AP Area Down and Up Flushing Treatability Study Work Plan
Nevada Environmental Response Trust Site Henderson, NV

PREPARED FOR

Nevada Environmental Response Trust
35 E. Wacker Drive, Suite 690
Chicago, IL 60601

PRESENTED BY

Tetra Tech, Inc.
150 S. 4th Street, Unit A
Henderson, NV 89015

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LIST OF ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ASTM	American Society for Testing and Materials
AWF	Athens Road Well Field
bgs	below ground surface
CPS	calcium polysulfide
CRB	Central Retention Basin
DO	dissolved oxygen
DVSR	Data Validation Summary Report
EC	electrical conductivity
FBR	Fluidized Bed Reactor
gpm	gallons per minute
GWETS	Groundwater Extraction and Treatment System
GWTP	Groundwater Treatment Plant
IC	Ion Chromatography
ID	Inner diameter
IWF	Interceptor Well Field
mg/L	milligrams per liter
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection
NDWR	Nevada Division of Water Resources
NERT or Trust	Nevada Environmental Response Trust
OM&M	Operation, Maintenance, and Monitoring
ORP	oxidation reduction potential
Qal	Quaternary alluvium
PVC	polyvinyl chloride
Site	Nevada Environmental Response Trust site
SLMW	stabilized Lake Mead water
SWF	Seep Well Field
Tetra Tech	Tetra Tech, Inc.
UIC	Underground Injection Control
UMCf	Upper Muddy Creek Formation
UNLV	University of Nevada at Las Vegas
USEPA	United States Environmental Protection Agency
Work Plan	AP Area Down and Up Flushing Treatability Study Work Plan

CERTIFICATION

AP Area Down and Up Flushing Treatability Study Work Plan

Nevada Environmental Response Trust Site
(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 NERT. Based on my own involvement and/or my inquiry of the person or persons who manage the systems(s) or those directly responsible for gathering the information or preparing the document, or the immediate supervisor of such person(s), the information submitted and provided herein is, to the best of my knowledge and belief, true, accurate, and complete in all material respects.

Office of the Nevada Environmental Response Trust

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

not individually but solely in Pres. Tr

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

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

Title: Solely as President and not individually

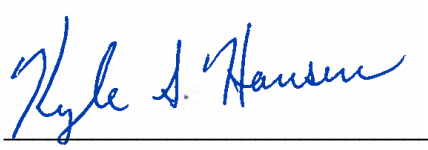
Company: Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Date: 2/12/18

CERTIFICATION

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 prepared 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. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

Description of Services Provided: Prepared the Ammonium Perchlorate (AP) Area Down and Up Flushing Treatability Study Work Plan for the AP Area at the NERT site presenting the technical approach and scope of work to release and transport perchlorate present in the vadose zone and saturated zone for extraction and treatment.



02/12/2018

Kyle Hansen, CEM
Field Operations Manager/Geologist
Tetra Tech, Inc.

Date

Nevada CEM Certificate Number: 2167
Nevada CEM Expiration Date: September 18, 2018

1.0 INTRODUCTION

On behalf of the Nevada Environmental Response Trust (NERT or Trust), Tetra Tech, Inc. (Tetra Tech) has prepared this Ammonium Perchlorate (AP) Area Down and Up Flushing Treatability Study Work Plan (Work Plan) for the AP Area at the NERT site (Site), located in Clark County, Nevada (Figure 1). The AP Area is located upgradient of the Interceptor Well Field (IWF), which is one of the three extraction well fields in operation at the Site.

This Work Plan is being submitted to the Nevada Division of Environmental Protection (NDEP) under the Interim Consent Agreement effective February 14, 2011. The Work Plan presents the technical approach and scope of work for this treatability study. Soil flushing will be used to release and transport perchlorate present in the vadose zone and saturated zone in the Quaternary alluvium (Qal) and the Upper Muddy Creek Formation (UMCf) for extraction and treatment. Two variants of the soil flushing technology, down flushing and up flushing, will be considered as part of this treatability study.

1.1 PROJECT OBJECTIVES

The objectives of this treatability study are to demonstrate and evaluate the effectiveness of down and up flushing, while building on the results of the recently completed soil flushing treatability study conducted in the Central Retention Basin (CRB) by testing a different water delivery system at a larger scale and testing the viability of up flushing to remove perchlorate from the lower permeability UMCf. The use of this alternate water delivery system will allow NERT to evaluate the cost-implications of implementing a large scale soil flushing system at source areas at the Site. This information will be critical for use during remedial option evaluations performed as part of the Feasibility Study. The previous soil flushing treatability study focused on an area with moderate concentrations of perchlorate in the soil whereas this study will focus on a source area with significantly higher concentrations of perchlorate in the unsaturated zone. The high aqueous solubility of perchlorate compounds and recently completed soil flushing treatability testing suggests that flushing the vadose zone, saturated alluvium, and UMCf with water is a viable means of removing perchlorate from vadose zone soils and groundwater at the Site.

1.2 WORK PLAN ORGANIZATION

This Work Plan is organized as follows:

- **Introduction (Section 1.0):** Provides relevant background information, including regional geology and hydrogeology.
- **Previous Soil Flushing Application (Section 2.0):** Provides a summary of the recent soil flushing treatability study.
- **Field and Laboratory Activities (Section 3.0):** Provides a description of the field and laboratory activities to be completed prior to implementing down and up flushing to optimize and finalize the field test design.
- **Effectiveness Monitoring Plan (Section 4.0)**: Presents the conceptual effectiveness monitoring program for field implementation, including the field, analytical, and groundwater monitoring.
- **Reporting (Section 5.0):** Summarizes reporting related to design and execution of the field activities and implementation.
- **Schedule (Section 6.0):** Summarizes the schedule for conducting the field activities, field implementation, and associated reporting.
- **References (Section 7.0):** Lists the documents referenced in this Work Plan.

1.3 BACKGROUND

1.3.1 General

The Site has been used for industrial purposes since 1942, when it was initially developed by the United States government as a magnesium plant to support World War II operations. Since that time, the Site and the surrounding properties have been used for chemical manufacturing, including the production of various chlorate and perchlorate compounds. Entities that operated at the Site include Western Electrochemical Company, American Potash and Chemical Company, Kerr-McGee Chemical Corporation, and Tronox. On February 14, 2011, NERT took title to the Site as part of the settlement of the Tronox Chapter 11 bankruptcy proceedings. As part of a long-term lease, Tronox operates a manufacturing facility on 114 acres of the Site to produce manganese and boron products. Historical industrial production and related waste management activities conducted at the Site and on adjacent properties have resulted in the contamination of various environmental media, including soil, groundwater, and surface water. The most notable site-related contaminants of potential concern are chromium and perchlorate (Tetra Tech, Inc., 2015a).

1.3.2 Regional Geology

The Site is located near the southeast end of the Las Vegas Valley, a structural basin that also includes the metropolitan areas of North Las Vegas, Las Vegas, and Henderson. Las Vegas Valley is bounded on the west by the Spring Mountains, on the north by the southern ends of the Sheep and Las Vegas Ranges, on the east by Frenchman and Sunrise Mountains, and on the south by the River Mountains and McCullough Range. The northwest-southeast trending structural basin that underlies Las Vegas Valley is composed of Precambrian crystalline rocks; Precambrian and Paleozoic carbonate rocks; Permian, Triassic, and Jurassic clastic rocks; and Miocene igneous rocks. Gravity data indicate that the deeper parts of the basin are filled with 3,000-5,000 feet of clastic sedimentary deposits that range in age from Miocene through Holocene (Plume, 1989).

The clastic sedimentary valley-fill deposits of Las Vegas Valley are generally believed to consist of Muddy Creek Formation and younger deposits. The Muddy Creek Formation also includes thick beds of gypsum and salt and basalt flows, though these are not exposed in the Las Vegas Valley. The thickness of the valley fill deposits in the vicinity of the Site is approximately 4,000 feet. Extraction of groundwater from the valley fill since the early 1900s has resulted in over two feet of subsidence centered on the areas with the heaviest groundwater pumping, such as downtown Las Vegas (Plume, 1989).

1.3.3 Local Geology and Hydrogeology

At and near the NERT Site, boring logs have encountered valley fill deposits including Quaternary alluvium, transitional Muddy Creek Formation, and the Pleistocene Upper Muddy Creek Formation (UMCf). The alluvium is generally described as reddish-brown discontinuous layers of sand and gravel with minor amounts of silt, clay, and caliche. The thickness of these alluvial deposits ranges from less than one foot to more than 50 feet beneath the Site (ENVIRON, 2014a). Thick deposits of alluvium that are structurally narrow and linear have been interpreted as stream-deposited sands and gravels that were deposited within paleochannels during flooding events. The paleochannel sand and gravel deposits often exhibit significantly greater permeability than the alluvium outside the paleochannels. At the base of the alluvium, the transitional Muddy Creek Formation is sometimes encountered. The transitional Muddy Creek Formation consists of reworked sediments derived from the Muddy Creek Formation. The UMCf underlies the transitional Muddy Creek Formation (if present) or alluvium, and consists of interbedded coarse-grained and fine-grained sediments that become progressively finer-grained to the north towards the central portion of the valley. The UMCf subcrops beneath a thin veneer of Quaternary alluvium near the Site. In that area, the contact between the alluvium and the Muddy Creek Formation is typically marked by the appearance of a well-compacted, moderate brown silt-to-sandy silt or stiff clay to-sandy clay (ENVIRON, 2014a).

The depth to water at the AP Area is approximately 30 feet. The water table is typically in the upper portion of UMCf due to pumping at the IWF since 1987. However, in areas where paleochannels or depressions in the Quaternary alluvium (Qal)/UMCf contact exist, saturated alluvium may be encountered. There are no monitoring wells within the AP Area for this treatability study, but nearby monitoring wells suggest that a vertical hydraulic gradient exists in the UMCf (ENVIRON, 2014a).

1.3.4 Groundwater Extraction and Treatment System

Groundwater extraction has been implemented at the Site to address impacts to groundwater resulting from releases of perchlorate and hexavalent chromium, among other contaminants. Collectively, the entire system of extraction wells, water conveyances, and treatment plants is referred to as the Groundwater Extraction and Treatment System (GWETS).

The GWETS treats water from three groundwater extraction well fields: the IWF; Athens Road Well Field (AWF); and Seep Well Field (SWF) (Figure 1). Pipelines and lift stations convey groundwater from the well fields to the Site to be treated by the on-site treatment plant. This treatment plant is comprised of the following components: the groundwater treatment plant (GWTP) to treat hexavalent chromium from the IWF; the Fluidized Bed Reactor (FBR) treatment plant to treat perchlorate in groundwater from all of the well fields; the GW-11 Pond, which is used for water storage and equalization; the Equalization Area, which includes equalization tanks and a granular activated carbon pretreatment system; and the effluent pump station and pipeline, which convey treated effluent from the FBR treatment plant to an outfall at the Las Vegas Wash (Tetra Tech, Inc., 2015a).

2.0 PREVIOUS SOIL FLUSHING APPLICATION

A recent Soil Flushing Treatability Study was conducted at the NERT site between March 2015 and August 2016 in the Central Retention Basin at the Site, which is located upgradient of the IWF and the AP Area (Figure 2). The primary objective of the study was to evaluate the feasibility of remediating contaminants, primarily perchlorate, in vadose zone soils using soil flushing. Four test plots were constructed and operated during this treatability study. Each test plot was operated using a variation on water application rates and use of a carbon substrate added to enhance perchlorate biodegradation.

The Soil Flushing Treatability Study Report (Tetra Tech, 2017) found that mass reductions ranging from 73 percent to 98 percent were obtained in two 30- by 30-foot test plots where water was applied at the maximum rate allowed by the local soils. In the Soil Flushing Treatability Study, water was applied using infiltration galleries. For large-scale implementation, infiltration galleries are not an ideal water application method, as it is difficult to control water application rates over large areas with non-uniform infiltration rates. In the AP Area Down and Up Flushing Treatability Study, the areas proposed for soil flushing are substantially larger than in the Soil Flushing Treatability Study (8,100 vs. 900 square feet) and contain significantly higher perchlorate concentrations in soil within the vadose zone. To address potential heterogeneity in infiltration rates as experienced in the first treatability study, microirrigation systems designed to apply water uniformly across the ground surface at a controllable rate will be used to apply water at rates approaching the maximum to mitigate the effects of heterogeneity. The purpose of this follow up treatability study is to evaluate the efficiency of soil flushing at source areas where perchlorate compounds were manufactured (and where perchlorate concentrations are considerably higher in concentration within the vadose zone).

3.0 FIELD AND LABORATORY ACTIVITIES

This section describes the various field and laboratory activities, including infiltration testing, soil sampling, groundwater well installation, slug testing, groundwater sampling, and laboratory bench tests. Results from these tasks will be used to finalize design details for field implementation and operation.

3.1 FIELD ACTIVITIES

All field work described herein will be conducted in general accordance with the existing Field Sampling Plan (ENVIRON, 2014b). Tetra Tech, on behalf of NERT, will prepare and submit all required applications and obtain required permits prior to the installation of any soil borings, injection wells, or monitoring wells. Once approval is granted, an underground utility survey will be performed before drilling commences. All wells will be drilled in accordance with the Nevada Division of Water Resources (NDWR) requirements, following submittal of a Notice of Intent to Drill.

3.2 DOWN FLUSHING

Stabilized Lake Mead water (SLMW) will be applied at the ground surface using a drip irrigation system set to deliver water at or near the maximum achievable infiltration rate to flush the perchlorate from the vadose zone into the alluvial aquifer. Down flushing is planned to be conducted in cells within two (2) 90 foot by 90 foot treatment areas within the former AP production area (Figure 2). These cells are located approximately 250 feet and 420 feet upgradient (south) of the IWF, respectively. Cell locations were selected due to the known nearby presence or inferred presence of high perchlorate concentrations in the vadose zone (e.g., historical soil boring SA179 had a perchlorate concentration of 8,810 milligrams per kilogram), and are upgradient of IWF wells discharging to the western manifold.

The following sections summarize the down flushing field program.

3.2.1 Utility Clearance

Prior to performing intrusive field work, a geophysical survey will be performed to identify subsurface utilities at each boring location. The geophysical survey will be conducted by Ground Penetrating Radar Systems, Inc. of Las Vegas, Nevada. In addition, all boring locations will be cleared for subsurface utilities to a depth of 12 feet or to the top of a competent soil layer using a vacuum excavation rig operated in water or air mode. The vacuum excavation rig will be operated by National Exploration, Wells & Pumps (National) of Las Vegas, Nevada.

3.2.2 Soil Borings

Nine soil borings will be drilled within Plot 1 and nine soil borings will be drilled within Plot 2 (Figure 3) to determine the concentration of perchlorate and other constituents in soil below the soil flushing plots. The soil borings will be drilled by National using the hollow stem auger method. All of the soil borings will be drilled to depths of 40 feet to 45 feet below ground surface (bgs).

Soil samples will be collected from the borings at depths of approximately 0.5 feet, 5 feet, and at 5-foot depth intervals thereafter using a 2.5-inch inside diameter, 18-inch long California split barrel sampler lined with three six-inch long, 2.5-inch diameter stainless steel sleeves. Upon retrieval from the borehole, the lowermost sleeve will be removed from the sampler and the ends of the sleeve will be covered with Teflon sheets and tightly fitting plastic caps. The soil samples will be labeled, placed in recloseable plastic bags, and stored in an ice chest cooled with ice pending delivery to the laboratory under chain-of-custody protocols. The soil samples will be analyzed for perchlorate using USEPA Method E314.0 and for hexavalent chromium using USEPA Method 7199. The chemical analyses will be performed by TestAmerica Laboratories, Inc.(TestAmerica) of Irvine, California, a

Nevada-certified analytical laboratory. Selected samples will also be analyzed for physical properties (dry bulk density, grain density, porosity, and moisture content) by PTS Laboratories (PTS) of Santa Fe Springs, California.

The soil borings will be logged by a trained geologist or engineer in general accordance with ASTM International (ASTM) Standard D-2488-09 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM International, 2009a).

After drilling, soil sampling and logging will be completed, then the borings will be backfilled with bentonite grout. The final boring locations will be surveyed by a state-licensed surveyor.

3.2.3 Vadose Zone Mass Estimates and Modeling

The analytical data from the down flushing soil borings and the up flushing wells (Section 3.3) will be used to develop a three-dimensional model of the spatial distribution of perchlorate in the vadose zone, Qal, and UMCf. This model will be developed using Earth Volumetric Studio, an advanced data visualization and geostatistical analysis software package (Earth Volumetric Studio [computer software], 2016). The Earth Volumetric Studio model will then used to estimate the mass of perchlorate in the vadose zone, Qal aquifer, and UMCf beneath Plots 1 and 2.

Analysis of the timing of flows and leachate concentrations in response to down flushing requires the simulation of fluid flow and solute transport in the vadose zone. Numerical models (computer models) are usually used for these simulations. The computer model VS2DT (Healy, 1990) will be used to conduct the preliminary numerical simulations. Additional modeling is planned to evaluate expected down flushing performance using site-specific soil properties (from soil samples to be collected from borings required for the AP Area) and to evaluate actual down flushing performance during implementation of this treatability study.

3.2.4 Infiltration Testing

Eighteen double-ring infiltrometer tests will be conducted near the eighteen soil borings advanced in Plots 1 and 2. The infiltration tests will be performed to estimate vertical infiltration rates in Plots 1 and 2. To obtain results that are representative of native soils, the shallow fill present at each test location will be removed with a backhoe and placed in covered stockpiles prior to testing. The double-ring infiltration tests will be conducted in general accordance with ASTM Standard D3385-09: Standard Test Method for Infiltration Rate of Soils in Field Using Double Ring Infiltrometer (ASTM International, 2009b). Testing will be performed by Geotechnical and Environmental Services, Inc. of Las Vegas, Nevada.

After testing is completed, the excavated soil will be sampled in accordance with the requirements of the Site Management Plan (Ramboll Environ, 2015) and if the sample results exhibit acceptable soil concentrations, then the excavated soil will be used to backfill the excavations.

3.2.5 Demolition and Scarification

A number of surface obstructions are present in Plots 1 and 2, including asphalt pavement, concrete building slabs, and cinder block blast walls. After a demolition permit is obtained, these structures will be demolished to prepare the Site for down flushing. After demolition is completed, the ground surface will be scarified to loosen compacted surface soils in preparation for down flushing.

3.3 UP FLUSHING PROGRAM

SLMW will be injected above and below the UMCf contact via injection wells to push the perchlorate-bearing groundwater toward the IWF and the supplemental extraction wells. By injecting water directly into the alluvial aquifer, the saturated zone thickness will increase to mobilize lower vadose zone perchlorate and increase groundwater flow rates to the IWF. Also, water will be injected below the alluvial aquifer to flush perchlorate-

bearing groundwater within the UMCf upward into the alluvial aquifer where it can be extracted more easily by the IWF and supplemental extraction wells.

The up flushing field testing program will consist of 1) installing injection and monitoring wells to characterize the subsurface, 2) assessing perchlorate impacts within the Qal and UMCf, and 3) assessing the hydraulic properties for up flushing implementation.

In addition, six soil boring locations will be drilled and four monitoring wells will be installed to characterize the subsurface, including the confirmation of a paleochannel, in the vicinity of the Central Retention Basin, BT tanks, and upgradient of the AP-5 Pond (Figure 2).

The following sections summarize the up flushing program.

3.3.1 Utility Clearance

Prior to performing intrusive field work, a geophysical survey will be performed to identify subsurface utilities at each boring location. The geophysical survey will be conducted by Ground Penetrating Radar Systems, Inc. of Las Vegas, Nevada. In addition, all boring locations will be cleared for subsurface utilities to a depth of 12 feet using a vacuum excavation rig operated in water or air mode. The vacuum excavation rig will be operated by National.

3.3.2 Injection and Monitoring Well Installation

Four triple-cluster completion injection wells and three triple-completion groundwater monitoring wells will be installed for Plot 1 (Figure 3). Four triple-cluster completion injection wells and three triple-completion groundwater monitoring wells will be installed for Plot 2 (Figure 3). Drilling and well installation will be conducted by National using the hollow stem auger method. Soil samples will be generally collected from the borings at depths of approximately 0.5 feet, 5 feet, and at 5-foot depth intervals thereafter using a 2.5-inch inside diameter, 18-inch long California split barrel sampler lined with three six-inch long, 2.5-inch diameter stainless steel sleeves. Upon retrieval from the borehole, the lowermost sleeve will be removed from the sampler and the ends of the sleeve will be covered with Teflon sheets and tightly fitting plastic caps. The soil samples will be labeled, placed in recloseable plastic bags, and stored in an ice chest cooled with ice pending delivery to the laboratory under chain-of-custody protocols. The soil samples will be analyzed for perchlorate using USEPA Method E314.0, hexavalent chromium using USEPA Method 7199, and total chromium using USEPA Method 6010B. The chemical analyses will be performed by TestAmerica. Selected samples will be also analyzed for physical properties (dry bulk density, grain density, porosity, moisture content, and hydraulic conductivity) by PTS. The soil borings will be logged by a trained geologist or engineer in general accordance with ASTM Standard D-2488-09 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM International, 2009a). Geologic cross-sections along with perchlorate and hexavalent chromium soil concentrations from the injection well borings will be generated.

All the injection and monitoring wells will consist of two-inch inner diameter Schedule 40 PVC blank casing and 0.020-inch slotted PVC screen. The shallow wells (designated “S”) will be screened in the Qal at 5 feet above the Qal/UMCf contact from approximately 25 to 30 feet bgs; the intermediate wells (designated “I”) will be screened in the UMCf at 5 feet below the Qal/UMCf contact from approximately 35 to 40 feet bgs; and the deep wells (designated “D”) will be screened in UMCf at 15 feet below the Qal/UMCf contact from 45 to 50 feet bgs. UFIW-02I and UFIW-06I will be installed with 10 feet screen intervals from 5 feet below the Qal/UMCf contact to 15 feet below the Qal/UMCf contact to evaluate the effect a larger screen interval has on injecting into the UMCf. Injection wells will be installed in single completions to avoid potential short circuiting during injection activities. Well locations and top of casing will be surveyed by a state-licensed surveyor. After installation, the injection, monitoring, and extraction wells will be developed following industry standard operating procedures.

3.3.3 Slug Testing

Slug testing will be conducted by Tetra Tech personnel at Plot 1 and Plot 2 well locations to estimate aquifer hydraulic conductivity in the study area, with the exception of the shallow wells due to the limited amount of water present in the wells. The slug tests will be performed in general accordance with American Society for Testing and Materials (ASTM) Standard D4044-96 (ASTM International, 2008). Prior to conducting each slug test, the water level in the well will be measured manually with an electronic water level probe to determine the static groundwater level. An electronic pressure transducer/data logger will then be suspended in the well, and water levels will be monitored manually until static conditions are reestablished. A falling-head test will then be conducted by smoothly lowering a length of weighted and sealed PVC pipe (slug) into the well, securing it in place above the transducer, and recording the rate of water level decline. Once static conditions are reestablished, a rising-head test will be conducted by removing the slug and allowing the water level to again recover to static conditions while recording the rate of recovery. Barometric pressure changes during testing will be monitored and recorded using a pressure transducer placed above the water table.

At the end of each test, the pressure transducer will be removed from the well, and the water level displacement data will be downloaded to a laptop computer and corrected for barometric pressure effects. The corrected data will be interpreted using AQTESOLV for Windows (Duffield, 2014), or similar aquifer test analysis software. If possible, both the falling-head and rising-head data will be analyzed to cross-check the interpretation results.

3.3.4 Baseline Groundwater Monitoring

Wells will be gauged and sampled following well development to obtain baseline groundwater conditions prior to performing injection testing and soil flushing activities. Groundwater samples will be collected using low flow sampling techniques and groundwater bailing, where necessary. General groundwater quality parameters (pH, temperature, specific conductivity, oxidation-reduction potential, dissolved oxygen, and turbidity) will be analyzed in the field using a water quality meter. The groundwater samples will be analyzed for perchlorate using USEPA Method E314.0, hexavalent chromium using USEPA Method 7199, and total chromium using USEPA Method 6010B. Selected groundwater samples will be also analyzed for Nitrate as N using USEPA Method 300.0 and total dissolved solids using USEPA Method SM 2540C. The chemical analyses will be performed by TestAmerica.

3.3.5 Injection Testing

Tetra Tech will perform injection testing in the shallow and intermediate injection intervals for Plot 1 and Plot 2. Plot 1 injection testing will be performed using an injection trailer. Plot 2 injection testing will be performed with a direct injection system designed and installed by Tetra Tech using the pressurized SLMW line located northwest of Plot 1. SLMW will be injected into the injection wells at various pressures to generate flow versus pressure curves for each injection interval. Tracer dyes, Rhodamine WT and fluorescein (a.k.a. uranine), will be injected to evaluate the vertical and horizontal distribution of the injections as well as the groundwater flow rate within the study area.

3.4 EXTRACTION WELL SYSTEM

Tetra Tech will install a groundwater extraction system as part of the AP Area Down and Up Flushing Treatability Study to capture a large percentage of the water being flushed through Plots 1 and 2 and convey the extracted water to the GWETS for treatment. Three groundwater extraction wells, designated E1-1 through E1-3, will be installed approximately 30 feet downgradient of Plot 1 and five groundwater extraction wells, designated E2-1 through E2-5, will be installed approximately 30 feet downgradient of Plot 2.

Drilling and well installation will be conducted by National using the hollow stem auger method. Soil samples will be collected at various depths from the borings at depths of approximately 10 to 60 feet bgs using a 2.5-inch inside diameter, 18-inch long California split barrel sampler lined with three six-inch long, 2.5-inch diameter stainless steel sleeves. Upon retrieval from the borehole, the lowermost sleeve will be removed from the sampler and the ends of

the sleeve will be covered with Teflon sheets and tightly fitting plastic caps. The soil samples will be labeled, placed in recloseable plastic bags, and stored in an ice chest cooled with ice pending delivery to the laboratory under chain-of-custody protocols. The soil samples will be analyzed for perchlorate using USEPA Method E314.0, hexavalent chromium using USEPA Method 7199, and total chromium using USEPA Method 6010B. The chemical analyses will be performed by TestAmerica.

The extraction wells will be installed with 6-inch Schedule 40 PVC blank casing and 0.020-inch slotted PVC screen. The extraction wells will be screened from approximately 5 feet above the Qal/UMCf contact to approximately 20 feet below the Qal/UMCf contact for a total screen interval of 25 feet. Well locations and top of casing will be surveyed by a state-licensed surveyor.

The groundwater extraction system will include eight ½-hp extraction well pumps, electrical panel, switches, control contactors and motor starters. The installed system pumps groundwater from the extraction wells to the existing GWTP equalization tank through the existing I-AR piping.

System controls will shut down the extraction well pumps on High-High level in the GWTP equalization tank. Extraction well pumps are protected against running dry by a motor pump protector, which turns off the well pumps when low water levels are present and will automatically restart the pumps (by means of individually adjustable timers). Extraction wells will shut down (by means of either a wireless float switch and a hard wired float switch and the red alarm light will activate and the auto dialer will send out an e-mail and call staff) on High level at GWTP equalization tank and will require a manual restart (reset button on control box). Secondary containment will be provided for all above ground piping and valves. Also, all above ground piping will be freeze-protected by using a heat tracing system, wrapping insulation around exposed pipe segments, and burying exposed piping with sand.

Totalizing flow meters, globe valves, and sample ports will be installed for each extraction well to monitor the extraction flow rate, total amount of water extracted, adjust extraction flow rates, and allow for sample collection. System operations will be coordinated with the GWETS operator, Envirogen Technologies, Inc. (ETI).

3.5 OPERATION OF DOWN FLUSHING AND EXTRACTION WELL SYSTEM

System operation will commence with a two-week startup period for down flushing and extraction wells. System startup will include the following:

- Inspecting down flushing piping, valves, and emitters for leaks;
- Inspecting extraction well system piping for leaks;
- Testing, troubleshooting, and adjusting of system controls, alarms, and telemetry; and
- Monitoring and adjusting flow rates for the down flushing and extraction wells.

After the start-up period, routine system operation, maintenance, and monitoring (OM&M) will be performed for the duration of the treatability study, assuming a duration of 12 months. See Section 4.1.1 for details on OM&M activities that will be performed on a daily, weekly, bimonthly, and monthly basis. For down flushing operation, each of the nine subplots or zones within Plots 1 and 2 will be flushed to infiltrate approximately two pore volumes of water. The time needed to flush two pore volumes of water may be adjusted based upon infiltration rates in the field. For extraction well operation, flow rates will be adjusted to pump at the maximum sustainable rate to capture groundwater. When groundwater gauging and sampling shows that the down flushing front has reached the extraction wells, the flow rates at the extraction wells will be increased to capture this additional water.

3.6 MANAGEMENT OF INVESTIGATION-DERIVED WASTES

Investigation-derived waste generated during the down flushing and up flushing programs will be managed according to applicable state, federal, and local regulations and as described in Field Guidance Document No.001, Managing Investigation-Derived Waste (ENVIRON, 2014b).

The investigation-derived waste that will be generated during the field testing program includes soil cuttings, personal protective equipment, equipment decontamination water, demolished surface obstructions, and groundwater generated during depth-discrete groundwater sampling and well development. Investigation-derived soil waste will be stored in plastic-lined roll-off bins. Solids will be characterized by collecting representative samples, as necessary, to determine disposal options. Waste water generated during purging or decontamination activities will be temporarily stored in totes and transferred into the GW-11 Pond. Soil bins will be labeled with "pending analysis" labels, the date accumulation began, contents, source, and contact information, and stored in a designated area.

3.7 DATA VALIDATION

The data validation for these field characterization activities will be reported in a Data Validation Summary Report (DVSR). Data validation will be a Level 2A validation effort. This includes verification and validation based on completeness and compliance checks of sample receipt conditions and only sample-related Quality Control results. Automated Data Review software will be used. Data packages will be provided by the TestAmerica through Tier II electronic data deliverables through downloads of data directly from the laboratory information management system. As a result, all data provided electronically comes from the same database, and is subject to the same quality control procedures, as data provided in hard copy formats. This study will use EQuIS® database intervention to produce tables for the DVSR and to provide the required database deliverable.

3.8 PERMITTING REQUIREMENTS

3.8.1 NDEP – Underground Injection Control Program

The AP Area treatability study will require an underground injection control (UIC) permit for the injection of the calcium polysulfide and tracer dyes into the saturated subsurface. Assuming injections may continue after the six-month timeframe, an application for a UIC General Permit for Long-Term Remediation will be prepared in lieu of the short-term UIC permit. The General Permit for Long-Term Remediation requires completion of UIC Form U200 - Permit Application and UIC Form U210 – Notice of Intent, as well as periodic injection/monitoring reports.

3.8.2 Nevada Division of Water Resources

The AP Area treatability study will require a NAC 534.441 Monitor Well Drilling Waiver and a NAC 534.320 Notice of Intent Card prior to installation of injection wells and monitoring wells. The Monitoring Well Drilling Waiver also requires a completed, signed, and notarized Affidavit of Intent to Abandon a Well as an attachment. As required, the injection and monitoring wells will be drilled by a licensed well driller pursuant to Nevada Revised Statutes 534.160 and will be constructed pursuant to NAC Chapter 534 – Underground Water and Wells. All injection and monitoring wells associated with this treatability study will be abandoned in accordance with the provisions contained in NAC 534.4365 and all other applicable rules and regulations for plugging wells in the State of Nevada upon completion of the treatability study.

Pursuant to Nevada Revised Statutes 533.335 and 533.437, the AP Area treatability study will require a Permit to Appropriate the Public Waters of the State of Nevada for Environmental Purposes (Water Appropriation Permit). The permit will support the installation and operation of extraction wells to extract up to 0.25 cubic feet per second (112 gallons per minute) at the AP Area.

3.8.3 Clark County

Two permits from Clark County are required for the AP Area treatability study: demolition and electrical permits. A demolition permit is required to remove two masonry blast walls and any surface materials that would impede infiltration of SLMW from down flushing. In the AP Area, these surface materials include concrete and asphalt.

Since the extraction well system has electrical components, the treatability study requires an electrical permit. Electrical drawings of the process controls system will be submitted to Clark County. A site inspection will also be conducted by Clark County to verify the electrical drawings.

Please note that a modification to the existing dust control permit associated with AP-5 solids removal (Permit #45436) was not required as the work was performed in the areas under the existing modification or was exempt under Clark County Air Regulation 94.4.2 due to the limited soil disturbance area.

3.9 HEALTH AND SAFETY

Fieldwork will be conducted in accordance with an Activity Hazard Analysis and other elements of the Site-wide Health and Safety Plan (Tetra Tech, Inc., 2015b), which addresses potential chemical and physical hazards associated with the field test. It is anticipated that modified Level D personal protective equipment will be required for all field activities.

4.0 EFFECTIVENESS MONITORING PLAN

This section describes the conceptual monitoring program associated with implementation, operation, and system shut down to determine treatment effectiveness.

4.1 GROUNDWATER SAMPLING PROCEDURES

General groundwater sampling activities will follow the guidance of the Field Sampling and Analysis Plan (ENVIRON, 2014b). Prior to groundwater sample collection, groundwater levels will be gauged in all monitoring and injection wells. After the installation of the wells, groundwater samples will be collected using low-flow purging and sampling techniques. During low-flow purging of the wells, a pump capable of purging between approximately 0.1 to 0.13 gpm will be used to minimize drawdown and induce inflow of fresh groundwater. The pump discharge water will be passed through a flow-through cell field water analyzer for continuous monitoring of field parameters (temperature, pH, turbidity, electrical conductivity, dissolved oxygen, and oxidation reduction potential). Field parameters will be monitored and recorded on field sampling forms during purging. The wells will be sampled when purging is complete, which is when the field parameter readings and water levels have stabilized.

4.1.1 Performance Monitoring

Groundwater samples will be collected from all injection and monitoring wells in the vicinity of the AP Area to establish baseline conditions prior to down flushing and up flushing. The following list shows the monitoring, maintenance, and operation requirements for the down flushing, up flushing, and extraction well systems. Table 1 presents the parameters, associated methods, purpose, and potential sampling frequency.

- **Monitoring, Maintenance, and Operation:**
    - Perform daily monitoring activities including the following:
        - Inspect and record the condition of the down flushing system including potential leaks, ponding, or clogging, and volume of water applied per infiltration zone;
        - Inspect and record the condition of the up flushing system including potential leaks and amount of calcium polysulfide remaining;
        - Inspect and record the condition of the extraction system for leaks, alarm conditions, extraction pump operation, volume of water extracted from each extraction well; and
        - Coordinate discharge pumping rate with ETI.
    - Perform weekly monitoring activities including the following:
        - Collect water samples from each of the eight extraction wells for electrical conductivity, perchlorate, and hexavalent chromium analysis through their respective sampling ports; and
        - Measure groundwater levels in each of the 18 monitoring wells.
    - Perform bimonthly monitoring activities including the following:
        - Measure groundwater levels and collect water samples from each of the 18 monitoring wells for perchlorate and hexavalent chromium analysis.

- Perform routine maintenance and troubleshooting activities including, but not limited to, the following:
  - Installation and operation of a telemetry system and controls for extraction system; and routine inspections and repairs;
  - Down flushing system reconfiguration and deployment from zone to zone;
  - Unclogging and replacing emitters and sample ports;
  - Cleaning and repairing extraction well and discharge pumps;
  - Inspecting and repairing piping, fittings, and valves; and
  - Inspecting secondary containment of manifold and piping.

Table 1 Example Performance Monitoring Sampling Protocol

Parameter	Analytical Method	Purpose	Potential Frequency
Field Parameters			
EC	Field Meter	Assess geochemical conditions	Baseline, Weekly, Bimonthly
pH	Field Meter		
DO	Field Meter		
ORP	Field Meter		
Temperature	Field Meter		
Turbidity	Field Meter		
Laboratory Parameters			
Perchlorate	E314	Assess down flushing effectiveness	Baseline, Weekly, Bimonthly
Hexavalent Chromium	SW846 7199	Assess down flushing effectiveness	Baseline, Weekly, Bimonthly
Acronyms and Abbreviations: DO: Dissolved oxygen EC: Electrical conductivity ORP: Oxygen reduction potential			

4.2 CONFIRMATION SOIL SAMPLING

General soil sampling activities will follow the guidance of the Field Sampling and Analysis Plan (ENVIRON, 2014b). Soil samples will be collected before and after system operation to verify down flushing system effectiveness. As stated in Section 3.2.2, baseline sampling will be conducted prior to down flushing system construction to establish baseline soil conditions. After this treatability study is completed, eighteen soil borings will be drilled adjacent to each of the eighteen baseline borings to evaluate changes in perchlorate and hexavalent chromium in the vadose zone. The post-testing borings will be sampled at the same depths as the baseline borings. Physical testing parameters, such as dry bulk density, moisture content, grain size, and porosity, will also be analyzed to evaluate the change in perchlorate mass in Plots 1 and 2.

4.3 DATA VALIDATION

The data validation for the effectiveness monitoring will be reported in a DVSR. Data validation will be a Level 2A validation effort. This includes verification and validation based on completeness and compliance checks of sample receipt conditions and only sample-related Quality Control results. Automated Data Review software will be used. Data packages will be provided by the TestAmerica through Tier II electronic data deliverables through downloads of data directly from the laboratory information management system. As a result, all data provided electronically comes from the same database, and is subject to the same quality control procedures, as data provided in hard copy formats. This study will use EQuIS® database intervention to produce tables for the DVSR and to provide the required database deliverable.

5.0 REPORTING

Monthly operational data will be provided to the Trust which will include extraction well flow rates, water-level elevations, and perchlorate and hexavalent chromium concentration data for the GWETS monthly reporting.

Following completion of the treatability study, an AP Area Down and Up Flushing Treatability Study Report will be prepared. This report will include the following:

- Results of infiltration tests, injection tests, and slug tests;
- Analytical results summary of soil and groundwater samples collected during the preliminary field activities and groundwater samples collected during the performance monitoring program;
- Data Validation Summary Report as an appendix;
- Evaluation of the effectiveness of soil flushing for reducing perchlorate mass in the vadose zone;
- Assessment of perchlorate mobilization into groundwater during system operations; and
- Assessment of the effectiveness of up flushing.

6.0 SCHEDULE

Table 2 provides the general schedule for the primary deliverables and activities associated with implementing the AP Area Down and Up Flushing Treatability Study. Multiple tasks will be performed concurrently during this study, and the total project duration is 2 years. This schedule is contingent upon Trust, NDEP, and US EPA approval of this Work Plan and Trust approval of funding and notice to proceed.

Table 2 Preliminary Project Schedule

Task/Milestone	Task Duration
Preliminary Field Activities	2 months
Permitting Applications and Approvals	4 months
Conceptual Down and Up Flushing Design	2 months
Down Flushing Characterization (Utility Clearance, Soil Borings, and Infiltration Testing)	3 months
Up Flushing Characterization (Utility Clearance, Well Installation, Slug Testing, Groundwater Monitoring, Bench-scale and Injection Testing)	4 months
Demolition and Scarification	2 months
Down Flushing System Installation	2 weeks
Down Flushing Startup and Operation	1 year, 3 months
Extraction Well System Installation	2 weeks
Extraction Well System Startup and Operation	1 year, 3 months
Performance Monitoring	1 year, 3 months
First UIC Permit Report	1 month
First Water Appropriation Permit Report	1 month
Second UIC Permit Report	1 month
Second Water Appropriation Permit Report	1 month
Third UIC Permit Report	1 month
Confirmation Soil Sampling	2 months
Treatability Study Report including Data Validation	4 months

7.0 REFERENCES

ASTM International. (2008). *Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers*.

ASTM International. (2009a) *Standard D-2488-09 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*

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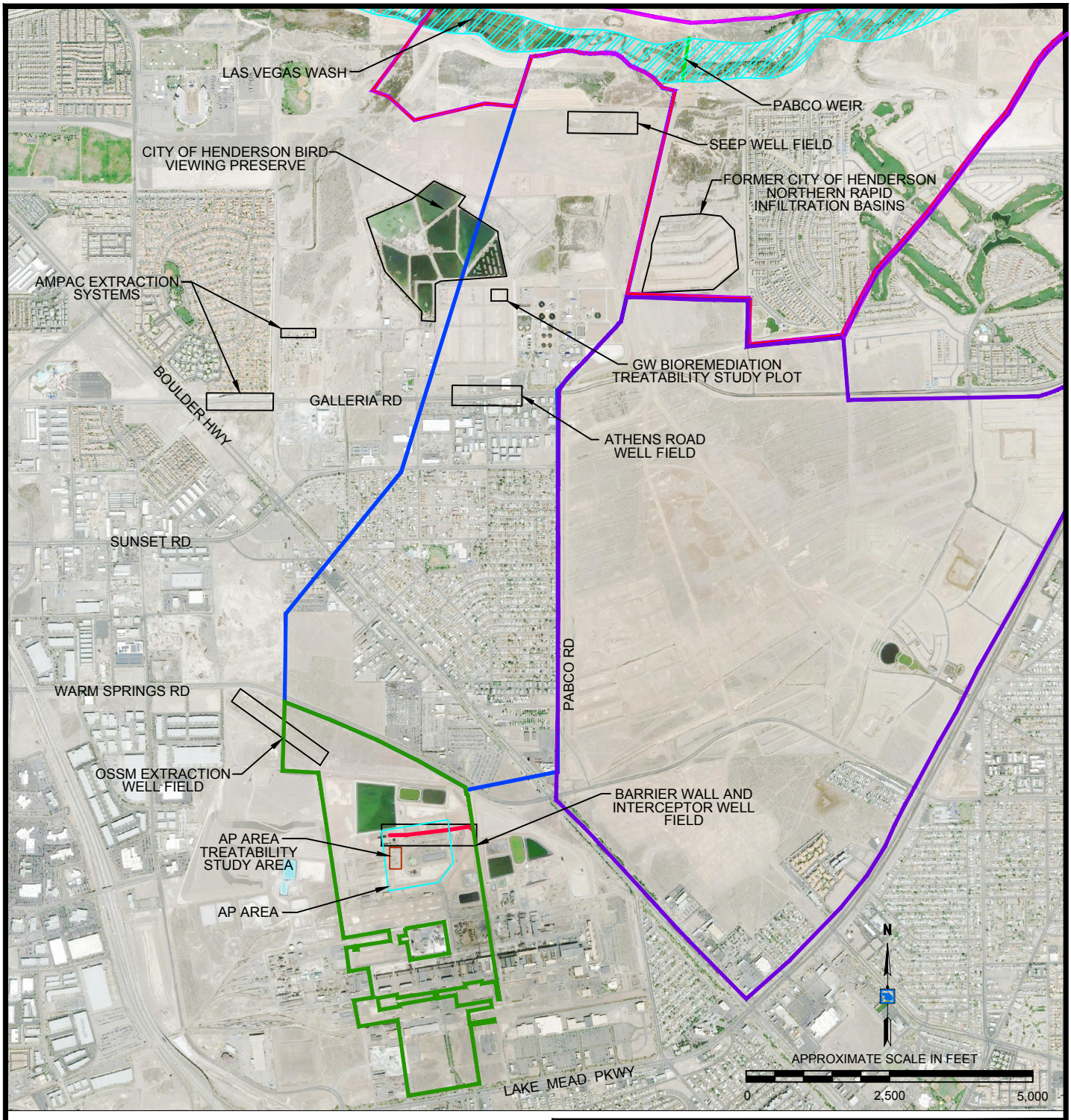
Tetra Tech, Inc. (2017) *Soil Flushing Treatability Study Report, Nevada Environmental Response Trust Site, Henderson, Nevada*.

Figures



LEGEND

- NERT SITE BOUNDARY
- EASTSIDE STUDY AREA
- NERT OFF-SITE STUDY AREA
- DOWNGRADIENT STUDY AREA
- AP AREA BOUNDARY
- AP AREA TREATABILITY STUDY AREA BOUNDARY

NOTES:
1. "LAS VEGAS, NV." MAP. GOOGLE EARTH PRO. GOOGLE, 22 MAR. 2015.
2. ALL LOCATIONS ARE APPROXIMATE.

SITE LOCATION MAP

NEVADA ENVIRONMENTAL RESPONSE TRUST — HENDERSON, NV

PREPARED BY:
TETRA TECH, INC.
1489 WEST WARM SPRINGS ROAD, SUITE 110
HENDERSON, NEVADA 89014
Phone (702) 966-8340

PROJECT NUMBER	APPROVED BY	DRAWN BY	DATE	FIGURE
117-7502016-K01	CL	WRI	NOV 2016	1

P:\CAD Temp\NERT\M-13\ORIGINAL DATA\FIGURE 1 - SITE LOCATION MAP-REV.dwg Feb 05, 2018 - 2:06pm diane.lucas

LEGEND

- M-55 — MONITORING WELL / WELL CLUSTER
- UFIW-02 — INJECTION WELL / WELL CLUSTER
- I-M — EXTRACTION WELL
- DFS-01 — SOIL BORING
- SA19 — HISTORICAL SOIL BORING
- EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING OVERHEAD ELECTRICAL LINE
- EXISTING UNDERGROUND ELECTRICAL CONDUIT
- EXISTING UNDERGROUND WATER LINE
- EXISTING HYDRANT
- STABILIZED LAKE MEAD WATER CONNECTION
- GROUNDWATER BARRIER WALL
- AP AREA BOUNDARY
- CENTRAL RETENTION BASIN
- AP AREA TREATABILITY STUDY AREA
- SOIL FLUSHING PLOT

REFERENCES:
1. AERIAL DEVELOPED BY AEROTECH MAPPING, INC. AUG. 2016.

N

APPROXIMATE SCALE IN FEET

0 60 120

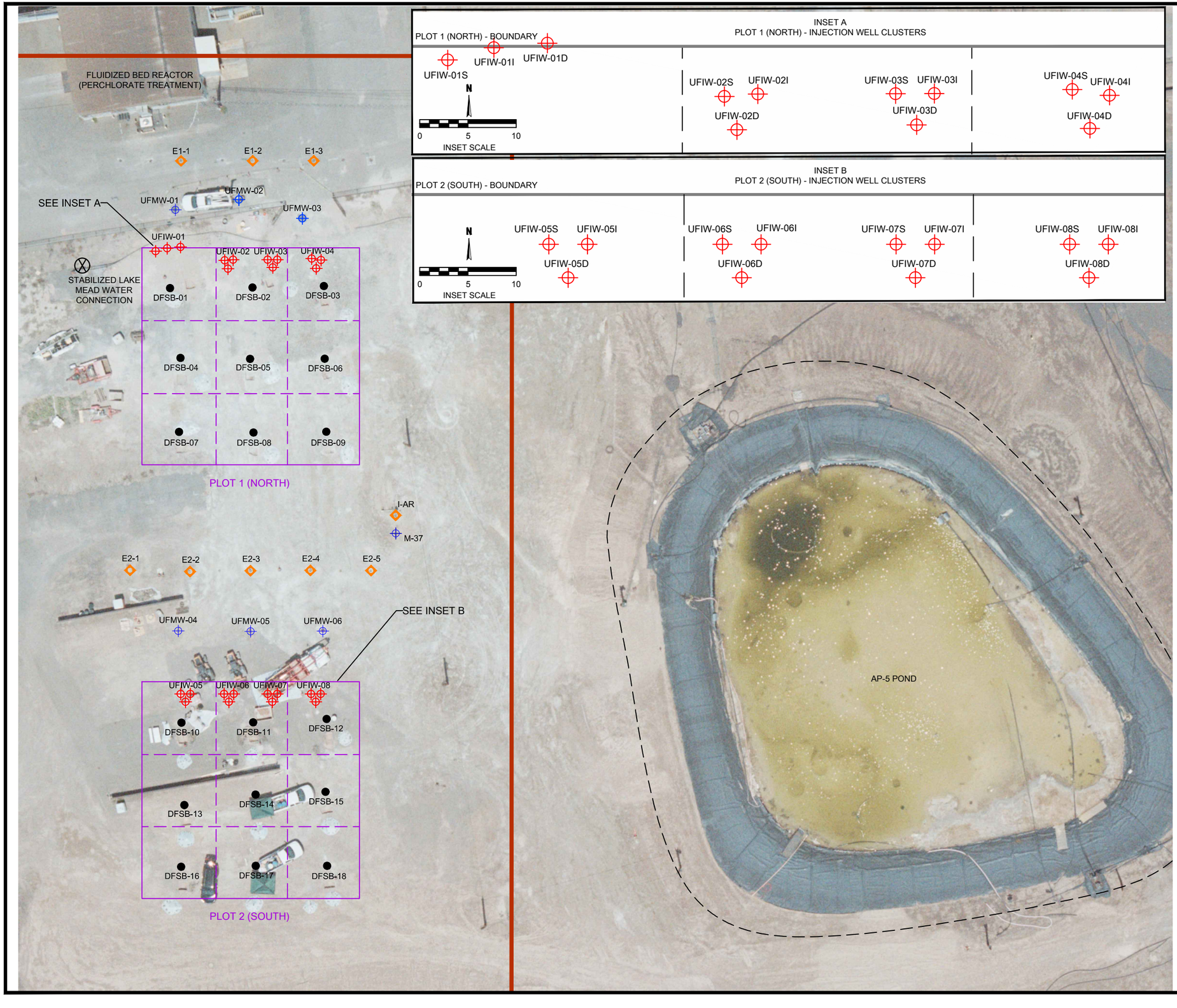
AP AREA SITE MAP

NEVADA ENVIRONMENTAL RESPONSE TRUST HENDERSON, NEVADA

PREPARED BY:
TETRA TECH, INC.
1489 WEST WARM SPRINGS ROAD, SUITE 110
HENDERSON, NEVADA 89014
Phone (702) 966-8340

PROJECT NUMBER	APPROVED BY	DRAWN BY	DATE	FIGURE
117-7502016-K01	CL	DVK	NOV 2016	2

P:\97600012-NERT-M13\CAD\Tech Memo\FIGURE 2 - AP AREA SITE MAP.dwg Jan 31, 2018 - 3:20pm daniel.keady



LEGEND

- UFMW-06 — MONITORING WELL
- UFIW-03 — INJECTION WELL
- E2-3 — EXTRACTION WELL
- DFSB-18 — SOIL BORING
- AP AREA TREATABILITY STUDY AREA BOUNDARY
- SOIL FLUSHING PLOT

N

APPROXIMATE
SCALE IN FEET

0 20 40

REFERENCES
1. AERIAL DEVELOPED BY AEROTECH MAPPING, INC. AUG. 2016.

PLOT 1 AND PLOT 2
AREA SITE MAP

NEVADA ENVIRONMENTAL RESPONSE TRUST HENDERSON, NEVADA

PREPARED BY:
TETRA TECH, INC.
1489 WEST WARM SPRINGS ROAD, SUITE 110
HENDERSON, NEVADA 89014
Phone (702) 966-8340

PROJECT NUMBER	APPROVED BY	DRAWN BY	DATE	FIGURE
117-7502016-K01	EP	JRL	NOV 2016	3