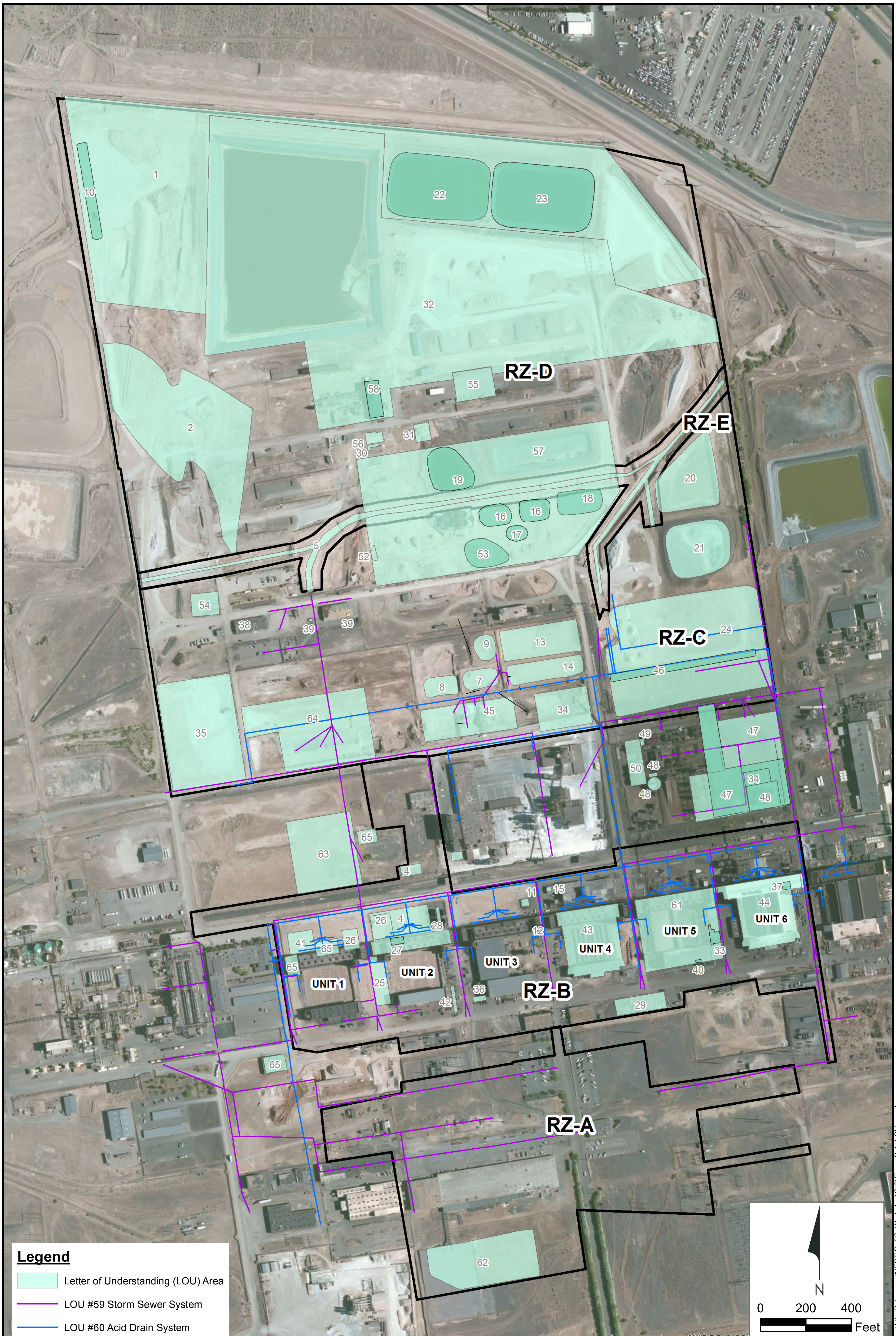

ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

LOU Locations

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure

B-1

Drafter: EA | Date: 12/20/2013 | Contract Number: 21-32100I | Approved by: | Revised:

LOU #	LOU Description
1	Trade Effluent Settling Ponds
2	Open Area Due South of Trade Effluent Settling Ponds
3	Air Pollution Emissions Associated with Industrial Processes
4	Former Hardesty Chemical Company Site
5	On-Site Portion of Beta Ditch Including the Small Diversion Ditch
6	Unnamed Drainage Ditch Segment
7	Old P-2 Surface Impoundment
8	Old P-3 Surface Impoundment
9	New P-2 Pond and Associated Piping
10	On-Site Hazardous Landfill
11	Sodium Chlorate Filter Cake Area North of Unit 3
12	Hazardous Waste Storage Area Between Units 3 and 4
13	Closed Surface Impoundment S-1
14	Closed Surface Impoundment P-1
15	Platinum Drying Unit North of Unit 4
16	Ponds AP-1, AP-2 and AP-3 and Associated Transfer Lines
17	Ponds AP-1, AP-2 and AP-3 and Associated Transfer Lines
18	Pond AP-4
19	Pond AP-5
20	Pond C-1 and Associated Piping
21	Pond MN-1 and Associated Piping
22	Ponds WC-West and Associated Piping
23	Ponds WC-East and Associated Piping
24	Leach Beds, Associated Conveyance Facilities and Former Manganese Tailings Area
25	Process Hardware Storage Area Between Units 1 and 2
26	Trash Storage Area North of Units 1 and 2
27	PCB Storage Area - Unit 2
28	Hazardous Waste Storage Area North of Unit 2
29	Solid Waste Dumpsters
30	Ammonium Perchlorate Area- Pad 35
31	Drum Crushing and Recycling Area
32	Groundwater Remediation Unit
33	Sodium Perchlorate Platinum By-Product Filter
34	Manganese Tailings Area
35	Truck Unloading Area
36	Former Satellite Accumulation Point - Unit 3, Maintenance Shop
37	Former Satellite Accumulation Point - Unit 6, Maintenance Shop
38	Former Satellite Accumulation Point - AP Laboratory
39	Former Satellite Accumulation Point - AP Maintenance Shop
40	PCB Transformer Spill
41	Unit 1 Tenants - Stains
42	Unit 2 Salt Redler
43	Unit 4 and 5 Basements
44	Unit 6 Basements
45	Diesel Storage Tank Area - Stains
46	Former Old Main Cooling Tower and Recirculation Lines
47	Leach Plant Area Manganese Ore Piles
48	Leach Plant Area Anolyte Tanks
49	Leach Plant Area Sulfuric Acid Storage Tank
50	Leach Plant Area Leach Tanks
51	Leach Plant Area Transfer Lines To/From Unit 6
52	AP Plant Area Screening Building, Dryer Building, and Associated Sump
53	AP Plant Area Tank Farm
54	AP Plant Area Change House/Laboratory and Septic Tank
55	AP Plant Area Storage Pads - Fire
56	AP Plant Area Old Building D-1 Washdown
57	AP Plant Area New Building D-1 Washdown
58	AP Plant SI and Transfer Lines To/From AP SI
59	Storm Sewer System
60	Acid Drain System
61	Old Sodium Chlorate Plant Decommissioning
62	State Industries Inc. Site, Including Impoundments and Catch Basin
63	J.B. Kellet, Inc. Trucking Site
64	Koch Materials Company
65	Assorted KMCC Tenants
66	Flintkote Company
67	Delbert Madsen and Estate of Delbery Madsen
68	Southern Nevada Auto Parts Site
69	Dillon Potter Site
70	US Vanadium Leasehold

LOUs 68 through 70 are not displayed in this map's extent.

Path: H:\LePetomane\NERT\RI.FS_Workplan\GIS\FigureB-1_LOUdescription.mxd

ENVIRON
2200 Powell St., Suite 700, Emeryville, CA 94608

LOU Locations

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure **B-1**

Drafter: EA | Date: 12/20/2013 | Contract Number: 21-32100I | Approved by: | Revised:

Appendix C

Soil Remediation Goals for the 2011 Interim Soil Removal Action

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C Soil Remediation Goals for the 2011 Interim Soil Removal Action

This appendix identifies the soil remediation goals (SRGs) used for the soil interim removal action completed in 2011 (see Section 3.2.1). As described in Section 3.2.1, Tronox performed two soil sampling programs (referred to as the Phase A and B Source Area Investigations) that were completed in 2006 and 2008, respectively (ENSR-AECOM 2006 and AECOM 2008). The results of the Phase A and B investigations identified a number of constituents within the upper 10 feet (ft) of soil in excess of Nevada Division of Environmental Protection (NDEP) worker Basic Comparison Levels (BCLs) or modified risk-based goals (as agreed upon by NDEP), which are collectively referred to as “soil remediation goals” (SRGs). The SRGs applied during the 2011 soil interim removal action (ENVIRON 2012) were generally taken from the January 2011 BCL Table (NDEP 2011). The identified chemicals of potential concern (COPCs) exceeding SRGs included dioxin toxicity equivilents (TEQs), hexachlorobenzene, other semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), asbestos, metals, organochlorine pesticides (OCPs), and perchlorate.

A 2009 Division Order (NDEP 2009) directed Tronox to remove from the Site all soils containing COPCs in excess of the SRGs, thus reducing the human health risks associated with potential exposures to contaminated soil. The SRGs applied at the time of the interim soil removal action are listed in Table C-1.

The following sections summarize the SRGs for specific chemicals that (1) have site-specific values, (2) are based on regional background soil concentrations, or (3) do not have NDEP BCLs (and for which alternative values were used). In addition, Section C.5 summarizes BCLs that have been added or updated (NDEP 2013) since completion of the interim soil removal action in 2011. NDEP BCLs current at the time of any future removal or remedial actions will be used for future comparisons.

C.1 Dioxin

The SRG listed in Table C-1 for dioxin toxicity equivalents (TEQs) is 2,700 parts per trillion (ppt). This site-specific value was derived based on *Northgate’s Bioaccessibility Study for Dioxins/Furans in Soil* (Northgate 2010a) and approved by NDEP as a site-specific, risk-based concentration for dioxins/furans (in terms of a 2,3,7,8-TCDD TEQ) (NDEP 2010a).

C.2 Asbestos

There are no BCLs for asbestos. For purposes of the interim soil removal action, "contaminated" soil was defined as one or more long amphibole fibers or greater than five long chrysotile fibers per sample, as indicated in Table C-1. These criteria were used in the NDEP-approved Remedial Action Work Plan (RAW) (Northgate 2010d) and in the *Interim Soil Removal Action Completion Report* (ENVIRON 2012).

C.3 Arsenic

For metals where background concentrations exceed NDEP BCLs, "contaminated" soil was defined as concentrations greater than background. Specifically, the arsenic SRG of

7.2 milligrams per kilogram (mg/kg) was based on regional background soil data from the McCullough Range as presented in *Background Shallow Soil Summary Report, BMI Complex and Common Area Vicinity* (Basic Remediation Company and Titanium Metals Corporation [BRC/TIMET] 2007). The arsenic SRG was approved as a target remediation goal for the Removal Action Work Plan for the Phase B soil remediation of Remediation Zones (RZs) B through E (revised May 28, 2010) as stated in the August 13, 2010 Errata (Northgate 2010b) and approved by NDEP on August 20, 2010 (NDEP 2010b). The arsenic background shallow soil concentration from the RZ-A background soil data set is 4.25 mg/kg for 0 to 2 ft below ground surface (bgs) and 3.13 mg/kg for 2 to 10 ft bgs, as presented in *Northgate's Technical Memorandum: Background Comparison for Metals in Remediation Zones B through E, Compared to Remediation Zone A* (Northgate 2010c).

C.4 Total Petroleum Hydrocarbons

While noncancer toxicity criteria based on selected petroleum fractions such as gasoline- or diesel-range hydrocarbons have been developed by some state agencies and industry groups, NDEP does not recommend using petroleum fraction toxicity criteria and has therefore not developed a BCL for petroleum hydrocarbon mixtures (NDEP 2013). In accordance with NDEP guidance (NDEP 2013), indicator chemicals for evaluating common petroleum hydrocarbon mixtures are benzene, toluene, ethylbenzene, and total xylenes (BTEX); methyl tert-butyl ether (MTBE); and polycyclic aromatic hydrocarbons (PAHs). In addition to these indicator chemicals, 100 mg/kg was used as the SRG for total petroleum hydrocarbon fractions of oil, gasoline, and diesel, as identified in Table C-1.

C.5 Chemicals with Added or Updated BCLs

Since the SRGs were developed, BCLs were added for two Site COPCs, delta-BHC and platinum. Additionally, BCLs for some Site COPCs have been revised since the SRGs were developed. For comparison, current SRGs (as of December 2013) and SRGs applied during the interim soil removal action are listed in Table C-2 to identify chemicals with added or updated BCLs. The chemicals for which the BCL is now higher than the SRG and those for which the BCL is now lower are also identified in Table C-2.

The SRGs used during the interim soil removal action only used the outdoor worker BCLs, instead of the lower of the indoor and outdoor worker BCLs. As shown in Table C-2, only the lower of the indoor and outdoor worker BCLs are listed for NDEP's 2013 worker BCLs. The differences in the BCL values as a result are not substantial (i.e., less than or equal to 10%).

C.6 References

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TABLE C-1. SOIL REMEDIATION GOALS (SRGs)
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	NDEP 2011 WORKER BCL[a] OR SITE-SPECIFIC SCREENING LEVEL APPLIED DURING THE INTERIM SOIL REMOVAL ACTION	BASIS	NOTE
Organic Acids	Benzenesulfonic acid	mg/kg	100,000	max	--
	4-Chlorobenzenesulfonic acid	mg/kg	117	sat	--
	Diethyl phosphorodithioic acid	mg/kg	90,800	N	--
	Dimethyl phosphorodithioic acid	mg/kg	100,000	max	--
	Phthalic acid	mg/kg	100,000	max	--
Organophosphate Pesticides	Azinphos-Methyl	mg/kg	--	--	--
	Bolstar	mg/kg	--	--	--
	Chlorpyrifos	mg/kg	2,050	N	--
	Coumaphos	mg/kg	--	--	--
	Demeton-O	mg/kg	--	--	--
	Demeton-S	mg/kg	--	--	--
	Diazinon	mg/kg	616	N	--
	Dichlorvos	mg/kg	6.6	C	--
	Dimethoate	mg/kg	--	--	--
	Disulfoton	mg/kg	27.4	N	--
	EPN	mg/kg	--	--	--
	Ethoprop	mg/kg	--	--	--
	Ethyl Parathion	mg/kg	4,100	N	--
	Famphur	mg/kg	--	--	--
	Fensulfothion	mg/kg	--	--	--
	Fenthion	mg/kg	--	--	--
	Malathion	mg/kg	13,700	N	--
	Merphos	mg/kg	--	--	--
	Methyl Parathion	mg/kg	171	N	--
	Mevinphos	mg/kg	--	--	--
	Naled	mg/kg	1,370	N	--
	Phorate	mg/kg	--	--	--
	Ronnel	mg/kg	34,200	N	--
	Stirophos (Tetrachlorovinphos)	mg/kg	79.8	N	b
	Sulfotep	mg/kg	--	--	--
	Thionazin	mg/kg	--	--	--
	Tokuthion	mg/kg	--	--	--
	Trichloronate	mg/kg	--	--	--
Organochlorine Pesticides	Aldrin	mg/kg	0.113	C	--
	Alpha-BHC	mg/kg	0.399	C	--
	Beta-BHC	mg/kg	1.4	C	--
	Delta-BHC	mg/kg	--	--	--
	Gamma-BHC (Lindane)	mg/kg	1.93	C	--
	Alpha-chlordane	mg/kg	--	--	--
	Gamma-chlordane	mg/kg	--	--	--
	Tech-Chlordane	mg/kg	7.19	C	--
	4,4'-DDD	mg/kg	11.1	C	--
	4,4'-DDE	mg/kg	7.81	C	--
	4,4'-DDT	mg/kg	7.81	C	--
	Dieldrin	mg/kg	0.12	C	--
	Endosulfan I	mg/kg	--	--	--
	Endosulfan II	mg/kg	--	--	--
	Endosulfan Sulfate	mg/kg	--	--	--
	Endrin	mg/kg	205	N	--
	Endrin Aldehyde	mg/kg	--	--	--
	Endrin Ketone	mg/kg	--	--	--
	Heptachlor	mg/kg	0.426	C	--
	Heptachlor Epoxide	mg/kg	0.210	C	--
	Methoxychlor	mg/kg	3,420	N	--

TABLE C-1. SOIL REMEDIATION GOALS (SRGs)
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	NDEP 2011 WORKER BCL[a] OR SITE-SPECIFIC SCREENING LEVEL APPLIED DURING THE INTERIM SOIL REMOVAL ACTION	BASIS	NOTE
Organochlorine Pesticides	Toxaphene	mg/kg	1.74	C	--
PAHs	Acenaphthene	mg/kg	2,560	N	--
	Acenaphthylene	mg/kg	147	sat	--
	Anthracene	mg/kg	9,920	N	--
	Benz(a)anthracene	mg/kg	2.34	C	--
	Benzo(a)pyrene	mg/kg	0.234	C	--
	Benzo(b)fluoranthene	mg/kg	2.34	C	--
	Benzo(g,h,i)perylene	mg/kg	34,100	N	--
	Benzo(k)fluoranthene	mg/kg	23.4	C	--
	Chrysene	mg/kg	234	C	--
	Dibenz(a,h)anthracene	mg/kg	0.234	C	--
	Fluoranthene	mg/kg	24,400	N	--
	Fluorene	mg/kg	3,670	N	--
	Indeno(1,2,3-cd)pyrene	mg/kg	2.34	C	--
	Naphthalene	mg/kg	17.4	C	--
	Phenanthrene	mg/kg	24.5	sat	--
	Pyrene	mg/kg	19,300	N	--
SVOCs	Butyl benzyl phthalate	mg/kg	240	sat	--
	Di-N-Butyl phthalate	mg/kg	68,400	N	--
	Diethyl phthalate	mg/kg	100,000	max	--
	Dimethyl phthalate	mg/kg	100,000	max	--
	bis(2-Ethylhexyl)phthalate	mg/kg	137	C	--
	Hexachlorobenzene	mg/kg	1.2	C	c
	2-Methylnaphthalene	mg/kg	--	--	--
	Nitrobenzene	mg/kg	15.1	C	--
	Octachlorostyrene	mg/kg	--	--	--
	Di-N-Octyl phthalate	mg/kg	--	--	--
	Pyridine	mg/kg	667	N	--
VOCs	Acetone	mg/kg	100,000	Max	--
	Benzene	mg/kg	4.5	C	--
	Bromobenzene	mg/kg	695	N	--
	Bromochloromethane	mg/kg	--	--	--
	Bromodichloromethane	mg/kg	51.3	C	--
	Bromoform	mg/kg	242	C	--
	Bromomethane	mg/kg	42.9	N	--
	2-Butanone	mg/kg	34,100	sat	--
	N-Butylbenzene	mg/kg	237	Sat	--
	sec-Butylbenzene	mg/kg	223	Sat	--
	tert-Butylbenzene	mg/kg	393	Sat	--
	Carbon tetrachloride	mg/kg	4.07	C	--
	Chlorobenzene	mg/kg	695	Sat	--
	Chloroethane	mg/kg	1,100	C	--
	Chloroform	mg/kg	1.71	C	--
	Chloromethane	mg/kg	8.95	C	--
	2-Chlorotoluene	mg/kg	511	sat	--
	4-Chlorotoluene	mg/kg	--	--	--
	cis-1,2-Dichloroethene	mg/kg	791	N	--
	cis-1,3-Dichloropropene	mg/kg	--	--	--
	1,2-Dibromo-3-chloropropane	mg/kg	0.0583	C	--
	Dibromochloromethane	mg/kg	6.15	C	--
	Dibromomethane	mg/kg	210	N	--
	1,2-Dichlorobenzene	mg/kg	373	Sat	--
	1,3-Dichlorobenzene	mg/kg	373	Sat	--
	1,4-Dichlorobenzene	mg/kg	14.3	C	--

TABLE C-1. SOIL REMEDIATION GOALS (SRGs)
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	NDEP 2011 WORKER BCL[a] OR SITE-SPECIFIC SCREENING LEVEL APPLIED DURING THE INTERIM SOIL REMOVAL ACTION	BASIS	NOTE
VOCs	Dichlorodifluoromethane	mg/kg	340	Sat	--
	1,1-Dichloroethane	mg/kg	23.3	C	--
	1,2-Dichloroethane	mg/kg	2.41	C	--
	1,1-Dichloroethene	mg/kg	1,400	N	--
	trans-1,2-Dichloroethylene	mg/kg	600	N	--
	1,2-Dichloropropane	mg/kg	4.54	C	--
	1,3-Dichloropropane	mg/kg	71.6	N	--
	2,2-Dichloropropane	mg/kg	--	--	--
	1,1-Dichloropropene	mg/kg	--	--	--
	trans-1,3-Dichloropropene	mg/kg	--	--	--
	1,4-Dioxane	mg/kg	174	C	--
	Ethyl t-butyl ether	mg/kg	--	--	--
	Ethylbenzene	mg/kg	21	C	--
	Ethylene dibromide	mg/kg	0.185	C	--
	Hexachlorobutadiene	mg/kg	24.6	C	--
	2-Hexanone	mg/kg	2,150	N	--
	Isopropyl ether	mg/kg	--	--	--
	Isopropylbenzene	mg/kg	647	Sat	--
	4-Isopropyltoluene	mg/kg	647	Sat	--
	2-Methoxy-2-methyl-butane	mg/kg	--	--	--
	Methyl tert butyl ether	mg/kg	216	C	--
	4-Methyl-2-pentanone	mg/kg	17,200	Sat	--
	Methylene chloride	mg/kg	60.4	C	--
	N-Propylbenzene	mg/kg	237	Sat	--
	Styrene	mg/kg	1,730	Sat	--
	t-Butyl alcohol	mg/kg	21,300	Sat	--
	1,1,1,2-Tetrachloroethane	mg/kg	20.3	C	--
	1,1,2,2-Tetrachloroethane	mg/kg	2.59	C	--
	Tetrachloroethene	mg/kg	3.28	C	--
	Toluene	mg/kg	521	Sat	--
	1,2,3-Trichloropropane	mg/kg	0.106	C	--
	1,2,3-Trichlorobenzene	mg/kg	--	--	--
	1,2,4-Trichlorobenzene	mg/kg	759	N	--
	1,1,1-Trichloroethane	mg/kg	1,390	sat	--
	1,1,2-Trichloroethane	mg/kg	5.8	C	--
	Trichloroethene	mg/kg	5.49	C	--
	Trichlorofluoromethane	mg/kg	1,980	Sat	--
	1,2,4-Trimethylbenzene	mg/kg	671	N	--
	1,3,5-Trimethylbenzene	mg/kg	254	sat	--
	Vinyl Chloride	mg/kg	1.86	C	--
	o-Xylene	mg/kg	282	Sat	--
	m,p-Xylene	mg/kg	214	Sat	--
	Xylenes, total	mg/kg	214	Sat	--
TPH	Oil Range Organics (TPH-oil)	mg/kg	100	--	d
	TPH-diesel	mg/kg	100	--	d
	TPH-gasoline	mg/kg	100	--	d
PCBs	Aroclor-1016	mg/kg	23.6	C	--
	Aroclor-1221	mg/kg	0.826	C	--
	Aroclor-1232	mg/kg	0.826	C	--
	Aroclor-1242	mg/kg	0.826	C	--
	Aroclor-1248	mg/kg	0.826	C	--
	Aroclor-1254	mg/kg	0.826	C	--
	Aroclor-1260	mg/kg	0.826	C	--

TABLE C-1. SOIL REMEDIATION GOALS (SRGs)
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	NDEP 2011 WORKER BCL[a] OR SITE-SPECIFIC SCREENING LEVEL APPLIED DURING THE INTERIM SOIL REMOVAL ACTION	BASIS	NOTE
PCBs	Total PCBs	mg/kg	0.826	C	--
	TCDD TEQ[e]	pg/g	2,700	C	f
General Chemistry	Cyanide	mg/kg	13,700	N	--
	Perchlorate	mg/kg	795	N	--
Dioxins/Furans	TCDD TEQ[g]	pg/g	2,700	C	f
Metals	Aluminum	mg/kg	100,000	Max	--
	Antimony	mg/kg	454	N	--
	Arsenic	mg/kg	7.2	--	h
	Barium	mg/kg	100,000	Max	--
	Beryllium	mg/kg	2,230	N	--
	Boron	mg/kg	100,000	Max	--
	Cadmium	mg/kg	560	N	--
	Chromium (III)	mg/kg	100,000	Max	--
	Chromium (VI)	mg/kg	1,360	C	--
	Cobalt	mg/kg	337	N	--
	Copper	mg/kg	42,200	N	--
	Iron	mg/kg	100,000	Max	--
	Lead	mg/kg	800	--	i
	Magnesium	mg/kg	100,000	Max	--
	Manganese	mg/kg	100,000	Max	--
	Mercury	mg/kg	182	N	--
	Molybdenum	mg/kg	5,680	N	--
	Nickel	mg/kg	21,800	N	--
	Platinum	mg/kg	--	--	--
	Potassium	mg/kg	--	--	--
	Selenium	mg/kg	5,680	N	--
	Silver	mg/kg	5,680	N	--
	Sodium	mg/kg	--	--	--
	Strontium	mg/kg	100,000	Max	--
	Thallium	mg/kg	79.5	--	i
	Tin	mg/kg	100,000	Max	--
	Titanium	mg/kg	100,000	Max	--
	Tungsten	mg/kg	8,510	N	--
	Uranium	mg/kg	3,400	N	--
	Vanadium	mg/kg	5,680	N	--
	Zinc	mg/kg	100,000	Max	--
Asbestos	Long amphibole fibers	fibers	1 or more	--	--
	Long chrysotile fibers	fibers	More than 5	--	--

TABLE C-1. SOIL REMEDIATION GOALS (SRGs)
Nevada Environmental Response Trust Site; Henderson, Nevada

Notes:
a = From User's Guide and Background Technical Document for Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas, Revision 6, January 2011 (http://ndep.nv.gov/bmi/technical.htm). Values listed are for the outdoor industrial/commercial worker.
b = BCL based on mixed isomer.
c = Hexachlorobenzene analyzed using both EPA Methods 8081 and 8270. Data reported based on EPA 8270 as it was deemed to be the superior method.
d = 100 mg/kg total TPH value used for screening.
e = TCDD equivalents based on WHO 2005 TEFs for the 12 co-planer PCBs; the detection limit was used for non-detect values.
f = Site-specific value.
g = TCDD equivalents based on WHO 2005 TEFs for the 17 dioxin and furan congeners.
h = Based on regional background concentrations.
i = A basis for the lead and thallium BCLs are not identified by NDEP.

C = Cancer
N = Noncancer
NA = Not applicable
sat = soil saturation
max = risk-based value is greater than 100,000 mg/kg
-- = no value
mg/kg = milligrams per kilogram
pg/g = picograms per gram
BCL = Basic comparison level
BMI = Black Mountain Industrial
EPA = Environmental Protection Agency
PAHs = Polycyclic aromatic hydrocarbons
PCBs = Polychlorinated biphenyls
TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF = Toxicity equivalent factor
TEQ = Toxicity equivalence
TPH = Total petroluem hydrocarbons
SVOCs = Semi-volatile organic compounds
VOCs = Volatile organic compounds
WHO = World Health Organization

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	2011 SRG	BASIS	2013 SCREENING LEVEL	BASIS	RATIO OF 2011 SRG TO 2013 SCREENING LEVEL	NOTE	SITE COPC
Organic Acids	Benzenesulfonic acid	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	4-Chlorobenzenesulfonic acid	mg/kg	117	Sat	117	Sat	1.0	--	Yes
	Diethyl phosphorodithioic acid	mg/kg	90,800	N	90,844	N	1.0	--	Yes
	Dimethyl phosphorodithioic acid	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Phthalic acid	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
Organophosphate Pesticides	Azinphos-Methyl	mg/kg	--	--	--	--	--	--	Yes
	Bolstar	mg/kg	--	--	--	--	--	--	Yes
	Chlorpyrifos	mg/kg	2,050	N	2,052	N	1.0	--	Yes
	Coumaphos	mg/kg	--	--	--	--	--	--	Yes
	Demeton-O	mg/kg	--	--	--	--	--	--	Yes
	Demeton-S	mg/kg	--	--	--	--	--	--	Yes
	Diazinon	mg/kg	616	N	616	N	1.0	--	Yes
	Dichlorvos	mg/kg	6.6	C	7	C	1.0	--	Yes
	Dimethoate	mg/kg	--	--	--	--	--	--	Yes
	Disulfoton	mg/kg	27.4	N	27	N	1.0	--	Yes
	EPN	mg/kg	--	--	--	--	--	--	Yes
	Ethoprop	mg/kg	--	--	--	--	--	--	Yes
	Ethyl Parathion	mg/kg	4,100	N	4,104	N	1.0	--	Yes
	Famphur	mg/kg	--	--	--	--	--	--	Yes
	Fensulfothion	mg/kg	--	--	--	--	--	--	Yes
	Fenthion	mg/kg	--	--	--	--	--	--	Yes
	Malathion	mg/kg	13,700	N	13,681	N	1.0	--	Yes
	Merphos	mg/kg	--	--	--	--	--	--	Yes
	Methyl Parathion	mg/kg	171	N	171	N	1.0	--	Yes
	Mevinphos	mg/kg	--	--	--	--	--	--	Yes
	Naled	mg/kg	1,370	N	1,368	N	1.0	--	Yes
	Phorate	mg/kg	--	--	--	--	--	--	Yes
	Ronnel	mg/kg	34,200	N	34,203	N	1.0	--	Yes
	Stirophos (Tetrachlorovinphos)	mg/kg	79.8	N	79.8	C	1.0	c	Yes
	Sulfotep	mg/kg	--	--	--	--	--	--	Yes
	Thionazin	mg/kg	--	--	--	--	--	--	Yes
	Tokuthion	mg/kg	--	--	--	--	--	--	Yes
	Trichloronate	mg/kg	--	--	--	--	--	--	Yes
Organochlorine Pesticides	Aldrin	mg/kg	0.113	C	0.113	C	1.0	--	Yes
	Alpha-BHC	mg/kg	0.399	C	270	N	0.0015	--	Yes
	Beta-BHC	mg/kg	1.4	C	54	N	0.026	--	Yes
	Delta-BHC	mg/kg	--	--	270	N	New BCL	--	Yes
	Gamma-BHC (Lindane)	mg/kg	1.93	C	9	N	0.21	--	Yes

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	2011 SRG	BASIS	2013 SCREENING LEVEL	BASIS	RATIO OF 2011 SRG TO 2013 SCREENING LEVEL	NOTE	SITE COPC
Organochlorine Pesticides	Alpha-chlordane	mg/kg	--	--	--	--	--	--	Yes
	Gamma-chlordane	mg/kg	--	--	--	--	--	--	Yes
	Tech-Chlordane	mg/kg	7.19	C	7.19	C	1.0	--	Yes
	4,4'-DDD	mg/kg	11.1	C	11	C	1.0	--	Yes
	4,4'-DDE	mg/kg	7.81	C	7.81	C	1.0	--	Yes
	4,4'-DDT	mg/kg	7.81	C	7.81	C	1.0	--	Yes
	Dieldrin	mg/kg	0.12	C	0	C	1.0	--	Yes
	Endosulfan I	mg/kg	--	--	--	--	--	--	Yes
	Endosulfan II	mg/kg	--	--	--	--	--	--	Yes
	Endosulfan Sulfate	mg/kg	--	--	--	--	--	--	Yes
	Endrin	mg/kg	205	N	205	N	1.0	--	Yes
	Endrin Aldehyde	mg/kg	--	--	--	--	--	--	Yes
	Endrin Ketone	mg/kg	--	--	--	--	--	--	Yes
	Heptachlor	mg/kg	0.426	C	0.426	C	1.0	--	Yes
	Heptachlor Epoxide	mg/kg	0.210	C	0.210	C	1.0	--	Yes
	Methoxychlor	mg/kg	3,420	N	3,420	N	1.0	--	Yes
	Toxaphene	mg/kg	1.74	C	1.74	C	1.0	--	Yes
PAHs	**Acenaphthene**	**mg/kg**	**2,560**	**N**	**2,351**	**N**	**1.1**	**--**	**Yes**
	Acenaphthylene	mg/kg	147	Sat	147	Sat	1.0	--	Yes
	Anthracene	**mg/kg**	**9,920**	**N**	**9,060**	**N**	**1.1**	**--**	**Yes**
	Benz(a)anthracene	mg/kg	2.34	C	2.34	C	1.0	--	Yes
	Benzo(a)pyrene	mg/kg	0.234	C	0.234	C	1.0	--	Yes
	Benzo(b)fluoranthene	mg/kg	2.34	C	2.34	C	1.0	--	Yes
	Benzo(g,h,i)perylene	mg/kg	34,100	N	34,067	N	1.0	--	Yes
	Benzo(k)fluoranthene	mg/kg	23.4	C	23.4	C	1.0	--	Yes
	Chrysene	mg/kg	234	C	234	C	1.0	--	Yes
	Dibenz(a,h)anthracene	mg/kg	0.234	C	0.234	C	1.0	--	Yes
	Fluoranthene	mg/kg	24,400	N	24,447	N	1.0	--	Yes
	Fluorene	**mg/kg**	**3,670**	**N**	**3,438**	**N**	**1.1**	**--**	**Yes**
	Indeno(1,2,3-cd)pyrene	mg/kg	2.34	C	2.34	C	1.0	--	Yes
	Naphthalene	**mg/kg**	**17.4**	**C**	**15.6**	**C**	**1.1**	**--**	**Yes**
	Phenanthrene	mg/kg	24.5	Sat	24.5	Sat	1.0	--	Yes
	Pyrene	mg/kg	19,300	N	19,340	N	1.0	--	Yes
SVOCs	Butyl benzyl phthalate	mg/kg	240	Sat	240	Sat	1.0	--	Yes
	Di-N-Butyl phthalate	mg/kg	68,400	N	68,407	N	1.0	--	Yes
	Diethyl phthalate	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Dimethyl phthalate	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	bis(2-Ethylhexyl)phthalate	mg/kg	137	C	137	C	1.0	--	Yes

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	2011 SRG	BASIS	2013 SCREENING LEVEL	BASIS	RATIO OF 2011 SRG TO 2013 SCREENING LEVEL	NOTE	SITE COPC
SVOCs	Hexachlorobenzene	mg/kg	1.2	C	1.20	C	1.0	d	Yes
	2-Methylnaphthalene	mg/kg	--	--	--	--	--	--	Yes
	Nitrobenzene	**mg/kg**	**15.1**	**C**	**13.6**	**C**	**1.1**	**--**	**Yes**
	Octachlorostyrene	mg/kg	--	--	--	--	--	--	Yes
	Di-N-Octyl phthalate	mg/kg	--	--	--	--	--	--	Yes
	Pyridine	mg/kg	667	N	667	N	1.0	--	Yes
VOCs	Acetone	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Benzene	**mg/kg**	**4.5**	**C**	**4.21**	**C**	**1.1**	**--**	**Yes**
	Bromobenzene	mg/kg	695	N	695	Sat	1.0	--	Yes
	Bromochloromethane	mg/kg	--	--	--	--	--	--	Yes
	Bromodichloromethane	**mg/kg**	**51.3**	**C**	**3.36**	**C**	**15**	**--**	**Yes**
	Bromoform	mg/kg	242	C	242	C	1.0	--	Yes
	Bromomethane	**mg/kg**	**42.9**	**N**	**39.1**	**N**	**1.1**	**--**	**Yes**
	2-Butanone	mg/kg	34,100	Sat	34,092	Sat	1.0	--	Yes
	N-Butylbenzene	mg/kg	237	Sat	237	Sat	1.0	--	Yes
	sec-Butylbenzene	mg/kg	223	Sat	223	Sat	1.0	--	Yes
	tert-Butylbenzene	mg/kg	393	Sat	393	Sat	1.0	--	Yes
	Carbon tetrachloride	**mg/kg**	**4.07**	**C**	**3.84**	**C**	**1.1**	**--**	**Yes**
	Chlorobenzene	mg/kg	695	Sat	695	Sat	1.0	--	Yes
	Chloroethane	mg/kg	1,100	C	1,096	C	1.0	--	Yes
	Chloroform	**mg/kg**	**1.71**	**C**	**1.55**	**C**	**1.1**	**--**	**Yes**
	Chloromethane	**mg/kg**	**8.95**	**C**	**8.05**	**C**	**1.1**	**--**	**Yes**
	2-Chlorotoluene	mg/kg	511	Sat	511	Sat	1.0	--	Yes
	4-Chlorotoluene	mg/kg	--	--	--	--	--	--	Yes
	cis-1,2-Dichloroethene	**mg/kg**	**791**	**N**	**737**	**N**	**1.1**	**--**	**Yes**
	cis-1,3-Dichloropropene	mg/kg	--	--	--	--	--	--	Yes
	1,2-Dibromo-3-chloropropane	**mg/kg**	**0.0583**	**C**	**0.0529**	**C**	**1.1**	**--**	**Yes**
	Dibromochloromethane	mg/kg	6.15	C	6.03	C	1.0	--	Yes
	Dibromomethane	**mg/kg**	**210**	**N**	**191**	**N**	**1.1**	**--**	**Yes**
	1,2-Dichlorobenzene	mg/kg	373	Sat	373	Sat	1.0	--	Yes
	1,3-Dichlorobenzene	mg/kg	373	Sat	373	Sat	1.0	--	Yes
	1,4-Dichlorobenzene	mg/kg	14.3	C	13.6	C	1.0	--	Yes
	Dichlorodifluoromethane	mg/kg	340	Sat	340	Sat	1.0	--	Yes
	1,1-Dichloroethane	**mg/kg**	**23.3**	**C**	**21.4**	**C**	**1.1**	**--**	**Yes**
	1,2-Dichloroethane	**mg/kg**	**2.41**	**C**	**2.24**	**C**	**1.1**	**--**	**Yes**
	1,1-Dichloroethene	**mg/kg**	**1,400**	**N**	**1,274**	**N**	**1.1**	**--**	**Yes**
	trans-1,2-Dichloroethylene	**mg/kg**	**600**	**N**	**547**	**N**	**1.1**	**--**	**Yes**
	1,2-Dichloropropane	**mg/kg**	**4.54**	**C**	**4.29**	**C**	**1.1**	**--**	**Yes**

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	2011 SRG	BASIS	2013 SCREENING LEVEL	BASIS	RATIO OF 2011 SRG TO 2013 SCREENING LEVEL	NOTE	SITE COPC
VOCs	**1,3-Dichloropropane**	**mg/kg**	**71.6**	**N**	**64.6**	**N**	**1.1**	**--**	**Yes**
	2,2-Dichloropropane	mg/kg	--	--	--	--	--	--	Yes
	1,1-Dichloropropene	mg/kg	--	--	--	--	--	--	Yes
	trans-1,3-Dichloropropene	mg/kg	--	--	--	--	--	--	Yes
	1,4-Dioxane	**mg/kg**	**174**	**C**	**19.2**	**C**	**9.1**	**--**	**Yes**
	Ethyl t-butyl ether	mg/kg	--	--	--	--	--	--	Yes
	Ethylbenzene	**mg/kg**	**21**	**C**	**19.6**	**C**	**1.1**	**--**	**Yes**
	Ethylene dibromide	mg/kg	0.185	C	0.177	C	1.0	--	Yes
	Hexachlorobutadiene	mg/kg	24.6	C	24.6	C	1.0	--	Yes
	2-Hexanone	**mg/kg**	**2,150**	**N**	**1,933**	**N**	**1.1**	**--**	**Yes**
	Isopropyl ether	mg/kg	--	--	--	--	--	--	Yes
	Isopropylbenzene	mg/kg	647	Sat	647	Sat	1.0	--	Yes
	4-Isopropyltoluene	mg/kg	647	Sat	647	Sat	1.0	--	Yes
	2-Methoxy-2-methyl-butane	mg/kg	--	--	--	--	--	--	Yes
	Methyl tert butyl ether	mg/kg	216	C	208	C	1.0	--	Yes
	4-Methyl-2-pentanone	mg/kg	17,200	Sat	17,196	Sat	1.0	--	Yes
	Methylene chloride	mg/kg	60.4	C	58.5	C	1.0	--	Yes
	N-Propylbenzene	mg/kg	237	Sat	237	Sat	1.0	--	Yes
	Styrene	mg/kg	1,730	Sat	1,734	Sat	1.0	--	Yes
	t-Butyl alcohol	mg/kg	21,300	Sat	21,283	Sat	1.0	--	Yes
	1,1,1,2-Tetrachloroethane	mg/kg	20.3	C	19.9	C	1.0	--	Yes
	1,1,2,2-Tetrachloroethane	mg/kg	2.59	C	2.54	C	1.0	--	Yes
	Tetrachloroethene	mg/kg	3.28	C	3.28	C	1.0	--	Yes
	Toluene	mg/kg	521	Sat	521	Sat	1.0	--	Yes
	1,2,3-Trichloropropane	mg/kg	0.106	C	0.106	C	1.0	--	Yes
	1,2,3-Trichlorobenzene	mg/kg	--	--	--	--	--	--	Yes
	1,2,4-Trichlorobenzene	**mg/kg**	**759**	**N**	**110**	**C**	**6.9**	**--**	**Yes**
	1,1,1-Trichloroethane	mg/kg	1,390	Sat	1,385	Sat	1.0	--	Yes
	1,1,2-Trichloroethane	**mg/kg**	**5.8**	**C**	**5.51**	**C**	**1.1**	**--**	**Yes**
	Trichloroethene	mg/kg	5.49	C	5.49	C	1.0	--	Yes
	Trichlorofluoromethane	mg/kg	1,980	Sat	1,983	Sat	1.0	--	Yes
	1,2,4-Trimethylbenzene	**mg/kg**	**671**	**N**	**604**	**N**	**1.1**	**--**	**Yes**
	1,3,5-Trimethylbenzene	mg/kg	254	Sat	246	N	1.0	--	Yes
	Vinyl Chloride	mg/kg	1.86	C	1.86	C	1.0	--	Yes
	o-Xylene	mg/kg	282	Sat	282	Sat	1.0	--	Yes
	m,p-Xylene	mg/kg	214	Sat	214	Sat	1.0	--	Yes
	Xylenes, total	mg/kg	214	Sat	214	Sat	1.0	--	Yes

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	2011 SRG	BASIS	2013 SCREENING LEVEL	BASIS	RATIO OF 2011 SRG TO 2013 SCREENING LEVEL	NOTE	SITE COPC
TPH	Oil Range Organics (TPH-oil)	mg/kg	100	--	100	--	1.0	e	Yes
	TPH-diesel	mg/kg	100	--	100	--	1.0	e	Yes
	TPH-gasoline	mg/kg	100	--	100	--	1.0	e	Yes
PCBs	Aroclor-1016	mg/kg	23.6	C	23.6	C	1.0	--	Yes
	Aroclor-1221	mg/kg	0.826	C	0.83	C	1.0	--	Yes
	Aroclor-1232	mg/kg	0.826	C	0.83	C	1.0	--	Yes
	Aroclor-1242	mg/kg	0.826	C	0.83	C	1.0	--	Yes
	Aroclor-1248	mg/kg	0.826	C	0.83	C	1.0	--	Yes
	Aroclor-1254	mg/kg	0.826	C	0.83	C	1.0	--	Yes
	Aroclor-1260	mg/kg	0.826	C	0.83	C	1.0	--	Yes
PCBs	Total PCBs	mg/kg	0.826	C	0.83	C	1.0	--	Yes
	TCDD TEQ[f]	pg/g	2,700	C	2,700	--	1.0	g	Yes
General Chemistry	**Cyanide**	**mg/kg**	**13,700**	**N**	**27.8**	**N**	**493**	**--**	**Yes**
	Perchlorate	mg/kg	795	N	795	N	1.0	--	Yes
Dioxins/Furans	TCDD TEQ[h]	pg/g	2,700	C	2,700	--	1.0	g	Yes
Metals	Aluminum	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Antimony	mg/kg	454	N	454	N	1.0	--	Yes
	Arsenic	mg/kg	7.2	--	7.20	--	1.0	i	Yes
	Barium	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Beryllium	mg/kg	2,230	N	2,228	N	1.0	--	Yes
	Boron	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Cadmium	mg/kg	560	N	1,114	N	0.50	--	Yes
	Chromium (III)	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Chromium (VI)	**mg/kg**	**1,360**	**C**	**1,226**	**C**	**1.1**	**--**	**Yes**
	Cobalt	mg/kg	337	N	337	N	1.0	--	Yes
	Copper	mg/kg	42,200	N	42,178	N	1.0	--	Yes
	Iron	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Lead	mg/kg	800	--	800	--	1.0	j	Yes
	Magnesium	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Manganese	**mg/kg**	**100,000**	**Max**	**24,927**	**N**	**4.0**	**--**	**Yes**
	Mercury	mg/kg	182	N	182	N	1.0	--	Yes
	Molybdenum	mg/kg	5,680	N	5,678	N	1.0	--	Yes
	Nickel	mg/kg	21,800	N	21,770	N	1.0	--	Yes
	Platinum	mg/kg	--	--	568	N	New BCL	--	Yes
	Potassium	mg/kg	--	--	--	--	--	--	Yes
	Selenium	mg/kg	5,680	N	5,678	N	1.0	--	Yes
	Silver	mg/kg	5,680	N	5,678	N	1.0	--	Yes
	Sodium	mg/kg	--	--	--	--	--	--	Yes

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

PARAMETER OF INTEREST	CHEMICAL	UNIT	2011 SRG	BASIS	2013 SCREENING LEVEL	BASIS	RATIO OF 2011 SRG TO 2013 SCREENING LEVEL	NOTE	SITE COPC
Metals	Strontium	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Thallium	**mg/kg**	**79.5**	**--**	**74.9**	**--**	**1.1**	**j**	**Yes**
	Tin	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Titanium	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
	Tungsten	mg/kg	8,510	N	8,513	N	1.0	--	Yes
	Uranium	mg/kg	3,400	N	3,400	N	1.0	--	Yes
	Vanadium	mg/kg	5,680	N	5,678	N	1.0	--	Yes
	Zinc	mg/kg	100,000	Max	100,000	Max	1.0	--	Yes
Inorganic Anions	Bromide	mg/kg	NA	NA	100,000	Max	Not applied during Interim Removal Action	--	Yes
	Chloride	mg/kg	NA	NA	--	--	--	--	Yes
	Fluoride	mg/kg	NA	NA	41,044	N	Not applied during Interim Removal Action	--	Yes
	Nitrate	mg/kg	NA	NA	100,000	Max	Not applied during Interim Removal Action	--	Yes
	Nitrite	mg/kg	NA	NA	100,000	Max	Not applied during Interim Removal Action	--	Yes
	Orthophosphate	mg/kg	NA	NA	--	--	--	--	No
	Sulfate	mg/kg	NA	NA	--	--	--	--	Yes
	Sulfide	mg/kg	NA	NA	--	--	--	--	No
Radionuclides	Radium-226	pCi/g	NA	NA	0.0230	C	Not applied during Interim Removal Action	--	Yes
	Radium-228	pCi/g	NA	NA	0.0410	C	Not applied during Interim Removal Action	--	Yes
	Thorium-228	pCi/g	NA	NA	0.0250	C	Not applied during Interim Removal Action	--	Yes
	Thorium-230	pCi/g	NA	NA	8.30	C	Not applied during Interim Removal Action	--	Yes
	Thorium-232	pCi/g	NA	NA	7.40	C	Not applied during Interim Removal Action	--	Yes
	Uranium-234	pCi/g	NA	NA	11.0	C	Not applied during Interim Removal Action	--	Yes
	Uranium-235	pCi/g	NA	NA	0.3500	C	Not applied during Interim Removal Action	--	Yes
	Uranium-238	pCi/g	NA	NA	3,400	N	Not applied during Interim Removal Action	--	Yes
Asbestos	Long amphibole fibers	fibers	1 or more	--	1 or more	--	1.0	--	Yes
	Long chrysotile fibers	fibers	More than 5	--	More than 5	--	1.0	--	Yes

TABLE C-2. SOIL REMEDIATION GOALS (SRGs) COMPARISONS
Nevada Environmental Response Trust Site; Henderson, Nevada

Notes:

*Chemicals that are gray highlighted have 2013 screening levels that are more than 5 percent higher than the 2011 SRGs.

**Chemicals that are gray highlighted and bolded have 2013 screening levels that are more than 5 percent lower than the 2011 SRGs.

a = NDEP 2011 worker BCL of site-specific screening level applied during the interim soil removal action. BCLs are from User's Guide and Background Technical Document for Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas, Revision 6, January 2011 (http://ndep.nv.gov/bmi/technical.htm). Values listed are for the outdoor industrial/commercial worker.

b = NDEP 2013 worker BCL or site-specific screening level. BCLs are from User's Guide and Background Technical Document for Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas, Revision 12, August 2013. Values for the worker are the lower of the indoor and outdoor worker soil BCLs.

c = BCL based on mixed isomer.

d = Hexachlorobenzene analyzed using both EPA Methods 8081 and 8270. Data reported based on EPA 8270 as it was deemed to be the superior method.

e = 100 mg/kg total TPH value used for screening.

f = TCDD equivalents based on WHO 2005 TEFs for the 12 co-planer PCBs; the detection limit was used for non-detect values.

g = Site-specific value.

h = TCDD equivalents based on WHO 2005 TEFs for the 17 dioxin and furan congeners.

i = Based on regional background concentrations.

j = A basis for the lead and thallium BCLs are not identified by NDEP.

C = Cancer
N = Noncancer
NA = Not applied
sat = soil saturation
max = risk-based value is greater than 100,000 mg/kg
-- = no value
mg/kg = milligrams per kilogram
pCi/g = picoCuries per gram
pg/g = picograms per gram
BCL = Basic comparison level
BMI = Black Mountain Industrial

COPC = Chemical of potential concern
EPA = Environmental Protection Agency
PAHs = Polycyclic aromatic hydrocarbons
PCBs = Polychlorinated biphenyls
TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF = Toxicity equivalent factor
TEQ = Toxicity equivalence
TPH = Total petroluem hydrocarbons
SVOCs = Semi-volatile organic compounds
VOCs = Volatile organic compounds
WHO = World Health Organization

Appendix D

Background Data Set for Soils

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D Soil Background Data Sets

This appendix describes available data sets for evaluating concentrations of metals and radionuclides in soils at the Nevada Environmental Response Trust Site (the Site) relative to background conditions for purposes of evaluating nature and extent of contamination and for identifying chemicals of potential concern for the baseline health risk assessment (BHRA). These data sets include the following:

(1) Metals: Analytical results for soil samples collected in Remediation Zone A (RZ-A) represent a background data set for metals in the 0-10 foot (ft) depth interval. This data set was first identified in *Technical Memorandum: Background Comparison for Metals in Remediation Zones B through E, Compared to Remediation Zone A* (Northgate Environmental Management, Inc. [Northgate] 2010b).

(2) Radionuclides: Analytical results for soil samples collected in the McCullough Range represent a background data set for radionuclides in the 0-10 ft depth interval. This data set was first identified in *Background Shallow Soil Summary Report, BMI Complex and Common Area Vicinity* (Basic Remediation Company and Titanium Metals Corporation [BRC/TIMET] 2007). It is noted that the RZ-A data set (Northgate 2010b) used for metals also included results for radionuclides that may be appropriate for conducting background evaluations.

In *Response to Background Issues and Determination of Background Dataset for Tronox* (Nevada Division of Environmental Protection [NDEP] 2010a), NDEP investigated differences between the analytical results for metals from RZ-A and from background samples collected in 2005 by BRC/TIMET in the McCullough Range[1]. NDEP noted that the analytical laboratories used various digestion methods that appear to have affected the reported results for metals. Further, NDEP observed that not all of the metals analyzed reacted in the same way to the digestion and that some of the observed differences between the two data sets may not be due to differences in the various digestion methods. Additionally, there may have been other reasons for the observed differences between the data sets (e.g. geologic differences) that had not been investigated in detail. Based on the observed results and lack of other rationale or investigation, and to further reduce potential for unacceptable exposure to soil contamination, NDEP determined that the RZ-A data set was appropriate for background comparisons regardless of the laboratory used for analysis for the purpose of identifying soils in RZ-B through RZ-E for remediation. This data set was also used for evaluating background conditions in the health risk assessment (HRA) for RZ-A (Northgate 2010c).

The following sections describe in more detail the RZ-A background soil data set and the McCullough Range background data set.

[1] The Black Mountain Industrial (BMI) Complex and Common Areas are located approximately 1 mile north of the McCullough Range, and the northern McCullough Range is the primary source of materials upslope of the BMI Complex [BRC/TIMET 2007]).

D.1 RZ-A Metals Background Data Set for Metals in Soils

RZ-A soils were sampled in November 2006 during the Phase A soil investigation (ENSR Corporation [ENSR] 2007) and from June 2008 through November 2009 as part of the Area IV Phase B soil investigation (ENSR 2008).

- Samples from the Phase A investigation were analyzed and validated in accordance with the *Phase A Source Area Investigation Work Plan* (ENSR 2006b), the *Draft Quality Assurance Project Plan* (ENSR 2006a), and standardized guidelines and procedures recommended by U.S. Environmental Protection Agency (USEPA 1992a,b and USEPA 1989) and NDEP (NDEP 2006). Based on this validation, 80 percent of the analytical results of the Phase A were accepted as reported by the laboratory and were considered valid for all decision-making purposes. Twenty percent of the results from the total analytical data set for this project were qualified as "estimated" due to minor quality control (QC) issues associated with precision, accuracy, and representativeness. Based on USEPA's data usability guidance (USEPA 1992a), results qualified as estimated were considered usable with appropriate interpretation (e.g., consideration of the potential bias). Only 0.4 percent of the results were rejected as unusable due to more serious QC issues such as gross holding time violations and low spike recoveries.

- Samples from the Phase B investigation were analyzed and validated in accordance with the *Revised Phase B Investigation Work Plan* (AECOM, Inc. [AECOM] 2008), the *Revised Phase B Quality Assurance Project Plan, Tronox LLC Facility* (AECOM and Northgate 2009), and NDEP's *Supplemental Guidance on Data Validation* (NDEP 2009c). Approximately 90% of the analytical data were validated by Stage 2B and approximately 10% were validated by Stage 4 data validation procedures (Northgate 2010a). The samples were evaluated for use as a background data set for the Site in Northgate's *Technical Memorandum: Background Comparison for Metals in Remediation Zones B through E, Compared to Remediation Zone A,* submitted to NDEP on July 22, 2010 (Northgate 2010b). NDEP commented on August 9, 2010, stating that their comments should be incorporated into the HRA(s) prepared for the Site (NDEP 2010b).

Northgate noted that one Phase A soil boring (SA02) and five Phase B soil borings (RSAU4, RSAU5, SA28, SA146, and SA147) were located in a boron source area (the former State Industries, Inc. site) in Letter of Understanding (LOU) 62 and contributed to elevated concentrations of boron and other metals, including barium, iron, and sodium. Comparisons of maximum and means from these six borings to the remaining RZ-A data revealed differences between the two data sets. Based on these findings, the data associated with these six borings were removed from the RZ-A data set. As shown in Table D-1, the final RZ-A background data set for surface and near-surface soils (generally defined as 0-10 ft below ground surface [bgs])[2] consists of a total of 31 samples collected from 14 borings. In preparing the data sets for the

[2] For the purpose of the background evaluations, surface and near surface soils are typically defined as 0-10 ft bgs. For any specific evaluation, the depth interval under evaluation will be specified. The 31 samples comprising the data set include 16 samples collected from 0.5-2 ft bgs and 15 samples collected from 10-11.5 ft bgs.

summary statistics presented in Table D-1, the full sample quantitation limit (SQL) is provided for the minimum and maximum non-detected values consistent with NDEP *Detection Limits and Data Reporting* guidance (NDEP 2008a), and one-half the SQL was used for the Shapiro-Wilk test, consistent with *NDEP Guidance on the Development of Summary Statistics Tables at the BMI Complex and Common Areas* (NDEP 2008b). The Shapiro-Wilk test was used to formally evaluate how consistent each data set is with normal and log-normal distributions. Primary samples and field duplicates were treated as independent samples on the basis of a preliminary evaluation indicating that the variance of the duplicates was similar to the variance of the primary samples, consistent with NDEP guidance (NDEP 2008c).

An additional 13 samples were collected from the middle depth interval (defined by Northgate 2010b,c as 10 ft bgs to the top of the Upper Muddy Creek Formation [UMCf]) and 22 samples from the deep depth interval (samples from the UMCf). Summary statistics will be prepared for these data sets, if it is determined that background comparisons will be made for deeper soils.

D.2 McCullough Range Background Data Set for Radionuclides

The McCullough Range background data set was first presented in the *Background Shallow Soil Summary Report BMI Complex and Common Areas Vicinity — Basic Remediation Company Titanium Metals Corporation* (BRC/TIMET 2007). The main objective of the background study was to collect and analyze background soil samples for metals and radionuclides.[3]

The BRC/TIMET (2007) evaluation included analytical data from both the BRC/TIMET investigation and from a background study by ENVIRON (2003). In previous documents prepared for the Site, this combined data set has been referred to as either the McCullough Range background data set or the BRC/TIMET background data set. Summary statistics for the combined data sets are presented in Table D-2. The samples were generally collected at 0, 5, and 10 ft bgs. The total number of samples in this data set ranges from 81 to 101, depending on the analyte, with approximately 30 to 40 samples available for each depth interval. The depth intervals presented in Table D-2 were based on combined data between 0 and 10 ft bgs.

D.2.1 BRC/TIMET Background Data Set

BRC/TIMET collected soil samples from 33 initial sampling locations on 11 undeveloped properties near and upgradient from the BMI Complex and Common Areas in 2005. At each of the properties, soil samples were collected from three borings drilled approximately 10 to 15 ft apart. The BRC/TIMET data set consists of 104 samples collected from 0 to 0.5, 4 to 6, and 9 to 11 ft bgs and analyzed for a total of 35 radionuclides. These samples are combined to represent the 0-10 ft depth interval.

Full validation was conducted on 10 percent of the BRC/TIMET data set, and a partial validation was conducted on the remaining 90 percent. In the absence of a standardized process for the validation of radionuclide data, the reviewer relied on professional judgment and other sources

[3] Given that NDEP determined that the McCullough Range data set for metals was not appropriate for use at the Site, only the data set for radionuclides is discussed.

for data qualification. Radionuclide data validation was conducted using several documents, including the USEPA document *Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)* (USEPA 2004b), the U.S. Department of Energy (USDOE) reference document titled *Evaluation of Radiochemical Data Usability* (USDOE 1997), and QC requirements and criteria summarized in the applicable methods.

D.2.2 ENVIRON Background Data Set

ENVIRON collected soil samples from eight borings from the City of Henderson in April 2002. The ENVIRON data set consists of 16 samples collected from 0 to 1 and 3 to 4 ft bgs and analyzed for a total of 15 radionuclides. These samples are combined to represent the 0-10 ft depth interval.

A partial validation was conducted on the entire ENVIRON data set by Neptune and Company, NDEP's consultant. Stable chemistry sample results for the ENVIRON background soil samples were validated in accordance with USEPA (2004a). Professional judgment and analytical method requirements were used to validate radionuclide data. Based on data validation and review, Neptune concluded that the validated ENVIRON data set was suitable for inclusion in the overall BRC/TIMET background data set for radionuclides with the provision that results for radium-224, radium-226, and radium-228 be excluded due to analytical and QC considerations (BRC/TIMET 2007). Specifically, it was unclear as to how the laboratory calculated the activity of radium-224 and there was a lack of relevant QC information for radium-224, radium-226, and radium-228.

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TABLE D-1. RZ-A BACKGROUND METAL CONCENTRATIONS FOR SURFACE AND NEAR-SURFACE SOILS[a,b]
Nevada Environmental Response Trust Remediation Project Site, Henderson, Nevada

				NON-DETECTS (mg/kg)		DETECTS (mg/kg)					SHAPIRO-WILK TEST	
CHEMICAL NAME	NO. OF SAMPLES	NO. OF DETECTS	% DETECTS	MINIMUM	MAXIMUM	MINIMUM	MEDIAN	MEAN	MAXIMUM	STANDARD DEVIATION	NORMAL (*p* -value)	LOGNORMAL (*p* -value)
Aluminum	31	31	100%	NA	NA	7,340	8,970	9,020	11,400	890	0.6	0.9
Antimony	31	13	42%	0.50	0.50	0.60	1.3	1.5	3.4	0.68	*<0.001*	*<0.001*
Arsenic	31	31	100%	NA	NA	1.6	2.4	2.4	4.3	0.54	0.02	0.5
Barium	31	31	100%	NA	NA	111	162	166	213	22.5	0.6	0.4
Beryllium	31	31	100%	NA	NA	0.36	0.46	0.46	0.59	0.048	0.6	0.7
Boron	31	31	100%	NA	NA	3.4	6.2	6.8	11.7	1.9	0.3	0.4
Cadmium	31	25	81%	0.04	0.04	0.11	0.19	0.20	0.48	0.085	*0.009*	*<0.001*
Chromium (Total)	31	31	100%	NA	NA	5.6	7.5	7.7	10.7	1.2	0.4	0.7
Chromium (VI)	31	1	3%	0.18	0.24	0.29	0.29	0.29	0.29	NA	*<0.001*	*<0.001*
Cobalt	31	31	100%	NA	NA	5.4	7.3	7.3	9.1	0.76	0.5	0.4
Copper	31	31	100%	NA	NA	15.8	19.1	23.1	140	21.8	*<0.001*	*<0.001*
Iron	31	31	100%	NA	NA	11,300	15,700	15,500	20,600	2,140	0.5	0.3
Lead	31	31	100%	NA	NA	7.1	8.9	11.3	72.8	11.6	*<0.001*	*<0.001*
Magnesium	31	31	100%	NA	NA	7,700	9,810	9,990	13,000	1,320	0.8	1
Manganese	31	31	100%	NA	NA	262	360	366	537	61.3	0.03	0.4
Mercury	31	31	100%	NA	NA	0.0060	0.015	0.033	0.36	0.065	*<0.001*	*<0.001*
Molybdenum	31	31	100%	NA	NA	0.27	0.48	1.6	32.7	5.8	*<0.001*	*<0.001*
Nickel	31	31	100%	NA	NA	12.7	15.6	15.9	21.4	1.8	0.08	0.5
Platinum	31	31	100%	NA	NA	0.0060	0.010	0.011	0.046	0.0074	*<0.001*	*<0.001*
Potassium	31	31	100%	NA	NA	1,450	2,080	2,180	4,210	658	*<0.001*	0.02
Selenium	31	6	19%	0.70	0.80	0.80	0.95	0.93	1.1	0.12	*<0.001*	*<0.001*
Silver	31	0	0%	0.20	0.20	NA	NA	NA	NA	NA	NA	NA
Sodium	31	31	100%	NA	NA	307	630	621	1,050	194	0.3	0.3
Strontium	31	31	100%	NA	NA	129	214	222	339	57	0.4	0.3
Thallium	31	31	100%	NA	NA	0.071	0.092	0.11	0.19	0.033	*<0.001*	*0.003*
Tin	31	31	100%	NA	NA	3.1	4.0	4.0	5.8	0.56	0.08	0.5
Titanium	31	31	100%	NA	NA	480	829	793	1,080	162	0.2	0.04
Tungsten	31	31	100%	NA	NA	0.098	0.17	0.21	0.62	0.11	*<0.001*	0.02
Uranium	31	31	100%	NA	NA	0.66	0.98	1.1	1.9	0.36	*0.002*	0.05
Vanadium	31	31	100%	NA	NA	28	46	43.8	54.9	7.6	0.08	0.02
Zinc	31	31	100%	NA	NA	25.8	33.3	40.4	254	39.9	*<0.001*	*<0.001*

Notes:
bgs = below ground surface
ft = feet
mg/kg = milligrams per kilogram
NA = value not available

p- values < 0.01 are shown in italic
Background dataset is from RZ-A, excluding the 6 borings in LOU 62.
Shapiro-Wilk test uses 1/2 the sample quantitation limit (SQL) for non-detects.

[a] Generally defined as the 0-10 foot depth interval. For the purposes of the background evaluations, surface and near surface soils are typically 0-10 ft bgs. For any specific evaluation, the depth interval under evaluation will be specified.
[b] The 31 samples comprising the data set include 16 samples collected from 0.5-2 ft bgs and 15 samples collected from 10-11.5 ft bgs.

TABLE D-2. MCCULLOUGH RANGE BACKGROUND RADIONUCLIDE CONCENTRATIONS
Nevada Environmental Response Trust Remediation Project Site, Henderson, Nevada

		CONCENTRATIONS (pCi/g)					SHAPIRO-WILK TEST	
CHEMICAL NAME	**NO. OF SAMPLES**	**MINIMUM**	**MEDIAN**	**MEAN**	**MAXIMUM**	**STANDARD DEVIATION**	**NORMAL (*p* -value)**	**LOGNORMAL (*p* -value)**
Ra-226	95	0.494	1.09	1.15	2.36	0.340	*<0.001*	0.2
Ra-228	81	0.946	1.93	1.89	2.92	0.391	0.8	0.04
Th-228	101	1.15	1.78	1.74	2.28	0.262	0.04	*0.002*
Th-230	101	0.730	1.21	1.29	3.01	0.389	*<0.001*	0.06
Th-232	101	1.22	1.66	1.66	2.23	0.255	0.01	0.01
U-234	101	0.630	1.05	1.19	2.84	0.456	*<0.001*	*<0.001*
U-235	101	0.0009	0.0600	0.0696	0.210	0.0381	*0.002*	*<0.001*
U-238	101	0.650	1.05	1.16	2.37	0.358	*<0.001*	*<0.001*

Notes:

pCi/g = picoCuries per gram

p- values < 0.01 are shown in italic

Background dataset is from BRC/TIMET's (2007) McCullough Range dataset.

Reference:

Basic Remediation Company and Titanium Metals Corporation (BRC/TIMET). 2007. Background Shallow Soil Summary Report, BMI Complex and Common Areas Vicinity. March 16.